Technical Report No. 189

HERBAGE DYNAMICS ON A MIXED PRAIRIE GRASSLAND, 1968-1970

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GRASSLAND BIOME

U.S. International Biological Program

November 1972

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ABSTRACT

Selected functional attributes of a mixed prairie site near Hays, Kansas, were investigated during the period 1968 to 1970. This report includes estimates of aboveground and belowground net primary productivity. Vegetation on the ungrazed treatment was mostly tall- and mid-grasses, such as big bluestem (*Andropogan girardi*), little bluestem (*A. scoparius*), and sideoats grama (*Bouteloua curtependula*). Vegetation on the grazed treatment was dominated by three grasses and one forb: big bluestem (*A. gerardi*), sideoats grama (*B. curtependula*), blue grama (*B. gracilis*), and few-flowered scurf pea (*Psoralea tenuiflora*). The principal differences between the two treatments was the presence of more shortgrasses and annual grasses but less forbs on the grazed treatment. The community peak standing crop on the ungrazed treatment was reached in late July during 1968 and 1969. The ungrazed treatment had two production peaks during 1970: one in mid-April and the other in mid-May. Productivity on the grazed treatment was higher than on the ungrazed treatment. This may be a result of more rapid warming of the soil, as a consequence of the thick layers of mulch which may retard growth rates early in the growing season. Differences in ash-free caloric values of plant material were small.

INTRODUCTION

The mixed prairie ecosystem was first described by Clements (1916) using dominant species as criteria for community delineation. Most ecological studies following Clements' initial work concentrated upon structural features of the grassland ecosystem. Recently investigators have undertaken the task of studying the functional aspects of grassland systems, namely energy flow and nutrient cycling.

This project, coordinated and partially financed by the Grassland Biome of the International Biological Program, was designed to study selected functional attributes of a mixed prairie grassland near Hays, Kansas. The study site was a part of the Comprehensive Network of the Grassland Biome project and has been under study for several years.

Specific objectives of the project included: (i) to estimate the net primary production of shoots and roots, (ii) to estimate standing dead and mulch standing crops, and (iii) to estimate the caloric content of biomass components.

DESCRIPTION OF STUDY AREAS

The study areas included an ungrazed and a grazed stand of mixed prairie vegetation typical of the grasslands located between the shortgrass plains of Colorado and the true prairie of eastern Kansas. They are dominated by an *Andropogon-Bouteloua* community. The remnant prairie contains 35 acres of grassland which has been free of grazing and burning for more than 60 years, while the grazed site is an enclosure located in a large, well-managed pasture. Both areas are on the Fort Hays Kansas State College Farm about 2 miles southwest of Hays, Kansas.

The ungrazed and grazed treatments are located in the middle of long, gentle, east-facing slopes. Approximately 5 acres along each slope was selected and enclosed for study of primary production.

The topography of the sites is characterized by steep to gentle slopes bordering a central drainage. Geologically the area contains strata of the Cretaceous Age, particularly materials of the Niobrara formation. The prominent stratum exposed is the Fort Hays limestone which is capped on the uplands by Loveland loess.

The soil on both treatments is a Brownell loam, a member of the loamy-skeletal, carbonatic, mesic family of Haplustic Rendolls (Table 1). The soil has developed in regolith weathered from local outwash from chalky limestone and from the underlying rock.

Meterological records have been kept at the Fort Hays Experiment Station (less than 2 miles from the IBP site) from 1868 to the present. Average annual precipitation is 22.8 inches and has varied from a low of 9.2 inches in 1956 to a high of 43.4 inches in 1951. Generally, about 75% of the precipitation occurs during the growing season, with May through August the heaviest months. Average mean annual temperature is 53.9°F, and mean summer temperature is 76.6°F (June, July, and August). Several days in summer have temperatures over 100°F, with as many as 34 days during drought years but with less than 10 during most years (Albertson and Tomanek, 1965). The average length of the growing season is 167 days, but varies from 137 to 198 days. The average date for the first killing frost in the fall is around October 12, and the average date of the last killing frost is April 27. The summer humidity is low and evaporation is high, averaging over 48 inches

Table 1. Soil profile description of Brownell loam, the substratum for both study areas at the Hays Site.

Horizon	Depth (inches)	Description
A_1	0-8	Grayish-brown (10YR 5/2) loam; very dark grayish-brown (10YR 3/2) when moist; moderate medium and fine granular structure; hard; friable; calcareous, strong effervescence; many fine pores; abundant fine, medium, and coarse roots becoming finer with depth; less than 5% of small chalk fragments up to ½-inch diameter, occasional chalk fragment up to 3-inches diameter; many worm casts; pH 8.0 (Hellige); clear, smooth boundary.
B_2	8-11	Light brownish-gray (10YR 6/2) gravelly loam; dark grayish-brown (10YR 4/2) when moist; moderate fine subangular blocky structure; hard; friable; calcareous; violent effervescence; many fine pores; many fine and medium roots; abundant worm casts; secondary carbonate pendents on lower side of some large chalk fragments; clear boundary.
C	11-26	Light gray (10YR 7/2) channery loam; grayish-brown (10YR 5/2) when moist; moderate very fine granular structure; hard; friable; calcareous, violent effervescaence; porous; common fine and medium roots decreasing in abundance with depth; most chalk fragments have a deposition of secondary carbonates on lower side as much as 1/16 inch thick; rests on
D	26 +	dense chalky limestone bedrock (Fort Hays chalky limestone member of the Niobrara formation).

from April through September. Wind velocities are generally high, averaging about 6 mph during the growing season.

Weather conditions during 1970 were not conducive to maximum production. Rainfall for 1970 was only 17.13 inches or 5.68 inches below the longtime average (Appendix Table 4). However, there was a good supply of moisture in June (6.05 inches) which may have influenced the period of greatest growth. All other months except September were below the longtime average. Average mean annual temperatures were similar to the longtime average, while wind velocities were slightly lower and evaporation rates slightly higher for 1970. Dry conditions for the growing season were also characterized by 24 days with temperatures over 100°F.

The vegetation on the ungrazed and grazed treatments on the Hays Site has been described in Technical Report No. 41 (Tomanek, 1970) and in Hulett, Brock, and Lester (1971).

The ungrazed community of the site is typical of much of the surrounding grassland and is dominated by *Andropogon gerardi*, *Andropogon scoparius*, and *Bouteloua curtipendula*. Other grasses found include *Bouteloua gracilis*, *B. hirsuta*, *Sorghastrum nutans*, *Panicum virgatum*, and *Sporobolus asper*. Some common forbs are *Schrankia uncinata*, *Echinacea angustifolia*, and *Aster oblongifolius*. The soils supporting the community are immature and shallow with only an A to C horizon development.

The grazed treatment dominants are *Bouteloua curtipendula* and *B. gracilis*. Other grasses found on this site are *Buchloe dactyloides*, *Aristida longiseta*, and *Agropyron smithii*. Some common forbs are *Echinacea angustifolia*, *Gutierrezia sarothrae*, *Psoralea tenuiflora*, and *Yucca glauca*. Soils under this community are also shallow with A to C horizon development.

The principal rodents in the ungrazed treatment are the white-footed mouse (*Peromyscus maniculatus*), cotton rat (*Sigmodon hispidus*), meadow vole (*Microtus ochrogaster*), and harvest mouse (*Reithodonomys montanus*) (Martin, 1960). On the grazed treatment the white-footed mouse, harvest mouse, and the thirteen-lined ground squirrel (*Citellus tridecimilineatus*) are most common. Larger mammals crossing both areas include the coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*), and least weasel (*Mustela frenata*). Common birds on both areas are the Meadowlark (*Sturnella neglecta*), Horned Lark (*Eremophila alpestris*), Grasshopper Sparrow (*Ammodramus savannarum perpallidus*), and Lark Bunting (*Calamospiza melanocorys*). Common birds of prey are the Marsh Hawk (*Circus cyaneus*), Swainson's Hawk (*Buteo swainsoni*), Sparrow Hawk (*Falco sparverius sparverius*), Rough-legged Hawk (*Buteo lagopus santijohannis*), and the Great Horned Owl (*Bubo virginianus virginianus*). The most common orders of insects are the Orthoptera, Diptera, and Hemiptera (Branson, 1942).

METHODS AND PROCEDURES

The methods used in this study followed the outline in Technical Report No. 35 (French, 1970) for the Comprehensive Network. A few modifications were made in cases in which it was impractical or impossible to follow IBP guidelines.

Aboveground Biomass

Aboveground biomass refers to standing live and standing dead plant material. Sampling sites were located randomly within replicates at the beginning of each sampling period. Aboveground biomass was sampled every 2 weeks during the period of active growth and monthly during the dormant

season. Quadrat size was ½ m^2 with five quadrats clipped in each replicate. The dry weight rank method was utilized through September 1970 and then abandoned due to high variability in the data. During the 1968 and 1969 seasons the quadrat size was 1/8 m^2.

The vegetation was clipped by species in the field, then dried for 24 hours at 65°C in the laboratory, and then weighed to the nearest .01 g. After weighing, five samples of major species, both live and dead, were selected randomly and analyzed in an oxygen bomb calorimeter to determine calories per gram ash-free dry weight.

Mulch

The quadrats used for aboveground biomass harvesting were also used for collecting mulch. The majority of the mulch was collected by hand and the rest by use of a vacuum cleaner. Two 20-g subsamples of mulch from each quadrat were taken in the laboratory and ashed at 600°C for 4 hours. The rest of the mulch was separated from the inorganic material by flotation, dried, and weighed. Subsamples were analyzed for caloric content in the same manner as aboveground biomass.

Belowground Biomass

Roots and soil organic matter were collected by means of 2.5-cm cores taken at three points in each harvest quadrat. Samples were taken at 0-5, 5-10, and 10-15 cm depths. These depths were combined to give a total of three root samples and three organic matter samples for each depth. The roots were washed over a 32-mesh screen to remove soil particles. These samples were dried, weighed, and analyzed for caloric content.

Climate

A meteorological station was established at the grazed treatment to record the following items at weekly intervals:

1. average wind velocity per week, height 60 cm,
2. relative humidity, 15 cm (Bendix Friese Hygrothermograph),
3. air temperature, (Bendix Friese Hygrothermograph),
4. soil temperature, 45 cm depth,
5. precipitation, and
6. solar radiation, 50 cm (Belfort Pyrheliometer).

VEGETATION STRUCTURE

Vegetation on the ungrazed treatment was mostly tall- and mid-grasses. Brock (1968) found the dominants to be big bluestem (*Andropogon gerardi*), little bluestem (*A. scoparius*), and sideoats grama (*Bouteloua curtipendula*), which together made up nearly 84% of the basal cover. Utilizing data collected in the present study, an average of only 67% of the total production was furnished by the three dominant grasses. When measuring composition by weight, forbs are much more important than they are when considering only basal cover. For example, the single-stemmed few-flowered scurf pea (*Psoralea tenuiflora*) furnished 6.58% of the total weight, almost equal to that furnished by *Bouteloua curtipendula*. Other common grasses found include *Bouteloua gracilis*, *B. hirsuta*, *Sorghastrum nutans*, *Panicum virgatum*, and *Sporobolus asper*. Some common forbs are *Schrankia uncinata*, *Echinacea angustifolia*, and *Aster oblongifolius*.

Vegetation on the grazed treatment was dominated by three grasses and one forb: big bluestem (*Andropogon gerardi*), sideoats grama (*Bouteloua curtipendula*), blue grama (*B. gracilis*), and few-flowered scurf pea

(*Psoralea tenuiflora*). Together these four species constituted an average of 67% of the total production (Table 2). Other prominent species are buffalo grass (*Buchloe dactyloides*), red three-awn (*Aristida longiseta*), and western wheatgrass (*Agropyron smithii*). Some common forbs are *Echinacea angustifolia*, *Gutierrezia sarothrae*, and *Yucca glauca*.

The principal differences between the two treatments were the presence of more shortgrasses and annual grasses but less forbs on the grazed treatment. Seventy-nine species were recorded within both study areas, including 15 grasses, 2 sedges, 59 forbs, and 3 woody plants (Appendix Table 1).

Net Primary Productivity

The first primary productivity estimates were made in the ungrazed *Andropogon gerardi-Andropogon scoparius-Bouteloua curtipendula* community during the 1968 growing season (Hulett, Brock, and Lester, 1971). The methodology employed during 1968 differed from IBP guidelines. At monthly intervals from January 1968 to December 1968, 30 randomly located 1/8-m^2 quadrats were harvested in the community. The aboveground biomass was separated into four categories: green herbage, standing dead, fresh mulch, and humic mulch, according to the procedures proposed by Dyksterhuis and Schmutz (1947). The green herbage was not harvested by species, although Odum (1960) considered that for maximum accuracy in estimating net primary productivity, estimates of individual species peak standing crop during the growing season must be obtained. However, Malone (1967) found that the community peak standing crop can give a statistically more reliable estimate, particularly in areas where the production is distributed among a few species and where those species reach their peak growth at about the same

Table 2. Average percent composition of dominants on grazed and ungrazed treatments based on weight of green herbage.

Species	Ungrazed	Grazed
Andropogon gerardi	37.18	18.52
Andropogon scoparius	20.46	
Bouteloua curtipendula	10.07	28.38
Bouteloua gracilis		10.00
Psoralea tenuiflora	6.58	10.16
Total	74.29	67.06

time. Brock (1968) reported that the three dominant grasses and most of the less important species attained peak standing crop near August 1, and thus, during the first sampling season (1968) the harvesting of green herbage was done on a community basis.

The community peak standing crop (170 g/m^2) on the ungrazed treatment was reached in late July 1968 (Table 3). Net gain in biomass between sample periods divided by number of days in the sampling interval resulted in monthly productivity rates ranging from 1.5 g/m^2/day in May to 2.7 g/m^2/day in July (Table 3). The peak standing crop values have not been corrected for any loss from the green herbage that occurred during the growing season, and thus, productivity estimates based on the 170 g/m^2 should be considered minimal. Golley (1965) stated that peak standing crop cannot be equated directly to net primary shoot production due to the input of green herbage into a standing dead state during the growing season, which he estimated at 73% of the peak standing crop of green herbage. Also, we estimated consumption by small mammals at 1% of peak standing crop. No correction was made for invertebrate consumption, likely a larger figure than for mammalian consumers. When these two losses (input to standing dead and mammalian consumption) are summed (126 g/m^2) and added to the community peak standing crop (170 g/m^2), a minimal net primary shoot production estimate of 296 g/m^2 is obtained (Table 3).

Most of the production in 1968 occurred during July when the productivity reached 2.7 g/m^2/day. This increase in growth during July is probably related to July precipitation (1.23 inches above average) (Appendix Table 1). May and June 1968 were dry at the Hays Site with a departure from normal for those 2 months of -3.87 inches. Net productivity to peak standing crop and

Table 3. Green biomass productivity on Hays Site (ungrazed), May 1968 to October 1968. (Data from Hulett, Brock, and Lester, 1971).

Period	Interval (days)	Standing Crop	Positive Gain	Rate ($g/m^2/day$)
May-June	31	45	45	1.5
June-July	31	95	50	1.6
July-August	28	170	75	2.7
August-September[a/]	32	130	--	--
September-October[a/]	30	65	--	--
Average productivity to peak standing crop	98	170	170	1.7
Average productivity for growing season[b/]	187	296	296	1.6

a/ Positive biomass change not detectable following peak standing crop.

b/ Estimated net shoot production based on peak standing crop plus 73% of peak standing crop.

for the growing season was 1.7 g/m^2/day and 1.6 g/m^2/day, respectively. These rates are low compared to values reported for other grasslands, but the precipitation at the Hays Site in 1968 was only 18.83 inches, 4.04 inches below the longtime average. Odum (1960) reported production rates in perennial grasslands as 2.2 g/m^2/day during spring and 1.5 g/m^2/day during summer. Hadley and Buccos (1967), working in North Dakota, estimated shoot productivity as 2.7 g/m^2/day. Harris (1966) and Kelley et al. (1969) reported production rates of 2.4 g/m^2/day and 3.34 g/m^2/day, respectively.

Investigations on the ungrazed treatment of the Hays Site continued during the growing season of 1969. Sampling during 1969 was started in February and then continued until December 1. Thirty 1/8-m^2 quadrats were used in the short-term harvest procedure. Fresh and humic mulch were not separated in the 1969 sampling. Table 4 gives the productivity estimates for the 1969 season. The peak standing crop of green biomass (249 g/m^2) was attained on July 30. This was almost the exact date of the peak standing crop during the 1968 growing season. The principal species contributing to the production were the three dominant grasses--*Andropogon gerardi*, *Andropogon scoparius*, and *Bouteloua curtipendula*. The productivity to peak standing crop (2.4 g/m^2/day) was higher in 1969 than in 1968. This is probably a result of more precipitation in June during 1969 (Appendix Table 3). June precipitation in 1969 was 5.36 inches (1.33 inches above the normal). This is reflected in the high productivity rates from June 11, 1969, to June 30, 1969 (Table 4).

We did not attempt to correct the 1969 productivity rate by adding on 73% of the peak standing crop. By 1969 we had doubts concerning the validity of applying Golley's (1965) findings to the Hays Site because of the

Table 4. Green biomass productivity on Hays Site (ungrazed), 1969.

Period	Interval (days)	Standing Crop	Positive Gain	Rate ($g/m^2/day$)
June 11	0	119	--	--
June 11-June 20	10	168	49	4.9
June 20-June 30	10	209	41	4.1
June 30-July 16	16	218	10	1.0
July 16-July 30	14	249	31	2.2
Average productivity to peak standing crop	102	249	249	2.4
Average productivity for growing season	178	249	249	1.4

magnitude of the correction involved. However, it should be kept in mind that without a correction factor for input to standing dead from green during the growing season the 1969 productivity estimates are minimal.

The total precipitation in 1969 was 25.12 inches, an above average precipitation year. This would probably account for the higher green biomass peak standing crop in 1969 (249 g/m^2) than in 1968 (170 g/m^2).

In 1970 herbage dynamics study was expanded to include the grazed treatment. Table 5 gives the productivity estimates for the ungrazed and grazed treatments. The peak standing crop of 222 g/m^2 was reached on July 17, 1970, on the ungrazed treatment. This is about 2 weeks earlier than the peak standing crop dates in 1968 and 1969. No explanation is available for this difference.

The average productivity to peak standing crop on the ungrazed treatment in 1970 was estimated at 1.80 g/m^2/day. This is comparable to the rate in 1968. Precipitation in 1968 was 18.83 inches, while in 1970 it was 17.13 inches. The average productivity for the growing season on the ungrazed treatment was 1.3 g/m^2/day, the same as for the 1969 growing season. This is not expected since the total precipitation in 1969 was 15.12 inches, while in 1970 it was only 17.13 inches (Appendix Table 4). However, the additional precipitation in 1969 (approximately 8 inches) came primarily in August, September, and October, after the peak standing crop of green biomass had occurred. Therefore, this excess precipitation contributed little to the production of the site.

The ungrazed treatment had two production peaks during 1970. The first of these occurred from April 15 to May 15, a 30-day period in which the green biomass increased 71 g/m^2, a rate of 2.4 g/m^2/day. This early

Table 5. Green biomass productivity on Hays Site, 1970.

Period	Interval (days)	Standing Crop (g/m^2)	Positive Gain	Rate ($g/m^2/day$)
		Ungrazed Treatment		
March 15-April 15	30	2	2	0.07
April 15-May 15	30	73	71	2.4
May 15-June 1	16	79	6	0.4
June 1-June 14	14	171	92	6.61
June 14-July 17	33	222	51	1.5
Average productivity to peak standing crop	123	222	222	1.8
Average productivity for growing season	174	222	222	1.3
		Grazed Treatment		
March 15-April 15	30	1	1	0.03
April 15-May 15	30	92	91	3.0
May 15-June 1	16	184	92	5.7
June 1-June 14	14	170	-14	-1.0
June 14-July 2	18	242	72	4.0
Average productivity to peak standing crop	90	242	242	2.7
Average productivity for growing season	174	242	242	1.4

growth was exclusively forb species, primarily *Solidago missouriensis*, *Echinacea angustifolia*, *Oenothera serrulata*, *Scutellaria resinosa*, and *Solidago rigida*. The growth of these forbs was a result of 2.26 inches of precipitation that occurred during the April 15 to May 15 period.

Net primary productivity on the grazed treatment of the Hays Site was higher than on the ungrazed treatment (Table 5). The average productivity to peak standing crop was 2.7 g/m^2/day compared to 1.8 g/m^2/day on the ungrazed treatment. The grazed treatment had been grazed in 1969, a factor that may have resulted in stimulated growth in 1970.

The peak standing crop was attained earlier on the grazed treatment than on the ungrazed treatment. Peak standing crop of 242 g/m^2 occurred on July 2, 1970, on the grazed treatment, while on the ungrazed treatment it did not occur until July 17, 1970. The quicker growth on the grazed treatment is reflected in the spring productivity rates. Growth on the ungrazed and grazed treatment was about the same during the April 15 to May 15, 1970, period with the grazed treatment slightly higher. However, growth during the May 15 to June 1, 1970, period was considerably different. Green biomass on the ungrazed treatment increased only slightly during late May, resulting in a productivity rate of only .4 g/m^2/day. On the grazed treatment during late May the green biomass increased from 92 g/m^2 to 184 g/m^2, a productivity rate of 5.7 g/m^2/day. This high rate of growth may be the result of more rapid warming of the soil on the grazed treatment since it did not have the heavy standing dead and mulch deposits that were present on the ungrazed site. Thick layers of mulch may retard growth rates, particularly early in the growing season.

Standing Dead

Estimates of standing dead, fresh mulch, and humic mulch standing crops for 1968 are presented in Table 6. The standing dead mean of 198 g/m^2

Table 6. Standing crop estimates (g/m^2) for four biomass compartments in Hays Site (ungrazed), 1968. Values in parentheses are percentages of total biomass. (Data from Hulett, Brock and Lester, 1971).

Sampling Date	Green Herbage	Standing Dead	Fresh Mulch	Humic Mulch	Total Biomass
		1968			
January 29	0 (0)	254 (22)	300 (26)	605 (52)	1159
February 29	0 (0)	260 (20)	312 (24)	710 (55)	1282
March 30	0 (0)	216 (22)	235 (24)	510 (53)	962
April 30	0 (0)	244 (22)	248 (23)	602 (55)	1094
May 30	45 (4)	184 (17)	266 (25)	566 (53)	1060
June 30	95 (11)	159 (18)	170 (19)	462 (52)	886
July 28	170 (15)	114 (10)	249 (22)	592 (53)	1123
August 29	130 (12)	147 (13)	203 (18)	625 (57)	1106
September 28	66 (6)	182 (15)	272 (23)	681 (57)	1201
October 30	0 (0)	218 (22)	207 (21)	574 (58)	999
December 2	0 (0)	213 (20)	266 (24)	610 (56)	1090
Average	46 (4)	198 (18)	247 (23)	594 (55)	1085

is similar to the 189 g/m^2 of Golley and Gentry (1966) but much lower than the 806 g/m^2 of Kelley et al. (1969). The higher standing dead values prior to the 1968 growing season reflect standing dead produced in the 1967 growing season. The lower values after the 1968 growing season indicate the relatively low input to the standing dead compartment from green herbage during the relatively dry 1968 growing season. Standing dead biomass only accounted for 18% of the total biomass on the ungrazed treatment in 1968.

Standing dead levels in 1969 were similar to those in 1968 in the Hays ungrazed treatment (Table 7). The average standing dead standing crop in 1969 was 216 g/m^2 or 21% of the total biomass. There does not seem to be any major change in standing dead from 1968 to 1969.

During 1970 the standing dead was harvested on the ungrazed and grazed treatment (Table 8). The average standing dead on the ungrazed treatment was only 99 g/m^2, much less than estimated in 1968 or 1969. This would appear to be a result of differences in separating standing dead during the growing season rather than a real decrease in standing dead biomass. The standing dead standing crop during January, February, March, and April 1970 on the ungrazed treatment were comparable to the 1969 and 1968 averages. Only the summer samples of June 15 through August 16 seem to be unusually low.

The grazed treatment in 1970 also had low levels of standing dead, but this was expected since the grazed treatment site had been grazed in 1969. The average standing dead biomass on the grazed treatment in 1970 was 62 g/m^2 or 12% of the total biomass. The low standing dead levels persisted on the grazed treatment until October 1970 when the standing dead biomass increased

Table 7. Standing crop estimates (g/m^2) for three biomass compartments in Hays Site (ungrazed), 1969. Dashes indicate no sample taken on that date. Values in parentheses are percentages of total biomass.

Sampling Date	Green Herbage	Standing Dead	Mulch	Total Biomass
		1969		
February 4	0 (0)	180 (19)	755 (81)	935
June 11	119 (10)	188 (16)	902 (74)	1209
June 20	168 --	-- --	-- --	--
June 30	209 (18)	310 (27)	646 (55)	1165
July 16	218 --	-- --	-- --	--
July 30	249 (22)	188 (17)	682 (61)	1119
August 28	192 (14)	122 (9)	1085 (77)	1399
September 16	170 (16)	126 (12)	747 (72)	1043
October 1	73 (9)	206 (26)	511 (65)	790
October 15	46 --	-- --	-- --	--
November 1	4 (1)	366 (41)	516 (58)	886
December 1	0 (0)	254 (31)	556 (69)	810
Average	121 (12)	216 (21)	711 (67)	1048

Table 8. Standing crop estimates (g/m^2) for biomass compartments on Hays Site (ungrazed), 1970. Dashes indicate no sample taken on that date. Values in parentheses are percentages of total biomass. Confidence limits are at 80% level.

Sampling Date	Green Herbage	Standing Dead	Mulch	Total Biomass
		1970		
January 16	0 (0)	114 ± 17 (10)	1043 (90)	1157
February 15	0 (0)	224 ± 54 (16)	1160 (84)	1384
March 15	0 (0)	234 ± 41 (17)	1178 (83)	1412
April 15	2 ± 1 (1)	184 ± 32 (14)	1091 (85)	1277
May 15	73 ± 10 --	-- --	479[a/] --	552
June 1	79 ± 22 (5)	199 ± 63 (13)	1251 (82)	1529
June 15	171 ± 19 (13)	7 ± 5 (1)	1134 (86)	1312
July 2	164 ± 17 (16)	19 ± 9 (2)	832 (82)	1015
July 17	222 ± 22 (18)	6 ± 3 (1)	985 (81)	1213
August 1	220 ± 30 (15)	15 ± 6 (1)	1195 (84)	1430
August 16	191 ± 15 (15)	5 ± 3 (1)	1067 (84)	1263
September 1	123 ± 38 (9)	121 ± 31 (9)	1148 (82)	1392
October 15	34 ± 6 (3)	156 ± 21 (13)	1004 (84)	1194
November 20	0 (0)	197 ± 9 (17)	992 (83)	1189
December 15	0 (0)	-- --	-- --	--
Average	85 (7)	99 (9)	970 (84)	1154

[a/] Probably aberrantly low due to changes in harvesting procedure and sampling crew.

to 140 g/m^2, approximating standing dead levels on the ungrazed treatment in 1968, 1969, and 1970 (Table 9).

Mulch

The average mulch level for 1968 on the Hays ungrazed treatment was estimated at 841 g/m^2 (Table 6). This is considerably higher than values reported on old fields by Odum (1960) (500 g/m^2), Golley (1965) (250 g/m^2), Harris (1966) (258 g/m^2), and Kelley et al. (1969) (181 g/m^2). However, it is very similar to the 697 g/m^2 on excellent condition rangeland and the 1082 g/m^2 on a relict prairie in Texas reported by Dyksterhuis and Schmutz (1947). Mulch was the dominant biomass state on the ungrazed treatment in 1968, making up approximately 78% of the total biomass. There was little variation in mulch levels during 1968. The ratio of fresh mulch to humic mulch was about 0.3 to 0.7.

Mulch levels in 1969 on the Hays ungrazed treatment were slightly lower than in 1968 (Table 7). The average mulch level was estimated at 711 g/m^2, approximately 67% of the total biomass. The 1969 mulch data were more variable than in 1968, although the mulch level was relatively constant when compared to green or standing dead biomass compartments.

The 1970 standing crop data for mulch on the ungrazed treatment continued to remain relatively constant at 970 g/m^2, about 84% of the total biomass (Table 8). The single abberant value for 1970 was the 479 g/m^2 of mulch recorded on May 15, 1970. However, this would appear to be a spurious value resulting from changes in harvesting procedure and sampling crews.

The grazed treatment of the Hays Site had much less mulch than the ungrazed treatment. The average mulch level on the grazed treatment was

Table 9. Standing crop estimates (g/m^2) for biomass compartments on Hays Site (grazed), 1970. Dashes indicate no sample taken on that date. Values in parentheses are percentages of total biomass. Confidence limits are at 80% level.

Sampling Date	Green Herbage	Standing Dead	Mulch	Total Biomass
		1970		
January 16	0	62 ± 12 (20)	247 (80)	309
February 15	0	128 ± 44 (24)	401 (76)	529
March 15	0	83 ± 29 (13)	537 (87)	620
April 15	1 ± 1 (1)	95 ± 18 (14)	568 (85)	664
May 15	92 ± 6 (21)	-- --	346 (79)	438
June 1	184 ± 43 (18)	113 ± 40 (11)	730 (71)	1027
June 14	170 ± 21 (30)	-- --	403 (70)	573
July 2	242 ± 29 (36)	2 ± 1 (1)	435 (63)	679
July 17	186 ± 20 (29)	11 ± 5 (2)	451 (69)	648
August 1	178 ± 22 (46)	2 ± 2 (1)	203 (53)	383
August 16	160 ± 14 (46)	2 ± 2 (1)	184 (53)	346
September 1	173 ± 35 (39)	32 ± 11 (7)	238 (54)	443
October 15	49 ± 13 (9)	140 ± 22 (36)	211 (55)	385
November 20	0 (0)	120 ± 11 (42)	165 (58)	285
December 18	0 (0)	144 ± 31 (100)	-- --	144
Average	95 (19)	62 (12)	341 (69)	498

341 g/m^2 for 1970 (Table 9). This is approximately one-third the levels on the ungrazed treatment. The proportion of the total biomass comprised by mulch was about the same on the grazed treatment as on the ungrazed treatment. Mulch made up 69% of the total biomass on the grazed treatment. It was anticipated that mulch would not be as abundant on the grazed treatment since the treatment was grazed in 1969. Grazing reduces mulch levels through consumption and trampling.

Belowground Biomass

Mean root biomass (0-15 cm) are given in Table 10 for the ungrazed and grazed treatments on the Hays Site. These estimates are highly variable and difficult to interpret. Peak root standing crops occurred in the summer (Table 10), while low root standing crops occurred during fall and winter months. Because of the statistical variation in the root standing crop estimates, it was not feasible to estimate root productivity to turnover rates.

CALORIC VALUES

Although the importance of caloric values of vegetative material in the energy relationships of a grassland ecosystem is obvious and necessary, published material on this topic is not plentiful. One of the first studies was made by Golley (1961) on an old field dominated by broomsedge (*Andropogon virginicus*). When comparing biomass compartments in this ecosystem using calories per gram weight, he found significant differences between green grass, forbs, standing dead, litter, and roots. However, when comparing calories per gram ash-free weight the differences were not significant. Golley (1961) did find significant differences in energy values of vegetation

Table 10. Mean root biomass (g/m^2) for 0 to 15-cm depth, Hays Site, 1970.

Month	Treatment	
	Ungrazed	Grazed
January	798	1052
February	769	815
March	1368	753
April	937	983
May	1375	1212
June	1934	1753
July	1861	1790
August	1439	1322
September	528	412
October	463	431
November	408	408
December	418	532
Average	1025	955

during different seasons. He found the highest values in the fall and winter, presumably from storage of energy in the roots and seeds.

In our study, ash-free caloric values of plant materials were tabulated under four categories: treatment, dominant species, biomass compartments, and month collected.

The biomass collected from the grazed treatment had a significantly higher caloric value than biomass from the ungrazed treatment (Table 11). However, when comparing the dominant species the only difference that appeared to be significant was between *Andropogon gerardi* and the other species in the grazed area. All other dominant species were similar with means varying only from 4404 ± 89 to 4601 ± 96 g cal/g ash-free wt (Table 12).

Green herbage on the ungrazed area had a significantly higher caloric value than the standing dead, mulch, or roots collected on that area (Table 13). However, there did not appear to be any differences between green herbage, standing dead, mulch, and roots on the grazed area. There was a considerable difference between the grass and forb parts of the green herbage in the grazed area. No great differences were found between monthly collections of material on either area, although vegetation collected in November on the grazed area seemed to be higher than that material from the growing season of both areas (Table 14).

In summary, differences in the ash-free caloric values of plant material seemed small. All mean values of dominant species, compartments, and monthly collections were not less than 4000 nor more than 4900 cal/g ash-free wt. Plant parts were not included in this study and might have shown some differences. Golley (1961) and Johnson and Robel (1968) found that many plant seeds have energy values of over 5000 cal/g ash-free wt. Long (1934)

Table 11. Average ash-free calorie per gram of biomass (green herbage + standing dead + mulch + roots) collected on the grazed and ungrazed treatment at the Hays Site.

Treatment	Calorie Per Gram
Ungrazed	4447 ± 2
Grazed	4558 ± 1

Table 12. Average ash-free calorie per gram of green herbage of the dominant grass species of the ungrazed and grazed treatments on the Hays Site.

Species	Treatment	
	Ungrazed	Grazed
Andropogon gerardi	4595 ± 94	4601 ± 96
Andropogon scoparius	4555 ± 69	
Bouteloua curtipendula	4494 ± 143	4438 ± 65
Bouteloua gracilis		4404 ± 89

Table 13. Average ash-free calorie per gram of vegetation from the major compartments of an ungrazed and grazed treatment on the Hays Site.

Compartments	Treatment	
	Ungrazed	Grazed
Grasses (green)	4555 ± 58	4474 ± 31
Forbs (green)	4562 ± 66	4719 ± 43
Green herbage	4558 ± 42	4584 ± 48
Standing dead	4463 ± 31	4565 ± 43
Mulch	4333 ± 145	4614 ± 103
Roots	4100 ± 77	4465 ± 82

Table 14. Average ash-free calorie per gram of green herbage collected each month on grazed and ungrazed treatments at the Hays Site.

Month	Treatment	
	Ungrazed	Grazed
May	4632 ± 150	4506 ± 180
June	4537 ± 151	4584 ± 68
July	4526 ± 97	4540 ± 85
August	4538 ± 58	4576 ± 53
September	4598 ± 117	4585 ± 81
October	4631 ± 161	4526 ± 206
November		4782 ± 97

and Golley (1961) also found significant differences between leaves, stems, roots, and seeds of various plant species.

SUMMARY

Net primary productivity of aboveground biomass on the Hays Site averaged 1.4 g/m^2 for the growing season. During the 3 years of study on the ungrazed treatment there were variations in the peak standing crop of green biomass. However, these variations were concomitant with variations in precipitation. Primary productivity rates to time of peak standing crop on the ungrazed treatment averaged 2 g/m^2/day. The productivity estimate for the grazed treatment was higher (2.7 g/m^2/day) than on the ungrazed treatment suggesting stimulation of aboveground growth by grazing. However, the increased growth on the grazed treatment during 1970 may be the result of faster warming in the spring due to the absence of a thick mulch layer. Net primary aboveground productivity for the growing season averaged about 1.5 g/m^2/day for both treatments, with the main period of growth in June if sufficient precipitation occurred.

The major contributors to net primary shoot production were the dominant grasses: *Andropogon gerardi*, *A. scoparius*, and *Bouteloua curtipendula* on the ungrazed treatment and *Andropogon gerardi*, *Bouteloua curtipendula*, and *Bouteloua gracilis* on the grazed treatment. Forbs comprised the major source of productivity in early spring months, particularly on the ungrazed treatment.

Standing dead biomass comprised about 20% of the total biomass on the ungrazed treatment. The grazed treatment had low levels of standing dead during the early months of 1970 since it had been grazed the previous year. However, by the fall and winter months the standing dead biomass had increased

to levels similar to the ungrazed treatment. Considerable difficulty was experienced in the separation of standing dead biomass from green biomass during the entire study, particularly during the growing season.

Mulch standing crop seemed the most constant biomasss compartment in the grassland. The average mulch standing crop on the ungrazed treatment for the period 1968 through 1970 was 766 g/m^2. Month-to-month variability within any year or year-to-year variability in mulch standing crop was relatively small compared to other biomass compartments.

The grazed treatment in 1970 had less mulch than the ungrazed treatment, which was expected due to the effect of the 1969 grazing on the treatment.

Caloric data gathered in this project were not conclusive in illustrating treatment, species, or seasonal differences. Species on the grazed treatment had a significantly higher caloric value, but only slightly higher. Differences in caloric values between the dominant species, biomass compartments, and months were minor and usually insignificant. All mean values of dominant species were about 4500 cal/g ash-free dry wt.

Standing crop estimates on the Hays Site would seem to be adequately documented in the data of 1968, 1969, and 1970. If any additional aboveground sampling is to be done, it should be directed towards establishing the ratio of standing dead green biomass, since the standing dead standing crop estimates are the most variable and unreliable. Belowground biomass estimates are much more variable, and more research is needed to establish root standing crops and annual productivity on the Hays Site.

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APPENDIX I

APPENDIX TABLES

Appendix Table 1. Plant species list, Hays Site.

Symbol	Scientific Name
	Grasses
AGSM	*Agropyron smithii*
ANGE	*Andropogon gerardi*
ANSC	*Andropogon scoparius*
ARLO	*Aristida longiseta*
BOCU	*Bouteloua curtipendula*
BOGR	*Bouteloua gracilis*
BOHI	*Bouteloua hirsuta*
BRJA	*Bromus japonicus*
BUDA	*Buchloe dactyloides*
CHVE	*Chloris verticillata*
PAVI	*Panicum virgatum*
SONU	*Sorghastrum nutans*
SPAS	*Sporobolus asper*
SPPI	*Sporobolus pilosus*
SPCR	*Sporobolus cryptandrus*
	Forbs
AMPS	*Ambrosia psilostachya*
ARPU	*Aristida purpurea*
ARTE	*Arenaria texana*
ASAR	*Aster arenosus*
ASFE	*Aster fendleri*
ASMO	*Astragalus mollissimus*
ASMU	*Aster multiflorus*

Appendix Table 1 (continued).

Symbol	Scientific Name
	Forbs (continued)
ASOB	*Aster oblongifolius*
ASPU	*Asclepias pumila*
ASVI	*Asclepias viridis*
CAIN	*Callirhoe involucrata*
CIOC	*Cirsium ochrocentrum*
CIUN	*Cirsium undulatum*
ECAN	*Echinacea angustifolia*
ERAS	*Erysium asperum*
ERRA	*Erigeron racemosus*
EUMA	*Euphorbia marginata*
EVPI	*Evolvulus pilosus*
GACO	*Gaura coccinea*
GRSQ	*Grindelia squarrosa*
GUSA	*Gutierrezia sarothrae*
HEAN	*Helianthus annus*
HEHI	*Hedeoma hispida*
HEMA	*Helianthus maximiliana*
HOAN	*Helianthus annuus*
HOPU	*Hordeum pusillum*
KUGL	*Kuhnia glutinosa*
LECA	*Leptilon canadensis*
LEOV	*Lesquerella ovalifolia*
LIPU	*Liatris punctata*

Appendix Table 1 (continued).

Symbol	Scientific Name
	Forbs (continued)
LYJU	*Lygodesmia juncea*
MACO	*Malvastrum coccineum*
MEAL	*Melilotus alba*
MEOF	*Melilotus officinalis*
OEFR	*Oenothera freemontii*
OELA	*Oenothera lavandulaefolia*
OESE	*Oenothera serrulata*
ONOC	*Onosmodium occidentale*
OXST	*Oxalis stricta*
PAJA	*Paronychia jamesii*
PEPU	*Petalostemon purpurea*
POAL	*Polygala alba*
PSCU	*Psoralea cuspidata*
PSES	*Psoralea esculenta*
PSTE	*Psoralea tenuiflora*
RACO	*Ratibida columnifera*
SCRE	*Scutellaria resinosa*
SCUN	*Schrankia uncinata*
SEPL	*Senecio plattensis*
SIHY	*Sitanion hystrix*
SISP	*Silphium speciosum*
SOMI	*Solidago missouriensis*
SOMO	*Solidago mollis*

Appendix Table 1 (continued).

Symbol	Scientific Name
	Forbs (continued)
SORI	*Solidago rigida*
STLI	*Stenosiphon linifolius*
THGR	*Thelesperma gracile*
TRRA	*Tragia ramosa*
VEBI	*Verbena bipinnatifida*
VEST	*Verbena stricta*
	Sedges
CAGR	*Carex gravida*
CASP	*Carex* spp.
	Woody plants
AMCA	*Amorpha canescens*
TEST	*Tetraneuris stenophylla*
YUGL	*Yucca glauca*

Appendix Table 2. Daily precipitation for 1968 compiled from records of the Fort Hays Experiment Station, Hays, Kansas.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
1						t[a/]	.08						
2	t			.01			.03	.18			t		
3				.25				.16			.05		
4	t								t				
5					.07						t		
6	t				.05		.03			.03	.06		
7					.75				.08		t		
8											.03		
9						.02	1.70			.21	t		
10					t	1.33		t			t		
11	t				.73	t		.25					
12	t						.07						
13		t			t								
14				.36	.11								
15		t	t			t					.52		
16						.25			.23	2.14	t		
17					.04	.03				1.12		t	
18												t	
19												.18	
20				.46	t		.24						
21		.07			t				t			t	
22		t	t	.20	.10		.16					.38	
23		.02			t				2.52				
24		t			t		.14						
25					t	.10	.72						
26		.01			.09		.03	.08					
27	t				.03		.08	.71				t	
28				.17			.31	.30					
29							.02	.02					
30												t	
31			.06		.33		.33					t	
Total	t	.10	.06	1.45	2.30	1.73	3.94	1.70	2.83	3.50	.66	.56	18.83

[a/] t indicates trace.

Appendix Table 3. Daily precipitation for 1969 compiled from records of the Fort Hays Experiment Station, Hays, Kansas.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
1						t	t		.65	.02			
2								1.42	.02				
3	t		.01			.42					.07		
4								.01		t			
5			.02	.13			.27		.23	1.12		.08	
6			.05		.41		.76			.03		.17	
7					.02		.04					t	
8		t	.17		1.35	.07						t	
9					.03	.01	.31						
10							.02			.09			
11							t			.09		.01	
12			t				t			.63			
13		t			.15					.07	.02		
14	t	.92				.11		t			t		
15	t	.23				.01		.05					
16				1.17		.28	.23						
17	.03			1.27		2.13		.02					
18				.02		.30			.10	.08	t		
19	t				t		t	t		.01			
20	t	.14	t					.02		.29			
21	t	.03			1.01	.52						.01	
22	.01				.04	1.30		.35					
23	t	.08				.01	t	.23				.01	
24	t	.03	.70		t	.03	.75	.35		.53			
25					.02	.02	.01	.15					
26		t		.01		.10		.01		t			
27	t	t	t			.05							
28	t											.04	
29	.04		.33		.34					.02			
30							.02			.50			
31								.97		.12			
Total	.08	1.43	1.28	2.60	3.37	5.36	2.41	3.58	1.0	3.60	.09	.32	25.12

Appendix Table 4. Daily precipitation for 1970. January to May data are compiled from records of the Fort Hays Experiment Station, Hays, Kansas; June to December data are from the IBP meteorological station.

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
1			t	.33	.19	.42							
2			.01	.02			.04						
3			.01										
4												t	
5						.30						t	
6			.05										
7													
8		t						.22					
9													
10			t								.19		
11			t									t	
12				.05		.33	1.11					t	
13					t								
14			t						.58				
15					.70	2.20			.16				
16			.18	1.14		1.33			t	.05			
17	t		t	.05				.79	.70			t	
18	t		.07	.08					.02			t	
19	t		t			1.47							
20													
21	.06			.10									
22	t							.70				t	
23											t	t	
24					1.10								
25			.05		.26				1.03				
26				t									
27										.04			
28			.21				.42			.16			
29					.01		.04						
30			.13										
31			.33		t								
Total	.06	t	1.04	1.77	1.96	6.05	1.61	1.71	2.49	.25	.19	5	17.13
Longtime Average													22.81

Appendix Table 5. Average wind velocity in miles per hour at weekly intervals specified, 1970.

Month	Dates and Wind Velocity					Monthly Average
January	No Data					
February	Jan. 29-5 5.86	6-12 5.46	13-19 6.81	20-26 5.99		5.88
March	Feb. 27-5 6.9	6-12 8.0	13-19 5.19	20-26 7.9		6.99
April	Mar. 27-3 6.85	4-9 6.79	10-16 10.32	17-23 9.23	24-30 7.01	8.04
May	1-7 9.03	8-14 6.76	15-21 8.99	22-28 6.17		7.73
June	May 29-4 6.87	5-11 6.85	12-18 6.85	19-25 4.91		6.37
July	June 26-2 7.26	3-9 3.69	10-16 1.07	17-23 5.84	24-30 7.3	4.93
August	July 31-6 5.13	7-14 5.23	15-21 4.61	22-28 4.34		4.82
September	Aug. 29-4 5.96	5-11 7.67	12-18 6.27	19-24 8.86		7.19
October	Sept. 25-2 4.42	3-9 9.99	12-18 7.39	20-28 7.69		7.32
November	Oct. 29-5 7.42	6-12 5.42	13-19 6.13	20-26 7.41		6.59
December	Nov. 27-5 8.46	6-12 5.31	13-19 6.28	20-31 4.97		6.25
Yearly Average						6.55

Appendix Table 6. Daily maximum and minimum temperatures for 1970.

Day	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	37	20	52	19	50	32	33	30	62	32	68	58
2	33	5	23	9	70	38	50	22	72	32	67	58
3	40	14	40	26	56	22	40	28	81	42	68	52
4	40	8	43	28	56	30	52	23	84	43	70	50
5	18	6	54	16	60	32	71	20	87	47	86	48
6	27	-2	61	26	56	30	76	33	88	48	92	55
7	21	-1	63	26	73	30	79	40	84	56	88	56
8	18	-9	54	20	80	37	64	43	82	49	87	64
9	35	-5	54	16	31	30	77	34	78	54	88	64
10	37	20	61	27	36	20	79	35	86	48	95	62
11	43	23	41	22	32	22	80	49	88	64	76	60
12	46	12	56	12	40	22	51	41	94	59	81	53
13	59	15	32	18	35	15[a]	54	33	65	61	88	54
14	45	18	38	14	49	16	58	29	64	29	86	63
15	49	17	50	28	35	20	71	50	73	40	92	62
16	18	17	69	22	34	26	70	39	85	43	88	62
17	9	8	88	31	34	22	58	41	92	50	92	64
18	13	2	37	35	32	30	74	37	94	60	84	58
19	19	9	55	11	43	24	61	24	93	68	74	48
20	19	13	61	16	46	19	58	35	93	78[a]	72	44
21	26	6	64	30	60	18	66	30	90	58	78	42
22	54	20	62	30	56	31	69	49	88	57	70	46
23	66	33	58	28	71	27	71	34	88	60	78	52
24	54	32	63	20	66	19	64	32	82	60	82	50
25	64	37	49	20	46	35	76	41	80	56	95	70
26	60	24	56	21	52	18	81	50	87	60	90	64
27	61	20	59	24	36	30	89	56	84	60	90	60
28	51	35	45	40	38	3	85	46	74	60	94	70
29	41	18			36	17	75	52	83	58	100	72
30	48	14			34	32	51	48	86	60	92	73
31	46	24			33	29			66	56	93	74
Monthly Average	38	14	52	22	49	25	66	38	85	53	84	56
Average	26		37		37		52		69		70	
Longtime Average	41	16	46	19	56	27	67	39	76	49	86	60
Average	29		32		42		53		63		73	

Appendix Table 6 (continued).

Day	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	97	71	108	68	92	66	87	49	51	33	69	37
2	101	67	110	76	94	67	86	44	42	31	60	22
3	92	60	104	72	94	60	70	42	40	31	58	38
4	88	52	110	80	88	53	87	48	50	34	65	17
5	84	55	105	78	98	70	85	60	65	22	45	25
6	93	60	108	80	102	74	85	60	73	27	55	19
7	94	64	108	74	93	54	67	65	68	36	63	22
8	96	70	94	72	94	60	57	34	65	50	66	24
9	94	70	90	72	82	72	55	32	57	38	48	30
10	97	68	94	68	77	43	61	37	68	28	38	37
11	84	64	92	60	94	45	50	45	43	37	36	18
12	88	66	100	59	57	54	70	31	45	22	49	13
13	95	70	100	60	45	60	60	36	39	33	52	10
14	99	68	101	63	56	50	48	40	38	29	55	17
15	88	64	98	65	50	42	55	34	55	12	43	30
16	92	60	84	65	66	52	58	26	66	23	52	18
17	100	62	101	66	59	48	47	40	64	32	57	23
18	108	75	104	65	80	58	52	44	62	24	27	27
19	90	68	98	68	88	62	55	45	50	38	32	6
20	75	55	71	61	94	71	69	41	61	25	34	15
21	80	58	78	61[a]	78	60	74	39	60	25	29	25
22	84	50	86	64	57	55	66	37	27	19	58	25
23	88	55	90	55	54	50	69	50	28	10	37	6
24	82	62	93	57	82	41	73	34	48	16	43	10
25	96	78	99	59	60	52	66	50	67	35	41	3
26	100	70	104	62	68	36	44	43	34	26	47	18
27	97	66	103	72[a]	80	48	50	33	38	24	52	24
28	96	70	100	66	82	43	56	28	42	17	44	13
29	104	70	92	60	82	46	59	28	67	20	57	19
30	108	68	96	62	81	48	60	41	73	37	46	17
31	112	75	93	63			46	34			61	14
Monthly Average	94	65	97	61	78	55	63	41	52	28	49	20
Average	79		79		66		52		39		34	
Longtime Average	93	65	92	64	83	55	71	42	56	28	44	19
Average	79		78		69		56		42		31	

[a] These figures are from the Fort Hays Experiment Station due to a malfunction in our equipment from March 15 to May 20.

Appendix Table 7. Daily percent relative humidity for 1970.

Day	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	[a]		90	60	82	80					76	38
2			90	80	80	50					66	30
3			90	68	78	40					76	38
4			80	50	60	26					76	33
5			75	45	66	30					73	30
6			82	42	74	26					60	30
7			70	28	76	18					70	28
8			76	30	50	20					66	34
9			60	30	76	50					72	36
10			70	30	77	42					70	24
11			80	49	73	58					70	56
12			81	36	73	48					78	50
13			77	50	[b]						74	30
14			82	48							74	49
15			82	44							76	47
16			72	18							75	38
17			74	42							74	38
18			80	50							72	50
19			89	42							90	50
20			92	32							82	50
21			75	35					65[b]	38	86	44
22			86	42					74	32	86	50
23			90	52					73	48	88	38
24			86	42					74	32	82	46
25			90	40					74	33	76	42
26			65	25					72	35	82	44
27			64	34					74	40	84	40
28		[a]	82	56					70	52	[b]	
29	80	50							75	36		
30	85	52							74	36		
31	80	58							75	56		

Appendix Table 7 (continued).

Day	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1			78	32	66	32	55	26	61	34	56	30
2	70	38	68	28	67	28	54	18	60	32	43	20
3	76	40	70	30	68	27	66	28	68	50	51	30
4	88	42	62	30	68	32	57	32	66	42	62	28
5	82	46	64	30	65	22	68	32	65	33	50	41
6	85	30	60	28	54	20	69	30	66	22	57	44
7	85	46	70	26	52	19	72	55	54	22	58	41
8	90	44	72	40	60	22	72	57	56	26	56	20
9	60	38	72	39	60	23	62	26	58	30	38	22
10	74	34	68	32	50	18	64	34	64	24	40	18
11	75	48	70	30	58	50	69	52	70	40	52	30
12	72	44	70	25	70	68	70	28	70	40	62	48
13	70	36	54	22	70	62	65	40	70	50	70	38
14	60	31	76	40	68	44	72	50	72	28	65	20
15	64	36	88	36	68	66	70	28	75	25	72	40
16	60	40	78	38	66	57	67	28	50	20	60	30
17	74	30	84	42	66	46	69	54	64	30	63	28
18	46	25	80	36	65	46	70	52	65	30	62	25
19	72	36	85	32	66	40	60	52	68	34	74	30
20	74	40	61	30	60	30	72	36	65	40	72	40
21	76	34		[b]	67	34	70	30	70	23	70	25
22	76	34			70	50	69	38	64	33	70	30
23	60	30			70	55	69	34	44	28	68	28
24	68	36			67	32	64	18	36	23	72	40
25	58	30			60	32	67	15	68	34	68	30
26	50	28			66	24	70	30	66	53	65	40
27	68	32		[b]	60	24	68	34	70	42	68	38
28	68	30	48	34	54	24	68	25	68	32	66	30
29	76	26	52	25	78	24	50	25	65	20	72	42
30	75	30	62	28	67	32	60	22	34	20	68	30
31	70	30	62	30			55	32				

[a] From January 1 to January 28 the station was not established.

[b] From March 15 to May 20 and from June 29 to July 1 data are not available due to a malfunction of the thermohygrograph.

Appendix Table 8. Daily, monthly, and seasonal evaporation from a free-water surface for the 1970 growing season; compiled from records of the Fort Hays Experiment Station, Hays, Kansas.

Day	Evaporation (in inches)						Seasonal
	Apr.	May	June	July	Aug.	Sept.	
1	.00	.19	.09	.40	.30	.35	
2	.03	.22	.28	.42	.40	.26	
3	.12	.26	.18	.37	.43	.30	
4	.12	.14	.15	.32	.37	.21	
5	.15	.25	.19	.37	.50	.45	
6	.12	.32	.22	.28	.47	.63	
7	.34	.37	.38	.20	.32	.28	
8	.24	.22	.43	.33	.26	.32	
9	.16	.26	.34	.26	.30	.44	
10	.18	.19	.31	.67	.25	.31	
11	.20	.28	.44	.22	.28	.38	
12	.36	.24	.35	.23	.34	.14	
13	.24	.26	.28	.30	.45	.05	
14	.21	.19	.45	.44	.46	.01	
15	.21	.16	.26	.23	.31	.06	
16	.13	.24	.24	.42	.12	.00	
17	.15	.28	.30	.47	.34	.00	
18	.17	.34	.63	.44	.33	.09	
19	.24	.39	.22	.34	.29	.18	
20	.08	.37	.35	.03	.10	.44	
21	.14	.31	.24	.38	.11	.26	
22	.32	.44	.26	.37	.25	.19	
23	.10	.11	.27	.34	.30	.08	
24	.21	.24	.36	.24	.29	.18	
25	.10	.21	.26	.39	.27	.21	
26	.21	.25	.29	.51	.42	.14	
27	.33	.27	.55	.30	.49	.12	
28	.35	.15	.47	.32	.57	.20	
29	.25	.16	.33	.41	.45	.20	
30	.16	.33	.31	.35	.22	.10	
31		.21		.35	.35		
Monthly total	5.62	7.85	9.43	10.70	10.34	6.58	50.52
Monthly daily average	.18	.25	.31	.35	.33	.22	
64-year average	5.73	6.84	8.63	10.21	9.33	7.22	47.96

APPENDIX II

FIELD DATA

Aboveground Biomass Data

Aboveground biomass data collected at the Hays (Kansas) Site in 1970 is Grassland Biome data set A2U0006. Data were collected on form NREL-01. A copy of the data form and an example of the data follow.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET - ABOVEGROUND BIOMASS

DATA TYPE	SITE	INITIALS	DATE Day	DATE Mo	DATE Yr	TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	CLIP-RANK	GROWTH FM.	GENUS	SPECIES	SUBSPECIES	PHENOLOGY	RANK	SACK NO.	DRY WT.	SPECIAL	DRY WT. SP.
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-23	25	27	29-30	31-32	34	36-37	39-40	42-45	47-52	54-5[illegible]	[illegible]

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
- 11 Vertebrate - Snap Trapping
- 12 Vertebrate - Collection
- 20 Avian Flush Census
- 21 Avian Road Count
- 22 Avian Road Count Summary
- 23 Avian Collection - Internal
- 24 Avian Collection - External
- 25 Avian Collection - Plumage
- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- 43 Microbiology - Root Decomposition
- [illegible] Microbiology - Respiration

SITE
- 01 [illegible]
- 02 Bison
- 03 Bridger
- 04 [illegible]
- [illegible] Dickinson
- [illegible]
- 07 [illegible]
- [illegible]
- 09 Osage
- 10 Pawnee
- 11 [illegible]

TREATMENT
- 1 [illegible]
- 2 [illegible] grazed
- 3 [illegible] grazed
- 4 [illegible] grazed
- 5 Grazed 1969, ungrazed 1970

PHENOLOGY
- 01 [illegible]
- 02 Early vegetation
- 03 Prebud
- 04 Bud stage
- 05 Early bloom
- 06 Mid-bloom
- 07 Full bloom
- 08 [illegible] bloom
- 09 [illegible] stage
- 10 Dough stage
- 11 Ripe seed
- 12 Post [illegible]
- 13 Stem cured
- 14 [illegible]
- 15 Regrowth flowering
- 16 Regrowth ripe seed
- 17 Standing dead
- 18 Winter dormant

CLIP RANK
- 1 [illegible]
- 2 [illegible] and ranked
- 3 Ranked

GROWTH FORM
- 1 Perennial grass
- 2 Annual grass
- 3 Sedge, [illegible]
- 4 Annual forb
- 5 Biennial forb
- 6 Perennial forb
- 7 Half-shrub
- 8 Shrub
- 9 Tree
- 0 Miscellaneous

*** EXAMPLE OF DATA ***

```
         1         2         3         4         5
12345678901234567890123456789012345678901234567890123456789

0106GH 19087011 .71
0106GH 19087011 .71   1 2 1 ANGE        1        62.57
0106GH 19087011 .71   1 2 6 SCUN        2        12.29
0106GH 19087011 .71   1 2 1 BOCU        3        14.97
0106GH 19087011 .71   1 2 6 SORI        4         9.97
0106GH 19087011 .71   1 2 6 MEAL        5          .84
0106GH 19087011 .71   1 2 6 SCRE        6         1.17
0106GH 19087011 .71   1 2 6 OELA       17          .98
0106GH 19087011 .71   1 2 6 OESE        8         1.69
0106GH 19087011 .71   1 2 6 ASMU        9         2.03
0106GH 19087011 .71   1 2 6 SOMI       10          .48
0106GH 19087011 .71   1 2 1 SONU        7         1.96
0106GH 19087011 .71   2 2 1 ANSC        1        57.33
0106GH 19087011 .71   2 2 1 ANGE        2        15.77
0106GH 19087011 .71   2 2 6 PSTE        3        14.46
0106GH 19087011 .71   2 2 1 BOCU        4         3.30
0106GH 19087011 .71   2 2 1 ANSC   17   5         6.21
0106GH 19087011 .71   2 2 6 SOMI        6         2.15
0106GH 19087011 .71   2 2 6 SCRE        7         2.66
0106GH 19087011 .71   2 2 6 OESE        8         1.52
0106GH 19087011 .71   2 2 5 CIUN   17   9         3.47
0106GH 19087011 .71   2 2 6 OELA       10         1.09
0106GH 19087011 .71   2 2 6 SCUN       11         1.10
0106GH 19087011 .71   2 2 1 SONU       12         3.53
0106GH 19087011 .71   3 2 1 ANGE        1        52.31
0106GH 19087011 .71   3 2 1 BOCU        2         8.71
0106GH 19087011 .71   3 2 6 TRRA        3         1.76
0106GH 19087011 .71   3 2 6 PSTE   05   4         1.72
0106GH 19087011 .71   3 2 6 OELA        5         1.62
0106GH 19087011 .71   3 2 6 OESE        6         1.38
0106GH 19087011 .71   3 2 6 SORI        7         1.50
0106GH 19087011 .71   3 2 6 SCUN        8          .97
0106GH 19087011 .71   4 2 1 PAVI        1        29.36
0106GH 19087011 .71   4 2 1 ANGC        2        48.91
0106GH 19087011 .71   4 2 6 HEMA        3        14.24
0106GH 19087011 .71   4 2 6 SCUN        4         4.54
0106GH 19087011 .71   4 2 1 ANSC        5         4.40
0106GH 19087011 .71   4 2 1 PAVI   17   6         4.00
0106GH 19087011 .71   4 2 6 MEAL        7         1.20
0106GH 19087011 .71   5 2 1 ANGE        1        43.88
0106GH 19087011 .71   5 2 6 AMCA        2        16.10
0106GH 19087011 .71   5 2 1 BOCU        3         2.41
0106GH 19087011 .71   5 2 1 ANSC        4         9.69
0106GH 19087011 .71   5 2 6 ASMU        6         1.21
0106GH 19087011 .71   5 2 6 OESE        7         2.11
0106LT 19087012 .71
```

0106LT	19087012	.71	1	2	1	ANGE		1	71.24
0106LT	19087012	.71	1	2	6	PSTE		2	13.76
0106LT	19087012	.71	1	2	1	ANSC		3	8.16
0106LT	19087012	.71	1	2	6	SCUN		4	1.82
0106LT	19087012	.71	1	2	6	THGR		5	4.39
0106LT	19087012	.71	1	2	6	OESE		8	2.54
0106LT	19087012	.71	1	2	6	SOMI	07	7	1.75
0106LT	19087012	.71	1	2	6	LEER		9	1.84
0106LT	19087012	.71	1	2	6	ASMU		10	1.49
0106LT	19087012	.71	1	2	6	ASOB		11	2.02
0106LT	19087012	.71	1	2	1	BOCU		6	4.00
0106LT	19087012	.71	1	2	6	YUGL		12	1.16
0106LT	19087012	.71	2	2	1	ANGE		1	35.52
0106LT	19087012	.71	2	2	1	BOCU		2	36.75
0106LT	19087012	.71	2	2	6	FCAN		3	8.13
0106LT	19087012	.71	2	2	1	SPPI		4	2.95
0106LT	19087012	.71	2	2	5	CIUN		5	2.79
0106LT	19087012	.71	2	2	6	ASMU		6	2.60
0106LT	19087012	.71	2	2	6	TRRA		7	1.09
0106LT	19087012	.71	3	2	1	BOCU		1	29.27
0106LT	19087012	.71	3	2	6	HOAN		2	15.99
0106LT	19087012	.71	3	2	6	SOMI	07	3	4.60
0106LT	19087012	.71	3	2	6	PSTE		4	3.54
0106LT	19087012	.71	3	2	6	SCUN		5	3.07
0106LT	19087012	.71	3	2	6	SORI		6	2.75
0106LT	19087012	.71	3	2	6	TRRA		7	4.28
0106LT	19087012	.71	3	2	6	ASOB		8	2.93
0106LT	19087012	.71	3	2	6	SCRE		9	1.62
0106LT	19087012	.71	3	2	1	BOGR		10	10.48
0106LT	19087012	.71	3	2	1	SPPI		11	1.96
0106LT	19087012	.71	3	2	1	ANSC		12	2.36
0106LT	19087012	.71	3	2	1	ANGE		13	9.49
0106LT	19087012	.71	3	2	6	STLI	17	14	3.80
0106LT	19087012	.71	3	2	6	FCAN		15	1.25
0106LT	19087012	.71	3	2	6	FCAN	17	16	2.31
0106LT	19087012	.71	3	2	1	BOCU		17	1.70
0106LT	19087012	.71	3	2	6	AMPS		18	2.05
0106LT	19087012	.71	3	2	6	STLI	02	20	2.94
0106LT	19087012	.71	3	2	6	OESE		21	.97
0106LT	19087012	.71	4	2	1	ANSC		1	48.69
0106LT	19087012	.71	4	2	6	HOAN		2	5.21
0106LT	19087012	.71	4	2	6	FCAN		3	2.62
0106LT	19087012	.71	4	2	6	THGR		5	1.68
0106LT	19087012	.71	4	2	1	BOCU		4	5.84
0106LT	19087012	.71	4	2	6	SCUN		6	2.54
0106LT	19087012	.71	4	2	6	SCRE		7	2.04
0106LT	19087012	.71	4	2	6	OESE		8	1.19
0106LT	19087012	.71	4	2	1	ANSC	17	9	1.46
0106LT	19087012	.71	4	2	6	PAJA		10	1.03
0106LT	19087012	.71	4	2	6	ITPU		11	1.16

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0106LT 19087012 .71    5 2 1 ANGE          1        65.01
0106LT 19087012 .71    5 2 1 ANSC          2        24.02
0106LT 19087012 .71    5 2 6 SORI          3         6.83
0106LT 19087012 .71    5 2 6 SCUN          4         6.51
0106LT 19087012 .71    5 2 1 BOCU          5         4.25
0106LT 19087012 .71    5 2 6 HOAN          6         3.68
0106LT 19087012 .71    5 2 6 PSTE          7         1.91
0106LT 19087012 .71    5 2 6 ECAN          8         1.44
0106LT 19087012 .71    5 2 6 SORI    17    9         3.87
0106LT 18087051 .71
0106LT 18087051 .71    1 2 1 ANGE          1        33.35
0106LT 18087051 .71    1 2 1 BOCU          2        13.63
0106LT 18087051 .71    1 2 1 BOGR          3         6.90
0106LT 18087051 .71    1 2 1 BUDA          4         8.99
0106LT 18087051 .71    1 2 6 AMPS          5         3.15
0106LT 18087051 .71    1 2 6 ERRA    19    6         2.36
0106LT 18087051 .71    1 2 6 RACO          7         1.67
0106LT 18087051 .71    1 2 6 LECA          8         1.16
0106LT 18087051 .71    1 2 2 BRJA    19    9         1.47
0106LT 18087051 .71    2 2 1 BOCU          1        24.91
0106LT 18087051 .71    2 2 1 BOGR          2         8.18
0106LT 18087051 .71    2 2 1 BUDA          3        16.90
0106LT 18087051 .71    2 2 6 RACO          4         2.36
0106LT 18087051 .71    2 2 6 AMPS          5         1.16
0106LT 18087051 .71    2 2 6 GUSA          6         1.10
0106LT 18087051 .71    2 2 6 GRSQ          7         4.03
0106LT 18087051 .71    3 2 1 ANGE          1        38.07
0106LT 18087051 .71    3 2 1 BOGR          2        14.21
0106LT 18087051 .71    3 2 1 BUDA          3         2.66
0106LT 18087051 .71    3 2 6 AMPS          4         5.15
0106LT 18087051 .71    3 2 6 GRSQ          5         2.76
0106LT 18087051 .71    3 2 1 BOCU          6         5.49
0106LT 18087051 .71    3 2 6 SOMO          7         1.09
0106LT 18087051 .71    3 2 6 RACO          8         1.24
0106LT 18087051 .71    4 2 6 PSTE          1        19.40
0106LT 18087051 .71    4 2 1 BOCU          2        27.50
0106LT 18087051 .71    4 2 1 BOGR          3        29.32
0106LT 18087051 .71    4 2 6 AMPS          4         1.93
0106LT 18087051 .71    4 2 1 BUDA          5         1.58
0106LT 18087051 .71    4 2 6 SISP          6         1.13
0106LT 18087051 .71    4 2 6 RACO          7          .96
0106LT 18087051 .71    4 2 6 SOMO          8         1.11
0106LT 18087051 .71    5 2 1 ANGE          1        14.96
0106LT 18087051 .71    5 2 1 BOCU          2        27.80
0106LT 18087051 .71    5 2 1 BUDA          3        36.32
0106LT 18087051 .71    5 2 6 GUSA          4         3.46
0106LT 18087051 .71    5 2 6 OPMA          5         2.04
0106LT 18087051 .71    5 2 6 PSTE          6         1.41
0106LT 16087052 .71
```

0106LT	16087052	.71	1	2	1	ANGE		1	64.83
0106LT	16087052	.71	1	2	1	ROCU		2	29.68
0106LT	16087052	.71	1	2	1	ARLO	19	5	6.37
0106LT	16087052	.71	1	2	6	AMPS		4	3.64
0106LT	16087052	.71	1	2	6	RACO		6	1.11
0106LT	16087052	.71	1	2	1	ROGR		3	12.67
0106LT	16087052	.71	2	2	1	ANGE		1	35.36
0106LT	16087052	.71	2	2	1	ROCU		2	19.65
0106LT	16087052	.71	2	2	6	LEER		3	8.39
0106LT	16087052	.71	2	2	6	GUSA		4	2.20
0106LT	16087052	.71	2	2	6	PSTE		5	2.63
0106LT	16087052	.71	2	2	6	OESE		6	1.68
0106LT	16087052	.71	2	2	6	THGR		7	1.40
0106LT	16087052	.71	2	2	6	RACO		8	1.04
0106LT	16087052	.71	2	2	6	AMPS		9	1.04
0106LT	16087052	.71	3	2	1	ANGE		1	43.12
0106LT	16087052	.71	3	2	1	ROCU		2	5.38
0106LT	16087052	.71	3	2	1	ARLO		3	3.37
0106LT	16087052	.71	3	2	6	GUSA		4	13.15
0106LT	16087052	.71	3	2	6	LEER		5	4.17
0106LT	16087052	.71	3	2	6	THGR		6	1.25
0106LT	16087052	.71	3	2	6	AMPS		7	1.39
0106LT	16087052	.71	3	2	6	OELA		8	1.01
0106LT	16087052	.71	3	2	6	SISP		9	1.13
0106LT	16087052	.71	4	2	1	ANGE		1	43.93
0106LT	16087052	.71	4	2	6	GUSA		2	10.36
0106LT	16087052	.71	4	2	1	ROCU		3	14.30
0106LT	16087052	.71	4	2	6	PSTE		4	6.05
0106LT	16087052	.71	4	2	6	OESE		5	2.51
0106LT	16087052	.71	4	2	6	RACO		6	1.22
0106LT	16087052	.71	4	2	6	THGR		7	2.74
0106LT	16087052	.71	4	2	6	ECAN		8	1.19
0106LT	16087052	.71	4	2	6	SISP		9	1.87
0106LT	16087052	.71	4	2	6	AMPS		10	3.97
0106LT	16087052	.71	4	2	6	LEER		11	1.07
0106LT	16087052	.71	5	2	1	ANGE		1	44.74
0106LT	16087052	.71	5	2	1	ROCU		2	19.45
0106LT	16087052	.71	5	2	6	PSTE		3	6.87
0106LT	16087052	.71	5	2	1	ARLO		4	8.52
0106LT	16087052	.71	5	2	1	ROGR		5	9.78
0106LT	16087052	.71	5	2	6	GUSA		6	5.09
0106LT	16087052	.71	5	2	6	SOMO		7	1.26

Litter Data

Litter data collected at the Hays (Kansas) Site in 1970 is Grassland Biome data set A2U0016. Data were collected on form NREL-02. A copy of the data form and an example of the data follow.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET - LITTER

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	TYPE	SACK NO.	DRY WT.	SACK WT.	ASH WT.	PREVIOUS DATE		
			Day	Mo	Yr										Day	Mo	Yr
1-2	3-4	5-7	8-9														55-66

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
- 11 Vertebrate - Snap Trapping
- 12 Vertebrate - Collection
- 20 Avian Flush Census
- 21 Avian Road Count
- 22 Avian Road Count Summary
- 23 Avian Collection - Internal
- 24 Avian Collection - External
- 25 Avian Collection - Plumage
- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- 43 Microbiology - Root Decomposition
- 44 Microbiology - Respiration

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hays
- 07 Hopland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

TYPE
- 1 Quadrat, total
- 2 Quadrat, part
- 3 Cleared plot
- 4 Litter bag

Example of Data

```
          1         2         3
12345678901234567890123456789012345678 9
0206ML 01067011 .71  1  1      668.725
0206ML 01067011 .71  2  1      623.86
0206ML 01067011 .71  3  1      626.38
0206ML 01067011 .71  4  1      633.303
0206ML 01067011 .71  5  1      563.498
0206ML 01067012 .71  1  1      696.661
0206ML 01067012 .71  2  1      651.773
0206ML 01067012 .71  3  1      551.180
0206ML 01067012 .71  4  1      885.472
0206ML 01067012 .71  5  1      356.544
0206LT 01067051 .71  1  1       307.45
0206LT 01067051 .71  2  1       398.74
0206LT 01067051 .71  3  1       536.09
0206LT 01067051 .71  4  1       325.89
0206LT 01067051 .71  5  1       393.85
0206LT 01067052 .71  1  1       401.75
0206LT 01067052 .71  2  1       449.67
0206LT 01067052 .71  3  1       197.26
0206LT 01067052 .71  4  1       347.82
0206LT 01067052 .71  5  1       292.31
```

Belowground Biomass Data

Belowground biomass data collected at the Hays (Kansas) Site in 1970 is Grassland Biome data set A2U0026. Data were collected on form NREL-03. A copy of the data form and an example of the data follow.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET - BELOWGROUND BIOMASS

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	CORE DIAM.	HORIZON	TOP DEPTH	BOTTOM DEP.	LENGTH	WASH WT.	DRY WT.	ASH WT.	CROWN DRY WT.
			Day	Mo	Yr													
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-23	25-27	29	31-33	35-37	39-41	43-47	49-54	56-61	63-68

DATA TYPE

01 Aboveground Biomass
02 Litter
03 Belowground Biomass
10 Vertebrate - Live Trapping
11 Vertebrate - Snap Trapping
12 Vertebrate - Collection
20 Avian Flush Census
21 Avian Road Count
22 Avian Road Count Summary
23 Avian Collection - Internal
24 Avian Collection - External
25 Avian Collection - Plumage
30 Invertebrate
40 Microbiology - Decomposition
41 Microbiology - Nitrogen
42 Microbiology - Biomass
43 Microbiology - Root Decomposition
44 Microbiology - Respiration

SITE

01 Ale
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 Hopland
08 Jornada
09 Osage
10 Pantex
11 Pawnee

TREATMENT

1 Ungrazed
2 Lightly grazed
3 Moderately grazed
4 Heavily grazed
5 Grazed 1969, ungrazed 1970
6
7
8
9

ORIZON

1 AO
2 A
3 B
4 C

*** EXAMPLE OF DATA ***

```
         1         2         3         4         5         6
12345678901234567890123456789012345678901234567890123456789012345678

0306DP 260170110.71  012.34 2  00  05  05      .653
0306DP 260170110.71  012.34 2  05  10  05      .189
0306DP 260170110.71  012.34 2  10  15  05      .156      .998
0306DP 260170110.71  022.34 2  00  05  05      .707
0306DP 260170110.71  022.34 2  05  10  05      .276
0306DP 260170110.71  022.34 2  10  15  05      .116     1.099
0306DP 260170110.71  032.34 2  00  05  05      .663
0306DP 260170110.71  032.34 2  05  10  05      .444
0306DP 260170110.71  032.34 2  10  15  05      .306     1.413
0306DP 260170110.71  042.34 2  00  05  05      .757
0306DP 260170110.71  042.34 2  05  10  05      .196
0306DP 260170110.71  042.34 2  10  15  05      .153     1.106
0306DP 260170110.71  052.34 2  00  05  05      .586
0306DP 260170110.71  052.34 2  05  10  05      .173
0306DP 260170110.71  052.34 2  10  15  05      .095      .854
0306DP 260170110.71  062.34 2  00  05  05     1.112
0306DP 260170110.71  062.34 2  05  10  05      .234
0306DP 260170110.71  062.34 2  10  15  05      .300     1.646
0306DP 260170110.71  072.34 2  00  05  05      .725
0306DP 260170110.71  072.34 2  05  10  05      .286
0306DP 260170110.71  072.34 2  10  15  05      .167     1.178
0306DP 260170110.71  082.34 2  00  05  05      .420
0306DP 260170110.71  082.34 2  05  10  05      .161
0306DP 260170110.71  082.34 2  10  15  05      .087      .668
0306DP 260170110.71  092.34 2  00  05  05     1.495
0306DP 260170110.71  092.34 2  05  10  05      .166
0306DP 260170110.71  092.34 2  10  15  05      .145     1.806
0306DP 260170110.71  102.34 2  00  05  05      .891
0306DP 260170110.71  102.34 2  05  10  05      .393
0306DP 260170110.71  102.34 2  10  15  05      .070     1.354
```

0306DP	260170510.71	012.54	2	00	05	05	1.311	
0306DP	260170510.71	012.54	2	05	10	05	.212	
0306DP	260170510.71	012.54	2	10	15	05	.220	1.743
0306DP	260170510.71	022.54	2	00	05	05	.521	
0306DP	260170510.71	022.54	2	05	10	05	.498	
0306DP	260170510.71	022.54	2	10	15	05	.368	1.387
0306DP	260170510.71	032.54	2	00	05	05	.898	
0306DP	260170510.71	032.54	2	05	10	05	.512	
0306DP	260170510.71	032.54	2	10	15	05	.337	1.747
0306DP	260170510.71	042.54	2	00	05	05	1.224	
0306DP	260170510.71	042.54	2	05	10	05	.579	
0306DP	260170510.71	042.54	2	10	15	05	.338	2.141
0306DP	260170510.71	052.54	2	00	05	05	1.168	
0306DP	260170510.71	052.54	2	05	10	05	.353	
0306DP	260170510.71	052.54	2	10	15	05	.205	1.726
0306DP	260170510.71	062.54	2	00	05	05	.696	
0306DP	260170510.71	062.54	2	05	10	05	.501	
0306DP	260170510.71	062.54	2	10	15	05	.100	1.297
0306DP	260170510.71	072.54	2	00	05	05	.757	
0306DP	260170510.71	072.54	2	05	10	05	.497	
0306DP	260170510.71	072.54	2	10	15	05	.265	1.519
0306DP	260170510.71	082.54	2	00	05	05	.755	
0306DP	260170510.71	082.54	2	05	10	05	.259	
0306DP	260170510.71	082.54	2	10	15	05	.154	1.168
0306DP	260170510.71	092.54	2	00	05	05	1.101	
0306DP	260170510.71	092.54	2	05	10	05	.511	
0306DP	260170510.71	092.54	2	10	15	05	.202	1.814
0306DP	260170510.71	102.54	2	00	05	05	.831	
0306DP	260170510.71	102.54	2	05	10	05	.405	
0306DP	260170510.71	102.54	2	10	15	05	.213	1.449