EFFECTS OF SUMMER CATTLE GRAZING ON BIG GAME WINTER RANGE IN NORTHERN UTAH

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ABSTRACT

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by Dean D. Doell

A study was conducted during the four-year period 1961-64 to determine the season and intensity of cattle grazing that would lessen competition between bitterbrush (Purshia tridentata) and herbaceous vegetation and at the same time result in minimal use of bitterbrush on big game winter range.

Three sets of paired pastures were established at the Hardware Ranch in northern Utah. Two grazing intensities -- moderate (40 percent use) and heavy (60 percent use) -- of a key grass species, beardless wheatgrass (Agropyron inerme), were imposed on the two pastures of each set during the early, mid-grazing and late grazing periods of the summer grazing season. Canopy-coverage data of the vegetation on each pasture were taken prior to grazing each year. Phenological data were recorded throughout the grazing season. Moisture content of the important grasses, forbs, and bitterbrush was determined throughout the summer. Utilization of the important grasses and forbs was determined by ocular estimates made at approximately seven day intervals on 25 permanent 96 square-foot circular plots located randomly within each pasture. Ocular estimates of bitterbrush use were obtained from 20 tagged bitterbrush plants in each pasture. During the early grazing season, cattle preferred the herbaceous forage plants, utilizing bitterbrush lightly. During both the mid-grazing and late grazing periods,

bitterbrush was utilized readily; although herbaceous forage was still taken in volume. This study indicates that big game winter ranges in northern Utah supporting browse and herbaceous forage should not be grazed with cattle after 1 July if maximal use of herbs and minimal use of bitterbrush is desired.

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By

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INTRODUCTION

Domestic livestock and big game animals jointly use much of Utah's big game winter range. In the past, those parts of the winter range that lie in the foothills have been used heavily by both livestock and big game animals. These foothill ranges are grazed during the spring, and often again in the fall by livestock, after which they are utilized by big game animals during the winter. Although some private ranges of this type are grazed by livestock during the summer, most foothill ranges in northern Utah lie intermediate between areas of winter and summer livestock use. These so-called spring-fall livestock ranges are thus the weak link in the management for big game animals in conjunction with livestock.

Several State and Federal agencies own and manage the major part of these winter ranges in Utah. The Utah State Department of Fish and Game owns approximately 116,500 acres and leases 66,417 acres of foothill ranges from the Utah State Land Board as well as from two Federal agencies. Most of the Department's big game winter ranges have not been grazed by livestock since acquisition; however, since the completion of this study, three such winter ranges have been placed on a cattle grazing program.

Studies show that when these winter ranges are grazed by big game animals alone, browse plants decrease and grasses and forbs increase (Ratcliff 1941, Smith 1949, Cysel 1960). Conversely, shrub components are increased by cattle use alone. Obviously then, regulated common use by cattle and big game animals should maintain a vegetational

balance that not only will furnish forage for livestock but also will support a big game herd.

Many big game winter ranges of northern Utah are within the sagebrush-grass type. Although big sagebrush (Artemisia tridentata) is nutritious and considered an important big game winter browse, it alone appears to be inadequate for deer. Big sagebrush, in mixtures with preferred browse, is readily eaten by big game animals and accounts for a better quality of feed (Smith 1950, Dietz and Yeager 1959).

Bitterbrush (Purshia tridentata) is an associate with big sagebrush on many sagebrush-grass type winter ranges in Utah. Bitterbrush is considered a key browse species where it is abundant on these ranges, because it is highly palatable and preferred (Smith 1950, Dietz and Yeager 1959) and can stand heavy use by big game animals.

Recent grazing studies with domestic and big game animals have mostly emphasized the effects of overgrazing and intensity of use. They have not emphasized species selection or preference as a factor influencing vegetational changes, nor proper period or season of use. This we tried to do. The objectives of this study were: (1) to determine the utilization of the important grasses, forbs, and bitterbrush under different periods and intensities of use by cattle; (2) to determine the degree to which cattle would utilize bitterbrush forage in the presence of an abundance of herbaceous forage; (3) to determine the effect of cattle on vegetational composition; and (4) to relate the stage of plant development and moisture content to species utilization. This study was initiated during the summer of 1961 and terminated in the fall of 1964.

DESCRIPTION OF STUDY AREA

The investigation was conducted at the Hardware Ranch, Blacksmith Fork Canyon, Cache County, Utah, a property of approximately 14,000 acres. The initial base property was purchased by the Utah State Department of Fish and Game in 1946. This area is the primary winter range for elk (Cervus canadensis nelsoni) in northern Utah. Each winter hay is fed to approximately 300 head of elk that winter on the "Ranch". Mule deer (Odocoileus hemionus hemionus) also frequent the Ranch. Winter deer use, as determined by pellet group counts, has varied from 17 to 45 deer-days-use-per-acre during the past five years. Both species of animals winter on this area for approximately seven months, from October through April. However, no livestock grazing has been permitted since the area was purchased.

The vegetation on the study site is a sagebrush-grass type, which is representative of the foothill winter ranges of northern Utah (Fig. 1). The most prominent plant species is big sagebrush, but other shrubby plants are present. These species, together with prominent herbaceous species, indicate that the area is marginal between the sagebrush association of Shantz (1925) and the mountain brush association of Stoddart and Smith (1955).

Temperature extremes at a weather station located at the Ranch headquarters ranged from 100° F to -36° F with a mean annual air temperatures of 38 to 42° F for the duration of the study (U. S. Weather Bureau 1961-1964).

Fig. 1. Typical aspect of big game winter range on the Hardware Ranch in northern Utah.

Average summer temperatures were 60 to 62° F for the years of study. The frost-free period is 90 to 130 days, but the growing period may be shortened by drought (Shantz 1925). The annual precipitation varied from 18 to 26 inches and was well distributed throughout the year -- a large proportion of it being winter snow. The study area near the center of the ranch property slopes to the south and southeast and varies in elevation from approximately 5800 feet to 6300 feet.

Soils of this area were typed by the Soil Conservation Service as belonging to the Ant Flat and Yeates Hollow series, which were derived from quartzite and quartzite-calcareous sandstone parent material respectively. These soils range in texture from a loam to an extra stony, silty clay loam that are deep, well drained, and have slow permeability and medium runoff (Mr. V. Mortensen, 1965, unpublished, Soil survey of Cache Co., Utah, Soil Conservation Service, Logan, Utah).

METHODS AND PROCEDURES

Six pastures, each approximately five acres in size, were constructed in 1961. Pastures A and B, C and D, and E and F were designated as paired pastures (Fig. 2). One pasture of each pair was assigned moderate cattle grazing pressure. The second pasture was assigned to heavy cattle grazing. The pressure in each pasture was based on the utilization of a particular key or indicator plant species -- beardless wheatgrass (Agropyron inerme). Moderate grazing was arbitrarily set at 40 percent and heavy grazing at 60 percent utilization of this key species. Grazing pressures were randomly assigned to the various pastures. Pastures A, C, and E received moderate grazing pressure, while pastures B, D, and F were heavily grazed. The grazing intensity remained unchanged throughout the study for all of the pastures.

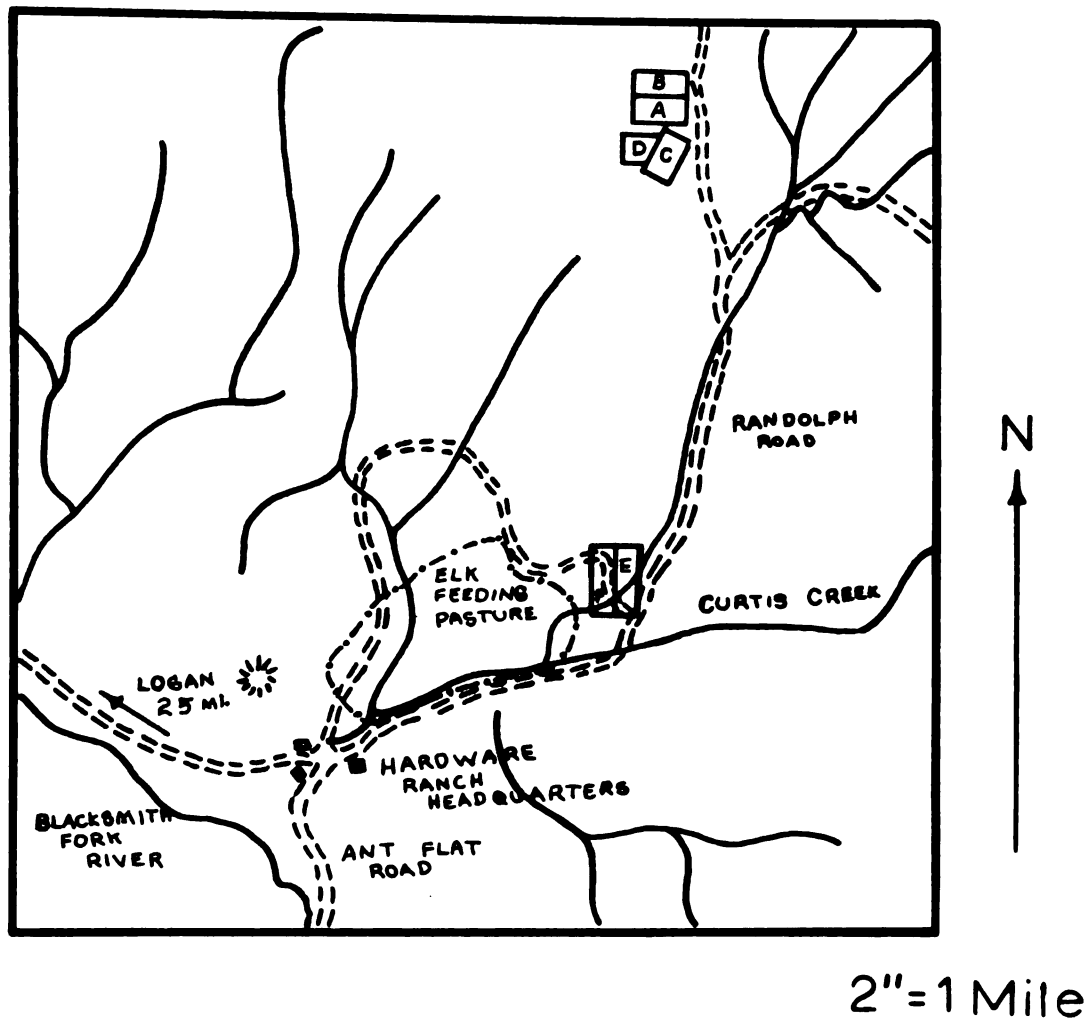

Fig. 2. Map of Hardware Ranch showing location of the experimental pastures.

The summer grazing season was divided into three grazing periods -- early summer, mid-summer, and late summer. The early grazing period extended from late May or early June to late June or early July, depending on the time of the snow melt. The mid-grazing period extended from early July to early August. The late grazing period extended from early August to early September. One pair of pastures was used during each grazing period. Pastures A and B were grazed during the early grazing period in 1961 and 1964 and during the late grazing period in 1962 and 1963. Pastures C and D were grazed all four years during the mid-summer period. Pastures E and F were grazed during the late summer period in 1961 and 1964, and during the early grazing period in 1962 and 1963. Undependable livestock water supplies prevented assignment of all pastures to all periods of use. Availability of water was the reason for pastures E and F to be separated from the other pastures.

Utilization of important grasses and forbs was determined by the Pechanec and Pickford (1937) ocular estimate-by-plot method on 25 permanent 96 square foot, circular plots in each pasture. These plots were randomly selected within each pasture. This utilization method involves an estimate of the percentage of herbage by species removed by weight. Preliminary clipping and weighing of important forage species was done to develop accuracy in estimating. Utilization of bitterbrush was determined by ocular estimates made from 20 tagged bitterbrush plants within each pasture. These bitterbrush plants were selected optically as being representative of the general condition of the plants in the immediate area. Utilization data were collected every seven to ten days during the grazing periods. When utilization on beardless

wheatgrass approached the assigned level of use for that particular pasture, more frequent utilization estimates were made so that utilization did not exceed the assigned levels.

Total plant cover data were collected in each pasture so that comparisons between pastures might be more representative. The first year a 75 foot tape was stretched over representative vegetation at four locations within each pasture. A square foot frame was placed at three foot intervals along this tape and the percentage cover, when viewed from directly above, was estimated for each species. One hundred plots per pasture were observed. The percent of cover of each species for each pasture was then determined for 1961. But, during the last three years of the study, a method proposed by Daubenmire (1959) was used to determine cover. This method consisted of a 75 foot tape stretched over representative vegetation at three locations within each pasture. A frame of 20 cm. x 50 cm. was positioned along one side of the tape and the percent cover by class was estimated for each species within the frame. These classes were: class 1 = 0-5 percent; class 2 = 5-25 percent; class 3 = 25-50 percent; class 4 = 50-75 percent; class 5 = 75-95 percent; and class 6 = 95-100 percent. The midpoint of each class was the value used in data tabulations. One hundred and twenty frame records were made in each pasture prior to grazing.

Phenological data involving plant growth and flower and fruit development of the more important grasses, forb, and browse species were recorded at seven to ten day intervals throughout the grazing periods in each pasture.

Cumulative temperatures and moisture data were used to help explain the relationship of the advancement of plant growth and the development

of the important forage species during the early growing season. A threshold value of 45° F was assumed and, beginning on May 1, the amounts by which the daily maximum temperatures exceeded 45° F were accumulated through June 30 for each year of study. Precipitation was accumulated for the same period for each year of study.

Moisture content of the important grasses, forbs, and bitterbrush was determined by oven-drying plant samples taken concurrently with phenological observations. These data were used to correlate cattle utilization changes on the range forage. Moisture content data from a previous study of bitterbrush were combined with moisture content data collected during the last year of this study to obtain an average moisture content for this species.

The grazing animals were predominantly yearling and two-year old steers and heifers. Six to eight animals were used each year -- half of them in each pasture. When the moderately grazed pasture was utilized to the desired level, the animals from that pasture were shifted to the paired pasture to achieve heavy utilization.

RESULTS AND DISCUSSION

Vegetation Composition

The sagebrush-grass type may be highly variable in vegetation composition depending on site and past use (Pickford 1932). According to Pickford (1932), the total plant cover of a climax sagebrush-grass foothill range of northern Utah consisted of approximately 68 percent perennial grasses, 11 percent big sagebrush, and 21 percent perennial forbs and shrubs other than sagebrush. The cover and composition data collected in 1961 (Table 1) prior to cattle grazing suggest that the area approached the climax condition. Pickford (1932) reported that heavy livestock grazing changed the total plant cover to a disclimax, which consisted of 26 percent perennial grasses and 24 percent big sagebrush (which became the dominant plant species. Cheatgrass (Bromus tectorum) and poor perennial forbs constituted 36 percent, and preferred forbs and bitterbrush constituted 14 percent of the total plant cover. He further reported that bitterbrush and preferred forbs increased in abundance with grazing, but the gains were of minor importance in the composition of the total cover.

Big sagebrush has the widest distribution -- latitudinally, longitudinally, and altitudinally -- of any sagebrush species in the western states. It grows on a great variety of sites from alkaline to non-alkaline soils, but avoids shallow soils (Beetle 1960). Little is known of interspecific relationships in the sagebrush-grass type. Several investigators have made observations on sagebrush-grass interactions and bitterbrush-grass interactions; but these observations

Table 1. Percent plant cover within each experimental pasture at the Hardware Ranch for 1961.[1]

Species	Pastures A	B	C	D	E	F	Ave.
Grasses							
Beardless wheatgrass	1.66	10.57	8.30	9.50	11.90	13.23	9.19
Bearded wheatgrass	1.42	6.35	--	0.10	--	--	1.31
Wheatgrass	2.90	--	10.32	1.65	6.30	14.60	5.96
Cheatgrass	6.91	0.17	0.25	0.15	9.27	0.48	2.87
Carex	0.69	2.61	2.51	2.12	--	--	1.32
Great Basin wild-rye	5.21	1.26	2.35	1.85	--	1.95	2.10
Bluebunch fescue	0.25	1.65	0.27	0.45	--	--	0.44
Junegrass	0.50	0.27	0.10	0.30	1.05	1.18	0.57
Oniongrass	--	--	--	0.90	0.35	--	0.21
Kentucky bluegrass	6.63	11.15	8.00	12.70	--	0.55	6.51
Sandberg bluegrass	2.19	7.54	2.37	1.05	11.40	11.17	5.95
Squirreltail	0.15	--	0.27	2.05	0.30	--	0.46
Columbia needlegrass	0.15	0.45	1.77	0.90	--	--	0.55
Letterman needlegrass	0.77	0.69	2.04	2.07	--	--	0.93
Cover[2]	29.43	42.71	38.55	35.79	40.57	43.16	38.37
Composition[3]	47.20	46.30	43.40	39.90	68.70	73.00	51.00
Forbs							
Yarrow	0.33	0.75	1.02	0.69	0.75	0.36	0.65
Horsemint	--	0.35	--	--	--	--	0.06
Aster	--	--	--	--	0.90	2.23	0.52
Arrowleaf balsamroot	0.89	4.50	--	--	2.70	0.25	1.39
Thistle	0.31	0.52	0.07	0.55	0.10	--	0.26
Buckwheat	--	--	--	1.44	0.25	0.10	0.30
Geranium	0.80	3.00	6.64	9.14	--	--	3.26
Little sunflower	--	--	--	0.20	--	--	0.03
Lupine	0.03	--	0.20	0.58	--	--	0.14
Cinquefoil	0.10	0.10	0.05	1.75	--	--	0.33
Dandelion	--	--	--	0.10	--	--	0.02
Salsify	0.01	--	0.24	0.05	--	--	0.05
Mule ears	--	2.67	4.26	5.80	0.10	--	2.14
Cover[2]	2.47	11.89	12.48	20.30	4.80	2.94	9.15
Composition[3]	4.00	12.90	14.10	22.70	8.10	5.00	12.20

Table 1. (Continued)

Species	Pastures A	B	C	D	E	F	Ave.
Shrubs							
Serviceberry	0.90	0.70	0.07	0.65	--	--	0.38
Wormwood	0.29	0.50	1.00	0.74	--	0.47	0.50
Big sagebrush	23.00	20.34	22.12	17.40	5.00	4.04	15.32
Rabbitbrush	1.94	2.42	--	2.49	4.40	3.99	2.54
Oregon grape	0.10	0.66	--	0.14	--	--	0.15
Bitterbrush	3.09	7.71	11.40	6.15	4.30	4.45	6.18
Wild rose	--	0.46	0.05	0.37	--	--	0.15
Snowberry	1.07	4.82	3.05	5.55	--	--	2.42
Cover[2]	30.39	37.61	37.69	33.49	13.70	12.95	27.64
Composition[3]	48.80	40.80	42.50	37.40	23.20	21.90	36.80
Total Cover	62.29	92.21	88.72	89.58	59.07	59.05	75.16

[1]Data are mean percentages for 100 one-square foot plots in each pasture.

[2]The proportion of the ground surface under live aerial parts of plants.

[3]The relative proportions of various plant species in the total plant cover for each pasture.

have come from widely separated geographic areas, which have undoubtedly influenced the findings. Robertson (1947), Pechanec et al. (1954) and Beetle (1960) reported that big sagebrush is an aggressive species, is drought resistant, and increases under heavy livestock grazing.

Cooper (1953) reported that if sagebrush-grass ranges in Wyoming are grazed conservatively by livestock, grass forage increases and the density of big sagebrush decreases. This area was marginal for sagebrush, which may explain the ease with which grass can compete. Big sagebrush reacts sharply to heavy use in Utah (Cook and Stoddart 1959). It can be eliminated by heavy game animal browsing in the winter (Smith 1949). Beetle (1960) stated that survival of big sagebrush seedlings or grass seedlings is directly related to the amount of litter present. That is, more litter favors grass seedlings; while less litter favors big sagebrush seedlings.

Bitterbrush is a pioneer species on some sites in California. Once established on a site, it helps succession by shielding the soil and other plants; ultimately giving other plant species a chance to take over the site after decades or even centuries (Nord 1965). Hormay (1943) found that cheatgrass retarded natural bitterbrush establishment in California. Holmgren (1956) also found that cheatgrass competes with bitterbrush seedlings on rehabilitated big game winter range in Idaho. He further reported that bitterbrush seedlings can compete better with broad-leaved, summer-annual forbs than with cheatgrass. Smith and Urness (1961) showed that removal of herbaceous vegetation by clipping from around bitterbrush plants increased bitterbrush plant vigor and forage production significantly in Utah. Hubbard and Sanderson (1961) reported similar findings in California. This study was not continued long

enough to provide conclusive evidence on the competitive relations.

The percent vegetational cover by species and vegetation groups for the different pastures for the four years of this study are presented in Tables 1, 2, 3 and 4. The cover and composition data of these pastures showed that the important grasses decreased in species cover and composition in all pastures with cattle grazing; whereas, the forb cover increased in pastures A and F, but decreased in the other pastures, while shrub cover decreased in pastures A, B, C and D, but increased in pastures E and F from 1961 through the summer of 1964.

The change in vegetation cover and composition for the pastures was not solely a result of cattle use. Both biotic and physical factors were involved. The open, cold winter of 1962-63 reduced the cover of snowberry (Symphoricarpos oreophilus); insect damage reduced the cover of big sagebrush in the fall of 1963; and rodents reduced bitterbrush and big sagebrush cover during the winter of 1963-64. Moreover, the different periods of time that the vegetation cover data were collected for the pastures also contributed to differences in vegetation composition. The total vegetation cover was reduced in all the pastures throughout the study.

The direct influences of cattle utilization and trampling upon the vegetation were not separated in this study, although trampling by cattle must have had some reducing effect upon the total vegetation cover (Reynolds and Packer 1963). Grazing and trampling effects are usually confounded although trampling has been shown to reduce vegetation cover.

Big sagebrush was the dominant shrub species on the study site. Bitterbrush, the most important browse forage plant, was next in

Table 2. Percent plant cover within each experimental pasture at the Hardware Ranch for 1962.[1]

Species	Pastures A	B	C	D	E	F	Ave.
Grasses							
Beardless wheatgrass	11.67	5.44	14.08	11.96	9.73	9.33	10.37
Bearded wheatgrass	--	--	--	--	0.77	--	0.13
Western wheatgrass	5.35	1.02	3.35	1.67	9.79	3.88	4.18
Cheatgrass	2.10	--	--	0.25	4.72	--	1.18
Carex	0.42	3.00	1.56	1.06	0.63	0.52	1.20
Great Basin wild-rye	2.15	2.46	0.79	--	--	0.58	0.99
Bluebunch fescue	--	0.15	--	--	--	--	0.03
Junegrass	0.33	0.25	0.27	0.02	--	0.63	0.25
Oniongrass	--	--	--	0.02	--	--	0.00
Kentucky bluegrass	3.48	8.77	4.02	5.46	0.50	0.77	3.83
Sandberg bluegrass	0.92	1.17	1.31	1.13	11.40	23.06	6.50
Squirreltail	2.21	2.54	0.90	0.38	--	--	1.01
Columbia needlegrass	1.56	0.02	--	0.46	--	--	0.34
Letterman needlegrass	1.13	1.06	0.81	1.65	--	--	0.78
Cover[2]	31.32	25.88	27.09	24.06	37.54	38.77	30.79
Composition[3]	35.80	31.00	33.00	25.80	51.90	56.50	37.90
Forbs							
Yarrow	2.38	1.44	1.56	1.00	1.29	3.19	1.81
Aster	3.10	2.35	2.15	2.25	1.88	3.73	2.58
Arrowleaf balsamroot	0.56	0.42	--	--	1.29	0.31	0.43
Thistle	4.50	1.19	--	--	0.29	0.15	1.02
Buckwheat	0.50	0.02	2.81	5.00	0.88	0.54	1.63
Geranium	1.88	4.50	4.15	8.40	--	--	3.16
Little sunflower	--	--	0.27	0.77	--	--	0.17
Lupine	0.13	0.83	0.42	1.06	0.46	1.40	0.72
Cinquefoil	--	--	0.38	0.69	--	--	0.18
Salsify	0.56	0.31	--	0.25	--	--	0.19
Violet	--	--	--	--	1.35	1.67	0.50
Mule ears	--	--	8.33	1.31	--	--	1.61
Cover[2]	13.61	11.06	20.07	20.73	7.44	10.99	14.00
Composition[3]	15.60	13.30	24.40	22.30	10.30	16.00	17.20

Table 2. (Continued)

Species	Pastures A	B	C	D	E	F	Ave.
Shrubs							
Serviceberry	2.48	0.75	0.31	0.92	--	--	0.74
Wormwood	0.96	0.90	1.50	--	0.54	--	0.65
Big sagebrush	19.52	15.56	16.92	17.38	8.50	7.67	14.26
Rabbitbrush	2.98	7.00	0.25	4.60	8.27	5.13	4.71
Oregon grape	0.44	0.19	--	0.46	--	--	0.18
Bitterbrush	8.71	13.23	14.60	16.58	10.00	6.10	11.54
Wild rose	--	0.02	--	0.40	--	--	0.07
Snowberry	7.46	8.85	1.42	7.96	--	--	4.28
Cover[2]	42.55	46.50	35.00	48.30	27.31	18.90	36.43
Composition[3]	48.60	55.70	42.60	51.90	37.80	27.50	44.90
Total Cover	87.48	83.44	82.16	93.09	72.29	68.66	81.22

[1]Data are mean percentages for 120 20cm. x 50cm. plots (40 from each of three transects) in each pasture.

[2]The proportion of the ground surface under live aerial parts of plants.

[3]The relative proportions of various plant species in the total plant cover for each pasture.

Table 3. Percent plant cover within each experimental pasture at the Hardware Ranch for 1963[1].

Species	Pastures[2] A	B	C	D	F	Ave.
Grasses						
Beardless wheatgrass	2.60	0.39	2.90	1.80	1.81	1.90
Western wheatgrass	0.04	--	--	0.04	1.93	0.40
Cheatgrass	0.53	0.76	0.04	0.09	--	0.28
Carex	--	0.59	0.02	--	0.04	0.13
Great Basin wild-rye	0.61	0.33	0.17	0.02	--	0.23
Junegrass	--	--	0.19	0.06	--	0.05
Kentucky bluegrass	0.59	2.70	--	--	0.27	0.71
Sandberg bluegrass	--	--	1.50	1.50	7.40	2.08
Squirreltail	0.65	0.31	0.02	--	--	0.20
Letterman needlegrass	0.40	0.28	0.08	0.48	--	0.25
Cover[3]	5.42	5.36	4.92	3.99	11.45	6.23
Composition[4]	14.30	13.90	10.80	11.00	29.20	15.70
Forbs						
Yarrow	1.10	0.80	0.46	0.29	0.90	0.71
Aster	0.27	0.49	0.02	0.21	1.01	0.40
Arrowleaf balsamroot	0.04	0.13	--	--	0.02	0.04
Thistle	0.25	0.13	--	--	--	0.08
Buckwheat	0.29	0.02	1.00	0.44	0.02	0.35
Geranium	0.37	0.60	2.50	1.90	--	1.07
Lupine	0.06	0.49	0.08	0.25	0.65	0.31
Cinquefoil	--	0.21	0.02	0.40	--	0.13
Salsify	0.13	0.02	--	0.04	--	0.04
Violet	--	--	--	--	0.15	0.03
Mule ears	--	--	3.20	0.33	--	0.71
Cover[3]	2.51	2.89	7.28	3.86	2.75	3.87
Composition[4]	6.70	7.50	15.90	10.60	7.00	9.80

Table 3. (Continued)

Species	Pastures[2] A	B	C	D	F	Ave.
Shrubs						
Serviceberry	2.20	0.33	0.02	0.42	--	0.59
Wormwood	0.27	0.43	0.13	--	--	0.17
Big sagebrush	14.10	11.90	17.10	14.10	8.80	13.20
Rabbitbrush	1.10	1.90	0.30	0.93	7.50	2.35
Oregon grape	0.29	0.06	0.02	0.09	--	0.09
Bitterbrush	6.70	11.40	15.70	9.50	8.70	10.40
Wild rose	--	0.02	--	0.12	--	0.03
Snowberry	5.20	4.30	0.30	3.40	--	2.64
Cover[3]	29.86	30.34	33.57	28.56	25.00	29.47
Composition[4]	79.00	78.60	73.30	78.40	63.80	74.50
Total Cover	37.79	38.59	45.77	36.41	39.20	39.57

[1]Data are mean percentages for 120 20cm. x 50 cm. plots (40 from each of three transects) in each pasture.

[2]Data for pasture E were lost.

[3]The proportion of the ground surface under live aerial parts of plants.

[4]The relative proportions of various plant species in the total plant cover for each pasture.

Table 4. Percent plant cover within each experimental pasture at the Hardware Ranch for 1964.[1]

Species	Pastures A	B	C	D	E	F	Ave.
Grasses							
Beardless wheatgrass	4.61	0.90	3.69	2.67	2.90	0.96	2.62
Western wheatgrass	0.77	0.21	0.82	0.48	1.67	1.40	0.89
Cheatgrass	0.42	0.04	0.02	0.15	2.10	--	0.45
Carex	--	0.33	--	0.02	--	--	0.06
Great Basin wild-rye	0.65	0.36	0.29	--	0.04	0.02	0.23
Junegrass	0.06	0.58	0.04	--	0.29	0.48	0.24
Kentucky bluegrass	0.06	4.00	1.32	0.98	0.58	1.25	1.36
Sandberg bluegrass	0.54	--	0.55	0.23	2.50	4.33	1.36
Squirreltail	--	--	0.17	0.02	0.02	--	0.04
Letterman needlegrass	--	0.15	0.08	0.17	--	--	0.07
Cover[2]	7.11	6.57	6.98	4.72	10.10	8.44	7.32
Composition[3]	20.90	19.50	21.40	16.50	28.40	31.10	22.90
Forbs							
Yarrow	0.85	1.19	0.58	0.25	0.69	1.33	0.82
Aster	0.40	0.59	0.52	0.79	0.96	1.02	0.71
Arrowleaf balsamroot	0.15	--	0.04	--	0.88	0.04	0.18
Thistle	1.04	0.15	--	--	0.04	0.02	0.21
Buckwheat	1.15	--	0.71	1.48	0.15	0.21	0.62
Geranium	1.56	0.96	2.71	2.38	--	--	1.26
Lupine	0.02	0.15	0.06	0.42	0.39	1.46	0.42
Cinquefoil	0.25	--	0.27	0.27	--	0.04	0.14
Mule ears	--	--	4.02	0.59	--	--	0.77
Cover[2]	5.42	3.04	8.91	6.18	3.11	4.12	5.13
Composition[3]	16.00	9.00	27.40	21.50	8.70	15.10	16.10

Table 4. (Continued)

Species	Pastures A	B	C	D	E	F	Ave.
Shrubs							
Serviceberry	1.60	0.50	0.31	0.42	--	--	0.47
Wormwood	0.67	1.13	0.75	0.02	0.13	--	0.45
Big sagebrush	12.62	11.44	7.73	7.94	6.02	6.56	8.72
Rabbitbrush	0.60	1.50	0.04	1.23	7.13	4.02	2.42
Oregon grape	0.07	0.13	--	0.08	0.06	--	0.06
Bitterbrush	1.58	4.21	7.31	5.54	9.07	4.04	5.29
Wild rose	--	0.02	--	0.06	--	--	0.01
Snowberry	4.29	5.13	0.50	2.50	--	--	2.07
Cover[2]	21.43	24.06	16.64	17.79	22.41	14.62	19.49
Composition[3]	63.10	71.50	51.20	62.00	62.90	53.80	61.00
Total Cover	33.96	33.67	32.53	28.69	35.62	27.18	31.94

[1]Data are mean percentages for 120 20cm. x 50cm. plots (40 from each of three transects) in each pasture.

[2]The proportion of the ground surface under live aerial parts of plants.

[3]The relative proportions of various plant species in the total plant cover for each pasture.

abundance of the shrubs. Smaller percentages of serviceberry (Amelanchier alnifolia), rabbitbrush (Chrysothamnus viscidiflorus), snowberry, and rose (Rosa spp.) occurred in different pastures. They were only of minor importance.

The important grasses consisted of beardless wheatgrass, western wheatgrass (Agropyron smithii), Great Basin wild-rye (Elymus cinereus), Sandberg bluegrass (Poa secunda), and Kentucky bluegrass (P. pratensis) (Tables 1, 2, 3 and 4). These same and similar grass species were described by Pickford (1932) as being present on climax and disclimax sagebrush-grass ranges of northern Utah.

The most important forbs within the pastures were arrowleaf balsamroot (Balsamorhiza sagittata), geranium (Geranium fremontii), and mule ears (Wyethia amplexicaulis). Pickford (1932) described the same or similar species as being present upon climax and disclimax sagebrush-grass foothill ranges.

Although some differences in the three vegetation groups between the paired pastures were indicated by the cover and composition data (Table 1) for 1961, these differences were not great. The three groups of vegetation were comparable in pastures A, B, C and D; but grasses assumed a greater importance in pastures E and F (Table 1), possibly due to the past history of heavy use of shrubs by concentrations of elk.

Plant Growth and Development

Stoddart (1946) stated that spring vegetative growth begins normally about April 1 on the foothill ranges in northern Utah and that growth is very slow previous to May 1. He further reported that

summer heat and drought conditions generally are such as to prohibit grass growth generally between June 15 and October 1 in this area. Cumulative temperatures and precipitation for the months of May and June for the four years of study are presented in Fig. 3. Phenological growth and development for the four important forage species selected to represent the vegetation groups are shown in Table 5.

Some annual variations in the plant growth patterns of the four important forage plants occurred during the study, although these changes were not great. The cool, dry early growing season of 1961 apparently had very little effect upon plant growth and development during that period. The early growing period of 1962 was warm and dry until mid-May, then the weather cooled and was rather wet. Yet, the development of the vegetation was similar to 1961. The early growing season of 1963 was warm and dry, delaying the vegetation development of beardless wheatgrass approximately one week from that observed in 1961 and 1962. The cold, wet weather during the early growing season of 1964 delayed until mid-June the growth and development of beardless wheatgrass, arrowleaf balsamroot, and bitterbrush approximately ten days behind that observed in 1961 and 1962. Thereafter the growth was similar to the other years.

Plant Moisture

The percent moisture contents of the important forage species throughout the four grazing seasons of the study are presented in Tables 6, 7, 8 and 9. The moisture contents of the important forage species were lowest in 1961, but the moisture contents of the same species for the other years were comparable to each other.

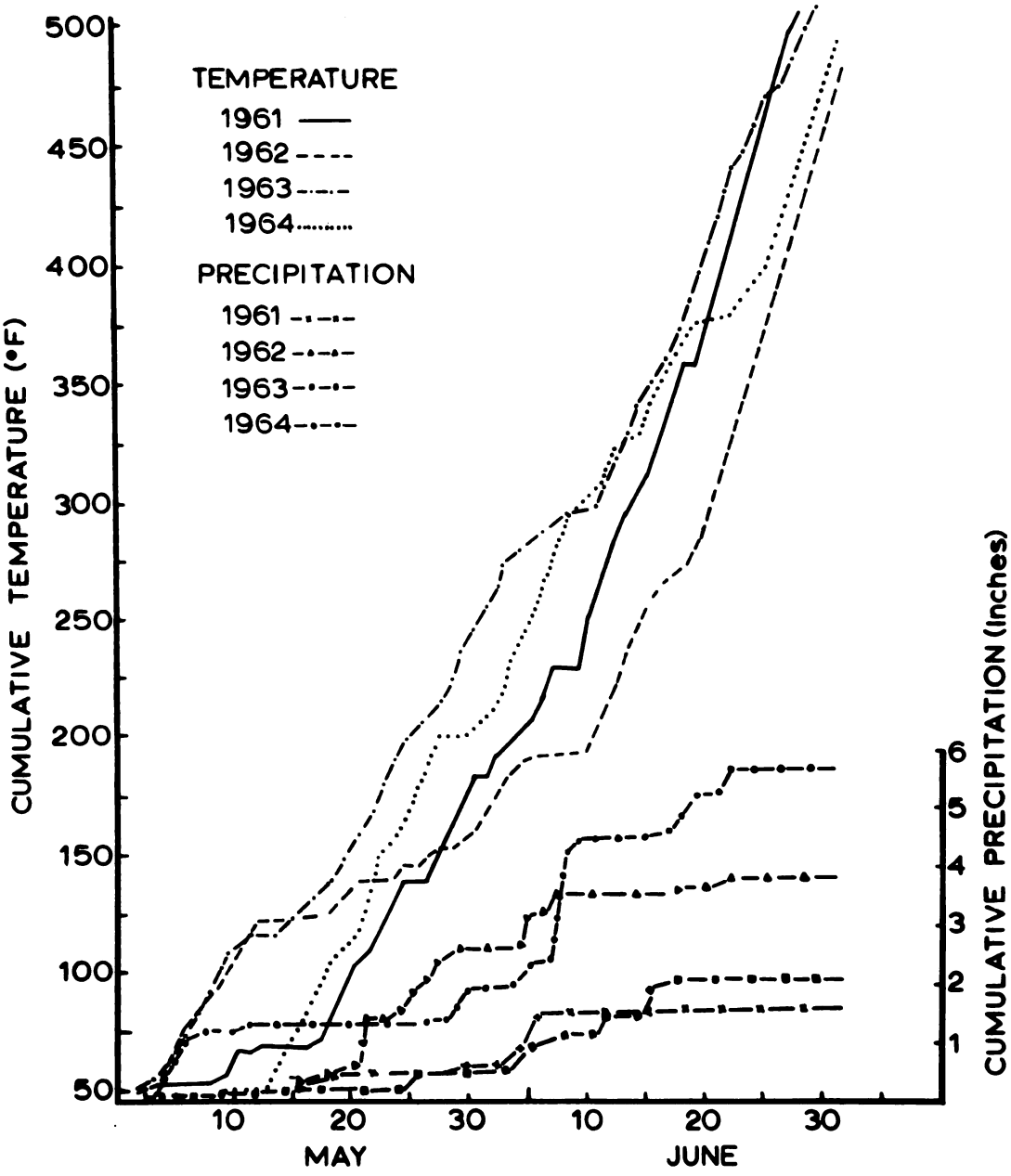

Fig. 3. Cumulative temperatures above threshold of 45° F and precipitation for May and June for the Hardware Ranch for the years, 1961-1964.

Table 5. Phenological development of beardless wheatgrass, arrowleaf balsamroot, geranium and bitterbrush during the years 1961-1964 from the experimental pastures at the Hardware Ranch.

Species	Growth stage	Date			
		1961	1962	1963	1964
Beardless wheatgrass	Heads showing	June 6	June 5	June 11	June 15
	Heads fully out	June 20	June 19	June 26	June 24
	Leaves drying	--	July 2	July 22	July 10
	Seed disseminated	--	--	Aug. 19	Aug. 20
Arrowleaf balsamroot	Full bloom	May 25	May 23	May 28	June 9
	Past bloom	June 20	June 16	June 20	June 19
	Plant drying	June 20	June 16	June 20	June 15
	Plant dried	--	July 2	July 1	July 10
Geranium	Full bloom	June 20	June 16	June 20	June 24
	Past bloom	July 6	July 2	July 1	July 10
	Plant drying	--	Aug. 3	Aug. 19	July 27
Bitterbrush	Flower buds appear	--	May 23	May 21	June 9
	Twig growth started	June 6	--	June 7	June 9
	In bloom	May 25	June 5	May 28	June 9
	Setting seed	June 20	June 16	June 11	June 19
	Seed development	June 20	June 19	June 20	June 19
	Seed disseminated	--	--	Aug. 19	Aug. 20

Table 6. Percent moisture content of plant samples obtained from the experimental pastures during the grazing season of 1961 at the Hardware Ranch.

Species	Percent moisture				
	June 12	June 30	July 21	Aug. 17	Sept. 1
Grasses					
Beardless wheatgrass	39.1	39.6	29.2	30.6	29.1
Western wheatgrass	34.3	35.6	28.0	22.7	17.3
Great Basin wild-rye	51.3	47.0	53.1	38.2	41.8
Sandberg bluegrass	46.1	39.0	30.6	17.7	12.8
Forbs					
Arrowleaf balsamroot	64.4	50.9	41.7	7.7	8.3
Geranium	66.3	64.1	58.0	49.8	34.7
Mule ears	58.4	56.6	42.9	15.6	8.5

Table 7. Percent moisture content of plant samples obtained from the experimental pastures during the grazing season of 1962 at the Hardware Ranch.

Species	June 5	June 12	June 24	July 2	July 17	July 25	Aug. 3	Aug. 11	Aug. 18	Aug. 27
Grasses										
Beardless wheatgrass	64.2	59.3	60.1	47.0	40.5	33.6	33.1	31.4	28.6	28.9
Great Basin wild-rye	75.4	68.8	69.6	64.7	59.1	56.6	50.7	50.2	56.0	54.5
Sandberg bluegrass	65.9	61.3	54.2	49.3	45.6	38.8	36.7	38.0	35.5	28.1
Forbs										
Arrowleaf balsamroot	83.4	78.2	74.7	71.4	63.1	51.2	55.9	31.1	14.2	8.9
Geranium	77.3	74.5	75.3	70.7	72.2	69.9	65.9	63.8	52.3	43.2
Mule ears	77.9	78.4	71.3	71.4	63.1	56.3	56.9	31.9	18.4	32.3

Table 8. Percent moisture content of plant samples obtained from the experimental pastures during the grazing season of 1963 at the Hardware Ranch.

Species	May 21	May 28	June 12	June 20	June 27	July 3	July 16	Aug. 13	Aug. 19	Aug. 22
Grasses										
Beardless wheatgrass	28.6	54.2	47.2	41.2	34.3	33.3	38.8	30.0	23.1	19.4
Western wheatgrass	60.0	--	61.1	44.9	47.9	30.4	--	36.4	18.8	33.3
Great Basin wild-rye	27.7	67.8	59.4	69.0	56.7	53.1	50.0	40.7	35.2	35.9
Sandberg bluegrass	66.7	35.8	30.0	44.8	34.8	32.2	--	--	--	--
Forbs										
Arrowleaf balsamroot	74.5	75.6	70.8	74.0	70.3	66.8	--	7.3	30.8	17.4
Geranium	64.1	62.2	75.1	71.5	72.5	71.5	70.0	60.0	63.6	38.5
Mule ears	73.2	72.3	75.4	79.3	70.7	73.3	67.9	44.2	51.1	23.4

Table 9. Percent moisture content of plant samples obtained from the experimental pastures during the grazing season of 1964 at the Hardware Ranch.

Species	June 10	June 19	June 24	July 17	July 23	July 30	Aug. 6	Aug. 13	Aug. 21	Aug. 31
Grasses										
Beardless wheatgrass	53.1	53.3	44.4	22.2	25.7	25.5	23.5	24.1	18.7	15.9
Western wheatgrass	45.5	44.4	37.0	21.7	24.1	30.6	16.7	17.1	17.4	12.2
Great Basin wild-rye	60.0	62.5	52.7	31.7	36.9	39.5	35.8	31.9	23.3	22.5
Sandberg bluegrass	23.3	20.0	--	3.7	7.1	2.3	3.7	6.7	3.6	3.6
Forbs										
Arrowleaf balsamroot	72.6	73.7	65.0	51.9	59.2	52.7	27.4	27.6	16.9	3.9
Geranium	69.3	72.2	67.8	37.5	48.9	52.2	43.1	46.2	57.5	41.3
Mule ears	75.1	76.1	67.3	58.5	58.3	50.7	15.0	42.9	33.0	4.8
Browse										
Bitterbrush	37.1	43.3	42.9	30.4	37.5	42.0	40.7	37.7	38.5	37.0

The mean percent moisture contents of four important forage plants throughout the four summer grazing seasons are shown in Fig. 4. The moisture contents of the arrowleaf balsamroot and geranium were the highest at the early growth stages, followed by beardless wheatgrass and bitterbrush. However, the moisture content of arrowleaf balsamroot rapidly declined. Geranium declined less rapidly and maintained moisture contents above 35 percent through August. Beardless wheatgrass exhibited a rapid decline in moisture until late July, but thereafter the moisture loss was slow. Bitterbrush changed little in moisture content throughout the season, remaining between 35 and 45 percent.

Utilization of Forage

Utilization of range plants by grazing animals depends on several factors: (1) the stage of plant development; (2) the amount of the plant species; and (3) the palatability of other available forage. Heady (1964) summarized the different factors contributing to palatability as being very complex. Because these factors change throughout the summer growing season, the results can best be presented by grazing periods.

Early Grazing Period

The utilization data for this period are presented in Table 10. Cattle utilized the grass forage readily during this grazing period under both grazing intensities. Great Basin wild-rye and beardless wheatgrass were the most preferred grasses under both intensities for the four years of study. Mean utilization of beardless wheatgrass under moderate and heavy use was 41 and 62 percent respectively.

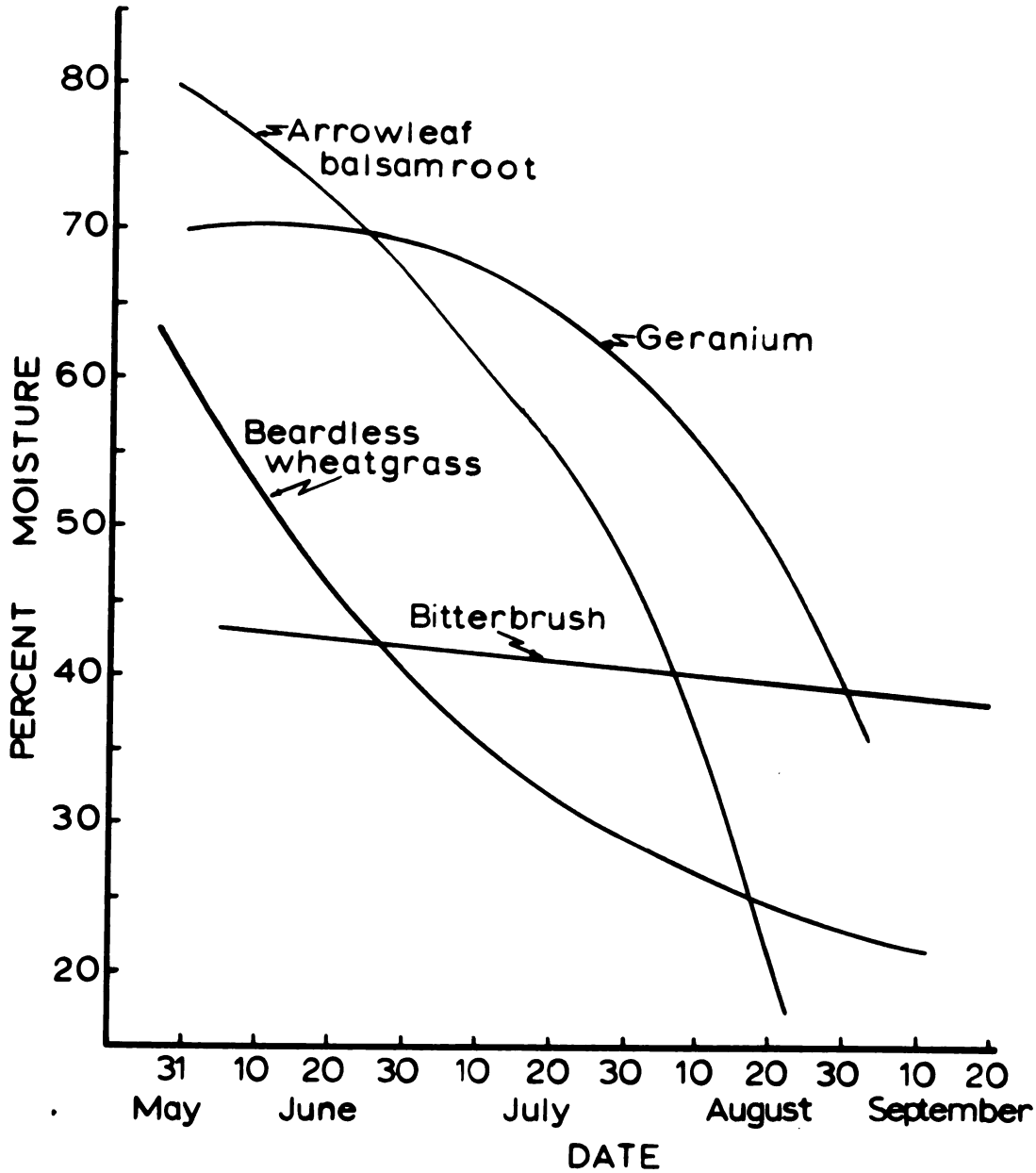

Fig. 4. Mean percent moisture content of beardless wheatgrass, arrowleaf balsamroot, geranium and bitterbrush obtained from the experimental pastures at the Hardware Ranch during the grazing seasons of 1961-1964.

Table 10. Percent utilization of major grasses, forbs, and bitterbrush obtained from the experimental pastures at the Hardware Ranch during the early grazing period for the years, 1961-1964.

	Moderate Use					Heavy Use				
	1961	1962	1963	1964	Mean	1961	1962	1963	1964	Mean
Species Pasture	A	E	E	A		B	F	F	B	
Grasses										
Beardless wheatgrass	46	44	36	38	41	66	63	56	61	62
Western wheatgrass	49	33	19	12	28	65	48	18	20	38
Great Basin wild-rye	67	54	50	54	56	83	66	59	64	68
Junegrass	22	8	11	2	11	10	31	11	4	14
Kentucky bluegrass	35	20	30	7	23	59	32	16	20	32
Sandberg bluegrass	37	36	27	9	27	49	55	23	13	35
Letterman needlegrass	41	--	--	8	25	58	--	--	16	37
Forbs										
Balsamroot	--	10	80	--	45	--	53	85	--	69
Arrowleaf balsamroot	28	50	45	20	36	53	48	55	14	43
Geranium	10	15	35	30	23	40	--	--	9	25
Mule ears	0	45	50	2	24	19	--	--	4	12
Browse										
Bitterbrush[1]	13	1	5	1	5	31	8	8	4	13

[1]Utilization data was obtained from the twenty tagged bitterbrush plants within each pasture.

Great Basin wild-rye was even more heavily used, but it was much less abundant than beardless wheatgrass and was therefore of less importance.

Utilization of the forbs was equally high under both intensities during this grazing period. Mean utilization of arrowleaf balsamroot was 36 and 43 percent for moderate and heavy use respectively. Blaisdell and Pechanec (1949) reported that arrowleaf balsamroot was highly palatable to livestock on spring-fall range in Idaho. Forbs were less abundant than grasses and, therefore, contributed less to the diet of the animals.

Mean utilization of bitterbrush under moderate use was 5 percent and ranged from 1 percent in 1962 and 1964 to 13 percent in 1961. Mean utilization of bitterbrush under heavy use for this period was 13 percent and ranged from 4 percent use in 1964 to 31 percent in 1961.

Mid-Grazing Period

Utilization data for this grazing period are shown in Table 11. The grass forage during this period was in a more mature stage with lower moisture content than during the early grazing period. The assigned utilization rates for beardless wheatgrass under both intensities of use were not attained during 1963 and 1964, because to have done so would have caused heavy use of bitterbrush. Mean utilization of beardless wheatgrass and Great Basin wild-rye was less under both grazing intensities than during the earlier grazing period. Mean utilization of beardless wheatgrass under moderate use ranged from 17 percent in 1964 to 45 percent in 1961 with a mean of 31 percent. Under heavy use, the mean utilization of beardless wheatgrass was 49 percent and ranged from 26 percent in 1964 to 66 percent in 1961.

Table 11. Percent utilization of important grasses, forbs, and bitterbrush obtained from the experimental pastures at the Hardware Ranch during the mid-grazing period, 1961-1964.

Species	Pasture	Moderate Use					Heavy Use				
		1961 C	1962 C	1963 C	1964 C	Mean	1961 D	1962 D	1963 D	1964 D	Mean
Grasses											
Beardless wheatgrass		45	39	22	17	31	66	61	42	26	49
Western wheatgrass		28	30	10	10	20	36	65	50	11	41
Slender wheatgrass		20	40	27	6	23	20	35	20	0	19
Great Basin wild-rye		--	--	33	24	29	10	60	60	29	40
Junegrass		25	25	13	1	16	41	33	14	2	23
Kentucky bluegrass		23	37	31	9	25	42	47	42	6	34
Sandberg bluegrass		41	31	4	0	19	73	35	0	2	28
Squirreltail		13	20	6	0	9	41	29	1	1	18
Letterman needlegrass		45	42	9	11	27	68	67	24	8	42
Forbs											
Geranium		14	26	12	7	15	19	30	10	10	17
Mule ears		1	2	3	7	3	1	5	4	4	4
Browse											
Bitterbrush[1]		26	31	29	28	29	30	36	40	36	36

[1]Utilization data was obtained from the twenty tagged bitterbrush plants within each pasture.

Mean utilization of the forbs during this grazing period under both grazing intensities was low. The balsamroots were not present within the utilization study plots. Geranium and mule ears were lightly utilized, with geranium being used heavier than mule ears. Geranium has a low palatability to cattle, but its palatability increases during the summer when it "greens up" following summer showers (Van Dyne 1958). According to Tingey and Cook (1955), cattle seldom utilize mule ears when other forage is available. Although, considerable use was made of it during the early grazing period mentioned in this study.

Cattle showed a preference for bitterbrush during this grazing period under both grazing intensities. Mean utilization of bitterbrush under moderate use was 29 percent and ranged from 26 percent during 1961 to 31 percent in 1962. Under heavy cattle use, the mean utilization for the four years of study of bitterbrush was 36 percent and ranged from 30 in 1961 to 40 percent in 1963. In 1963 and 1964, the cattle were removed from these pastures short of the projected utilization of beardless wheatgrass because of their heavy use of bitterbrush.

During this grazing period, bitterbrush produced substantial twig growth during the four years of study and was thus more readily available than earlier. Einarsen (1956) reported that browse became an important fraction of the daily diet of cattle during mid-July in Oregon. He gave two reasons for this: (1) lack of succulent herbaceous forage; and (2) lack of food value in the grass forage. He inferred that as the grasses and forbs matured, the crude protein decreases and crude fiber, lignin, cellulose, and other carbohydrates increase; whereas, browse forage remains high in crude protein and does not show great seasonal

fluctuations. These seem incomplete explanations for the shift to browse in this study, for many of the herbaceous plants had moisture contents fully as high as that of bitterbrush during this period (Fig. 4) and (Tables 6, 7, 8 and 9). However, Springfield and Reynolds (1951) found that grasses with the highest moisture contents were most preferred by cattle during late summer and fall grazing periods on reseeded grass forage in New Mexico.

Late Grazing Period

Utilization data for this period are shown in Table 12. Again, beardless wheatgrass and Great Basin wild-rye were the preferred grasses throughout the study during this grazing period. Mean utilization of beardless wheatgrass for the four years of study under moderate and heavy use was 36 and 60 percent respectively. Under moderate grazing, utilization of beardless wheatgrass ranged from 17 percent in 1964 to 49 percent in 1961, under heavy use it ranged from 31 percent in 1964 to 83 percent in 1961. The assigned use of beardless wheatgrass was not attained in 1964 when it was observed that utilization of bitterbrush was even greater than on beardless wheatgrass.

Utilization of arrowleaf balsamroot under moderate use ranged from 0 percent in 1962 to 14 percent in 1963 with a mean of 6 percent. Under heavy use, mean utilization of arrowleaf balsamroot was 10 percent and ranged from 4 percent in 1962 to 14 percent in 1964.

Mean utilization of bitterbrush under moderate and heavy cattle use was 31 and 41 percent respectively. Use of bitterbrush was heaviest during this period (the late grazing period). The use of bitterbrush forage coincided with the maturing of the important grasses

Table 12. Percent utilization of important grasses, forbs, and bitterbrush obtained from the experimental pastures at the Hardware Ranch during the late grazing period for the years, 1961-1964.

		Moderate Use					Heavy Use				
Species	Pasture	1961 E	1962 A	1963 A	1964 E	Mean	1961 F	1962 B	1963 B	1964 F	Mean
Grasses											
Beardless wheatgrass		49	40	38	17	36	83	62	62	31	60
Western wheatgrass		14	26	12	8	15	29	43	14	6	23
Great Basin wild-rye		7	41	51	14	28	43	63	65	53	56
Junegrass		7	20	5	1	8	18	38	8	3	17
Kentucky bluegrass		40	30	22	10	26	40	53	22	3	30
Sandberg bluegrass		16	28	25	14	21	32	54	25	13	31
Squirreltail		--	12	13	--	13	--	15	20	--	18
Letterman needlegrass		--	42	19	--	31	--	55	23	--	39
Forbs											
Arrowleaf balsamroot		--	0	14	5	6	--	4	13	14	10
Geranium		10	8	20	10	12	--	14	9	--	12
Mule ears		--	--	0	13	7	0	0	10	13	8
Browse											
Bitterbrush[1]		18	38	39	29	31	39	38	47	38	41

[1]Utilization data was obtained from the twenty tagged bitterbrush plants within each pasture.

and forbs, the high moisture content of bitterbrush (Fig. 4), and with the maximum new growth of bitterbrush.

Periodic Use of Major Species

The relationships of use between the important forage species is shown better by analyzing the degree of utilization attained as the grazing periods progressed. The cumulative utilization data are shown in Figures 5 to 10. Mean percent utilization of the key and important grasses, forbs, and bitterbrush for moderate and heavy use for the three grazing periods are presented in Fig. 11. Although some variations occurred, general patterns can be recognized.

The progression of utilization of the important species during the early grazing periods under moderate and heavy cattle use are presented in Figures 5 and 6 respectively. During the early grazing period, bitterbrush was lightly used under both grazing intensities. Furthermore, no use was made of it until well into the grazing period. The herbaceous forage provided almost all of the diet during this period. The early grazing period of 1961 was an exception in that substantial amounts of bitterbrush were taken. One important factor may have been responsible for this utilization by cattle. The moisture content of the herbaceous species had the lowest content of the four years of study (Tables 6, 7, 8 and 9). The light use of bitterbrush during this period may be attributed to the attractiveness of the herbaceous forage and lack, until the end of the grazing period, of substantial new bitterbrush growth.

Utilization progression during the mid-grazing periods under moderate and heavy cattle use are shown in Figures 7 and 8. The mid-grazing period showed a less consistent pattern of use than did the early

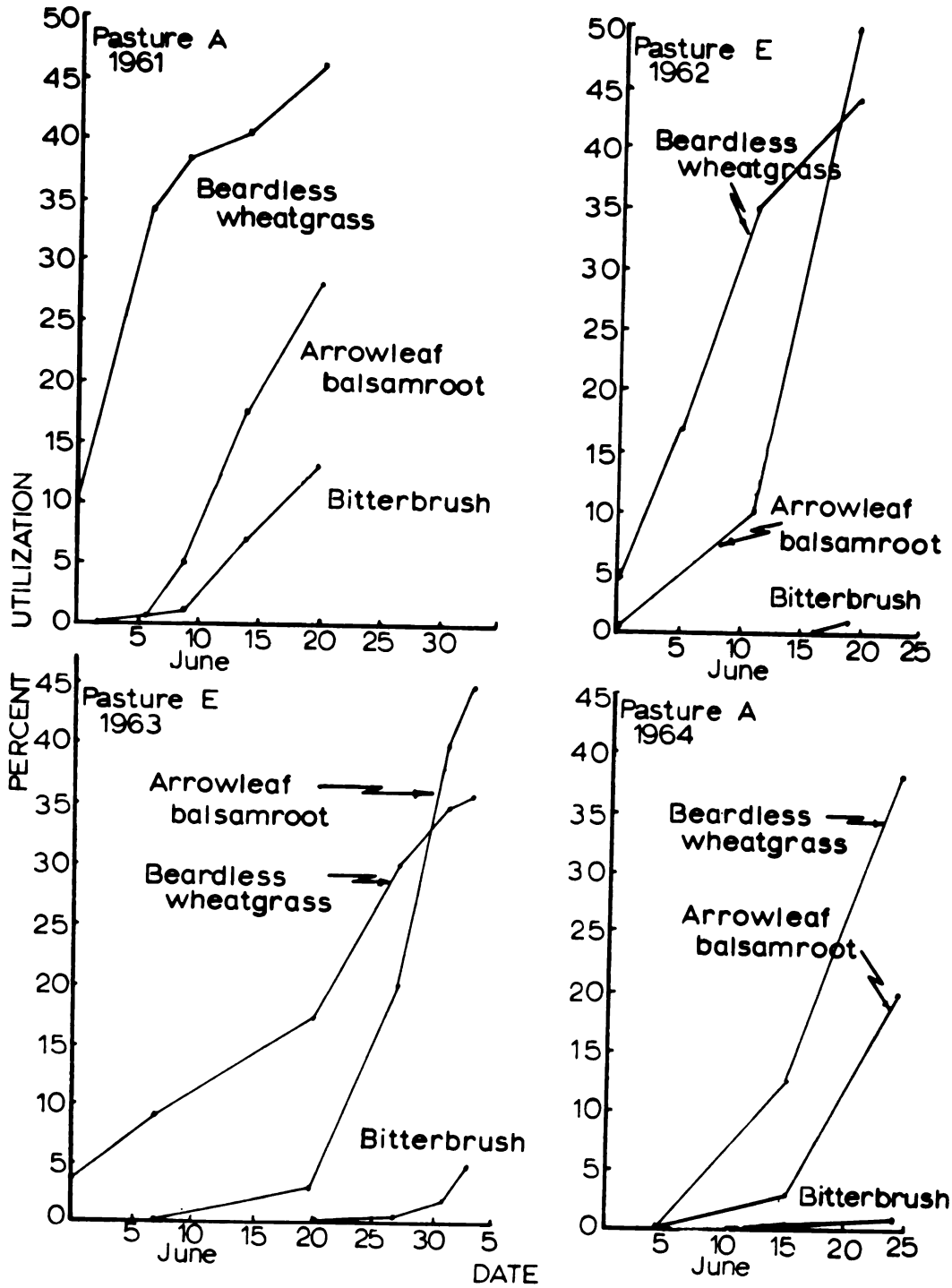

Fig. 5. Cumulative utilization of beardless wheatgrass, arrowleaf balsamroot and bitterbrush obtained from the experimental pastures for moderate cattle use during the early grazing period at the Hardware Ranch for 1961-1964.

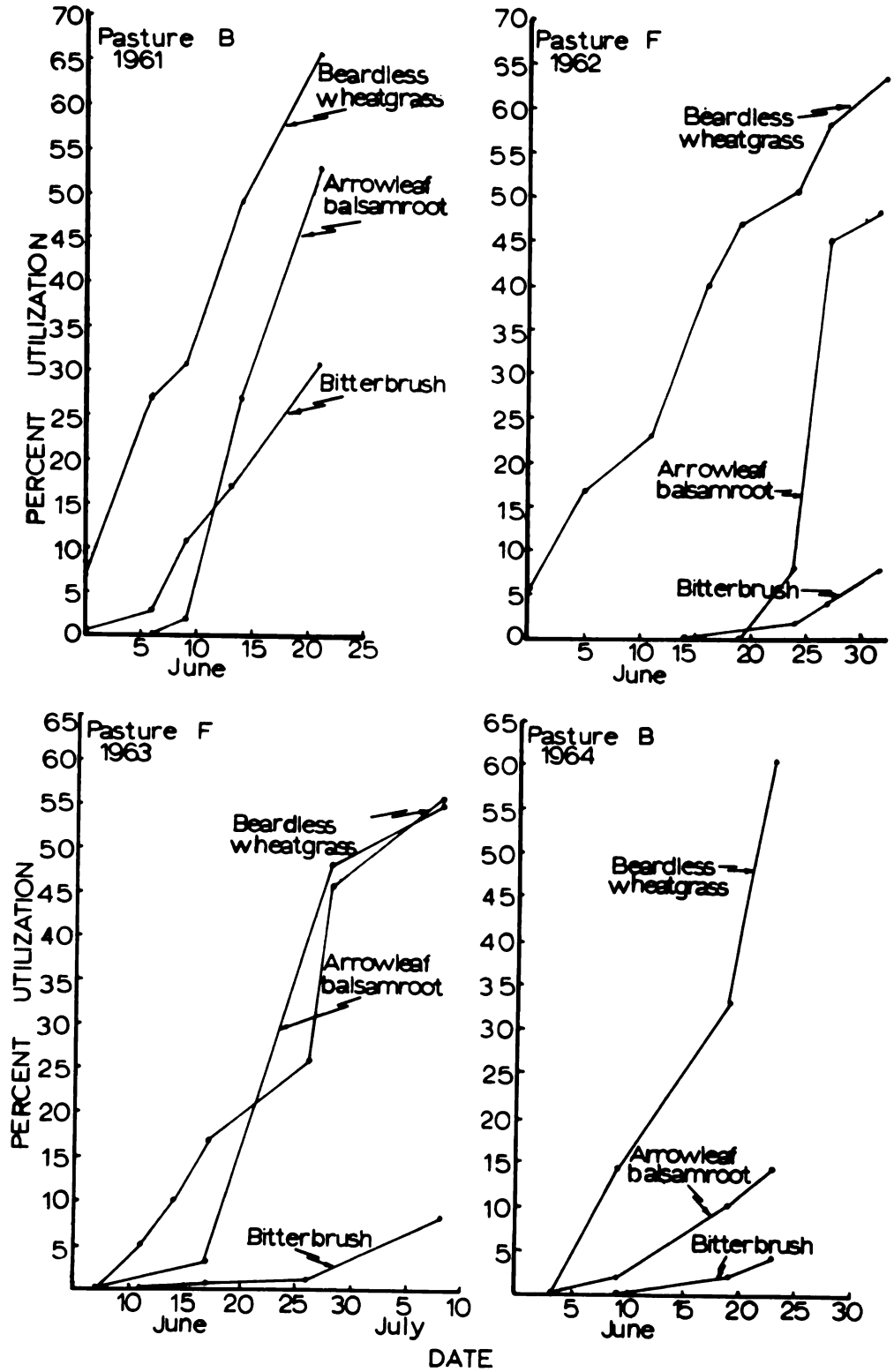

Fig. 6. Cumulative utilization of beardless wheatgrass, arrowleaf balsamroot and bitterbrush obtained from the experimental pastures for heavy cattle use during the early grazing period at the Hardware Ranch for 1961-1964.

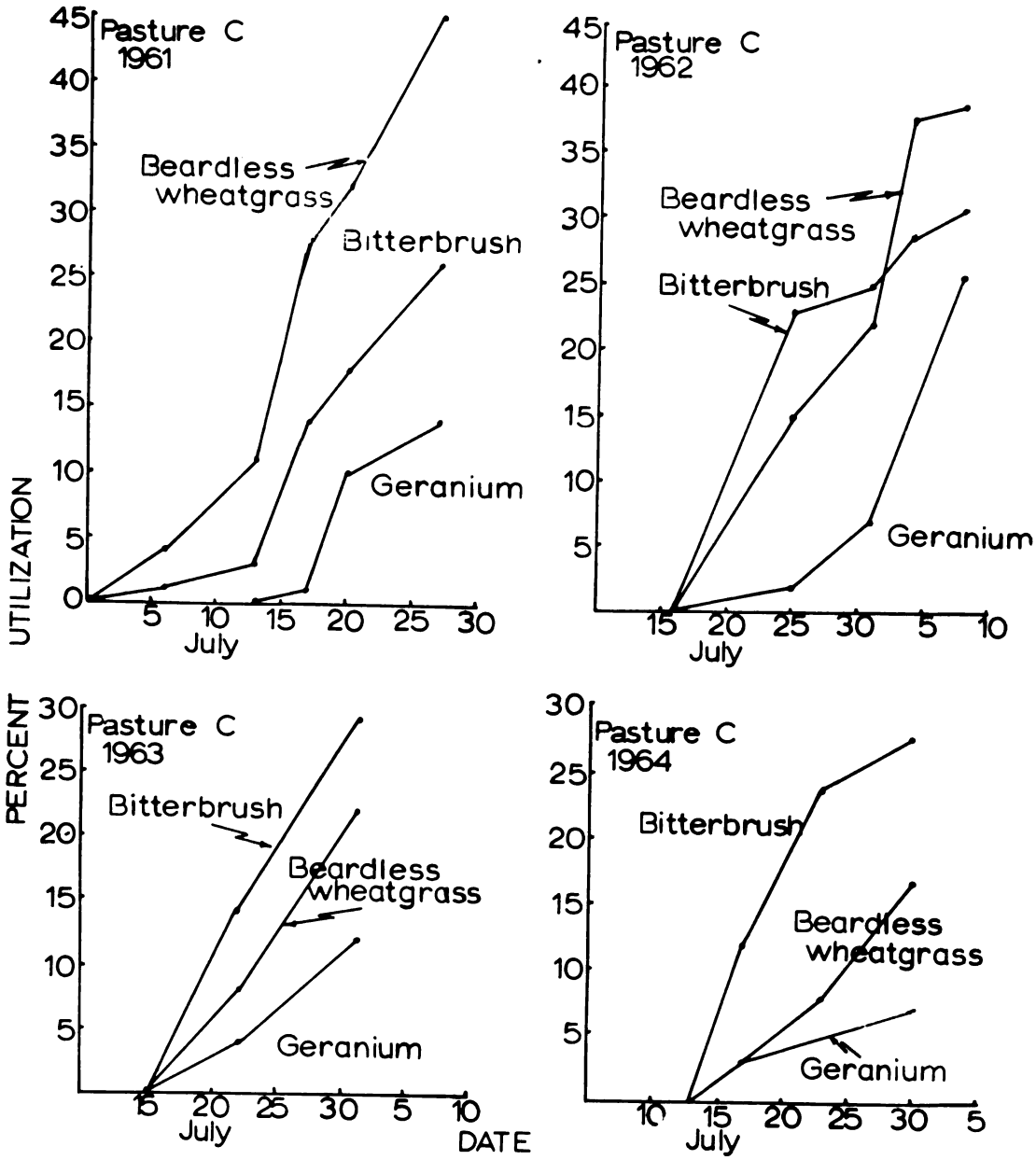

Fig. 7. Cumulative utilization of beardless wheatgrass, geranium and bitterbrush obtained from the experimental pastures for moderate cattle use during the mid-grazing period at the Hardware Ranch for 1961-1964.

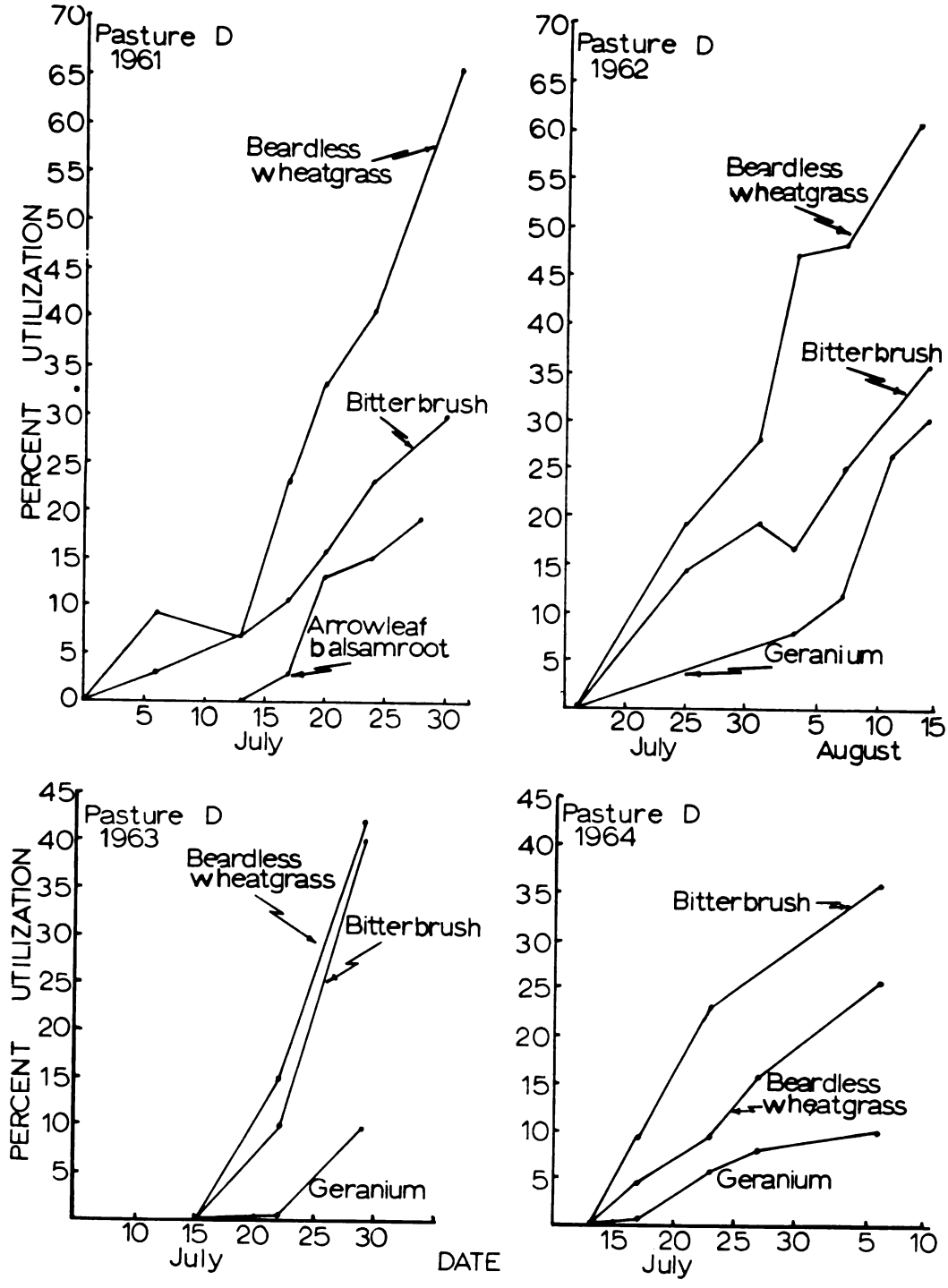

Fig. 8. Cumulative utilization of beardless wheatgrass, geranium and bitterbrush obtained from the experimental pastures for heavy cattle use during the mid-grazing period at the Hardware Ranch for 1961-1964.

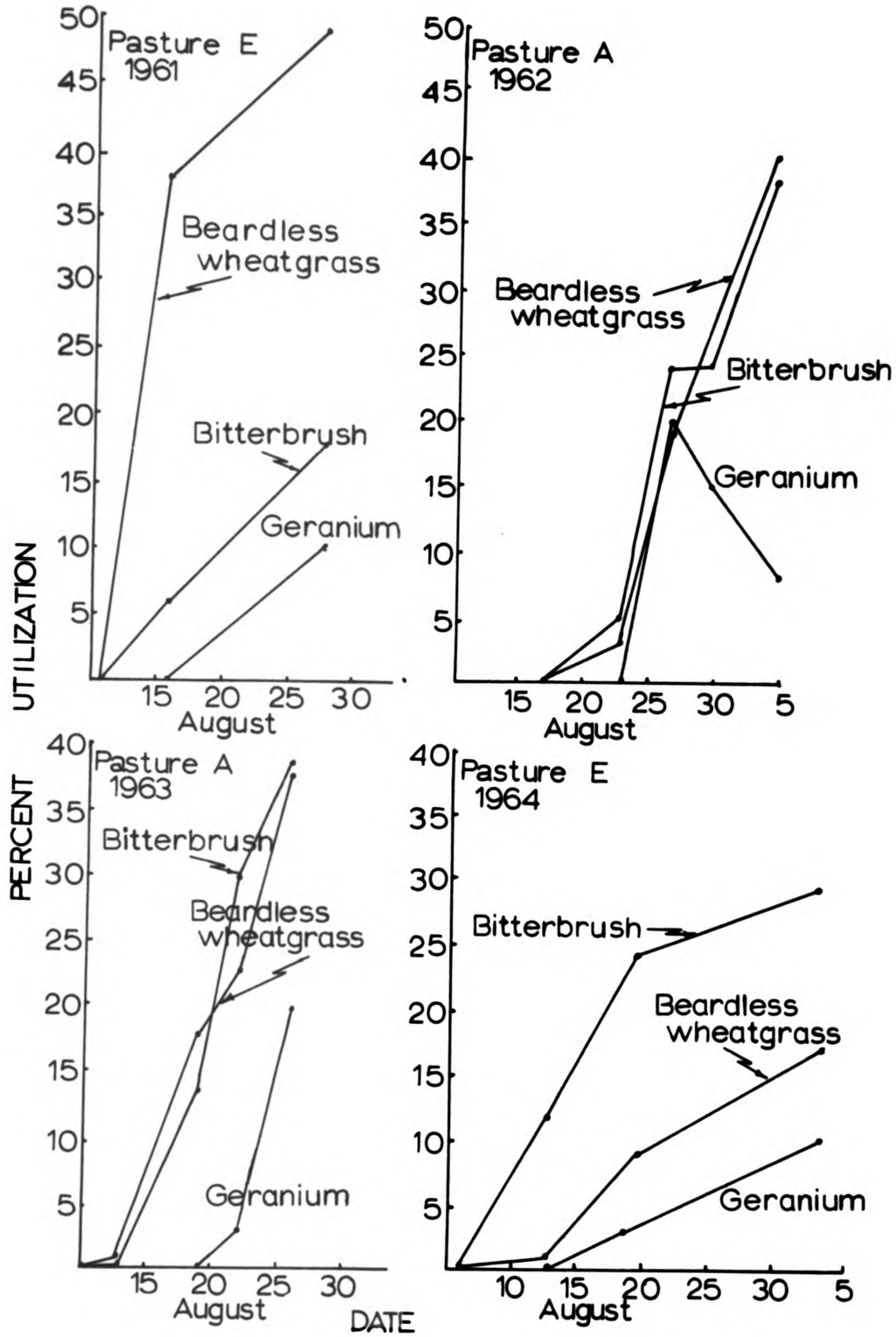

Fig. 9. Cumulative utilization of beardless wheatgrass, geranium and bitterbrush obtained from the experimental pastures for moderate cattle use during the late grazing period at the Hardware Ranch for 1961-1964.

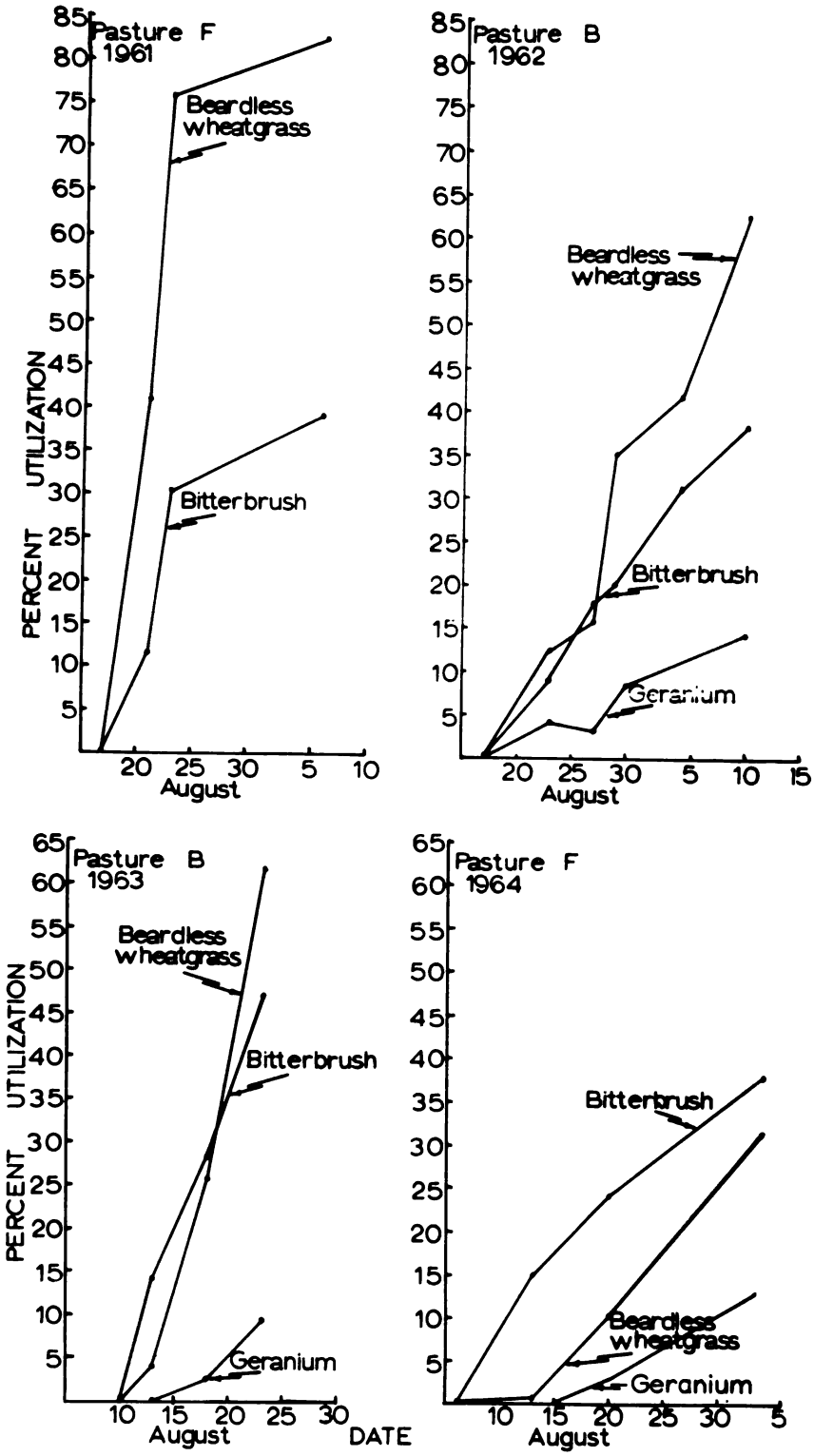

Fig. 10. Cumulative utilization of beardless wheatgrass, geranium and bitterbrush obtained from the experimental pastures for heavy cattle use during the late grazing period at the Hardware Ranch for 1961-1964.

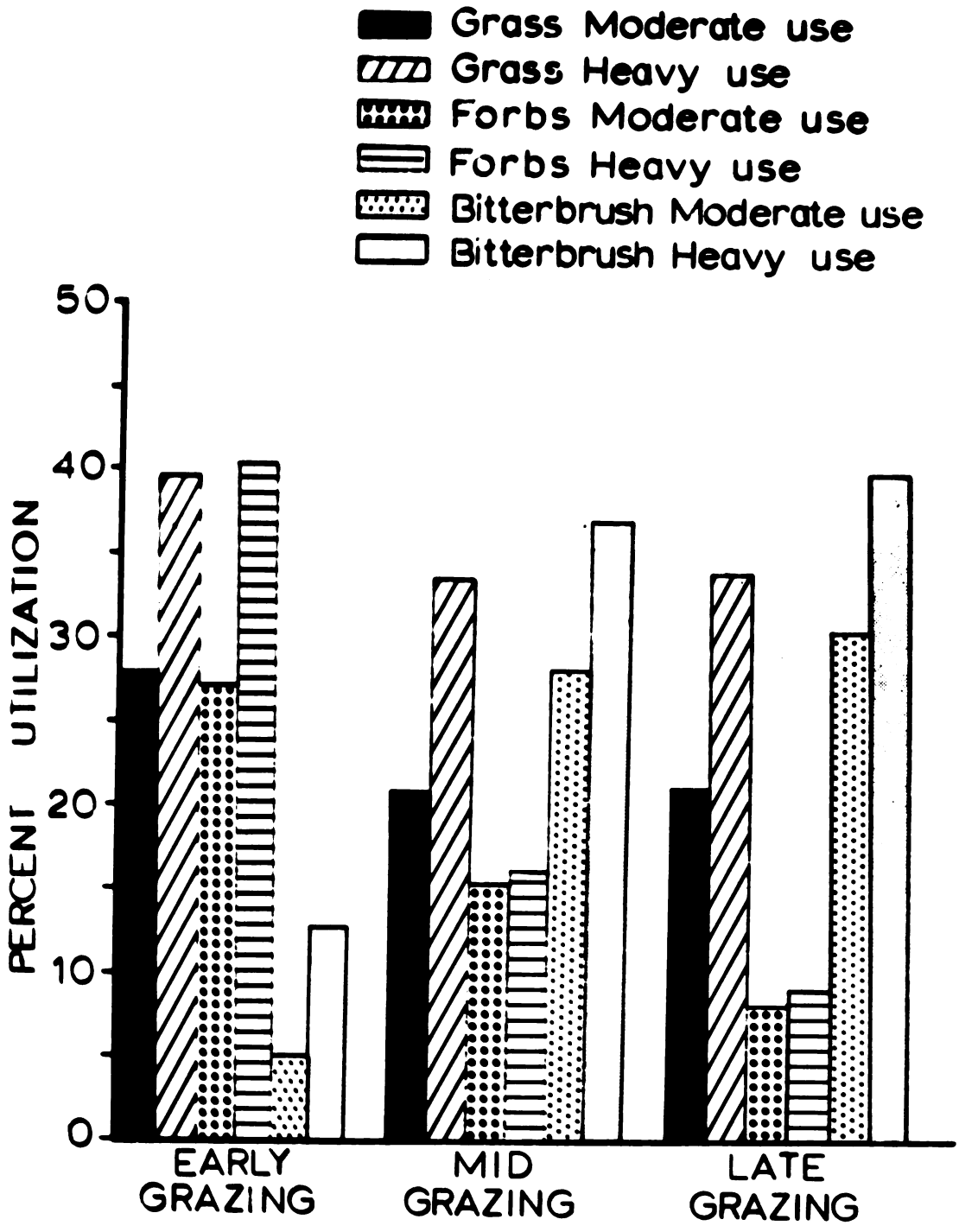

Fig. 11. Mean utilization of the grasses, forbs and bitterbrush obtained from the experimental pastures for moderate and heavy cattle use during the three grazing periods at the Hardware Ranch for 1961-1964.

period. In general, grass was most readily eaten; but bitterbrush was taken at the outset in substantial amounts. In 1964, under both intensities of use and under moderate intensity of grazing in 1963, the percent utilization of bitterbrush exceeded that of beardless wheatgrass. Forbs were much less readily utilized than either grasses or bitterbrush during this grazing period.

Several important factors that may have influenced cattle utilization during this period are: (1) the moisture content of the herbaceous forage dropped rapidly; (2) the herbaceous forage had matured, decreasing the preference for it; (3) the reduced available herbaceous forage may have altered the preference of the forage; and (4) the advancement of bitterbrush stem elongation made this forage more available.

The progression of utilization for the late grazing periods under moderate and heavy cattle use are presented in Figures 9 and 10. The pattern shown during the late summer period is substantially the same as during the mid-summer period. Cattle used bitterbrush from the start and, except in 1961, the percentage utilization was equal to or exceeded that observed for beardless wheatgrass. Forbs were more lightly used than during the other periods. The same factors that caused the forage preference during the mid-grazing period were active during this period.

No use of big sagebrush by cattle was observed during any of the grazing periods.

Effects of Cattle Grazing Upon Bitterbrush Plants

Cattle use of bitterbrush during the early and late grazing periods increased the vigor and stem elongation of the bitterbrush

plants within these pastures. Observations indicated that bitterbrush seedlings were being released within these same pastures, although no data were collected. According to Nord (1965), moderate cattle use of bitterbrush in California had little effect on the number of established plants and more bitterbrush seedlings were released from moderate cattle use than where bitterbrush was unused. Apparently cattle trampling under moderate use enhances bitterbrush reproduction.

Nord (1965) found that heavy livestock grazing upon bitterbrush reduced the plant crown and height spread 40 to 50 percent respectively. He further reported that as a bitterbrush plant approached maturity and became senescent, that the plant cannot withstand heavy livestock use. Mean big game use upon the bitterbrush plants within the pastures for the duration of the study was 50 percent. Proper utilization of bitterbrush by big game animals is considered to be 40 to 60 percent with 50 percent utilization being a reasonably safe use (Hill 1956). However, heavier use of bitterbrush weakens and kills the plant (Ratcliff 1941). But light to moderate use of bitterbrush stimulates stem elongation (Hill 1956, Nord 1965).

Management Implications

Any grazing program designed to manage big game winter range in favor of browse species must be based on several factors: first, the management objectives in regard to holding the big game herds in balance with the carrying capacity of the winter range; second, the maintenance of livestock use of the browse forage at a low level; thirdly, the grazing period during which the herbaceous plants are most preferred

by domestic animals; and fourthly, the grazing intensity that most affects subsequent growth vigor of herbaceous plants and reduces herbaceous competition from the preferred browse species on that particular range.

To date, several studies have reported correlating clipping of bluebunch wheatgrass (Agropyron spicatum) to plant vigor upon foothill ranges. Beardless wheatgrass is considered a subspecies or a variety of bluebunch wheatgrass by some. McIlvanie (1942) reported that clippings of bluebunch wheatgrass, made either in the seven inch height stage or when the plant was in the middle of vegetative growth, reduced the plant vigor in Montana. Stoddart (1946) stated that the vigor of bluebunch wheatgrass was most affected by grazing during the month of May on foothill ranges of northern Utah. Blaisdell and Pechanec (1949) reported that bluebunch wheatgrass was most susceptible to clipping during the "heads showing" stage, which is about early June on spring-fall livestock range in southern Idaho.

Arrowleaf balsamroot growth vigor was reduced most when clipped during late May or early June (Blaisdell and Pechanec, 1949) on the same range.

Although early and moderate cattle grazing resulted in the least utilization of bitterbrush when the herbaceous forage was preferred, it may be advantageous to sacrifice a somewhat greater amount of bitterbrush forage for heavy cattle use of the grasses and forbs during the early grazing period. Increased growth of bitterbrush due to reduced competition from the herbaceous species could at least partially compensate for the loss of bitterbrush forage to cattle

from grazing pressure exerted during early summer. Cattle utilization of bitterbrush during the mid-grazing and late-grazing periods under both intensities would be too severe and would have little effect on the vigor of herbaceous forage.

SUMMARY

A cattle grazing study was conducted from 1961 through 1964 at the Hardware Ranch, Blacksmith Fork Canyon in northern Utah. The objective of the study was to determine the seasons and intensities of cattle use that would result in substantial utilization of the herbaceous plants with minimal utilization of bitterbrush.

Three sets of paired pastures were used. Moderate and heavy grazing pressure was exerted on the two pastures of each set during the early, middle and late grazing periods of the grazing season.

Canopy-coverage data of the vegetation on each pasture were taken prior to grazing each year. Phenological and moisture content data were collected through the grazing season.

Utilization of the important grasses and forbs was determined by ocular estimates obtained from 25 permanent 96 square foot circular plots within each pasture. Ocular estimates of bitterbrush use were procured from 20 tagged representative bitterbrush plants in each pasture.

Light use was made of bitterbrush during the early grazing period at either intensity of use. Herbaceous plants were clearly preferred. Preference for the important herbaceous forage species during the early grazing period was attributed to the moisture content and stage of growth.

During both the mid-summer and the late summer periods, bitterbrush was readily eaten from the outset. Its use could not, therefore, be attributed to lack of herbaceous forage. And, although the moisture content and general succulence of herbaceous plants had declined somewhat from the early period, the herbaceous forage continued to be taken in volume. I believe that increased stem elongation of bitterbrush was partially responsible for the use observed during these periods.

The results obtained lead to the conclusion that mixed browse-herbaceous ranges used by big game animals in winter should be grazed by cattle prior to July 1 in northern Utah to maintain the maximum amount of bitterbrush browse. Cattle use during this period would reduce the vigor of the herbaceous vegetation competing with bitterbrush plants upon big game winter ranges.

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APPENDIX I

Check list of scientific and common names of plants encountered within the experimental pastures at the Hardware Ranch from 1961-1964.[1]

Scientific Name	Common Name
Achillea lanulosa	Yarrow
Agastache urticifolia	Horsemint
Agropyron cristatum	Crested wheatgrass
Agropyron inerme	Beardless wheatgrass
Agropyron smithii	Western wheatgrass
Agropyron subsecundum	Bearded wheatgrass
Agropyron trachycaulum	Slender wheatgrass
Allium spp.	Wild onion
Amelanchier alnifolia	Serviceberry
Artemisia ludoviciana	Wormwood
Artemisia tridentata	Big sagebrush
Aster spp.	Aster
Astragalus spp.	Locoweed
Balsamorhiza macrophylla	Balsamroot
Balsamorhiza sagittata	Arrowleaf balsamroot
Bromus tectorum	Cheatgrass
Calochortus nuttallii	Sego lily
Carex spp.	Carex
Castilleja spp.	Indian paint brush

Scientific Name	Common Name
Chrysothamnus viscidiflorus	Rabbitbrush
Cirsium spp.	Thistle
Cordylanthus canescens	Cordylanthus
Elymus cinereus	Great Basin wild-rye
Eriogonum spp.	Buckwheat
Festuca idahoensis	Bluebunch fescue
Geranium fremontii	Geranium
Helianthella uniflora	Little sunflower
Juncus spp.	Rush
Koeleria cristata	Junegrass
Lupinus caudatus	Lupine
Lithospermum incisum	Gromwell
Mahonia repens	Oregon grape
Melica bulbosa	Oniongrass
Potentilla gracilis	Cinquefoil
Poa compressa	Canada bluegrass
Poa fendleriana	Muttongrass
Poa pratensis	Kentucky bluegrass
Poa secunda	Sandberg bluegrass
Poa wheeleri	Wheeler bluegrass
Prunus virginiana	Chokecherry
Purshia tridentata	Bitterbrush
Ribes spp.	Wild currant
Rosa spp.	Wild rose
Sambucus coerulea	Blueberry elder

Scientific Name	Common Name
Sidalcea spp.	Prairie mallow
Sitanion hystrix	Squirreltail
Stipa columbiana	Columbia needlegrass
Stipa lettermani	Letterman needlegrass
Symphoricarpos oreophilus	Snowberry
Taraxacum officinale	Dandelion
Tragopogon dubius	Salsify
Viola spp.	Violet
Wyethia amplexicaulis	Mule ears
Zygadenus paniculatus	Deathcamus

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[1] Scientific and common names for the grasses were derived from Hitchcock, A. S. Manual of the grasses of the United States. Misc. Pub. No. 200. Gov. Printing Office, Washington, D. C. The scientific and common names for the forbs and shrubs were derived from Holmgren, A. H. 1959. Handbook of the vascular plants of the northern Wasatch. Lith-o-type Process Co., San Francisco, Calif.