Technical Report No. 173

HERBAGE DYNAMICS OF A TALLGRASS PRAIRIE, OSAGE, 1971

Paul G. Risser and Robert K. Kennedy

Botany Department

University of Oklahoma

Norman, Oklahoma

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ABSTRACT

The results contained in this report represent the abiotic and producer data collected during the 1971 growing season on a tallgrass prairie at the Osage Comprehensive Network Site. Precipitation and soil water were higher during 1971 than in 1970, and temperature minima and maxima were not as variable during the second year. Aboveground biomass was greater during 1971. Measured litter values were also greater in 1971, but this is partially due to vacuum techniques of collection used during the current year. Belowground biomass amounts were essentially equivalent for both years. Live aboveground biomass was approximately the same on both treatments, but standing dead was greater on the ungrazed treatment. The amount of accumulated litter was greater on the grazed treatment. Belowground biomass values did not change appreciably during the growing season and were similar under both treatments.

INTRODUCTION

The objectives of this study include the quantitative analysis of various structural and functional characteristics of a tallgrass prairie in northeastern Oklahoma. This particular grassland represents the Osage Site within the Comprehensive Network of the U.S. IBP Grassland Biome. The work reported includes data collected on the abiotic and primary producer components of this grassland ecosystem. During the 1971 growing season, this grassland was studied intensively at several functional levels simultaneously. Systematic, coordinated data collection occurred in the abiotic, producer, invertebrate, bird, mammal, and decomposer components. The invertebrates were studied by Dr. Derrick Blocker of Kansas State University, the birds were studied by Dr. John Wiens of Oregon State University, the mammals were studied by Dr. Bob Hoffmann of Kansas University and Dr. Elmer Birney of the University of Minnesota, and the decomposers were studied by Dr. John Harris from Kansas State University. Data analysis and synthesis across all these functional groups will be presented in a separate technical report.

The information summarized in this report was collected to elucidate the relationship between various parts of the primary producer component so that it may be related to other components on the Osage Site and to other network studies.

DESCRIPTION OF THE OSAGE SITE

The Osage Site is located on the Adams Ranch 19 km north of and 5 km east of Shidler, Oklahoma, in Osage County in the northeast corner of Oklahoma. The ranch (approximately 14,000 ha) is owned by Mr. K. S. Adams and managed by Mr. Dick Whetsell.

The Osage Site is located at an elevation of 375 m on mostly rolling topography. Long-term climatic records are available from the U.S. Weather Bureau Station in Pawhuska, Oklahoma, which is 32 km southeast of the ranch. The average January temperature is 2.7°C, and the average July temperature is 23.7°C. The average annual precipitation is 100 cm with 60 cm occurring during the July to September warm season. The growing season is 205 days.

The soils of the Osage Site are Brunizems of the Labette-Summit-Sogan Association. These are dark colored soils, mostly with clayey subsoils developed on shales, sandstone, and limestones under tallgrass. Specifically, the experimental area is on a labette soil with a dark silty clay A horizon 35 to 45 cm. The B_1 is dark brown 45 to 60 cm; the B_2 is reddish brown 60 to 90 cm; the B_3 is brown silty clay 90 to 120 cm; and most of the bedrock is limestone at 1 to 2 m.

The ungrazed treatment is 5 ha and has existed in an ungrazed condition for at least 20 years, although there has been some mowing for hay. The grazed area is located adjacent to the ungrazed treatment and is normally grazed during the fall and winter. The grazing intensity is light to moderate, and the grass is in good to excellent condition.

METEOROLOGICAL METHODS

A small meteorological station was estabilished on the ungrazed treatment in the spring of 1970. Accumulated precipitation was measured either semi-monthly or monthly in a standard weather bureau rain gage located 76 cm above the soil surface throughout the 1971 season; wind was measured with a totalizing anemometer mounted 153 cm above the soil surface;

and solar radiation was recorded with a pyranometer located at a height of 76 cm. Air temperature and humidity were continuously measured with two recording hygrothermographs, 31 and 153 cm high, respectively. Continuous soil temperature was recorded at depths of 1.0 and 10.0 cm below the soil surface. Soil water was measured gravimetrically from two quadrats per replicate on each sampling date.

During the middle of the 1971 growing season, an attempt was made to establish an automatic data recording system for a series of sensors which have been described in the Grassland Biome Continuation Proposal (Van Dyne, 1970). However, this system did not function properly, so no data are available for this report.

Table 1 presents the meteorological equipment which was in operation during the 1971 field season. These instruments were located on the ungrazed treatment except that soil water was taken both on the ungrazed and grazed treatment.

PRIMARY PRODUCER METHODOLOGY

The sampling of the primary producer component of the grassland was done essentially according to the techniques outlined in Technical Report 85 (French, 1971). Any deviation from this report will be described in the following text.

STATUS OF THE 1971 DATA

The status of the data taken on the Osage Site during the 1971 growing season is presented in tabular form (Appendix I). At the time of this writing, essentially all of the samples have been processed but complete data analysis has not yet been accomplished.

Table 1. Meteorological equipment. With the exception of the soil water which was taken in both treatments, the abiotic factors were measured in the ungrazed plot.

Factor	Equipment	Sensor Location
Precipitation	U.S. Weather Bureau Rain Gage	76 cm above soil surface
Wind	Bendix Corporation Totalizing Anemometer	153 cm above soil surface
Solar radiation	Belfort Instrument Co. Recording Pyranometer	76 cm above soil surface
Maximum and minimum air temperature	Taylor Max-Min Thermometer	153 cm above soil surface
Continuous air temperature	Friez-Bendix Instruments Recording Hygro-thermo-graph	153 and 31 cm above soil surface
Continuous air humidity	Friez-Bendix Instruments Recording Hygro-thermo-graph	153 and 31 cm above soil surface
Continuous soil temperature	Friez-Bendix Instruments Thermograph	25.0 and 2.5 cm below soil surface
Soil water	Gravimetric Technique	Two 5.1 cm diameter cores/replicate on each biomass sampling date at depths of 0 to 15, 15 to 30, and 30 to 45 cm

RESULTS OF ABIOTIC MEASUREMENTS AND SITE CHARACTERIZATION

As can be seen from Table 2, air temperature reached peak values in July and August where the average weekly maxima were approximately 95°F. There was very little difference between measurements at 1.5 and 0.3 m, at least on the basis of semi-monthly averages. Minimum temperatures were somewhat lower at 0.3 m than at 1.5 m, although fluctuation in temperature seemed to be greater at 1.5 m. Soil temperatures were consistently lower than air temperatures (Table 3) in terms of maximum temperature, but the minimum temperature was higher in the soil than in the air. Soil temperatures also peaked during the month of July and were much less variable than the air temperatures.

Average wind speed was higher in the spring than during the middle of the summer. However, since this was a totalizing anemometer, it was difficult to make judgments concerning instantaneous wind speed in any particular season. During the 1971 growing season, most of the precipitation fell in the spring or late fall, with July having the lowest amount of precipitation (5.7 cm). The total amount of rainfall for the year was much above the average of approximately 88.9 cm, but a large proportion of this rainfall occurred after the growing season. Table 4 also presents the amount of solar radiation which reached its maximum in the early summer.

A number of soil samples were collected during this past season for the purpose of more adequately characterizing the Osage Site. For each treatment area six 5-cm diameter cores were collected for soil chemical analysis at 0 to 10 cm, 10 to 20 cm, and 20 to 40 cm depths on 19 August 1971 and 10 October 1971; ten 5-cm diameter cores were collected from

Table 2. Air temperature at 1.5 and 0.3 m for the 1971 season.

Interval Date	1.5 m				0.3 m			
	Max	SD	Min	SD	Max	SD	Min	SD
March 31	74.1	7.8	46.9	7.5	72.5	17.3	45.8	9.5
May 12	79.0	5.7	55.3	9.6	80.3	5.5	53.1	10.7
June 2	85.8	3.5	69.3	3.4	84.0	5.2	66.9	3.0
June 18	86.6	14.6	70.8	12.6	91.3	7.3	68.5	2.4
July 10	95.4	4.5	72.3	6.5	95.0	1.7	70.0	3.5
July 24	86.5	11.6	65.5	19.4	87.0	17.0	62.7	5.4
August 19	93.1	4.9	75.0	10.5	93.0	5.2	66.3	2.0
September 19	79.0	9.5	61.6	10.5	79.6	9.1	59.7	12.3
October 10	78.6	4.1	60.3	6.5	79.1	3.9	56.3	7.6
November 6								

Table 3. Soil temperature at 25.0 and 2.5 cm for the 1971 season.

Interval Date	25.0 cm				2.5 cm			
	Max	SD	Min	SD	Max	SD	Min	SD
March 31	52.3	2.1	51.3	2.7	59.0	3.2	51.0	3.5
May 12	61.0	1.4	59.0	1.8	65.0	2.9	57.0	4.3
June 2	68.0	1.7	67.0	1.5	73.0	1.4	68.0	1.9
June 18	72.0	0.6	71.0	0.6	77.0	3.2	71.0	4.7
July 10	75.0	0.6	74.0	0.8	79.0	1.6	73.0	1.0
July 24	71.0	2.1	69.5	1.9	73.0	4.0	70.0	3.6
August 19	73.7	0.9	72.8	0.7	77.3	2.4	67.5	1.1
September 19	62.5	1.0	61.2	5.6	62.6	4.7	57.7	5.0
October 10	62.0	1.3	60.0	1.3	62.7	3.3	58.7	4.4
November 6								

Table 4. Average wind speed, interval and accumulated precipitation, and solar radiation for the 1971 season.

Interval Date	Wind (1.5 m)	Precipitation (cm)		Solar Radiation (cal cm^{-2} m^{-1})
	$\bar{x}$ miles/hr	Interval	Accumulation	$\bar{x}$ max
March 31	8.5	5.3	5.3	1.26
May 12	6.2	5.4	10.7	1.30
June 2	6.0	9.2	19.9	1.31
June 18	5.7	6.7	26.6	1.33
July 10	5.4	0.8	27.4	1.30
July 24	4.2	4.9	32.3	1.22
August 19	a/	4.7	37.0	1.30
September 19	a/	13.9	50.9	1.16
October 10	a/	9.2	60.1	1.06
November 6				

a/ Instrument failure.

each treatment for soil characterization at 0 to 10 cm, 10 to 20 cm, 20 to 40 cm, 40 to 60 cm, and 60 to 100 cm depths on 19 August 1971; and four 5-cm diameter cores were collected for soil water from each treatment at 0 to 15 cm, 15 to 30 cm, and 30 to 45 cm for each sampling date (31 March, 12 May, 2 June, 18 June, 10 July, 24 July, 19 August, 19 September, 10 October, and 6 November).

PRIMARY PRODUCER COMPONENTS

During the 1971 growing season a double sampling technique was attempted in order to obtain better estimates of the individual species. This technique involved clipping some quadrats and estimating the weight of the species components in these quadrats and an additional set of quadrats. The number of clipped and estimated quadrats for aboveground biomass at each sample date is shown in Table 5.

During the first two sample periods litter was collected from these same quadrats by hand. However, beginning with the June sample, the litter was collected with a vacuum cleaner (D-vac). The number of quadrats sampled for litter can be found in Table 6.

The inclusion of the estimation technique reduced the variation for some components on both the grazed and ungrazed treatment (Table 7). With the clip-estimate technique on the ungrazed treatment, the variation for the live material was always under the specified limit ($SD - 0.2\bar{X}$, $P > 0.8$); the old dead was adequately sampled on all but two dates, and the recent dead was adequately sampled on all but one date. Similar results were found on the grazed treatment with the exception that the recent dead was always sampled adequately, whereas the old dead was only adequately

Table 5. Sample dates and number of clipped and estimated quadrats per treatment on each sample date for the 1971 season.

Sample Date	Ungrazed		Grazed	
	Clipped	Estimated	Clipped	Estimated
March 31	6	16	6	16
May 12	6	46	10	70
June 2	6	55	10	99
June 18	6	40	10	60
July 10	6	40	10	60
July 24	6	36	10	60
August 19	6	32	10	50
September 19	6	34	10	50
October 10	6	24	10	40
November 6	6	26	10	30

Table 6. Sample dates and number of quadrats per treatment from which litter material was collected for the 1971 season.

Sample Date	Ungrazed	Moderately Grazed
March 31	6	6
May 12	6	10
June 2	6	10
June 18	6	10
July 10	6	10
July 24	6	10
August 19	6	10
September 19	6	10
October 10	6	10
November 6	6	10

Table 7. Comparison of clip and clip-estimate techniques on ungrazed and grazed aboveground biomass (g/m^2) for the 1971 season.

Sample Date	Clip Live	SD	Clip Live	SD	Clip Old Dead	SD	Clip Old Dead	SD	Clip Recent Dead	SD	Clip Recent Dead	SD
					Ungrazed							
March 31	no data	no data	no data	no data	445.42	107.2[a]	396.55	43.3[a]	no data	no data	no data	no data
May 12	24.60	8.4	7.04	2.9[a]	513.38	102.2[a]	549.78	44.8[a]	no data	no data	no data	no data
June 2	119.83	10.8[a]	123.43	4.5[a]	584.04	79.3[a]	595.09	30.7[a]	no data	no data	no data	no data
June 18	220.07	45.7	206.55	13.2[a]	462.49	87.0[a]	385.82	33.6[a]	no data	no data	no data	no data
July 10	335.63	96.5	381.03	24.3[a]	455.99	63.4[a]	455.63	36.6[a]	no data	no data	no data	no data
July 24	284.74	46.3[a]	255.69	11.4[a]	329.84	85.7	258.70	36.4[a]	86.67	57.6	348.80	25.8[a]
August 19	246.56	40.8[a]	255.67	17.3[a]	175.90	83.6	104.56	29.8	279.44	101.1	186.86	55.6
September 19	281.76	39.5[a]	337.56	19.0[a]	187.42	106.7	154.69	44.0	468.11	120.0	240.22	46.0[a]
October 10	189.42	40.4	180.89	18.6[a]	248.33	99.9	256.21	41.8[a]	374.36	103.5	333.55	55.2[a]
November 6	20.25	8.9	21.82	4.0	308.48	71.1	331.26	27.9	363.04	89.5	320.32	29.3
					Grazed							
March 31	no data	no data	no data	no data	196.85	70.3	132.44	32.5	no data	no data	no data	no data
May 12	83.26	15.3[a]	82.65	7.8[a]	96.61	36.2	126.66	15.9[a]	no data	no data	no data	no data
June 2	203.76	24.2[a]	200.04	12.8[a]	115.63	61.9	86.06	24.1	no data	no data	no data	no data
June 18	243.78	56.1	234.48	22.0[a]	141.87	55.9	130.05	21.3[a]	no data	no data	no data	no data
July 10	278.00	29.1[a]	278.00	29.1[a]	152.81	35.3	152.81	35.3	no data	no data	no data	no data
July 24	298.98	51.5[a]	270.39	23.6[a]	89.53	64.5	94.48	26.8	98.19	32.9	96.84	15.6[a]
August 19	254.21	29.6[a]	254.20	14.9[a]	55.86	27.1	63.35	12.6[a]	160.27	54.7	153.84	21.8[a]
September 19	272.25	57.8	260.03	29.6[a]	98.31	71.1	134.29	31.0	200.97	63.2	272.3	20.2[a]
October 10	279.71	104.9	287.85	43.2[a]	70.11	43.6[a]	62.86	15.8	207.96	87.4	200.85	37.4[a]
November 6	57.08	42.8	68.86	16.7	88.88	77.5	79.55	35.7	323.31	67.7	340.21	25.4

[a] SD < $.2\bar{x}$.

sampled three times. These data make it reasonably clear that the clipped estimate is of some value in reducing the variation for the total biomass in each of these components.

The maximum aboveground biomass obtained during the 1971 growing season was 863 g/m^2 during the 10 July to 24 July interval. The maximum value obtained in the aboveground biomass in the grazed treatment was between 19 August and 19 September when the material totaled 666 g/m^2. Peak live vegetation was 381 g on the ungrazed treatment and 287 g on the grazed treatment; both old standing dead and recent standing dead demonstrated higher values on the ungrazed treatment (Table 8). The same relationships are shown graphically in Fig. 1 through 4.

The biomass of the major species on both grazed and ungrazed treatments is shown in Tables 9 through 16. Little bluestem, *Andropogon scoparius*, is the dominant species on this grassland and reached its maximum live biomass of 252 g/m^2 in September. At the end of the growing season this species contributed 748 g/m^2 of the biomass on the ungrazed treatment. The biomass in the grazed treatment was much more variable, ranging from 93 g/m^2 to 620 g/m^2. On the basis of biomass, little bluestem averaged 85% composition on the ungrazed treatment and 47% composition on the grazed treatment.

The amount of litter present on the sampled quadrats is quite variable from sample period to sample period (Table 17). Collections were made by hand on the first two sample dates, and all subsequent ones were done with the D-vac. However, even though a fairly large sample was taken, i.e., a sample equal in biomass to the aboveground biomass compartments, the variability was still very large at any one sample date and between sample

Table 8. Clip-estimate of aboveground biomass (g/m^2) on the ungrazed and grazed treatment for the 1971 season.

Sample Date	Live	SD	Old Dead	SD	Recent Dead	SD	Total
			Ungrazed				
March 31	--	--	396.55	43.3	--	--	396.55
May 12	7.04	2.9	549.78	44.8	--	--	556.82
June 2	123.43	4.5	595.09	30.7	--	--	718.52
June 18	206.55	13.2	385.82	33.6	--	--	592.37
July 10	381.03	24.3	455.63	36.6	--	--	836.66
July 24	255.69	11.4	258.70	36.4	348.80	25.8	863.19
August 19	255.67	17.3	104.56	29.8	186.86	55.6	547.09
September 19	337.56	19.0	154.69	44.0	240.22	46.0	732.47
October 10	180.89	18.6	256.21	41.8	333.55	55.2	770.65
November 6	21.82	4.0	331.26	27.9	320.32	29.3	673.40
			Grazed				
March 31	--	--	132.44	32.5	--	--	132.44
May 12	82.65	7.8	126.66	15.9	--	--	209.31
June 2	200.04	12.8	86.06	24.1	--	--	286.10
June 18	234.48	22.0	130.05	21.3	--	--	364.53
July 10	278.00	29.1	152.81	35.3	--	--	430.81
July 24	270.39	23.6	94.48	26.8	96.84	15.6	461.71
August 19	254.20	14.9	63.35	12.6	153.84	21.8	471.39
September 19	260.03	29.6	134.29	31.0	272.13	20.2	666.45
October 10	287.85	43.2	62.86	15.8	200.85	37.4	551.56
November 6	68.86	16.7	79.55	35.7	340.21	25.4	488.62

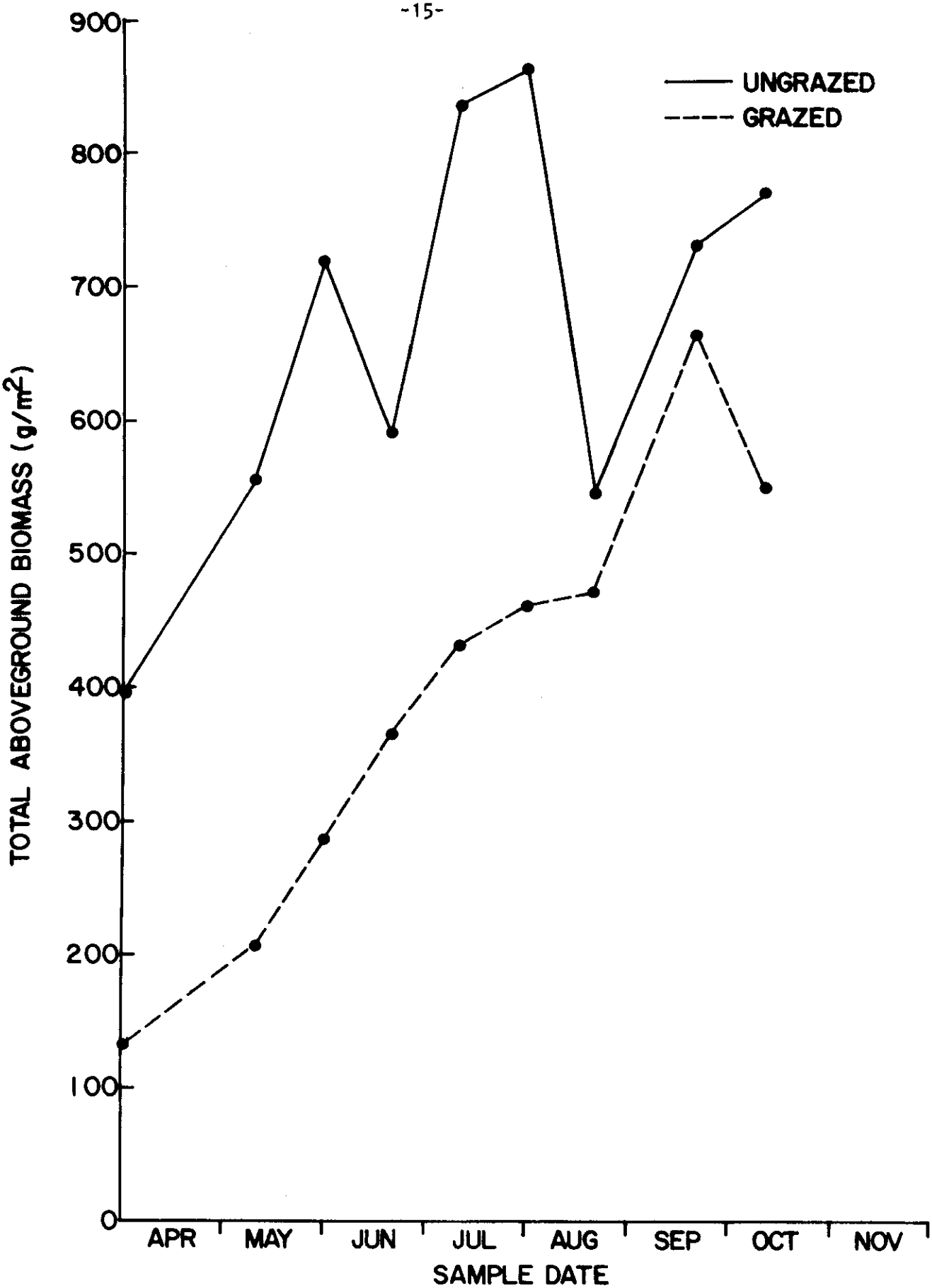

Fig. 1. Total aboveground biomass through season on grazed and ungrazed treatments.

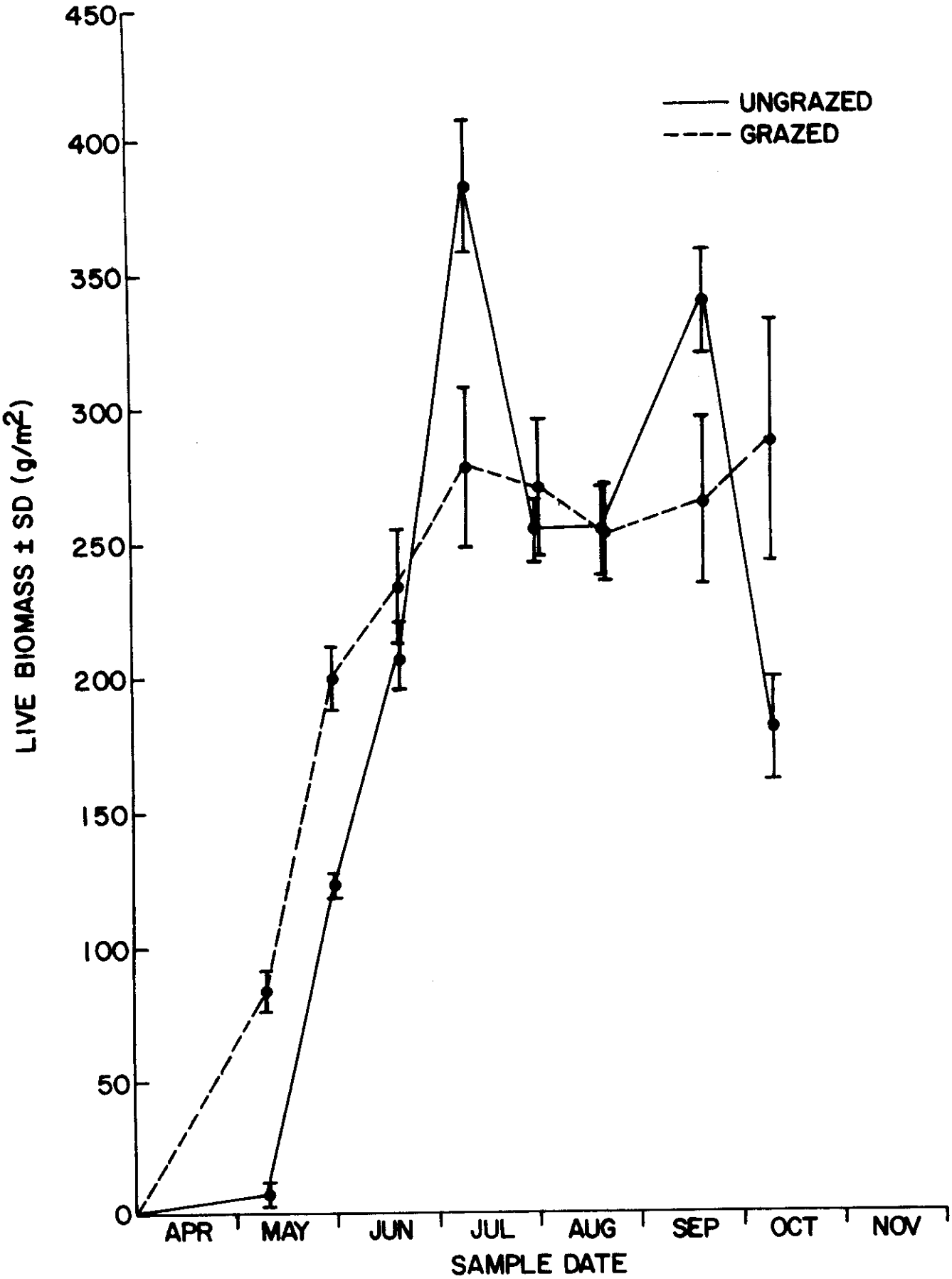

Fig. 2. Total live biomass through season on grazed and ungrazed treatments.

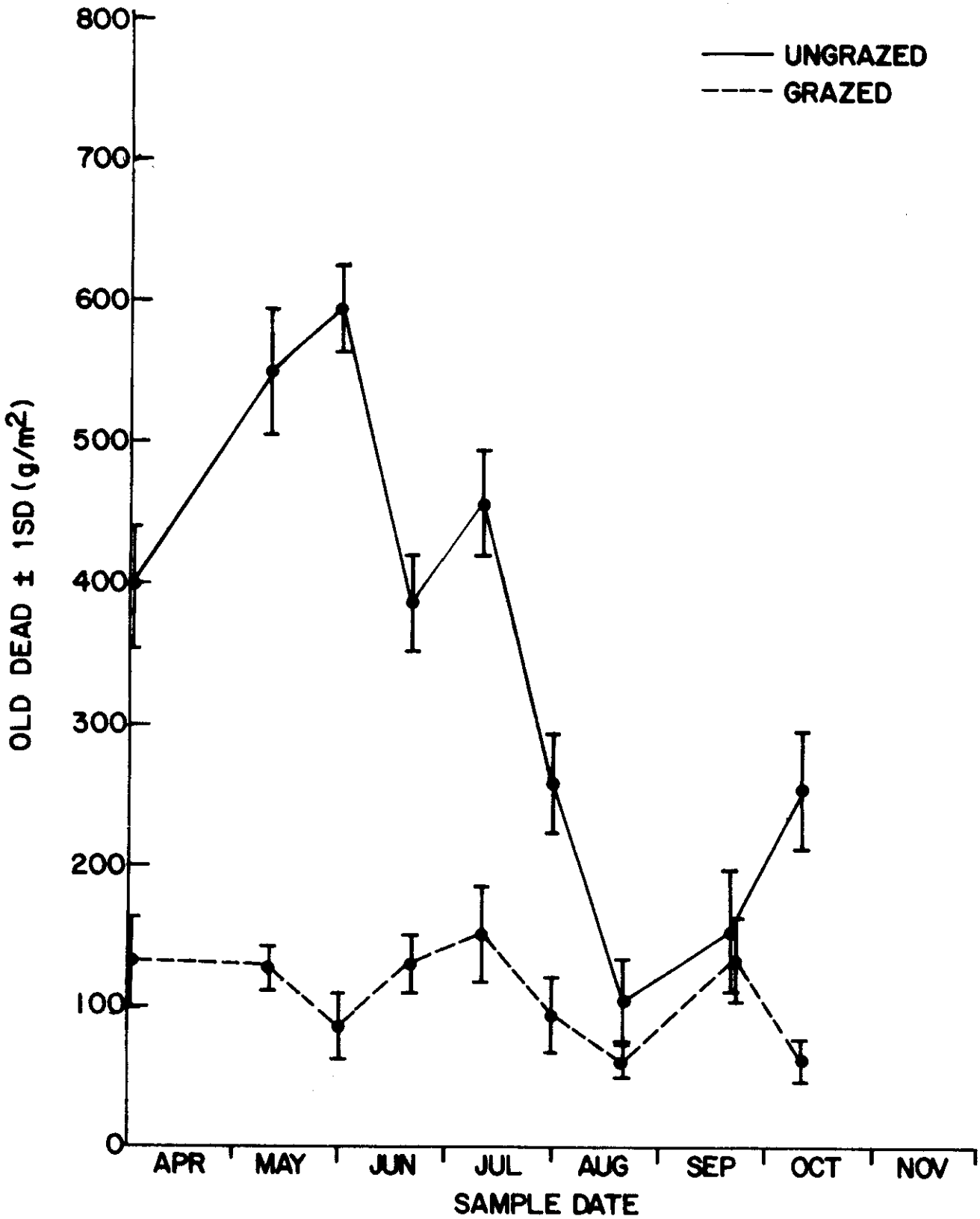

Fig. 3. Total old dead biomass through season on grazed and ungrazed treatments.

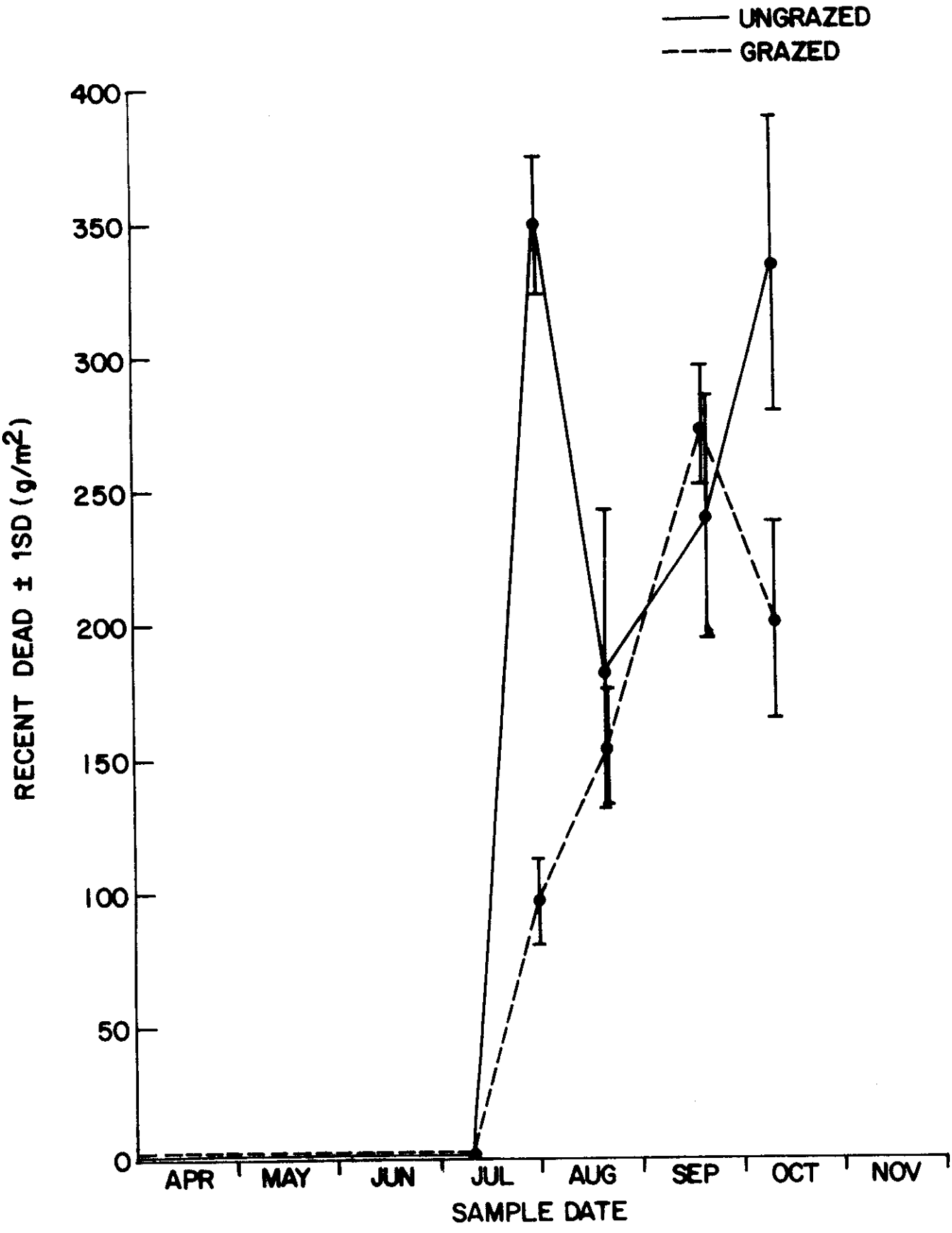

Fig. 4. Total recent dead biomass through season on grazed and ungrazed treatments.

Table 9. *Andropogon scoparius* biomass (g/m^2) for the 1971 season on the ungrazed and grazed treatment.

Sample Date	Live	SD	Old Dead	SD	Recent Dead	SD	Total	Composition (%)
				Ungrazed				
March 31	--	--	357.30	62.8	--	--	357.30	91.8
May 12	26.74	1.7	499.70	26.0	--	--	526.44	93.1
June 2	53.68	9.9	444.13	52.3	--	--	497.81	86.2
June 18	133.76	16.2	331.20	61.5	--	--	464.96	77.7
July 10	216.44	22.7	329.31	44.3	--	--	545.75	84.8
July 24	211.07	20.0	423.44	22.7	87.34	33.9	721.85	92.1
August 19	166.07	16.8	69.49	31.4	401.10	33.4	636.66	88.8
September 19	252.88	20.0	138.85	70.3	331.13	71.7	722.86	72.9
October 10	111.10	15.5	229.13	52.2	407.73	32.3	747.96	82.5
November 6	7.99	0.6	312.98	16.3	174.61	41.6	495.58	77.1
				Grazed				
March 31	--	--	130.53	27.0	--	--	130.53	61.5
May 12	3.51	3.9	11.32	3.8	--	--	14.83	16.6
June 2	45.67	10.8	32.47	12.9	--	--	78.14	47.6
June 18	92.36	33.7	31.73	26.8	--	--	124.09	51.4
July 10	148.64	30.6	56.50	11.3	--	--	205.14	60.3
July 24	125.23	20.8	62.01	21.0	50.09	13.5	237.33	62.8
August 19	44.49	10.9	21.21	5.9	27.40	6.2	93.10	25.0
September 19	86.18	23.1	405.59	20.1	129.71	19.6	621.48	52.2
October 10	45.36	15.3	44.86	14.2	122.00	32.9	212.22	49.0
November 6	2.95	1.3	52.13	29.1	113.03	33.2	168.11	53.4

Table 10. *Andropogon gerardi* biomass (g/m^2) for the 1971 season on the ungrazed and grazed treatment.

Sample Date	Live	SD	Old Dead	SD	Recent Dead	SD	Total	Composition (%)
				Ungrazed				
March 31	--	--	2.03	--	--	--	2.03	0.4
May 12	--	--	--	--	--	--	--	0
June 2	--	--	--	--	--	--	--	0
June 18	--	--	--	--	--	--	--	0
July 10	--	--	--	--	--	--	--	0
July 24	1.67	--	2.50	--	0.56	--	4.73	0.5
August 19	12.12	0.5	4.38	--	4.31	0.9	20.81	2.8
September 19	54.43	23.1	32.42	6.0	72.17	71.0	159.02	16.7
October 10	16.71	13.3	14.39	14.5	26.88	13.7	57.98	6.2
November 6	1.49	0.8	6.39	6.4	63.45	13.2	71.33	9.6
				Grazed				
March 31	--	--	1.25	--	--	--	1.25	3.7
May 12	0.29	--	0.29	--	--	--	0.58	0.8
June 2	--	--	--	--	--	--	--	0
June 18	--	--	--	--	--	--	--	0
July 10	0.28	--	--	--	--	--	0.28	0.1
July 24	--	--	--	--	--	--	--	0
August 19	48.74	19.8	9.20	8.0	44.76	19.6	102.70	27.7
September 19	32.50	13.4	39.17	4.3	16.39	7.3	88.06	15.4
October 10	9.60	10.9	4.41	4.6	4.33	4.6	18.34	4.7
November 6	4.33	5.9	3.74	2.4	7.84	6.5	15.91	5.1

Table 11. *Panicum virgatum* biomass (g/m^2) for the 1971 season on the ungrazed and grazed treatment.

Sample Date	Live	SD	Old Dead	SD	Recent Dead	SD	Total	Composition (%)
				Ungrazed				
March 31	--	--	7.26	2.5	--	--	7.26	1.8
May 12	1.89	0.1	12.63	4.7	--	--	14.52	2.7
June 2	1.76	2.6	7.83	5.8	--	--	9.59	1.5
June 18	16.17	8.0	6.04	4.2	--	--	22.21	3.7
July 10	7.49	5.1	3.62	1.7	--	--	11.11	1.7
July 24	2.80	6.5	2.10	1.7	0.42	0.8	5.32	0.7
August 19	6.11	5.4	1.76	0.4	2.63	0.5	10.50	1.5
September 19	8.52	1.7	4.06	--	4.75	0.8	17.33	1.8
October 10	12.56	4.5	3.88	1.5	12.14	2.3	28.58	3.3
November 6	3.66	1.3	4.10	4.1	16.98	11.2	24.74	3.9
				Grazed				
March 31	--	--	14.42	6.0	--	--	14.42	14.1
May 12	0.83	0.3	15.13	4.4	--	--	15.96	20.5
June 2	16.90	8.4	15.00	8.9	--	--	31.90	20.3
June 18	23.08	9.7	7.67	4.0	--	--	30.75	12.8
July 10	47.63	30.4	19.35	14.8	--	--	66.98	20.6
July 24	30.06	17.7	9.30	7.2	0.20	--	39.56	10.5
August 19	40.13	9.0	6.33	2.5	0.83	0.4	47.29	12.4
September 19	41.92	23.9	9.80	4.2	6.05	3.9	57.77	10.1
October 10	27.15	11.6	0.96	0.8	3.22	1.2	31.33	8.0
November 6	4.05	2.5	7.06	6.8	17.24	22.1	28.35	9.0

Table 12. *Sporobolus asper* biomass (g/m^2) for the 1971 season on the ungrazed and grazed treatment.

Sample Date	Live	SD	Old Dead	SD	Recent Dead	SD	Total	Composition (%)
				Ungrazed				
March 31	--	--	1.02	0.7	--	--	1.02	0.2
May 12	0.43	--	1.30	--	--	--	1.73	0.3
June 2	0.93	--	0.94	--	--	--	1.87	0.3
June 18	21.46	6.0	11.86	1.2	--	--	33.32	5.6
July 10	12.99	9.1	8.64	3.7	--	--	21.63	3.0
July 24	9.68	2.7	0.44	--	4.44	--	14.56	1.7
August 19	9.42	1.6	1.36	0.6	1.94	0.5	12.72	1.8
September 19	21.08	11.9	2.55	0.8	15.37	4.6	39.00	4.2
October 10	18.61	2.6	6.13	4.9	4.09	1.6	28.83	3.1
November 6	--	--	8.28	5.2	15.68	4.3	23.96	3.6
				Grazed				
March 31	--	--	25.00	7.5	--	--	25.00	15.4
May 12	10.97	2.3	13.80	1.3	--	--	23.77	30.1
June 2	20.09	8.8	12.33	5.3	--	--	33.42	19.2
June 18	50.23	11.4	12.03	7.8	--	--	62.26	25.5
July 10	39.29	14.5	6.32	3.4	--	--	45.61	14.4
July 24	70.93	19.8	3.46	2.5	1.45	3.0	75.30	20.0
August 19	78.36	14.3	15.89	5.7	10.84	3.8	105.09	27.1
September 19	60.40	11.6	20.45	13.2	19.52	13.1	100.37	15.9
October 10	68.66	12.0	9.33	2.2	15.01	3.9	93.00	23.0
November 6	12.36	5.3	5.13	3.5	57.15	23.2	74.64	23.6

Table 13. *Sorghasthrum nutrans* biomass (g/m^2) for the 1971 season on the ungrazed and grazed treatment.

Sample Date	Live	SD	Old Dead	SD	Recent Dead	SD	Total	Composition (%)
				Ungrazed				
March 31	--	--	24.41	16.5	--	--	24.41	7.4
May 12	4.78	--	15.51	10.7	--	--	20.29	3.4
June 2	20.89	2.4	44.60	16.1	--	--	65.49	10.7
June 18	15.03	5.5	13.01	8.0	--	--	28.04	4.8
July 10	15.57	9.3	19.19	10.7	--	--	34.76	5.1
July 24	14.12	2.2	2.83	--	3.16	1.9	20.11	2.9
August 19	23.10	12.6	2.10	2.4	11.32	16.8	36.52	5.4
September 19	23.79	3.6	6.53	--	11.35	0.6	41.67	4.1
October 10	22.66	10.6	2.58	2.0	17.67	6.9	42.91	4.8
November 6	--	--	3.55	10.8	25.65	21.2	29.20	5.4
				Grazed				
March 31	--	--	0.69	--	--	--	0.69	0.6
May 12	6.35	1.6	15.62	--	--	--	21.95	27.2
June 2	8.73	6.5	7.38	5.9	--	--	16.11	9.7
June 18	13.45	5.1	1.78	0.8	--	--	15.23	6.4
July 10	8.21	6.9	1.51	4.5	--	--	9.72	2.9
July 24	15.33	4.4	5.27	--	2.62	0.6	23.22	6.1
August 19	11.72	10.5	1.39	0.5	2.48	3.0	15.59	4.2
September 19	10.20	6.4	2.24	--	3.38	3.0	15.82	3.1
October 10	31.67	10.6	5.53	5.6	16.52	12.1	53.82	12.8
November 6	0.40	--	2.92	0.3	13.24	14.3	16.56	5.3

Table 14. Miscellaneous forb biomass (g/m^2) for the 1971 season on the ungrazed and grazed treatment.

Sample Date	Live	SD	Old Dead	SD	Recent Dead	SD	Total	Composition (%)
				Ungrazed				
March 31	--	--	3.33	0.9	--	--	3.33	0.8
May 12	1.46	1.6	1.75	1.4	--	--	3.21	0.6
June 2	2.61	1.0	4.35	--	--	--	6.96	1.3
June 18	45.92	15.6	1.40	--	--	--	47.32	7.9
July 10	34.95	12.8	5.18	0.8	--	--	40.13	5.4
July 24	8.79	5.2	2.31	0.7	2.17	--	13.27	1.8
August 19	6.01	4.4	0.25	--	2.71	2.0	8.97	1.3
September 19	0.65	0.2	0.47	--	--	--	1.12	0.1
October 10	0.64	1.1	0.36	1.0	--	--	1.00	0.1
November 6	0.92	--	4.02	1.18	0.54	--	5.48	0.8
				Grazed				
March 31	--	--	1.73	0.50	--	--	1.73	4.3
May 12	2.52	0.8	1.63	--	--	--	4.15	4.8
June 2	4.73	1.0	0.73	--	--	--	5.46	3.2
June 18	9.52	4.5	0.20	--	--	--	9.72	3.9
July 10	5.34	1.1	0.27	--	--	--	5.61	1.8
July 24	1.93	2.1	0.14	--	0.51	--	2.58	0.7
August 19	9.41	3.8	--	--	3.31	1.9	12.72	3.5
September 19	13.78	2.5	2.58	2.5	0.80	0.6	17.16	3.3
October 10	8.89	3.8	--	--	1.44	0.6	10.33	2.5
November 6	2.96	1.4	6.29	4.4	2.74	1.1	11.99	3.8

Table 15. Miscellaneous grasses (clipped only) biomass (g/m^2) for the 1971 season on the ungrazed and grazed treatment.

Sample Date	Live	SD	Old Dead	SD	Recent Dead	SD	Total	Composition (%)
				Ungrazed				
March 31	--	--	16.62	22.1	--	--	16.62	3.9
May 12	8.52	5.3	8.46	3.4	--	--	16.98	3.2
June 2	40.38	14.3	68.78	56.3	--	--	109.16	15.7
June 18	19.92	18.4	88.49	83.5	--	--	108.41	15.9
July 10	24.33	11.6	21.44	23.4	--	--	45.77	5.8
July 24	21.51	18.1	4.59	3.4	0.94	2.2	27.04	3.8
August 19	12.50	8.8	1.75	4.3	4.50	9.0	18.75	2.7
September 19	13.40	12.5	0.30	0.7	6.40	10.1	20.10	2.2
October 10	17.78	9.3	2.03	3.1	3.38	7.2	23.19	2.9
November 6	9.04	9.4	--	--	11.04	7.5	20.08	3.4
				Grazed				
March 31	--	--	57.79	20.8	--	--	57.79	30.2
May 12	65.66	14.8	60.47	22.9	--	--	126.13	70.3
June 2	89.01	28.5	22.82	12.6	--	--	111.83	35.2
June 18	48.04	56.7	78.40	44.7	--	--	126.44	32.8
July 10	21.34	18.1	61.03	34.3	--	--	82.37	16.9
July 24	21.30	17.9	4.72	5.8	36.11	21.2	62.13	12.8
August 19	29.12	48.1	3.00	9.5	61.13	30.9	93.25	19.3
September 19	34.84	81.9	0.48	1.5	47.86	23.7	83.18	14.1
October 10	76.81	129.9	5.78	14.8	65.52	68.6	148.11	25.8
November 6	30.91	42.3	0.30	0.9	91.33	49.8	122.54	24.1

Table 16. *Amorpha canescens* biomass (g/m^2) for the 1971 season on the ungrazed treatment.

Sample Date	Live	SD	Old Dead	SD	Recent Dead	SD	Total	Composition (%)
March 31	--	--	--	--	--	--	--	0
May 12	--	--	--	--	--	--	--	0
June 2	--	--	--	--	--	--	--	0
June 18	2.25	--	--	--	--	--	2.25	0.4
July 10	--	--	--	--	--	--	--	0
July 24	--	--	--	--	--	--	--	0
August 19	--	--	--	--	--	--	--	0
September 19	1.18	--	--	--	--	--	1.18	0.1
October 10	--	--	--	--	--	--	--	0
November 6	--	--	--	--	--	--	--	0

Table 17. Litter biomass (g/m^2) by sample date and associated standard deviation for the 1971 season.

Sample Date	Ungrazed		Grazed	
	Litter	SD	Litter	SD
March 31	200.93	20.89	179.70	114.39
May 12	172.06	19.24	156.21	54.95
June 2	246.06	102.71	687.85	249.07
June 18	324.65	197.34	549.28	290.15
July 10	284.27	172.87	445.10	248.48
July 24	283.39	152.57	309.76	89.57
August 19	297.82	143.82	220.83	494.10
September 19	233.25	133.58	391.62	106.87
October 10	274.11	150.79	533.06	278.06
November 6	316.06	18.35	499.01	245.23

dates. This may relate in part to the effect of the clumped distribution of grasses which assures that litter distribution will be very heterogeneous. Also, the litter found on the grazed treatment was in greater quantities than that found on the ungrazed treatment. This was due to the trampling effect of cattle on the grazed treatment, i.e., the litter was trampled and packed near the soil surface, retarding the rate of decomposition. A comparison of the litter biomass on grazed and ungrazed treatments is shown in Fig. 5.

The rate of transfer of biomass from the standing dead compartment to the litter compartment was estimated in the field from a series of litter screens which were attached to the soil surface. Thirty-six screens were collected on the ungrazed treatment for each sample date. As can be seen from Table 18, the maximum weight of litter accumulation occurred during the month of June, when more than 1 g/m^2/day was transferred from the standing dead compartment to the litter compartment.

The rate of litter decay was measured by a series of screen wire litter bags (Table 19). From the data available there apparently is no significantly different rate of decomposition between the four major species (Table 20).

On each sample date, a portion of the litter was sent to the Central Laboratory for composition analysis. The reference samples obtained for this purpose are listed in Table 21. In addition, a number of samples from both aboveground biomass and litter were submitted for caloric, ash, phosphorus, and nitrogen analysis (Table 22).

Belowground biomass for each treatment was sampled on 31 March, 18 June, 19 August, and 12 October during 1971. It was our procedural decision to

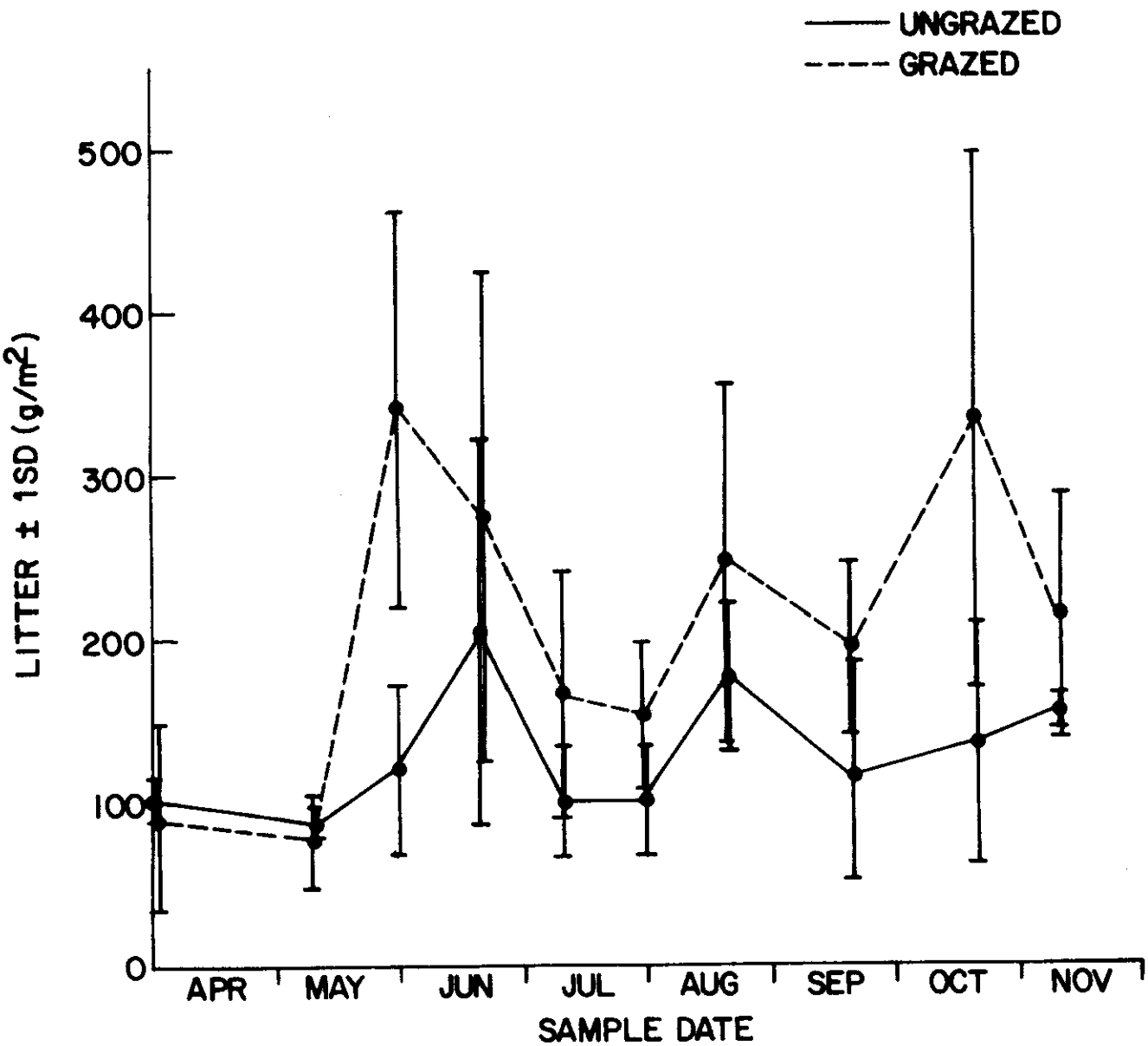

Fig. 5. Amount of litter on grazed and ungrazed treatments.

Table 18. Litter accumulation (g/m^2) on screens and accumulation rate for the 1971 season.

Sample Date	Accumulative Days	$\bar{X}$ Accumulation (g/m^2)	Accumulation Rate (g/m^2/day)
March 31	137	54.64	0.399
May 12	42		
June 2	21	26.19	1.247
July 24	52	53.16	0.388
August 19	26	26.41	0.193
September 19	31	13.94	0.102
November 6	48	24.49	0.51

Table 19. Number of litter bags collected from the ungrazed treatment.

Sample Date	No. Litter Bags Collected				
	Litter	ANSC2	ANGE	PAVI2	SONU2
March 31, 1971	20	1	1	1	2

Table 20. Mean decomposition rate for litter over a 308-day interval ($g/m^2/day$).

Species	No. Litter Bags	$\bar{\chi}$ Decomposition Rate	SD	Decomposition 308 Days (%)	SD
Litter	10	0.198	0.03	28.2	2.0
ANSC2	1	0.208	--	21.6	--
ANGE	1	0.247	--	28.0	--
PAVI2	1	0.215	--	20.0	--
SONU2	2	0.191	0.04	22.3	1.9

Table 21. Sample dates from which litter samples were submitted for species composition analysis and list of species submitted as reference material for the 1971 season.

Sample Dates	List of Reference Species
Litter	
May 12	*Andropogon scoparius*
	Andropogon gerardi
	Bouteloua curtipendula
June 18	*Panicum virgatum*
July 10	*Sorghastrum nutans*
July 24	*Sporobolus asper*
August 19	Sedge (*Carex* sp.)
September 19	
October 10	*Amorpha canescens*
	Aster ericoides
November 6	*Baptisia leucophaea*
Litter Screen	
November 6	*Psoralia tenuiflora*
	Rumex crispis

Table 22. Number of aboveground biomass and litter samples submitted for caloric, ash, phosphorus, and nitrogen analysis from each treatment for the 1971 season.

Sample Date	Ungrazed		Grazed	
	Aboveground Biomass[a]	Litter	Aboveground Biomass[a]	Litter
March 31	24[b]	2	--[b]	2
May 12	18	2	20	2
June 2	23	2	22	2
June 18	23	2	23	2
July 10	22	2	23	2
July 24	30	2	35	2
August 19	30	2	38	2
September 19	27	2	29	2
October 10	29	2	35	2
November 6	15	2	23	2

[a] Includes individual samples from all categories except litter, i.e., live, old dead, and recent dead.

[b] Composited over both treatments.

sample fewer dates this year but to collect a larger sample at each sampling period, in the hope of getting a better estimate. Twenty-four 5-cm diameter cores were collected at 0 to 5 cm, 5 to 10 cm, 10 to 20 cm, and 20 to 50 cm depths. However, as can be seen from Table 23, the standard deviation was still relatively large in terms of the total biomass. Each quadrat was sampled with five, 2-inch cores, and these five cores were pooled for each quadrat. On both treatments, the biomass was greatest in the earliest part of the season and decreased gradually thereafter. As can be seen from Fig. 6, there was essentially no difference between the two grazing treatments.

For each treatment ten 5-cm diameter, 20-cm deep cores were collected on 19 August 1971 and 10 October 1971 for root chemical analysis and on 19 August 1971 for root ash analyses; six soil samples were collected on 19 September 1971 for nitrogen-fixation analysis. As of this date no laboratory analyses have been returned to the Osage Site.

The soil water was somewhat higher in 1970 during the initial part of the growing season than it was during 1971; however, during most of the growing season, the soil water was higher during the 1971 season, especially in the ungrazed treatment (Table 24 and Fig. 7 and 8). Probably as a partial consequence, the total standing crop was higher in 1971 on both the grazed and ungrazed treatment (Table 25 and Fig. 9, 10, and 11). Although the live component was greater on the ungrazed treatment in 1971, there was not a particularly large difference on the ungrazed treatment (Fig. 12 and 13). The old standing dead was much higher on the ungrazed treatment and during the first part of the growing season was considerably higher in 1971 than in 1970 (Fig. 13 and 14). Recent standing dead showed a similar pattern in both 1970 and 1971, although at the time

Table 23. Belowground biomass (g/m^2) from ungrazed and grazed treatment for the 1971 season.

Sample Date	Depth Increment (cm)							
	0-5	5-10	10-20	20-50	Total	SD	Crown	SD
				Ungrazed				
March 31	559.71	176.86	214.64	356.72	1307.93	696.58	123.04	83.34
June 18	403.25	91.69	118.90	98.51	712.19	206.04	41.65	15.19
August 19	339.47	70.88	103.93	214.09	728.63	366.65	97.76	68.06
October 10	269.74	108.41	133.26	111.25	622.66	262.31	43.94	51.90
				Grazed				
March 31	459.02	115.66	208.26	403.68	1186.62	502.65	73.44	58.39
June 18	368.37	162.64	182.73	92.90	806.64	162.10	191.55	118.59
August 19	413.36	70.31	45.31	155.56	684.53	338.81	55.86	30.24
October 10	340.45	77.74	80.84	122.76	625.79	196.96	49.98	44.73

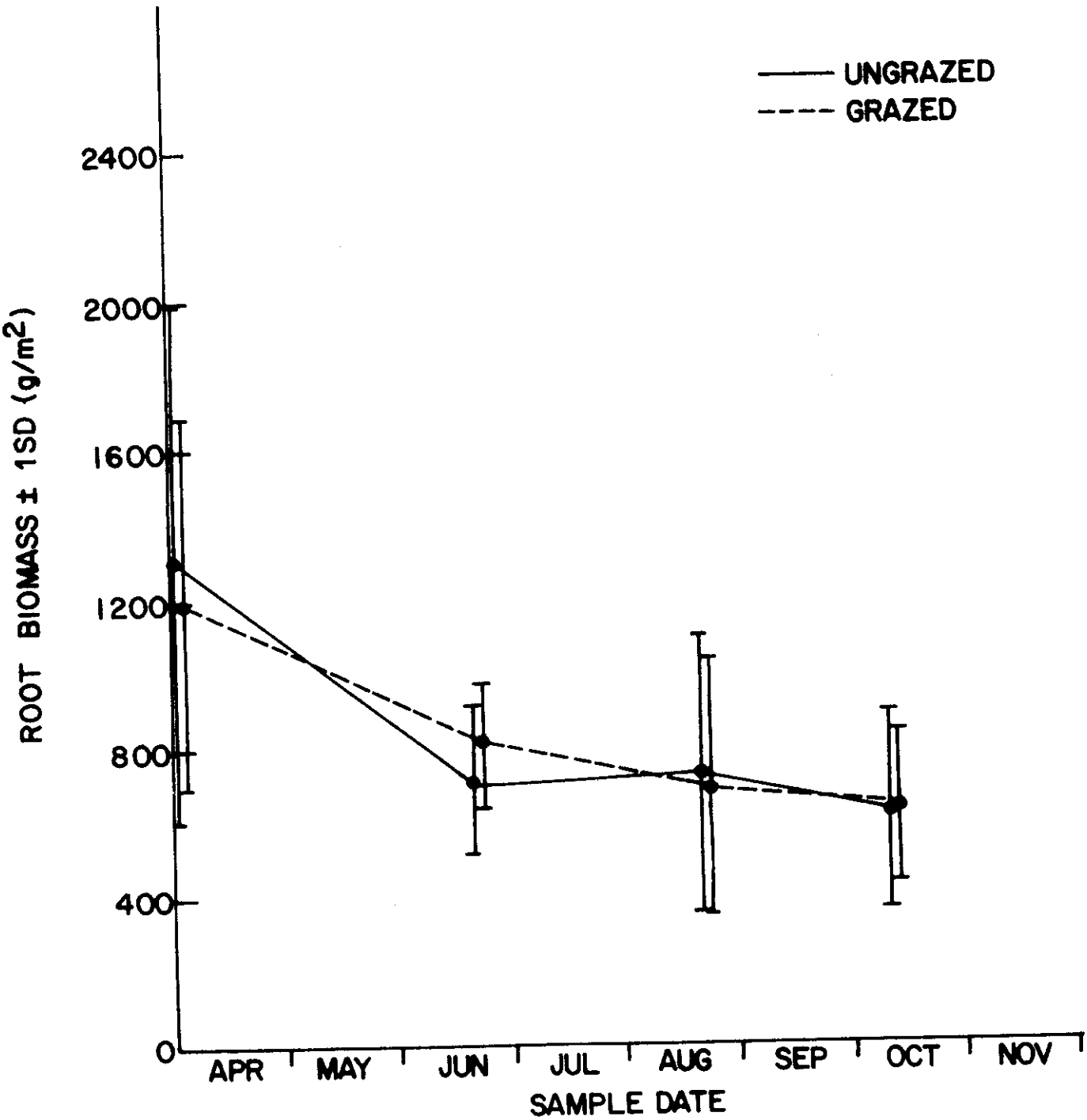

Fig. 6. Belowground biomass for the grazed and ungrazed treatments.

Table 24. Comparison of percent soil water on ungrazed and grazed treatments for 1970 and 1971.

Plot Date	Sample Date		0-15 cm		15-30 cm		30-45 cm		0-45 cm	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
					Ungrazed					
April 1	April 1	March 31		31.45		29.45		30.15		30.35
May 1	May 1		36.8		33.9		33.4		34.7	
May 10		May 12		31.23		29.59		29.89		30.24
June 1	June 1	June 2	32.3	22.24	30.1	22.05	30.2	21.66	30.8	21.98
June 20	June 17	June 18	25.1	28.46	25.7	28.52	26.1	27.85	25.6	28.28
July 1	July 1		19.7		20.1		21.8		20.5	
July 10		July 10		24.20		21.78		21.13		22.37
July 20	July 16	July 24	14.8	16.05	14.8	17.00	16.2	18.40	15.2	17.15
August 1	August 1		17.1		15.0		15.3		15.8	
August 20	August 17	August 19	12.0	13.88	13.4	15.15	14.9	15.80	13.4	14.94
September 20		September 19		31.48		29.02		28.59		29.70
October 1	September 26		27.1		25.3		21.5		24.6	
October 10		October 10		29.53		28.33		27.93		26.7
October 20	October 17		26.8		27.1		26.2		26.7	
November 10	November 14	November 6	26.1	31.8	26.5	30.4	26.3	30.1	26.3	30.8
					Grazed					
April 1	April 1	March 31		24.36		27.79		27.47		26.54
May 1	May 1		30.6		30.2		30.3		30.3	
May 10		May 12		21.98		24.82		25.93		24.24
June 1	June 1	June 2	29.9	18.30	25.8	17.98	20.9	18.70	25.5	18.33
June 20	June 17	June 18	21.4	24.72	21.1	25.63	21.5	25.80	21.3	25.38
July 1	July 1		15.2		16.6		18.3		16.7	
July 10		July 10		24.73		20.66		19.72		21.70
July 20	July 16	July 24	12.6	15.29	13.9	15.61	14.3	16.79	13.6	15.90
August 1	August 1		14.7		15.5		15.5		15.2	
August 20	August 17	August 19	11.6	13.63	12.9	15.61	13.4	15.82	12.6	15.02
September 20		September 19		30.23		28.57		28.08		28.96
October 1	September 26		25.3		25.8		17.1		22.7	
October 10		October 10		27.26		27.26		26.61		27.04
October 20	October 17		25.7		25.7		23.7		24.8	
November 10	November 14	November 6	25.2	32.1	25.2	29.7	25.0	30.5	24.1	30.8

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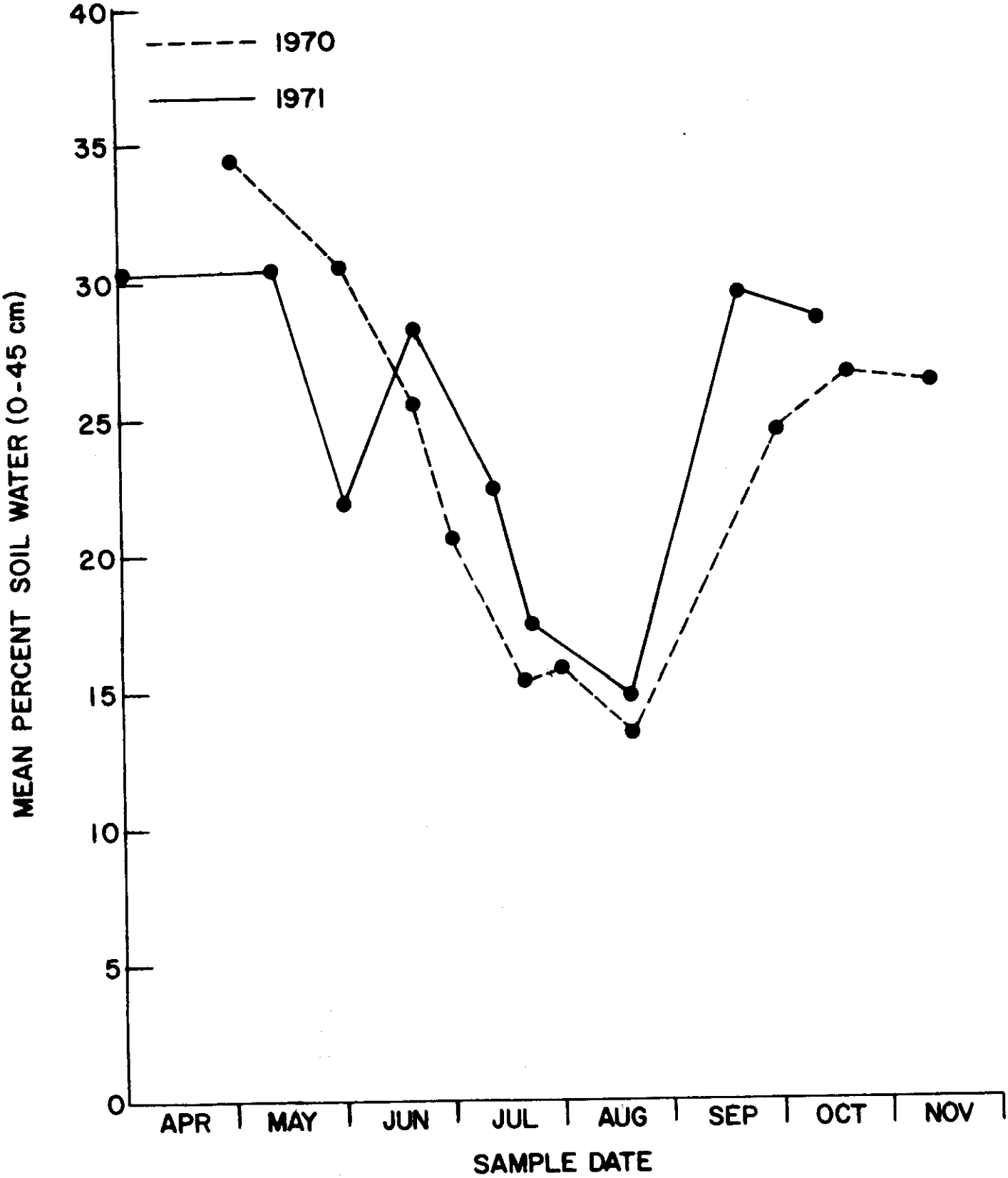

Fig. 7. Comparison of soil water on ungrazed treatment for 1970 and 1971.

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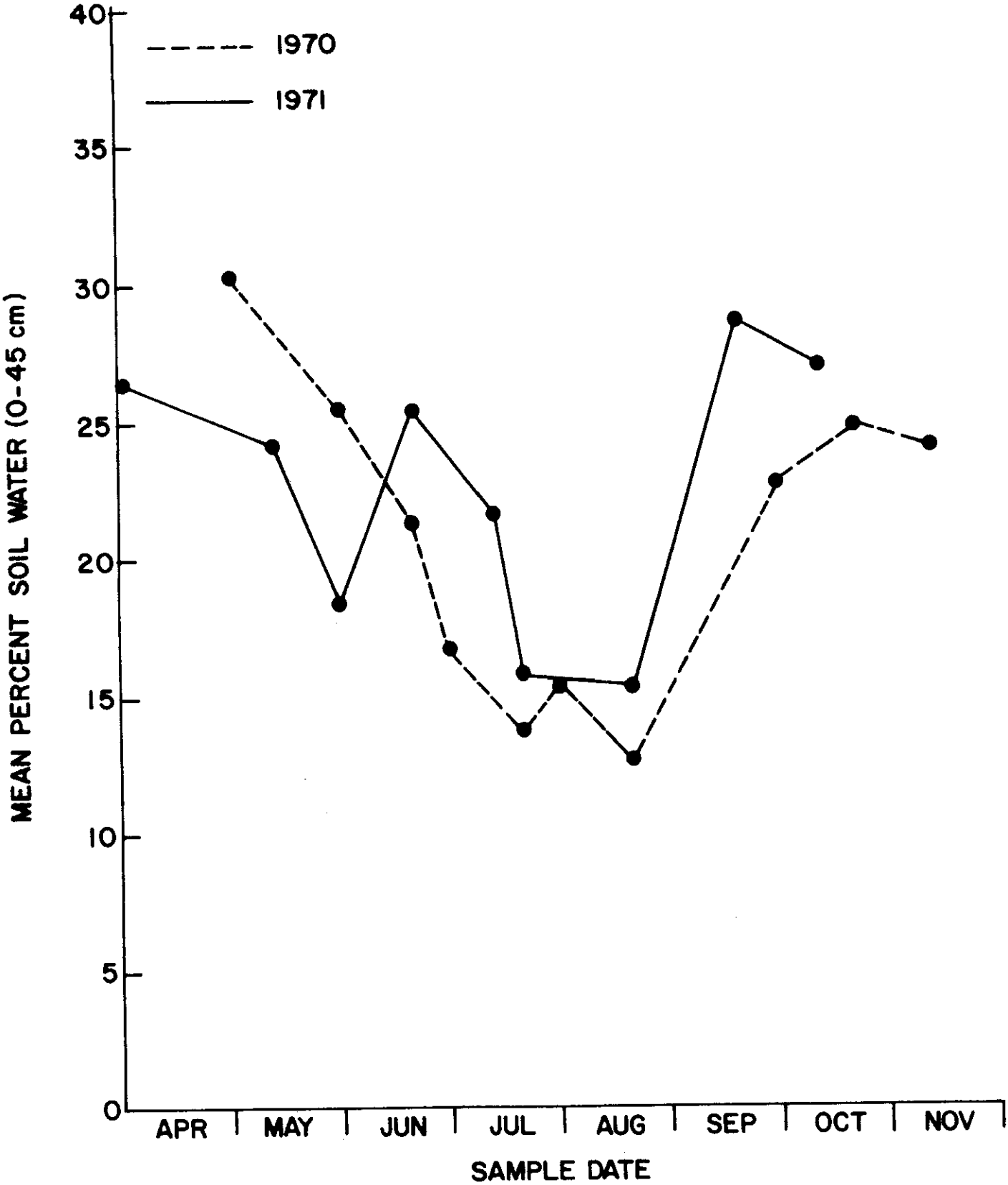

Fig. 8. Comparison of soil water on grazed treatment for 1970 and 1971.

Table 25. Comparison of aboveground biomass (g/m^2) on ungrazed and grazed treatments for 1970 and 1971.

Plot Date	Sample Date		Live		Old Dead		Recent Dead		Total	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
					Ungrazed					
April 1	April 1	March 31	0.21	--	289.53	396.55	--	--	289.74	395.55
May 1	May 1		19.62		255.56		--		275.18	
May 10		May 12		7.04		549.78		--		556.82
June 1	June 1	June 2	145.33	123.43	298.67	595.09	--	--	444.00	718.52
June 20	June 17	June 18	240.18	206.55	149.56	385.82	--	--	389.74	592.37
July 1	July 1		270.37		222.90		0.76		494.03	
July 10		July 10		381.03		455.63		--		836.66
July 20	July 16	July 24	249.31	255.69	278.09	258.70	7.84	348.80	535.74	863.19
August 1	August 1		215.79		156.00		127.12		498.91	
August 20	August 17	August 19	207.59	255.67	156.86	104.56	162.35	186.86	526.86	547.09
September 20		September 19		337.56		154.69		240.22		732.47
October 1	September 26		172.38		141.33		165.65		479.36	
October 10		October 10		180.89		256.21		333.55		770.65
October 20	October 17		130.57		120.48		353.41		604.46	
November 10	November 14	November 6	0.39	21.82	195.53	331.26	430.71	320.06	626.63	673.40
					Grazed					
April 1	April 1	March 31	--	--	74.50	132.44	--	--	74.50	132.44
May 1	May 1		27.20		29.87		--		57.07	
May 10		May 12		82.65		126.66		--		209.31
June 1	June 1	June 2	181.18	200.04	37.97	86.06	--	--	219.15	286.10
June 20	June 17	June 18	249.78	234.48	46.67	130.05	--	--	296.45	364.53
July 1	July 1		210.90		21.79		28.85		261.54	
July 10		July 10		278.00		152.81		--		430.81
July 20	July 16	July 24	286.12	270.39	74.64	94.48	44.00	96.84	404.76	461.71
August 1	August 1		193.81		29.80		78.08		301.79	
August 20	August 17	August 19	260.63	254.20	65.53	63.35	109.57	153.84	435.73	471.39
September 20		September 19		260.03		134.29		272.13		666.45
October 1	September 26		143.22		26.60		109.32		279.14	
October 10		October 10		287.85		62.86		200.85		551.56
October 20	October 17		121.99		55.27		209.46		386.72	
November 10	November 14	November 6	12.69	68.86	33.70	79.55	258.63	340.21	305.02	488.62

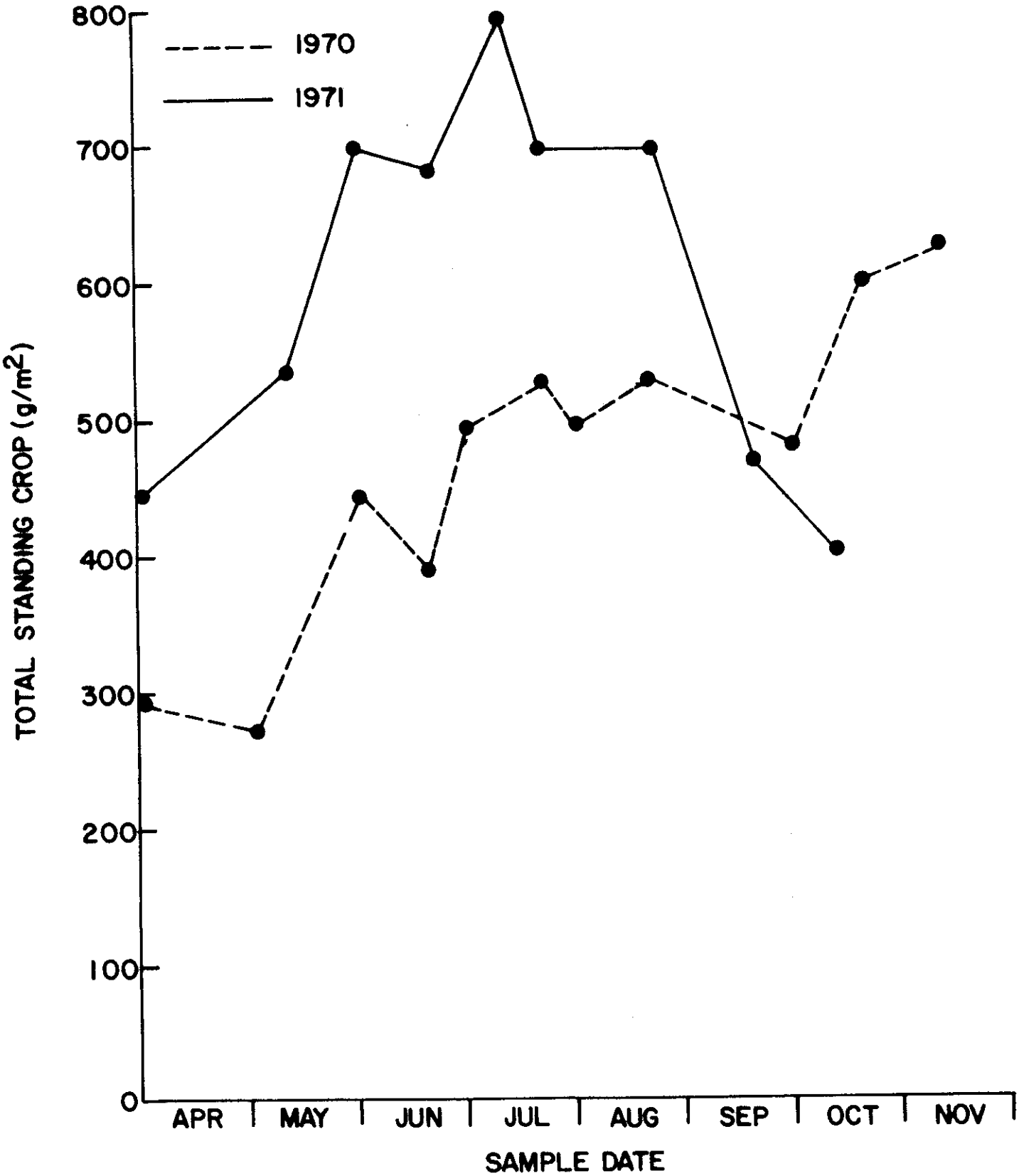

Fig. 9. 1970 and 1971 total standing crop on the ungrazed treatment.

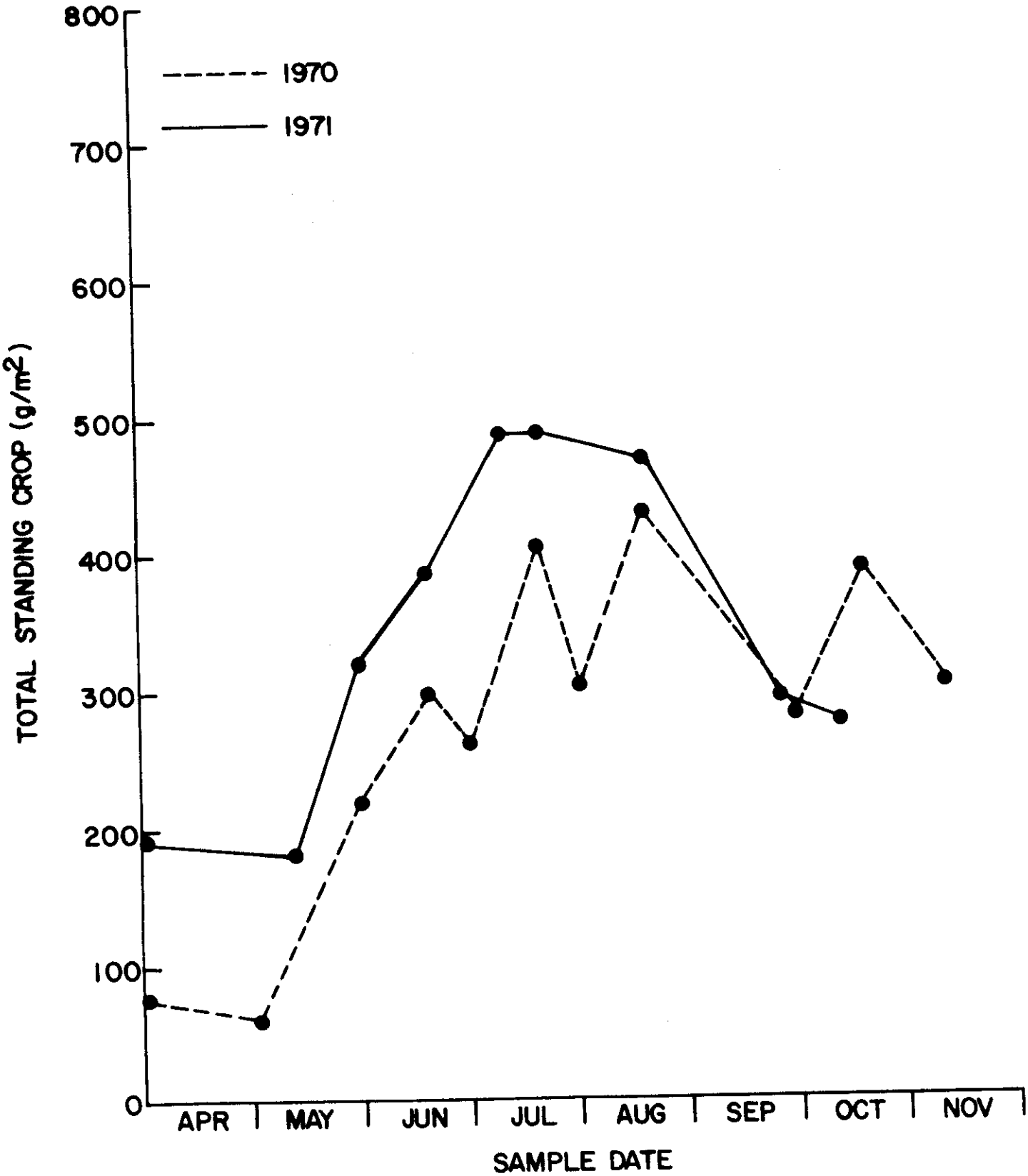

Fig. 10. 1970 and 1971 total standing crop on grazed treatment.

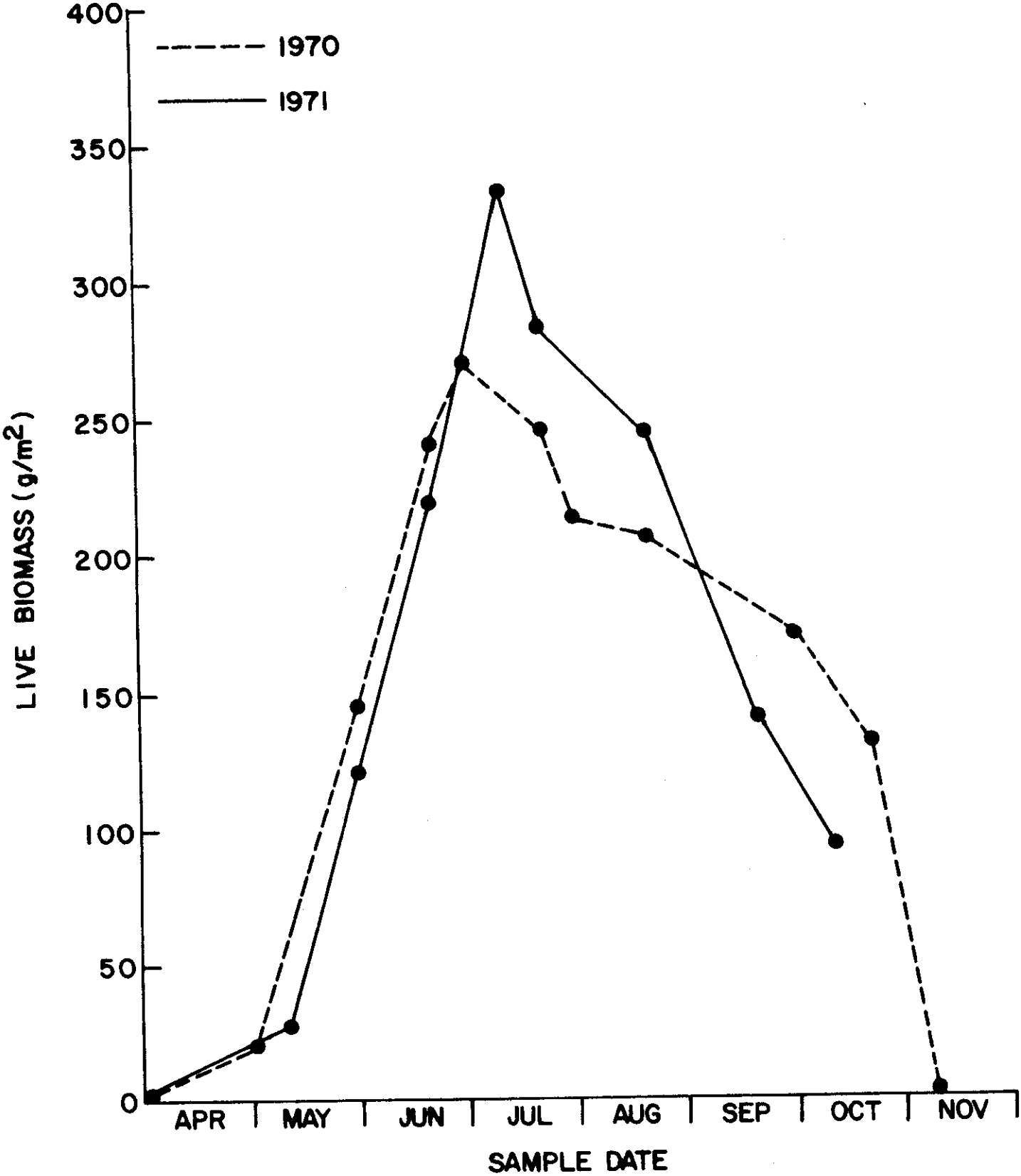

Fig. 11. 1970 and 1971 total live material on ungrazed treatment.

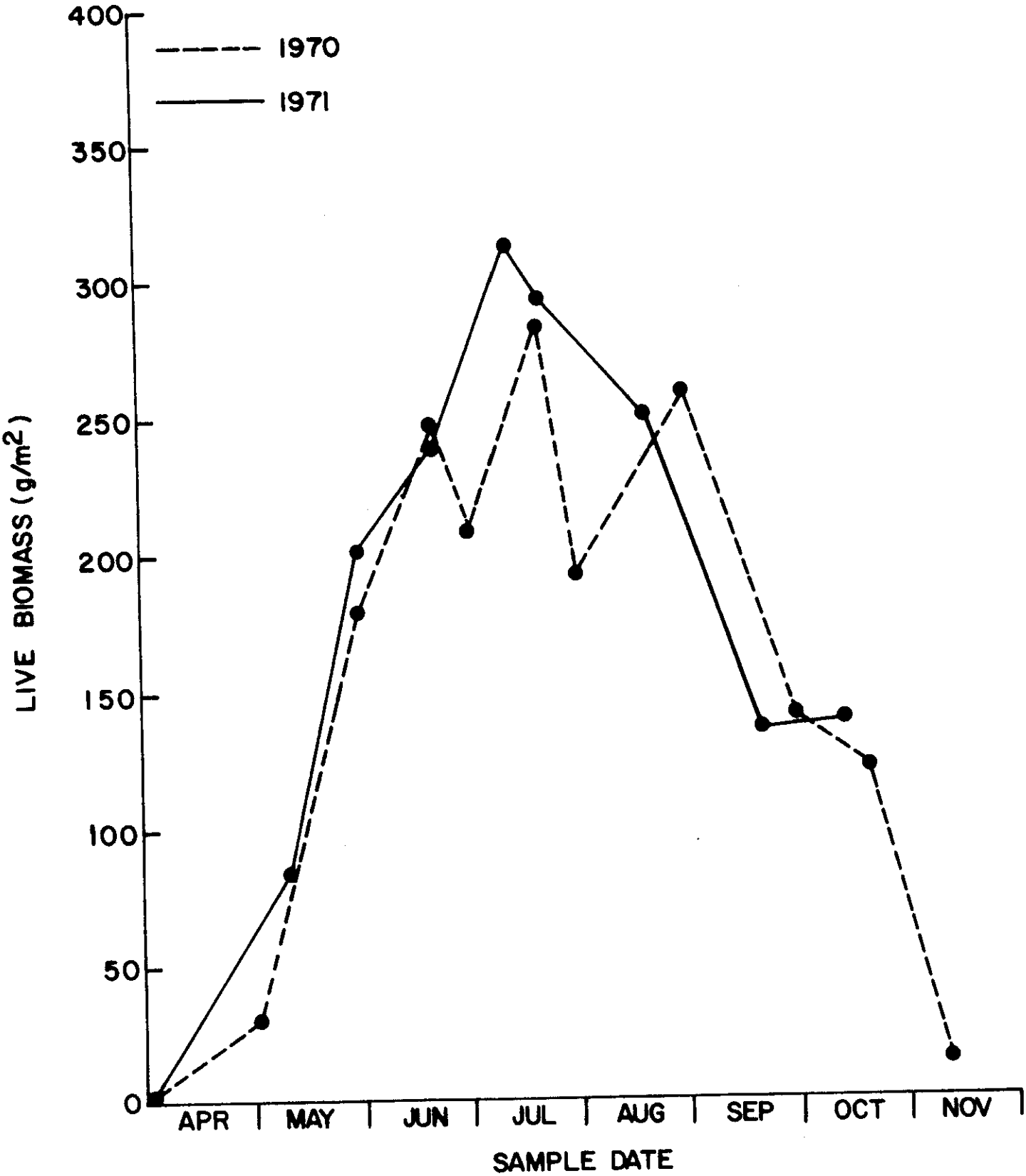

Fig. 12. 1970 and 1971 total live material on grazed treatment.

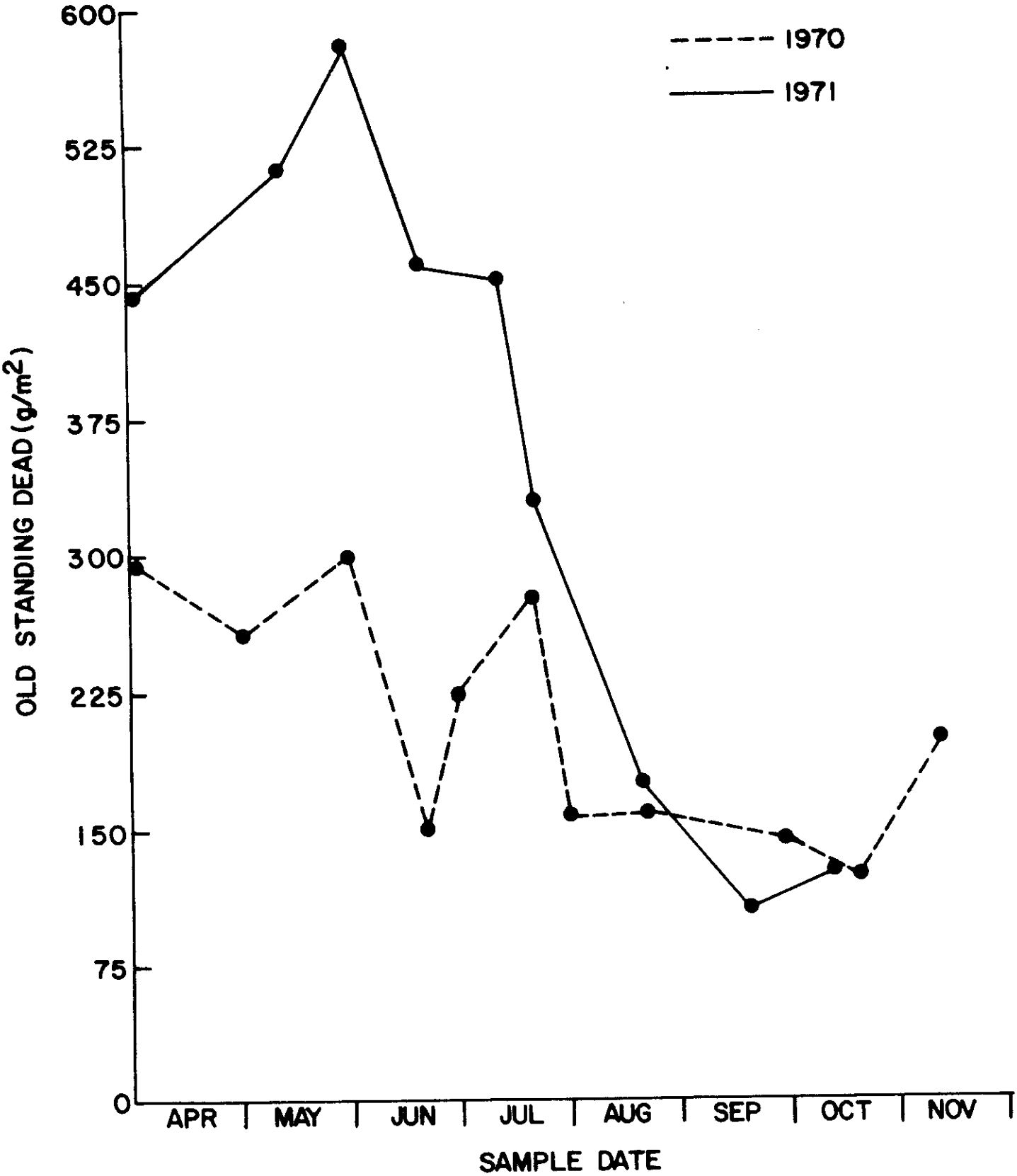

Fig. 13. 1970 and 1971 old dead material on ungrazed treatment.

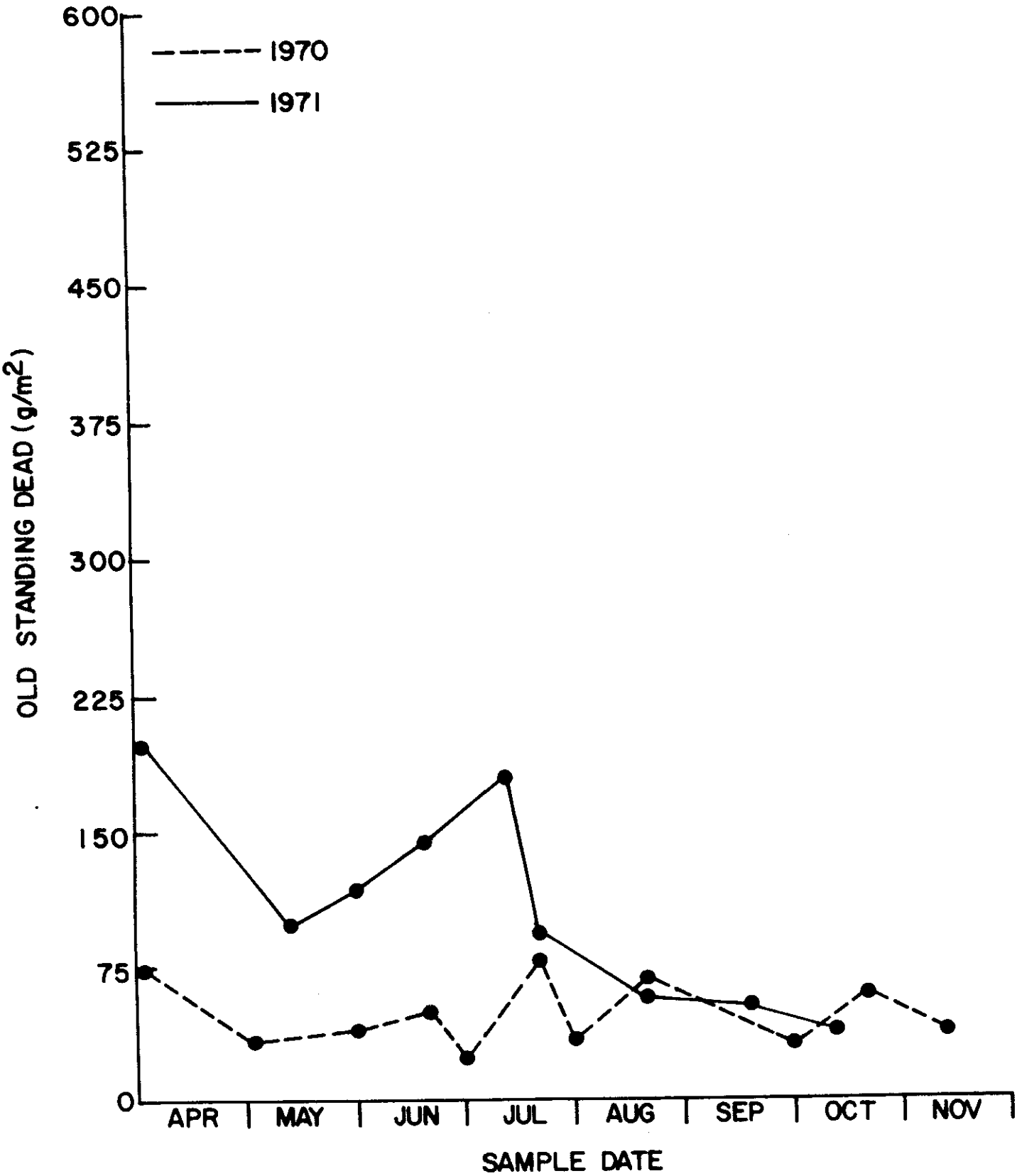

Fig. 14. 1970 and 1971 old dead material on grazed treatment.

of the writing, the November sample has not been returned from the Central Laboratory, and this is the best estimate of the recent standing dead component (Fig. 15 and 16). The values for the litter compartment were so variable it was difficult to draw any real conclusions, but the amount of litter seemed to be somewhat higher in 1971 (Table 26 and Fig. 17 and 18).

Frequency data were taken during one date in September and are presented in Table 27. The 15 most frequent species for both a grazed and ungrazed treatment are presented in Table 28. It should be noted that *Panicum scribnerianum* has a very high frequency, but in terms of total biomass does not contribute a significant amount. On the other hand, *Andropogon gerardi* has a relatively low frequency, but when it does occur, it contributes a large amount of biomass. There are more species with a high relative frequency on the grazed treatment than on the ungrazed treatment. Both the *Bromus japonicus* and the *Sporobolus asper* are increaser species under grazing conditions. However, as was pointed out previously in this report, the grazing intensity on the grazed treatment is such that range condition is still high.

The investigators on the Osage Site have combined data to produce a preliminary compartment model. This is a static model in the sense that it simply describes the amount of biomass in each compartment and the transfer of biomass between compartments at the time of peak standing crop (essentially 1 July). The amount of biomass in each of the eight compartments is presented in Table 29. We are now in the process of developing this model further, so that it can become a dynamic and mechanistic one.

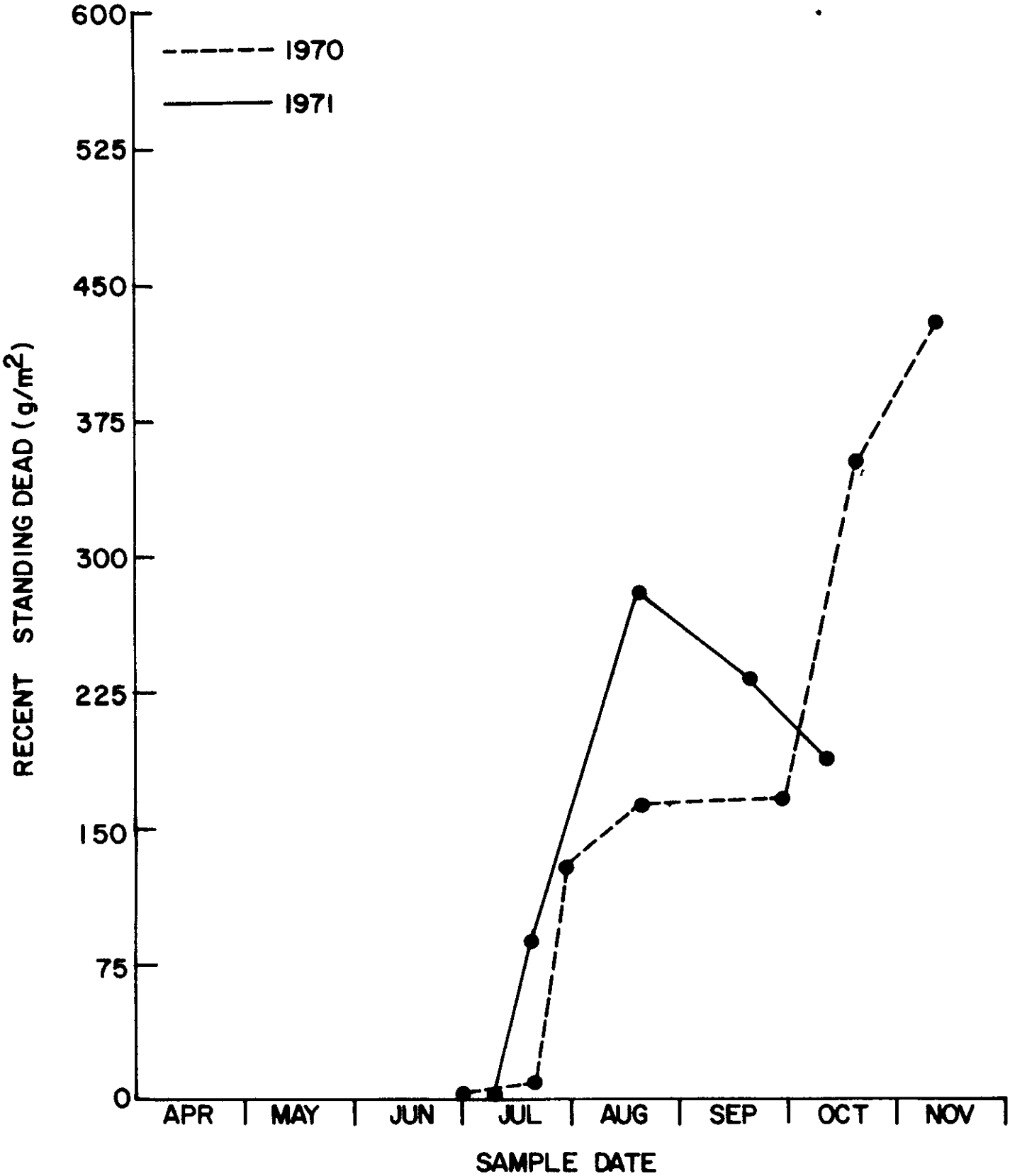

Fig. 15. 1970 and 1971 recent standing dead on the ungrazed treatment.

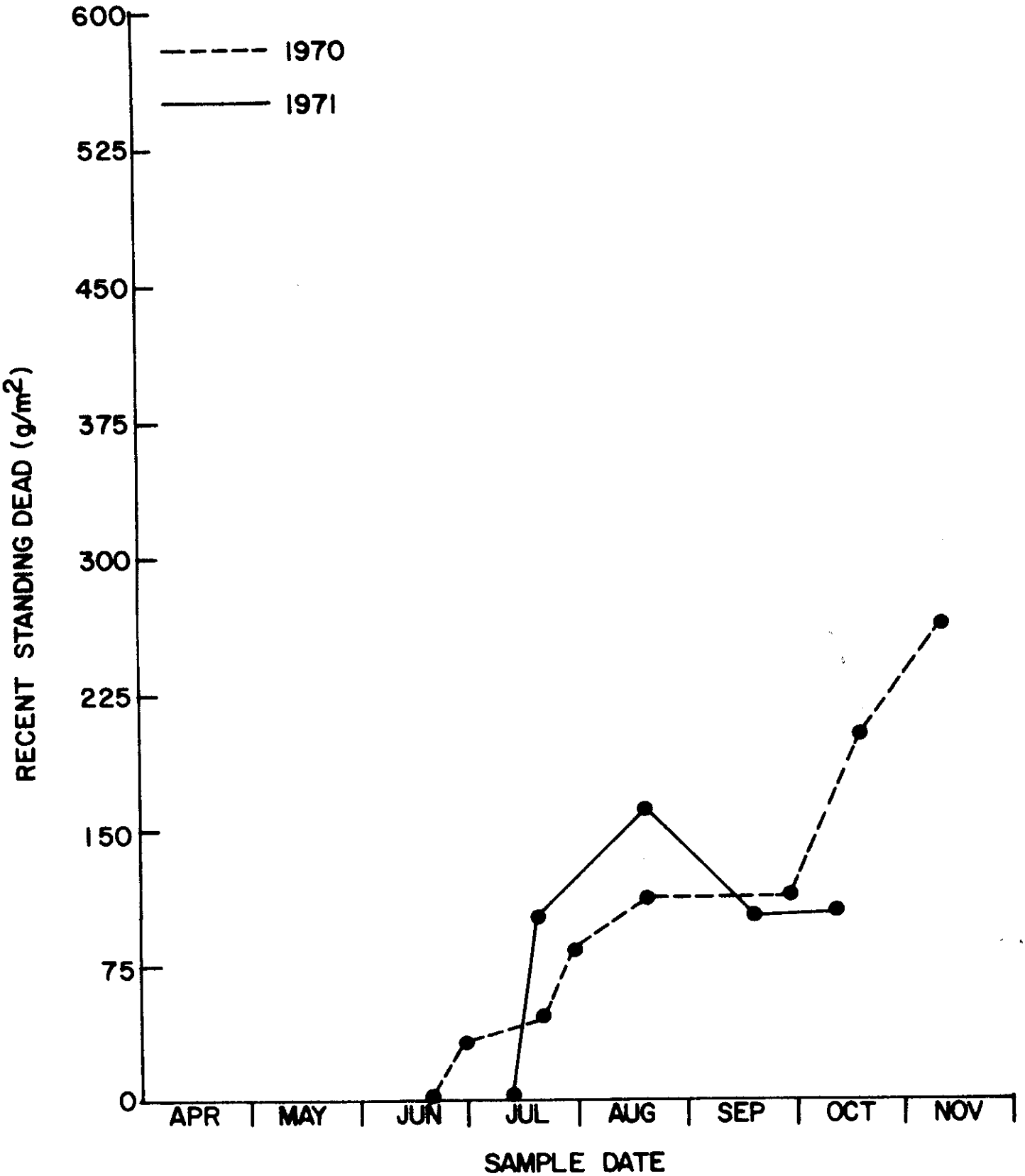

Fig. 16. 1970 and 1971 recent standing dead on the grazed treatment.

Table 26. Comparison of litter (g/m^2) on ungrazed and grazed treatment for 1970 and 1971.

Plot Date	Sample Date		Litter (Ungrazed)		Litter (Grazed)	
	1970	1971	1970	1971	1970	1971
April 1	April 1	March 31	108.53	200.93	251.02	179.70
May 1	May 1		98.41		177.26	
May 10		May 12		172.06		156.21
June 1	June 1	June 2	68.22	246.06	129.53	687.85
June 20	June 17	June 19	82.72	324.65	181.22	549.28
July 1	July 1		154.34		124.83	
July 10		July 10		284.27		445.10
July 20	July 16	July 24	87.56	283.29	144.68	309.76
August 1	August 1		130.47		246.52	
August 20	August 17	August 19	124.58	297.82	262.05	220.83
September 20		September 19		233.25		391.62
October 1	September 26		155.36		215.63	
October 10		October 10		274.11		533.06
October 20	October 17		95.96		222.75	
November 10	November 14		82.55	316.06	158.04	499.01

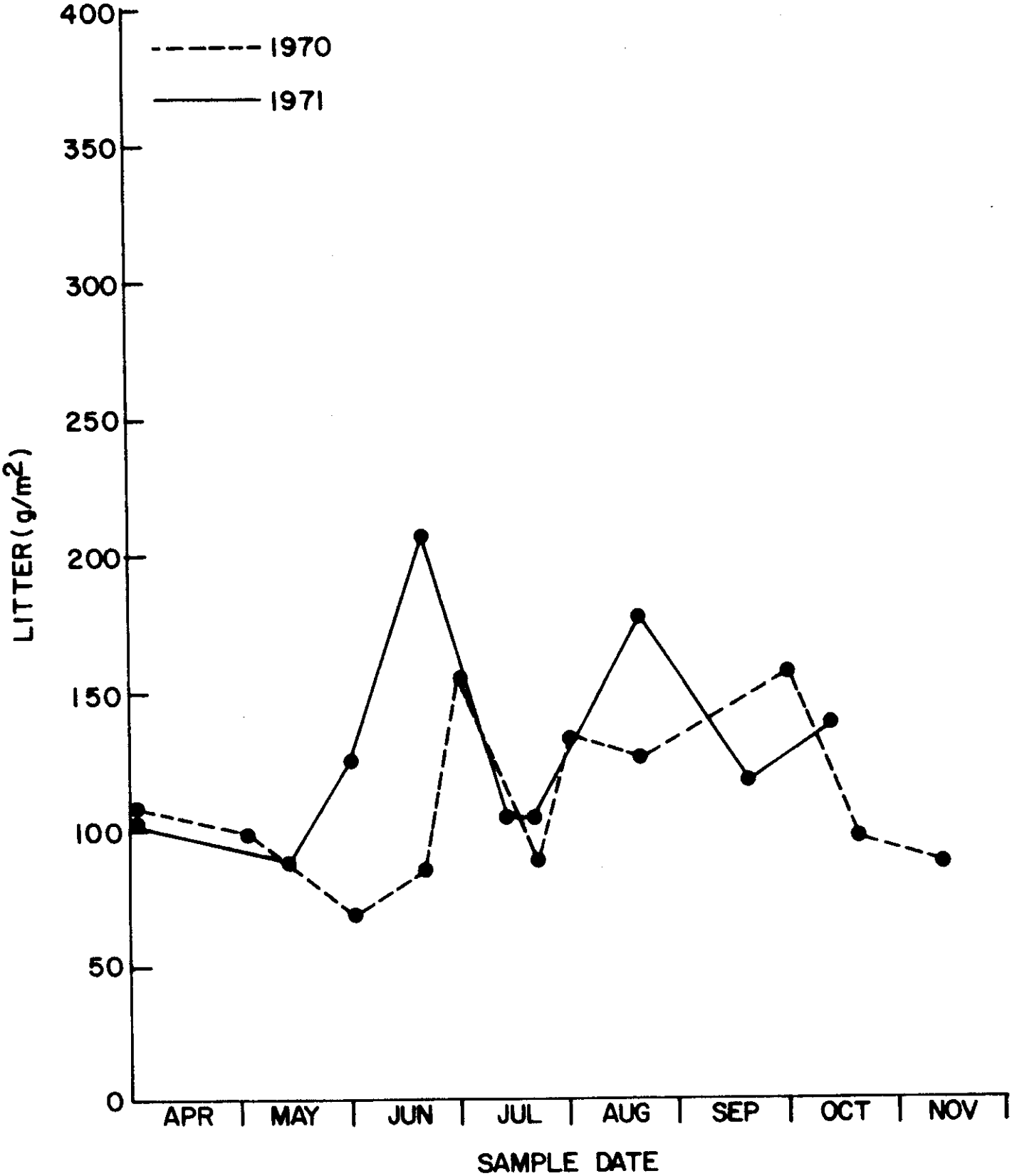

Fig. 17. 1970 and 1971 litter on the ungrazed treatment.

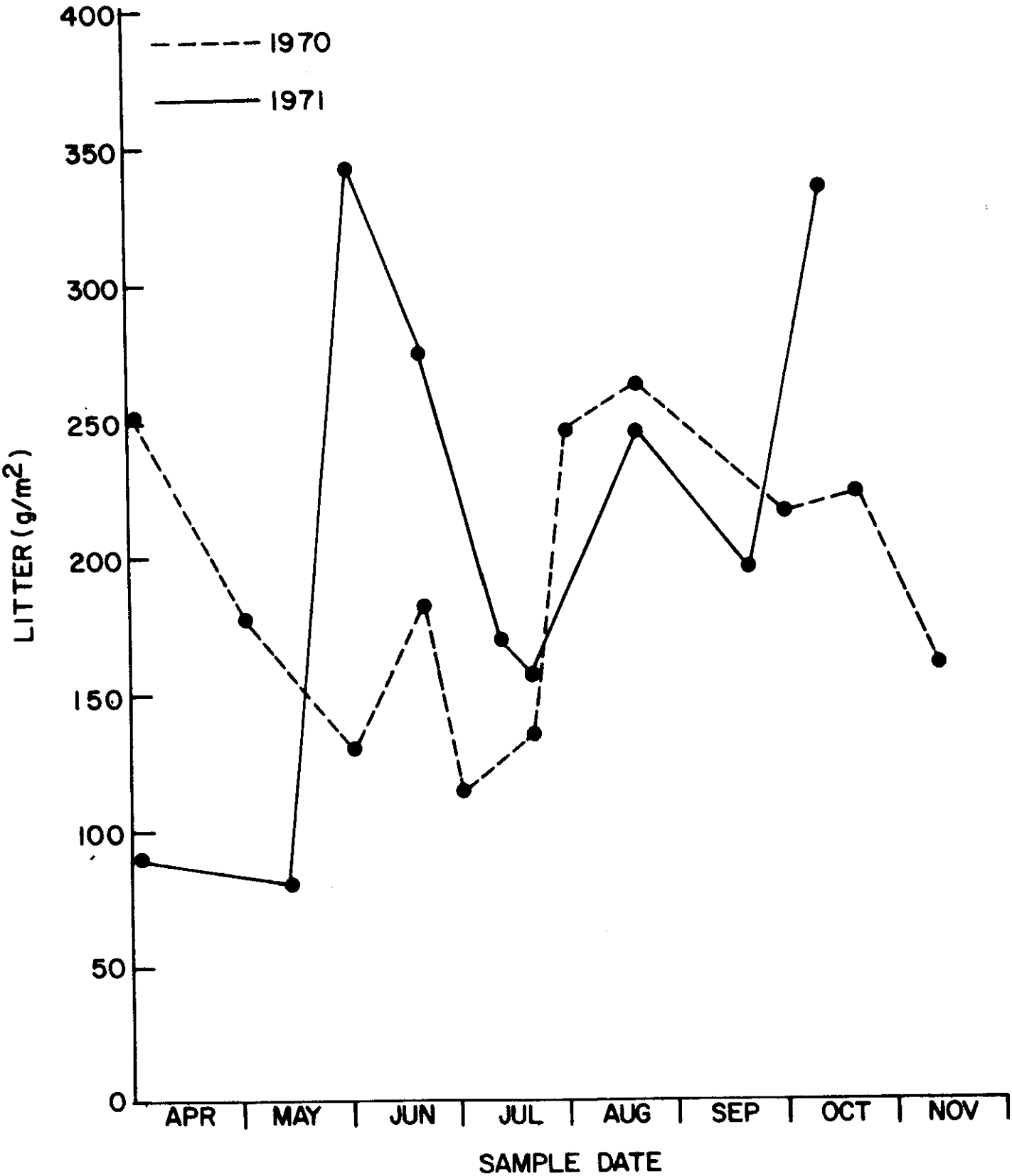

Fig. 18. 1970 and 1971 litter on the grazed treatment.

Table 27. Frequency data was taken on September 4, 1971, on the Osage Site. Twenty-five 0.5 m^2 quadrats were taken in each replicate of both grazed and ungrazed treatments. The following data are percentage frequency for each of the species.

Code	Species Name	Treatment					
		Grazed			Ungrazed		
		Rep 1	Rep 2	Trt	Rep 1	Rep 2	Trt
ANSC2	*Andropogon scoparius*	80	68	74	100	100	100
PASC5	*Panicum scribnerianum*	76	64	70	100	100	100
SONU2	*Sorghastrum nutans*	40	20	30	52	28	40
SPAS	*Sporobolus asper*	68	84	76	20	56	38
PAVI2	*Panicum virgatum*	80	44	62	44	28	36
CAREX	*Carex* spp.	0	4	2	32	32	32
PSTE3	*Psoralea tenuiflora*	0	8	4	0	64	32
BOCU	*Bouteloua curtipendula*	4	4	4	32	24	28
BRJA	*Bromus japoniceus*	92	88	90	0	52	26
LECO	*Leptoloma cognatum*	32	56	44	12	36	24
AGHI	*Agrostis hiemalis*	16	4	10	32	12	22
VEBA	*Vernoma baldwini*	0	8	4	24	20	22
RUHU	*Ruellia humilis*	28	32	30	24	20	22
ANGE	*Andropogon gerardi*	16	24	20	28	12	20
ASER3	*Aster ericoides*	0	0	0	24	12	18
SAAZ	*Salvia azurea*	0	0	0	8	20	14
OXST	*Oxalis stricta*	24	8	16	28	0	14
CRCA6	*Croton capitatus*	16	20	18	0	24	12
STLE6	*Strophostyles leiosperma*	4	16	10	16	0	8
AMCA6	*Amorpha canescens*	4	0	2	0	16	8
SCNU	*Schrankia nuttallii*	0	0	0	0	8	4
POPR	*Poa pratensis*	12	16	14	4	4	4
AMPS	*Ambrosia psilostachya*	44	56	50	8	0	4
COGR5	*Coreopsis grandiflora*	0	0	0	8	0	4
ACLA	*Achillea lanulosa*	4	32	18	8	0	4
SOMI2	*Solidago missouriensis*	0	0	0	4	0	2
EUSU	*Euphorbia supina*	24	16	20	0	4	2
GATE3	*Galium texense*	0	0	0	4	0	2
PHPU8	*Physalis pumila*	0	0	0	4	0	2
BOGR2	*Bouteloua gracilis*	0	0	0	0	4	2
NEGE	*Nemastylis geminiflora*	0	0	0	0	0	0
BALE3	*Baptisia leucophaea*	0	0	0	0	0	0
LEST3	*Lespedeza stipulacea*	28	24	26	0	0	0
AROL	*Aristida oligantha*	8	40	24	0	0	0
SEVI14	*Setaria viridis*	16	8	12	0	0	0
DEIL2	*Desmodium illinoiense*	8	4	6	0	0	0
MELU	*Medicago lupulina*	4	0	2	0	0	0
EUCO10	*Euphorbia corollata*	0	8	4	0	0	0

Table 27 (continued).

Code	Species Name	Treatment					
		Grazed			Ungrazed		
		Rep 1	Rep 2	Trt	Rep 1	Rep 2	Trt
ANVI2	*Andropogon virginicus*	4	0	2	0	0	0
ANSA	*Andropogon saccharoides*	4	0	2	0	0	0
LALU	*Lactuca ludoviciana*	4	0	2	0	0	0
ELCA4	*Elymus canadensis*	0	4	2	0	0	0
GUDR	*Gutierrezia dracunculoides*	0	8	4	0	0	0
TRFL2	*Tridens flavus*	0	12	6	0	0	0
MUSO	*Muhlenbergia sobolifera*	0	4	2	0	0	0
PEPU6	*Petalostemum purpureum*	0	4	2	0	0	0
	Unknown B	0	0	0	8	0	4
	Unknown E	0	0	0	0	4	2
	Unknown F	0	0	0	0	4	2
Number of species				36			35
Total number of species	*49*						

Table 28. The values in parenthesis are percentage frequency values for the 15 most frequent species from 50, 0.5m^2 quadrats taken in each treatment on September 4, 1971, at the Osage Site.

Ungrazed Treatment	Grazed Treatment
Andropogan scoparius (100)	*Bromus japonicus* (90)
Panicum scribnerianum (100)	*Sporobolus asper* (76)
Sorghastrum nutans (40)	*Andropogon scoparius* (74)
Sporobolus asper (38)	*Panicum scribnerianum* (70)
Panicum virgatum (36)	*Panicum virgatum* (62)
Carex spp. (32)	*Ambrosia psilostachya* (50)
Psoralea tenuiflora (32)	*Leptolma cognatum* (44)
Bouteloua curtipendula (28)	*Sorghastrum nutans* (30)
Bromus japonicus (26)	*Ruellia lumilis* (30)
Leptoloma cognatum (24)	*Lespedeza stipulacea* (26)
Agrostis hiemalis (22)	*Aristida oligantha* (24)
Vernonia baldwini (22)	*Euphorbia supina* (20)
Ruellia humilis (22)	*Andropogon gerardi* (20)
Andropogon gerardi (20)	*Croton capitatus* (18)
Aster ericoides (18)	*Achillea lanulosa* (18)

Table 29. Total biomass in each of eight compartments of the preliminary Osage model. These biomass estimates are at the time of peak live herbage.

Compartment	Biomass	
	g/m^2	Percentage
Roots	981.6000	40.24360 (40)
Decomposers	634.9600	26.03207 (26)
Dead Plant Parts	356.20000	14.60347 (15)
Live Plant Parts	311.8600	12.78562 (13)
Litter	154.3500	6.32804 (6)
Invertebrates	0.1257	0.00515 (<1)
Mammals	0.0438	0.00180 (<1)
Birds	0.0062	0.00025 (<1)
TOTAL	2439.1457	100.00000

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Van Dyne, G. M. [Principal Investigator]. 1970. Analysis of structure and function of grassland ecosystems: A progress report and a continuation proposal. U.S. IBP Grassland Biome, Colorado State Univ., Fort Collins. 269 p.

Appendix Table 1. Status of samples taken on Osage Site, 1971.

Data Type	March 31	May 12	June 2	June 18	July 10	July 24	August 19	September 19	October 10	November 6
					Aboveground Biomass					
Clip estimate data	OU-CSU-OU	OU-CSU-OU	OU-CSU-OU	OU-CSU-OU	OU-CSU-OU	OU-CSU-OU	OU-CSU-OU	OU-CSU-OU	OU-CSU-OU	OU- +[a/]OU
Chemical analysis	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU	OU-CSU	OU-CSU-	OU-CSU-	OU-CSU	OU-CSU-	OU-CSU-
					Litter					
Quadrat	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU	OU-CSU-	OU-CSU-	OU-CSU-
Chemical analysis	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU	OU-CSU	OU-CSU-	OU-CSU-
Species composition		OU-CSU-OU	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU-	OU-CSU	OU-CSU	OU-CSU-	OU-CSU-
Screens	OU-CSU-	OU-CSU-	OU-CSU-OU			OU-CSU-OU	OU-CSU-OU	OU-CSU-OU		OU-CSU-OU
Bags	OU-CSU-									
					Roots					
Quadrat	OU-CSU-			OU-CSU-			OU-CSU-		OU-CSU-	
Chemical analysis							OU-CSU-		OU-CSU-	
Ash analysis							OU-CSU-			
Calorimetric				OU-CSU-			OU-CSU-		OU-CSU-	
					Soil					
Moisture	OU- +	OU- +	OU- +	OU- +	OU- +	OU- +	OU- +	OU- +	OU- +	OU- +
Dynamic-chemical analysis							OU-CSU-		OU-CSU-	
Characterization							OU-CSU-			
N-fixation								OU-CSU-		
					Species List					
Frequency							OU-CSU			
					Large Herbivore					
Diet analysis						OU-UW-				
					Root calorimetry					
1970							OU-CSU-			

APPENDIX II

FIELD DATA

Aboveground Biomass Data

The Osage Site aboveground biomass data collected in 1971 is Grassland Biome data type number A2U00C9. The data are reported on form NREL-01. A sample data form and a listing of these data from one sample date follows.

••• EXAMPLE OF DATA •••

```
         1         2         3         4         5         6
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0109RKK12057111  .5  41 2 1 ANSC  2  180 1002 223.33
0109RKK12057111  .5  41 2 1 ANSC  1    5  533   4.75
0109RKK12057111  .5  41 2 1 PAVI  2    5  534   5.95
0109RKK12057111  .5  41 2 1 PAVI  1   10         0
0109RKK12057111  .5  41 2 1 SONU  2   15  536   1.63
0109RKK12057111  .5  41 2 1 SONU  1    0  537    .51
0109RKK12057111  .5  41 2 1 MISC  2    0  538   6.33
0109RKK12057111  .5  41 2 1 MISC  1    0  539   3.16
0109RKK12057111  .5  41 2 1 SPAS  2    0  540   5.48
0109RKK12057111  .5  41 2 1 SPAS  1    0  541    .45
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0109RKK12057111  .5  42 2 1 ANSC  2  140 1003 251.90
0109RKK12057111  .5  42 2 1 ANSC  1    5  543   1.41
0109RKK12057111  .5  42 2 1 PAVI  2   40  544  28.55
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0109RKK12057111  .5  42 2 6 FORB  1   10  547   1.00
0109RKK12057111  .5  42 2 6 FORB  2    5  549   3.28
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0109RKK12057111  .5  10 3 1 ANSC  1  05
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0109RKK12057112	.5	44	2	1	ANSC	1	5	600	6.98
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0109RKK12057151	.5	61	2	1	MISC	1	0	592	26.29
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