Kansas Rangelands

their management, based on a half century of research

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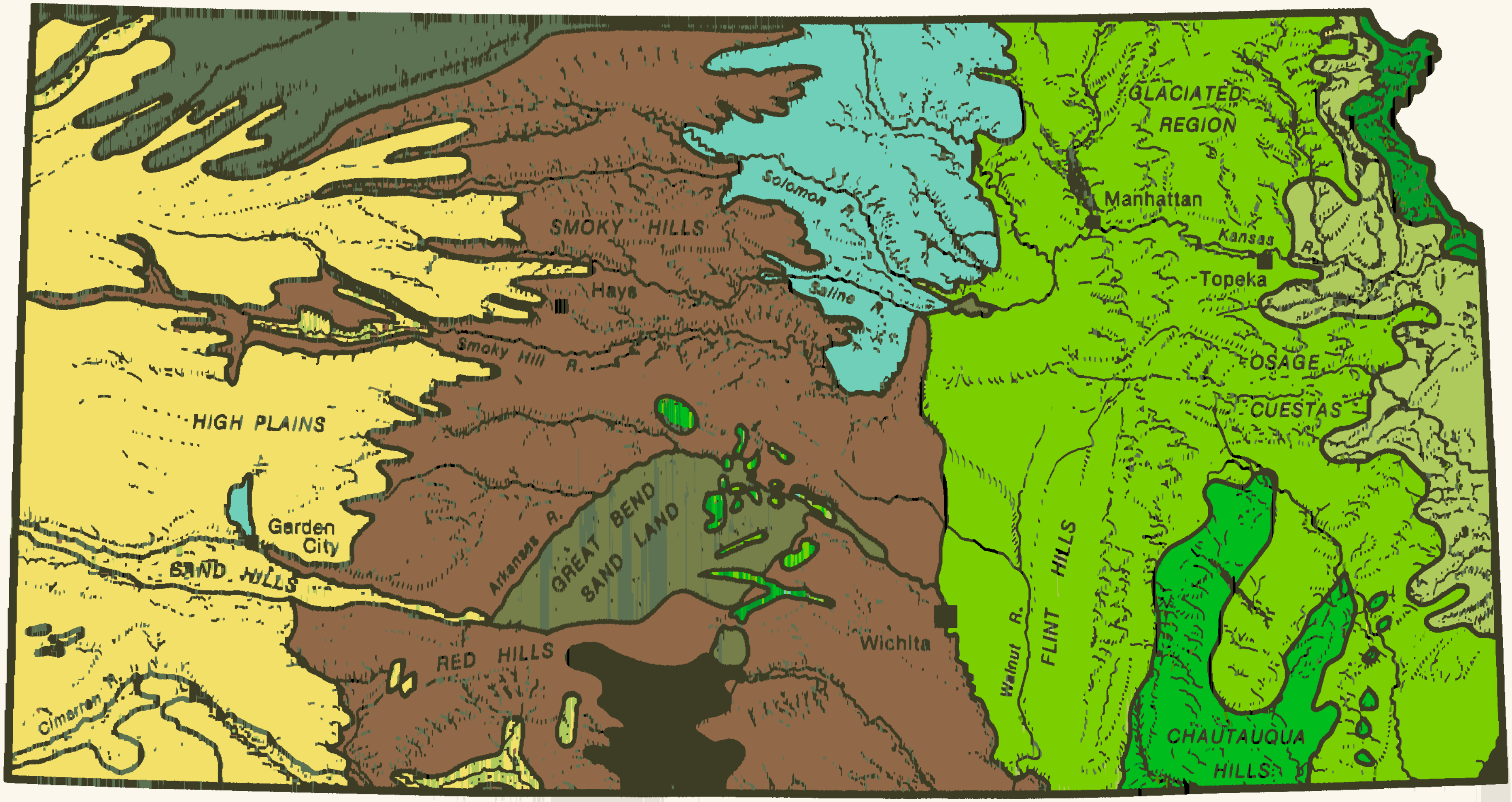

Generalized Native Vegetation Types of Kansas

Loess Breaks Prairie
Grama—Wheatgrass—Bluestem

High Plains Prairie
Blue grama—Buffalograss

Chalkflats Prairie
Bluestem—Grama—Saltgrass

Alkali flats Prairie
Wheatgrass—Saltgrass—Sacaton

Central Dissected Prairie
Grama—Bluestem

Mesic Sandhills Prairie
Bluestem—Sandreed

Xeric Sandhills Prairie
Sandsage—Bluestem—Sandreed

Gypsum Hills Prairie
Bluestem—Grama—Redcedar

Cross Timbers
Oak—Bluestem

Dakota Sandstone Prairie
Bluestem—Grama

Eastern Subhumid Prairie
Bluestem—Indiangrass

Salt Marsh Prairie
Saltgrass—Bulrush—Sacaton

Northeast Deciduous Forest
Oak—Hickory

Northeast Deciduous Forest
Eastern Subhumid Prairie Mosaic

Ozark Deciduous Forest
Oak—Hickory

KANSAS RANGELANDS

Their Management Based on a Half Century of Research[1]

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CONTENTS

INTRODUCTION

Native Range Resource of Kansas

Kansas grasslands evolved under semi-arid to subhumid climates, characterized by much the same weather extremes of temperature, rainfall, and snowfall we are familiar with today. As a result of prehistoric glacial activity and other natural forces then and later, plants have migrated from their places of origin, so that today Kansas ranges are simple-to-complex mixtures of perennial grasses and forbs, plus a few native annuals and biennials. Species composition has been modified by the introduction of Kentucky bluegrass and cool-season annual grasses, particularly Japanese brome. Most of the introductions are now "naturalized" enough to be considered permanent parts of Kansas range vegetation (Harlan 1960).

Through the ages to modern times, wildfires - many started by lightning, but most by primitive people - influenced development of fire-tolerant grasses and suppressed woody vegetation (Sauer 1950). Certain woody plants, however, always were present as natural components of some grasslands. Browsing by animals and frequent prairie fires were largely responsible for maintaining "normal" amounts of woody species (Dyksterhuis 1958).

In prehistoric time, numerous large herbivores subjected herbaceous vegetation to grazing stress. After the last glacial retreat (15,000 to 25,000 years ago), buffalo emerged as the major dominant large grazer, although the prairies and plains simultaneously supported many pronghorn antelope, elk, deer, prairie dogs, rabbits, rodents, and insects. And each exerted grazing pressures on the vegetation. There is little doubt that during and long before Spanish explorations into Kansas, most of the grassland was used almost continuously throughout the year by one roving herd of buffalo after another and other grazing animals (early exploration accounts reviewed by Dary 1974; diaries of early Kansas residents cited by Choate and Fleharty 1975). Grazing and trampling by buffalo and their associates were often intensive, as was uncontrolled grazing by livestock in the late 1800s after most of the wild grazers had been eliminated.

Palatable plants have persisted under nearly all grazing regimes by domestic livestock, whether or not the ranges have been managed economically. The ability of desirable range plants to endure and recover from heavy use underscores the important role of prehistoric grazers in range-plant evolutionary development.

Approximately two-fifths of Kansas (about 20 million acres) is native rangeland, reestablished native range, and grazed woodland. Native vegetation is characterized by various kinds of grassland (Frontispiece). Most stockmen and others in the field of range management have general knowledge of kinds and amounts of forage that can be produced on conservatively stocked ranges in different geographical areas. Although important features of range production are reasonably well understood, grazing management and related practices that affect livestock performance are not so well understood.

Importance of Range and Range Livestock Management

Kansas has more than 6 million head of cattle. About 1.7 million beef cows and their calves depend entirely or in part on native range, and 1.75 million grass-fed cattle and calves are marketed in the state each year. In addition, 170,000 sheep and a variety of wildlife, including approximately 35,000 deer, share the range resources and supplementary roughages. The need to improve conversion efficiency of forages to livestock products already exists; future demands on the state's grazing resources will be even greater,

Use of native range for livestock production involves change, including problems and opportunities that accompany change in management. Grazing procedures should be appraised regularly and altered to take advantage of practices that research demonstrates to be more profitable than existing ones.

Early research by the Kansas Agricultural Experiment Station on range and range livestock related burning practices and stocking rates to the conservation of Flint Hills grazing resources. Over the years, research priorities have shifted toward increasing range livestock production efficiency on a sustained basis throughout the state. Investigations at both Manhattan and Hays have centered on improved livestock performance in harmony with maintaining desirable plant composition, optimum forage yields, wildlife habitat needs, watershed protection, recreational requirements, and esthetic values.

Presented here are recommendations for range and range-livestock management based on experiments at Manhattan and Hays, augmented by applicable research from Colorado, Nebraska, and Oklahoma. Practices that make more efficient use of grazing resources should increase livestock production and improve economic returns to producers, communities, and the state.

SECTION 1 *Proper Stocking Rates*

Proper grazing intensity of native range requires stocking so livestock can convert forage to saleable products most efficiently and economically on a sustained basis. The plant community must be maintained in a vigorous condition to provide desirable vegetation, sufficient ground cover for soil and water conservation, and habitat for wildlife and to increase the probability of a reliable forage supply during drought.

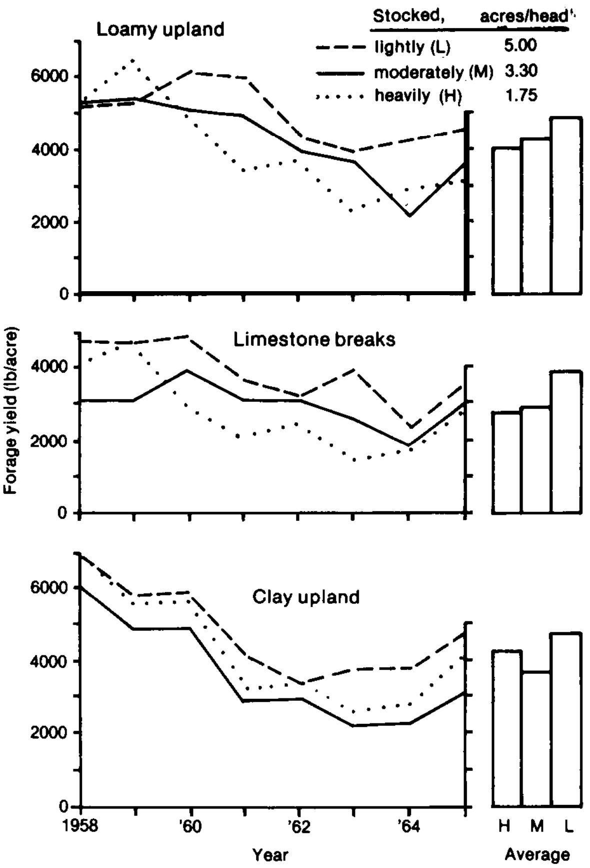
In long-term, rate-of-stocking studies at Manhattan and Hays, forage production was greatest on lightly stocked, intermediate on moderately stocked, and least on heavily stocked ranges (Figures 1 and 3). Moderate stocking, the most economically efficient grazing intensity, left 40 to 60 percent of the current year's forage ungrazed at the end of the growing season (Figures 2 and 4, and Tables 1 and 2).

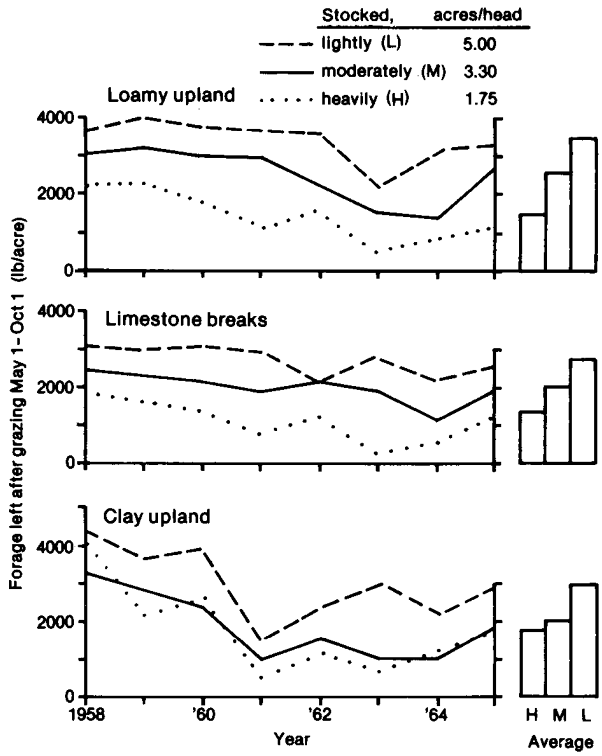
Quality of range vegetation varies not only among plant species, plants of the same species, and plant parts, but also with weather and soil characteristics, and seasonally with plant development, age of regrowth, grazing management, and such range treatments as burning, mowing, nitrogen fertilization, and pesticide applications. Forage samples collected from esophageal-fistulated steers grazing Flint Hills bluestem range had consistently higher crude protein and digestible energy than did forage samples clipped to approximate grazing activities of the livestock (Table 3). Properly stocked ranges are grazed in small-to-large patches, rather than uniformily throughout, because given the opportunity, livestock choose their diets. Selective grazing is highly important for animal performance, so ample forage should be available to livestock the entire time they are on range. Overstocking ranges to the extent that grazing animals are restricted to forage they would not otherwise select is a major cause for reduced stocker gains, reproductive performance, and weaning weights.

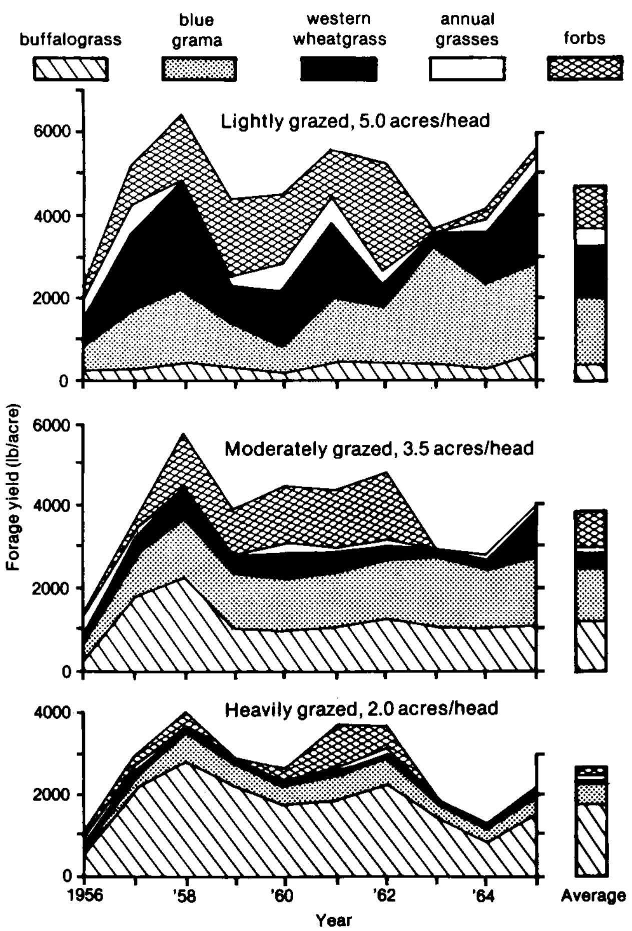
Proper stocking of native range is using the fewest acres a grazing animal requires to achieve maximum performance in a specified time (Table 4, and Figures 5 and 6). Proper stocking also maintains desirable and vigorous range plant communities (Figures 7, 8, and 9). Overstocking shortgrass range near Hays throughout the growing season for seven years reduced soil-moisture intake on a clay upland range site (Table 5). Lowered plant vigor from heavy grazing and decreased water penetration from intensified soil packing interacted to change plant species composition and to reduce forage production.

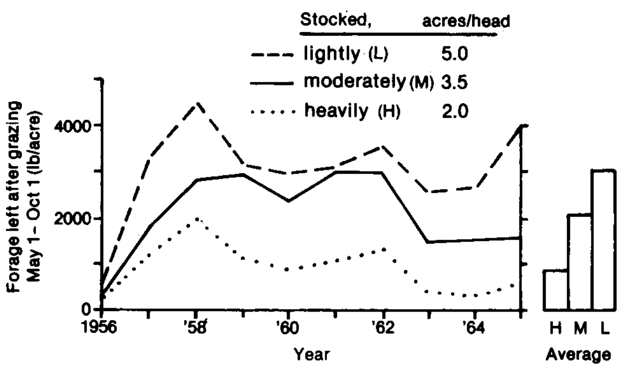
Recommendations

- ***Stock ranges at "long-term" rates that will maintain desirable, vigorous plant species from season to season.***
- ***Encourage livestock to graze the range as evenly as economically feasible: Control availability of drinking water at wells and by fencing ponds; place salt boxes, mineral feeders, back oilers, dust bags, and other objects that attract livestock to less-used parts of the range: and fertilize small areas with nitrogen or burn an acre or less on sites where conventional aids do not attract grazing animals satisfactorily. Ride the range frequently and drive livestock into underutilized areas.***
- ***Keep in mind that range forage production may vary widely from season to season, but that livestock performance is not benefited by varying stocking rates seasonally in attempts to match changes in plant production. During severe drought, however, remove stock from ranges earlier than normally anticipated to avoid weight losses.***
- ***Judge proper stocking rates by evaluating these factors: Individual animal performance (profitable stocker gains, weaned calving percentages, and weaning weights): presence of the major desirable grasses and forbs that are adapted to each range site; and patchy covering of ungrazed forage remaining at the end of the growing season and at the start of the next growing season.***



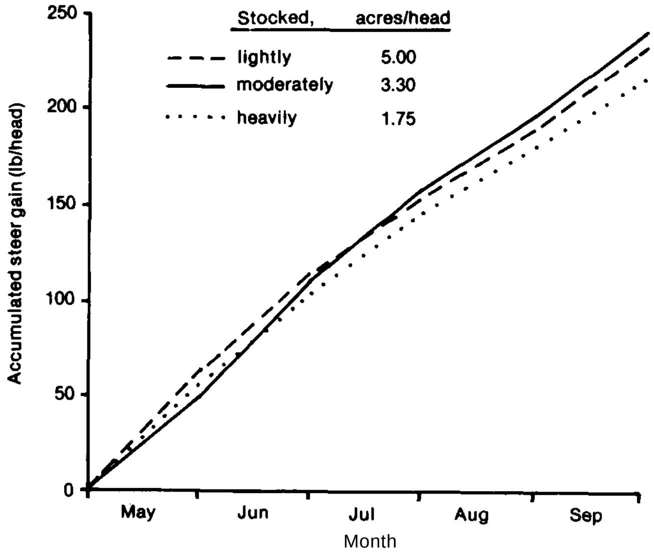


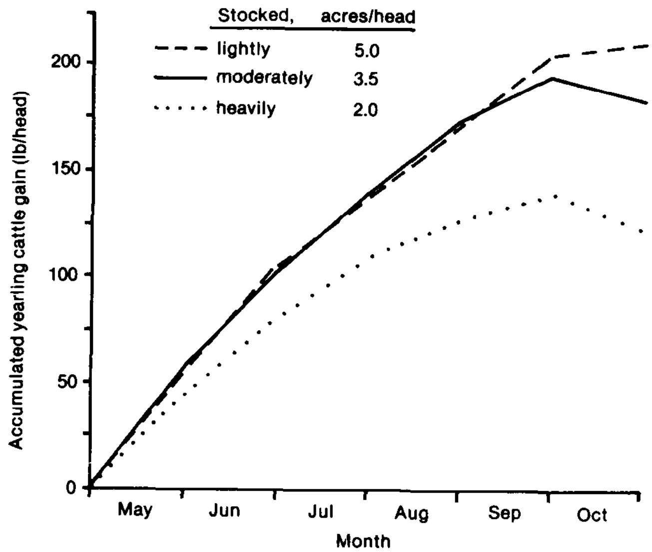




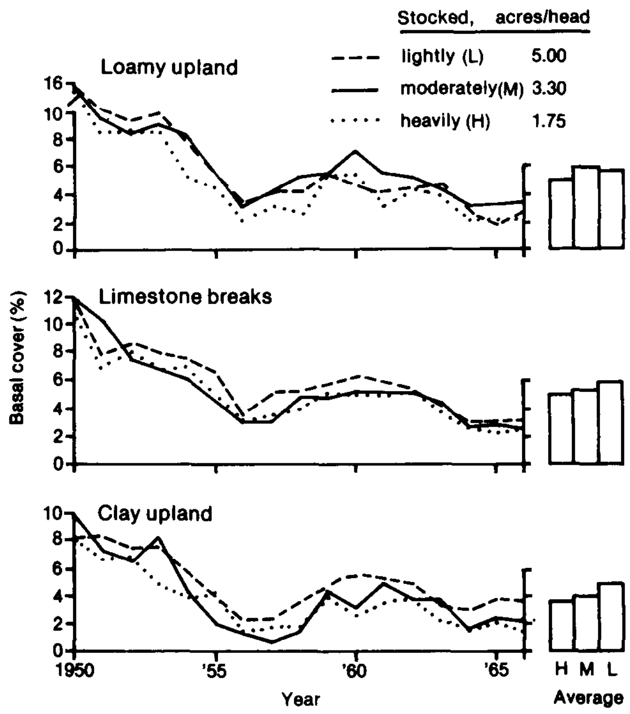
Figures 1, 2, 3, 4. *Forage yields (Fig. 1, left top) and forage left at the end of the grazing season (Fig. 2, right top) on three major Flint Hills bluestem range sites: and yields of major plant species (Fig. 3, left bottom) and forage left at the end of the grazing season (Fig. 4, right bottom) on clay upland shortgrass range near Hays. Both ranges stocked heavily, moderately, or lightly with yearling steers May 1 to October 1 (1958 to 1966 on Flint Hills bluestem range and 1956 to 1966 on shortgrass near Hays).*

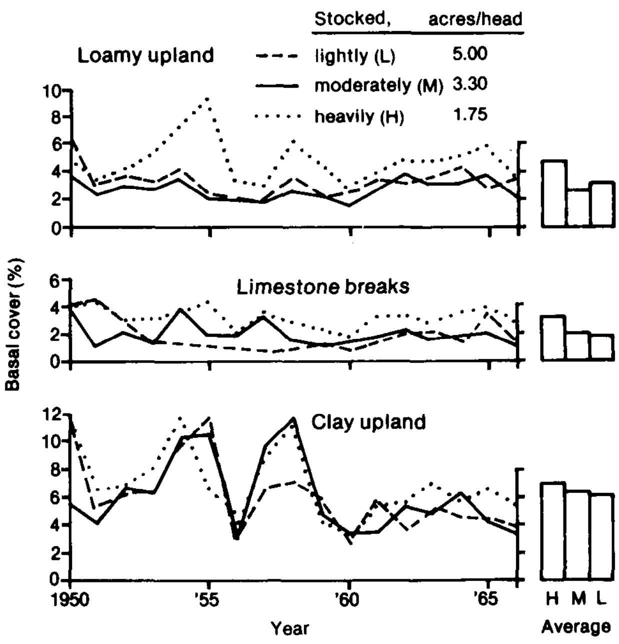
(At the Hays site, forbs under light and moderate grazing were mostly western ragweed; under heavy grazing, upright prairieconefower. Annual grasses under light and moderate grazing at that site were mostly Japanese brome; under heavy grazing, little barley.)





Figures 5 and 6 (left to right). Average gains of yearling steers on Flint Hills bluestem range (Fig. 5) and average gains of yearling cattle on clay upland shortgrass range at Hays (Fig. 6) stocked lightly, moderately, or heavily May 1 to October 1, 1950 to 1967 (on bluestem), or May 1 to November 1, 1946 to 1957 (on shortgrass).





Figures 7 and 8 (left to right). Percentages of ground covered by living plant bases (basal cover): (Fig. 7) of desirable grasses (principally big bluestem, indiangrass. and little bluestem) classed as decreasers; and (Fig. 8) of grasses classed as increasers (principally tall dropseed, Kentucky bluegrass, and sideoats grama) that replace desirable decreaser grasses-on Flint Hills bluestem range stocked lightly, moderately, or heavily with yearling steers May 1 to October 1, 1950 to 1957.

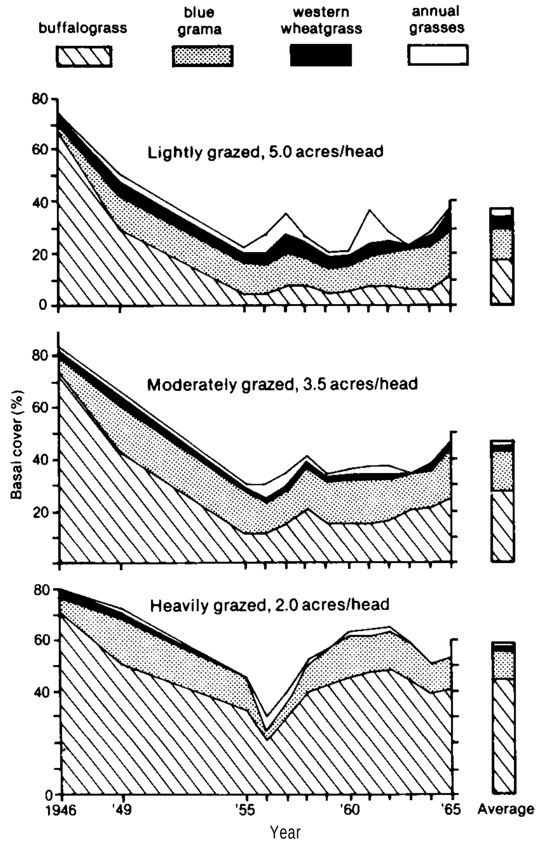


Figure 9. Percentages of ground covered by living plant bases (basal cover) of major species on clay upland shortgrass range near Hays stocked lightly, moderately, or heavily with yearling cattle May 1 to November 1, 1946 to 1956, and with yearling steers May 1 to October 1. 1956 to 1966. (Annual grasses under light and moderate grazing were mostly Japanese brome: under heavy grazing, little barley. Basal cover of forbs was not great enough to be shown on the small scale of the graphs.)

Table 1. Grass and forb average yields and amounts left at the end of the grazing season on three major Flint Hills bluestem range sites stocked heavily, moderately, and lightly with yearling steers May 1 to October 1, 1958 to 1966.

Range site	Range stocked		Group	Forage		
				Yield	Amount left	
	May 1-Oct 1	Acres/ head		lb dry matter/acre	lb dry matter/acre	%
Loamy upland	Heavily	1.75	Grass	3490	1220	35.0
			Forbs	560	190	33.9
			Total	4050	1410	34.8
	Moderately	3.30	Grass	3880	2250	58.0
			Forbs	370	170	45.9
			Total	4250	2420	56.9
	Lightly	5.00	Grass	4500	3100	68.9
			Forbs	400	140	35.0
			Total	4900	3240	66.1
Limestone breaks	Heavily	1.75	Grass	2340	830	35.5
			Forbs	460	200	43.5
			Total	2800	1030	36.8
	Moderately	3.30	Grass	2530	1750	69.2
			Forbs	370	180	48.6
			Total	2900	1930	66.6
	Lightly	5.00	Grass	3560	2410	67.7
			Forbs	340	120	35.3
			Total	3900	2530	64.9
Clay upland	Heavily	1.75	Grass	3850	1480	38.4
			Forbs	450	360	80.0
			Total	4300	1840	42.8
	Moderately	3.30	Grass	3150	1620	51.4
			Forbs	450	270	60.0
			Total	3600	1890	62.5
	Lightly	5.00	Grass	4210	2510	59.6
			Forbs	590	350	59.3
			Total	4800	2860	59.6
Average [1]	Heavily	1.75	Grass	3290	1190	36.2
			Forbs	510	240	47.1
			Total	3800	1430	37.6
	Moderately	3.30	Grass	3360	1970	58.6
			Forbs	390	200	51.3
			Total	3750	2170	57.9
	Lightly	5.00	Grass	4190	2780	66.3
			Forbs	430	190	44.2
			Total	4620	2970	64.3

1. Averages weighted according to relative proportion of the three range sites.

Table 2. Forage average yields and amounts left at the end of the grazing season on clay upland shortgrass range near Hays stocked heavily, moderately, and lightly with yearling steers May 1 to October 1, 1956 to 1966.

Range stocked		Forage			
		Group[1]	Yield	Amount left	
May 1-Oct 1	Acres/ head		lb dry matter/acre	lb dry matter/acre	%
Heavily	2.0	Buffalograss	1720	630	36.7
		Blue grama	490	160	32.7
		Western wheatgrass	50	10	20.0
		Annual grasses	70	10	14.3
		Total grass	2330	810	34.8
		Forbs	270	70	25.9
		Total forage	2600	880	33.8
Moderately	3.5	Buffalograss	1140	680	59.6
		Blue grama	1360	690	50.7
		Western wheatgrass	370	130	35.1
		Annual grasses	130	30	23.1
		Total grass	3000	1530	51.0
		Forbs	710	360	50.7
		Total forage	3710	1890	50.9
Lightly	5.0	Buffalograss	340	240	70.5
		Blue grama	1590	1040	65.4
		Western wheatgrass	1260	710	56.4
		Annual grasses	410	160	39.0
		Total grass	3600	2150	59.7
		Forbs	1020	610	59.8
		Total forage	4620	2760	59.7

1. At 2.0 acres/steer, annual grasses were mostly little barley, forbs were largely upright prairie-coneflower. At 3.5 and 5.0 acres/steer, annual grasses were mostly Japanese brome, forbs were practically all western ragweed.

Table 3. Crude protein and digestible energy in the diets selected by yearling steers (fitted with esophageal fistulas) compared with those measures of forage quality in samples hand-clipped from similar forage alongside the steers grazing on Flint Hills bluestem range during the months indicated, 1972.

	Measure of forage quality			
	Crude protein in		Digestible energy in	
Month	Hand clippings	Steer diets	Hand clippings	Steer diets
	% of dry matter			
Jun	5.84	8.84	47.34	50.44
Jul	5.36	8.35	48.48	52.87
Aug	4.01	6.23	41.65	42.04
Sep	3.91	6.16	42.03	45.27
Oct	2.74	5.12	38.82	40.79
Average	4.25	6.94	43.66	46.28

Table 4. Average daily gains of yearling steers on Flint Hills bluestem range stocked lightly. moderately, and heavily May 1 to October 1, 1950 to 1966.

Range stocked		Month					May-Oct average
		May	Jun	Jul	Aug	Sep	
May 1-Oct 1	Acres/ head	Yearling steer daily gain (lb/head)					
Lightly	5.00	1.99	1.71	1.37	1.21	1.34	1.52
Moderately	3.30	1.83	1.74	1.58	1.24	1.24	1.57
Heavily	1.75	1.86	1.75	1.28	1.16	1.10	1.43

Table 5. Soil moisture intake rate from simulated rain May 10, 1953, on clay upland shortgrass range near Hays that had been stocked heavily, moderately, and lightly with yearling cattle May Z to November 1, 1946 to 1954. (The grazing treatments caused differences in amounts of living vegetation.)

Range stocked		May 10, 1953	
		Soil-moisture intake	Living vegetation
May 1 - Nov 1	Acres / head	Inches / hour	lb dry matter / A
Heavily	2.0	0.73	560
Moderately	3.5	1.19	880
Lightly	5.0	1.58	1270

SECTION 2 *Deferred Grazing*

Throughout Kansas smooth brome, tall fescue, irrigated cool-season pasture, or winter cereals furnish early-spring grazing. All such pastures can be used much earlier than warm-season range and for some time after native vegetation starts growth, which lengthens the grazing season and increases carrying capacity over native ranges used alone.

For most efficient use by livestock, cool-season pastures usually are grazed from about March 15 to approximately June 1 in eastern Kansas and from about April 1 to near June 15 in western Kansas, so grazing native range is delayed until early to mid-June. Deferred grazing requires sacrifice of native range use during early growth, then stocking it above normal rates the remainder of the growing season. When grazing animals are restricted to early-spring pasture until after native-range growth is well under way, cool-season forages complement warm-season range (McIlvain 1976).

During a 12-year study at Manhattan, livestock gains per head were slightly higher and gains per acre were much higher from a system of deferred grazing on Flint Hills bluestem range complemented with smooth brome than from native range alone. Yearling steers gained an average of 1.32 pounds per head daily for 85 days on deferred range, compared with 1.17 pounds per head daily for 127 days on native range stocked season-long at normal rates. Proper timing in the utilization of early pasture and then of native range permitted the steers to graze both cool- and warm-season grasses when quality of each was ideal. That not only lengthened the total grazing season but rested warm-season range the first six weeks of the growing season each year.

To defer grazing warm-season range, any method of carrying livestock the first month and a half of the growing season may be used; livestock performance will depend on backgrounding and stocking rate.

Plant species composition on deferred range, was as good as or better than that on grassland stocked season-long. Grazing deferment tends to increase forage yields on depleted ranges, but it may have little or no advantage for top-condition ranges (Harlan 1960). Where range burning is customary, fire controls most woody plants and forbs. Because grazing animals prefer immature forbs to more mature ones, livestock are more likely to suppress growth of “weedy” vegetation under conservative season-long stocking than under deferred grazing. Yearly deferment and favorable soil moisture conditions early in the growing season may favor unusually high forb increases on most range sites that are not burned frequently.

Recommendations

- ***Graze cool-season forages from the time they start late-winter growth until June 1 to 15, depending on development of local vegetation. Move livestock to native range for the remainder of the intended grazing period.***
- ***Allow warm-season species in native range to grow about one and a half months before grazing.***
- ***Under deferred grazing, stock the entire system at rates about 30 percent higher than those considered normal for continuously grazed ranges.***
- ***If range burning is not practiced, rotate deferment among several units on range sites that become ‘weedier than usual” when not grazed season-long.***
- ***Compensate for grazing shortages by moving livestock to native range early, by selling marketable stock earlier than expected, or by taking livestock off late-summer range sooner than normal.***

SECTION 3 *Deferred-rotation Grazing*

Results of Kansas Research

A three-pasture rotation system was compared with season-long, continuous grazing from 1950 to 1967 at Manhattan (Figure 10). Concentrating livestock on two pastures to defer grazing on the third, and grazing the deferred pasture heavily the latter part of the growing season reduced gains of yearling steers an average of 23 pounds per head (Figure 11). Compared with season-long continuous grazing, average daily gains of steers in the deferred-rotation system decreased significantly after the first two months of the grazing season (Figure 12). The deferred-rotation system, however, favored desirable plant species (Figures 13 and 14), increased grass production, and decreased forb yields (Table 6).

Results of Nebraska Research

Stubbendieck et al. (1976) compared divisional rotation and season-long continuous grazing systems, with and without nitrogen fertilization, by stocking native ranges near Scottsbluff with yearling steers May 15 to September 15 from 1969 to 1977 (Figure 15). Adding 30 pounds of N per acre to range annually and grazing continuously produced highest average carrying capacities and livestock gains per head and per acre (pasture 2, Table 7). Gains per head and per acre were second highest in the fertilized set of the simple, four-division rotation system (pasture set 4). Among specialized systems without added N (pasture sets 3, 5, and 6), stocking rates and beef gains per acre exceeded those from unfertilized range grazed continuously (pasture 1), but only steers in pasture set 5 (complex rotation) gained more per head as well as per acre. Desirable cool-season grasses increased while warm-season ones decreased on ranges that received N or were used in complex rotation grazing systems. Nitrogen fertilization also stimulated large increases in broadleaf weeds.

Results of Oklahoma Research

Continuous April-to-October grazing was compared with seasonal rest-rotation grazing, 1942 to 1950, at Woodward (McIlvain and Savage 1951). In 1942, rotating steers among three divisions every two months lowered gains 51 pounds per head (Figure 16). To reduce detrimental effects on vegetation and cattle, rotation time was shortened to one month the next six seasons and to 15 days the seventh season. Also, after the 1942 grazing season, the design was changed to compare two-division rotations with continuous grazing (April to October) with yearling steers at both heavy and moderate stocking rates. Small, nonsignificant average-gain advantages were shown for continuous grazing-over short-interval rotations for the seven years (Figure 17). Rotationally grazed pastures, particularly heavily stocked ones, improved slightly-but-not enough to justify the added expense of rotation grazing. Later at Woodward, a rotation system involving a full year's rest was compared with continuous, year-long grazing (McIlvain and Shoop 1969). Steers grazing continuously outgained those on the alternate-year rotation by 22 pounds per head during the four-year study. Neither type of management affected range condition noticeably.

Using reproductive cow herds to compare year-long, continuous grazing with two-divisional rotational deferment (deferment alternated between units from about May 1 to June 10 each year for four years) in further work at Woodward, McIlvain et al. (1955) found that under that rotation system, cows calved one to two weeks later and their calves weighed 40 to 50 pounds less at weaning than did those under continuous, year-long grazing (Table 8).

None of the following systems was superior to continuous, yearlong grazing at Woodward: (1) Summer and winter grazing separately; (2) alternate-year grazing; (3) three-unit rotations with rotations at two months, one month, 15 days, or 10 days; (4) two unit-one herd rotation every six weeks when grass was growing; or (5) six unit-one herd rotations every six days (McIlvain and Shoop 1969).

Major Conclusions from Research on Grazing Systems

The indicated increase in carrying capacity shown by the deferred-rotation system studied in Flint Hills bluestem at Manhattan was approximately 16 percent. Considering that under deferred-rotation grazing, yearling steers gained an average of 23 pounds per head less than did those under continuous grazing stocked at the same rate, "stocking up" to take advantage of increased carrying capacity would have further reduced individual gains while possibly increasing gains per acre.

Livestock performance per head is a function of stocking rate rather than of range condition (Harlan 1960). Increasing stocking rates to take advantage of improved range condition increases livestock gain per acre but reduces individual animal performance. Usually it is most profitable to stock range for maximum individual animal performance, with as many individuals as possible making top performance (reproductive efficiency, weaning weight, gain per head). It is unrealistic to assume that increased gain per acre will compensate for reductions in gain per head, unless livestock market prices and production costs are compatible.

In planned grazing systems, as with other methods of managing livestock on range, the practicality of procedures that increase carrying capacity and/or livestock production must be evaluated on the basis of livestock market prices, production per animal, production costs (fertilization, expansion of facilities, additional labor and management costs, etc.), and the role of such systems in integrated livestock production programs. Profitability of livestock gains on range may depend on compensatory gain efficiency of young animals and cost items in the total livestock production enterprise.

Rotational deferment and seasonal rest-rotation systems tend to increase forage production compared with moderate, continuous grazing, but under most seasonal rest-rotation systems livestock performance is commonly reduced (grazing systems research reviewed by Hickey 1969; Herbel 1971; Shiflet and Heady 1971). Shiflet and Heady (1971) stated: "Apparently the systems that disturb livestock the least combine the advantages to livestock of continuous grazing and the advantages to pastures of no grazing." Their conclusion: "A review of the literature plus considerable field experience leads us to view specialized grazing systems with a certain amount of skepticism and to question, in particular, their wholesale use." Table 9 briefly describes major grazing systems.

Recommendations

- ***Poor-condition range probably benefits more from deferred-rotation grazing at stocking rates commensurate with optimum livestock performance than does comparably stocked range in good-to-excellent condition. Therefore, consider current range condition when contemplating specialized grazing systems.***
- ***In so far as possible, base stocking rates on livestock performance and attempt to arrive at the optimum production per head in relation to beef production per acre.***
- ***To resolve grazing-distribution problems that cannot be overcome by conventional livestock distribution measures, force animals to use the entire range more uniformily by cross-fencing. Place division fences so that resulting units will be of optimum size. Pay particular attention to livestock watering developments, and relative location of under- and overused areas. Stock each range unit simultaneously or in a deferred-rotation system, depending on the adaptability of management options and livestock performance (in relation to grazing system) during two or three seasons.***
- ***Avoid moving livestockfrom relatively immature to mature vegetation.***
- ***Adapt all grazing systems to the nutritional and reproductive needs of livestock.***

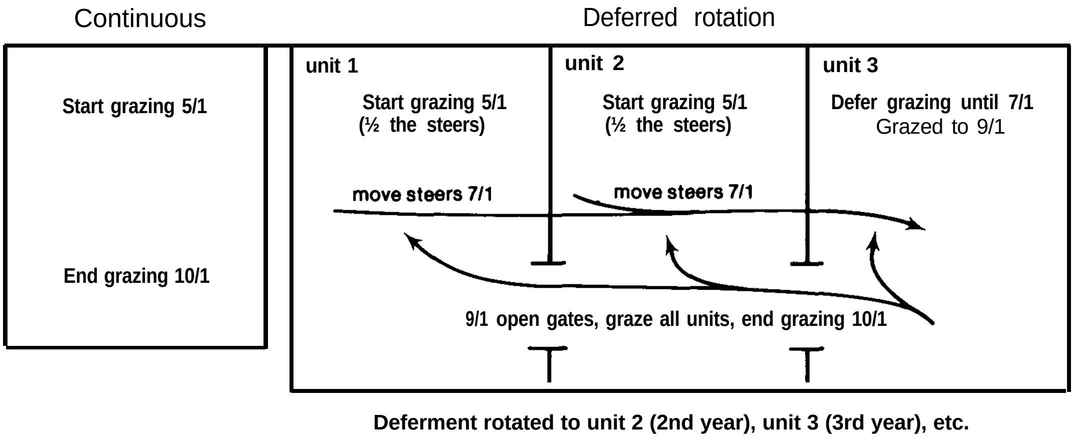
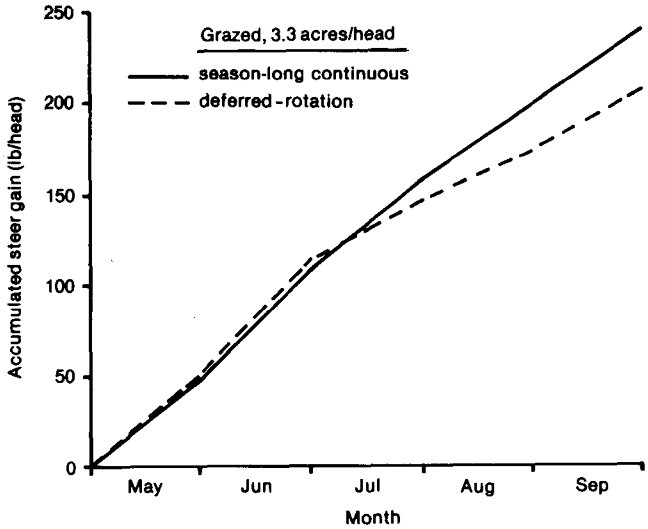
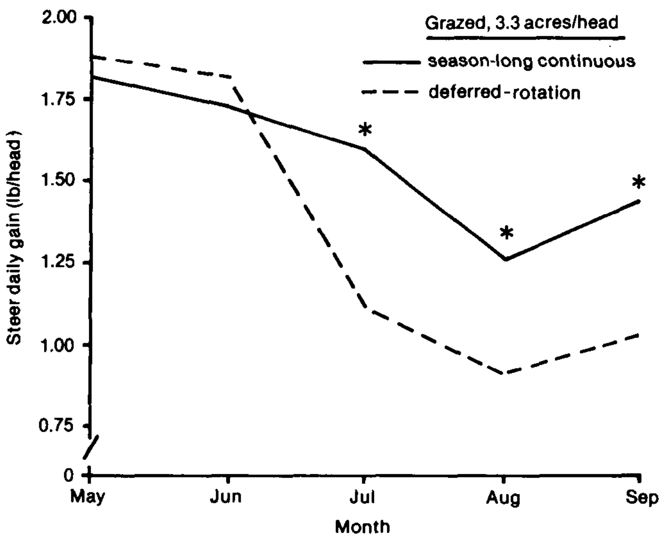
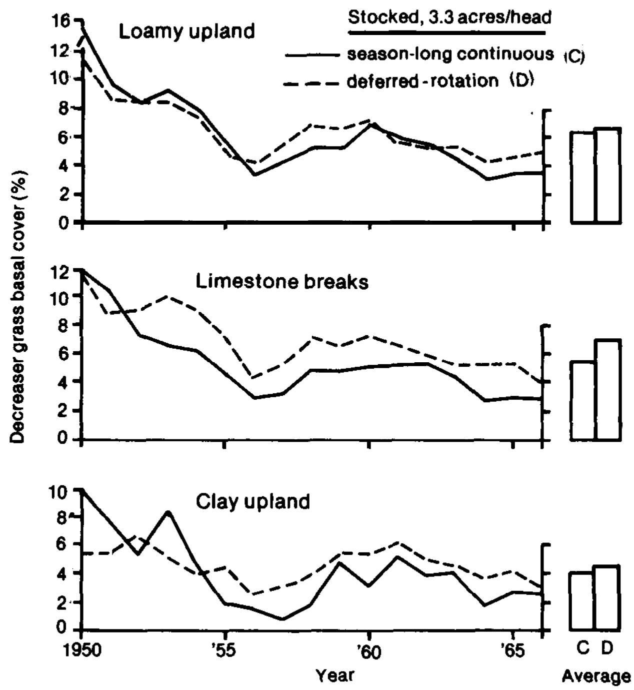


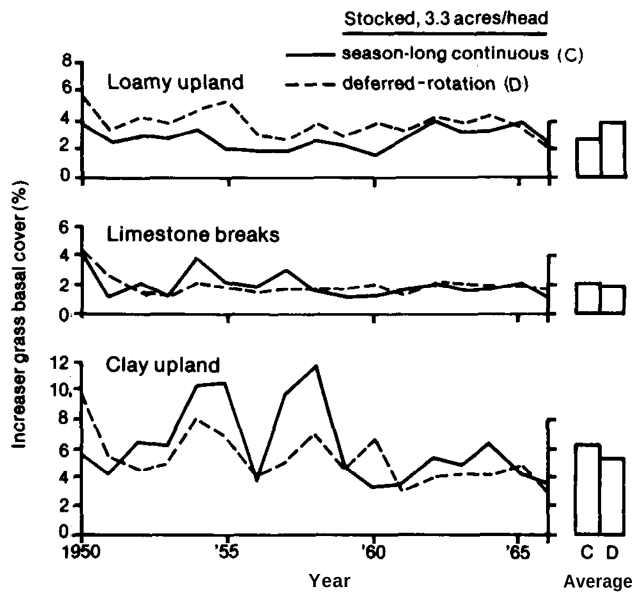
Figure 10. Experimental design to compare yearling steer gains and vegetation responses in season-long grazing systems on Flint Hills bluestem range stocked at 3.3 acres per head May 1 to October 1, 1950 to 1967. Treatments: Grazed continuously; and grazed in a seasonal deferred-rotation system.



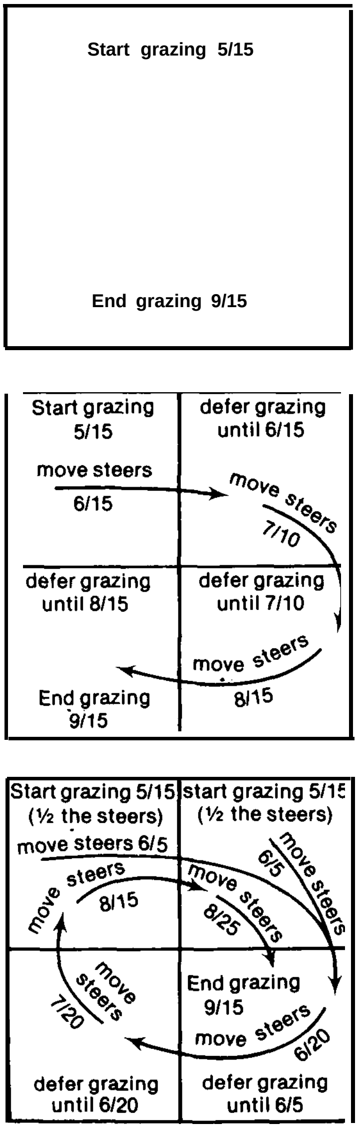


*Figures 11 and 12 (top and bottom respectively). Average gains (Fig. 11) and average daily gains (Fig. 12) of yearling steers on Flint Hills range stocked season long, continuously, or in a seasonal deferred-rotation system May 1 to October 1, 1950 to 1967. * = Differences between daily gains in a given month that are significant (p < 0.05).*





Figures 13 and 14 (top and bottom, respectively). Percentages of ground covered by living plant bases (basal cover): (Fig. 13) of desirable grasses (primarily big bluestem, indiangrass. and little bluestem) classed as decreasers and (Fig 14) of grasses (primarily tall dropseed, Kentucky bluegrass, and sideoats grama) classed as increasers that replace desirable decreaser grasses-on Flint Hills bluestem range stocked with yearling steers season long continuously, or in a seasonal deferred-rotation system May 1 to October 1, 1950 to 1967.



Continuous

Grazing system for pastures 1 and 2,
1 not fertilized
2 fertilized with N.

Simple deferred rotation

Grazing system for pasture sets 3 and 4,
3 not fertilized
4 fertilized with N.

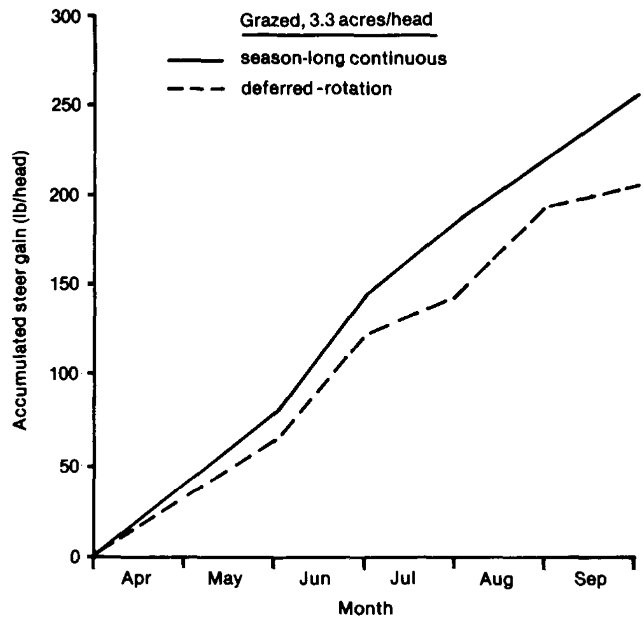
Grazing sequence rotated one pasture each year.

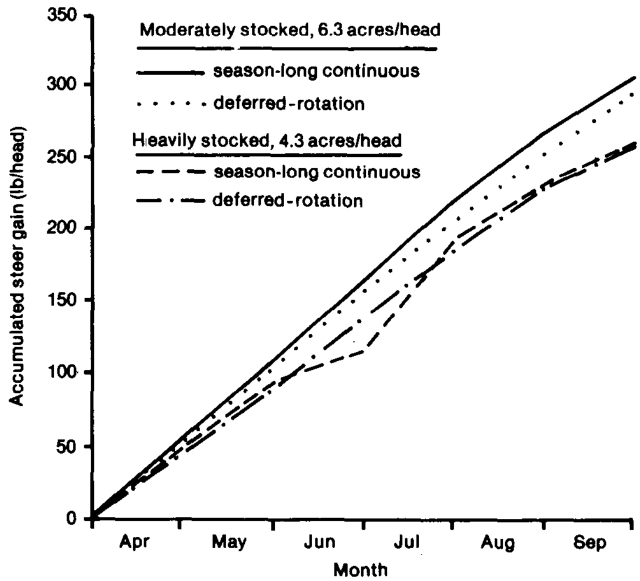
Complex deferred rotation

Grazing system for pasture sets 5 and 6, neither fertilized.

Grazing sequence rotated one pasture each year

Figure 15. Experimental design to compare yearling steer gains and vegetation responses in season-long grazing systems on native range near Scottsbluff, Nebraska, May 15 to September 16, 1969 to 1977. Treatments: Pasture 1 grazed season long continuously, without N fertilization; Pasture 2 grazed season long continuously, range fertilized with N: Pasture set 3 simple deferred rotation, without N fertilization; Pasture set 4 simple deferred rotation, range fertilized with N; and Pasture sets 4 and 5 complex deferred rotations (both replications without N fertilization). See Table 7 for N fertilization and stocking rates. (Adaptedfrom Stubbendieck 1976.)





Figures 16 and 17 (top and bottom, respectively). Average gains of yearling steers on native range near Woodward, Oklahoma: (Fig. 16) on range stocked season long continuously or in a seasonal three-division deferred rotation, April 1 to October 1, 1942-steers rotated every 2 months among the three divisions of the deferred-rotation system: and (Fig. 17) on range stocked moderately or heavily season long continuously or in seasonal two-division deferred rotations. April 1 to October 1. 1943 to 1950-steers rotated monthly within each two-division deferred-rotation system. (Adapted from McIlvain and Savage 1951.)

Table 6. Grass and forb average yields on indicated Flint Hills bluestem range sites grazed by yearling steers season long continuously and in a seasonal deferred-rotation system. May 1 to October 1, 1950 to 1967.

Forage group	Grazing	Range site: Loamy upland	Limestone breaks	Clay upland	Average[1]
	3.3 acres/head	Yield (lb/acre, air-dry)			
Grass	Season-long, continuous	3920	2560	3160	3390
	Deferred rotation	4250	3400	3970	3970
Forbs	Season-long, continuous	300	340	490	360
	Deferred rotation	270	160	340	260

1. Averages weighted according to relative proportion of the three range sites.

Table 7. Grazing systems, nitrogen fertilization, average stocking rates, and yearling steer average gains on native range near Scottsbluff, Nebraska, May 15 to September 15, 1969 to 1977. (Adapted from Stubbendieck 1976.)

Pasture & pasture set	Grazing management May 15-Sep 15	Nitrogen applied annually	Average stocking rate	Average steer gain	
Number	System	lb N/acre	Acres/steer	lb/ head	lb/acre
1	Season long, continuous	0	6.2	203	33.2
2	Season long, continuous	30	4.5	222	50.1
Set 3	Simple rotation, 4 division	0	5.6	195	35.3
Set 4	Simple rotation, 4 division	30	5.2	213	44.3
Set 5	Complex rotation, 4 division	0	5.3	208	39.8
Set 6	Complex rotation, 4 division	0	5.8	195	35.3

Table 8. Average stocking rates, calving dates, weaning weights, cow weights, and vegetation responses on native range near Woodward, Oklahoma, under year-long continuous grazing and under year-long grazing including rotational deferment May 1 to June 10, 1952 to 1956. (Adapted from McIlvain et al. 1955.)

Item	Grazing system: Year-long continuous grazing	Year-long with May 1-Jun 10 rotational deferment[1]
Stocking rate, acres/cow	15.0	14.6
Calving date, month and day	3/22	4/02
Weaning weight, lb/calf	414	371
Cow weight, lb/head[2]		
Weaning weight, lb/calf	893	871
Cow weight, lb/head[2]	941	909
Range vegetation		
Species composition	Same under both grazing systems	
Forage yield	Same under both grazing systems	

1. Livestock confined to one-half of pasture May 1-June 10; confined to other half for 6 weeks or to end of summer, depending on amount of growth in deferred pasture. Deferment was rotated annually between pasture halves. Cattle were given entire pasture during seasonal drought and in winter.
2. No significant differences in cow weights between grazing systems.

Table 9. Grazing systems classified. (Adapted from Lewis 1969.)

Procedure[1]	System
I. All subunits grazed one or not more than two periods per year.	
A. Continuous occupation by grazing animals during the same grazing period each year.	
1. Growing season or year long.	Continuous grazing.
2. Early-season use of diverse types as they become available.	Seasonal suitability.
B. Grazing deferred on one or more subunits.	
1. Deferment not rotated.	Deferred grazing.
2. Deferment rotated.	
a. Grazed subunits used continuously.	Rotational deferment.
b. Grazing rotated in subunits.	Deferred rotation.
II. One or more subunits rested.	
A. Rest not rotated.	Range resting.
B. Rest rotated.	Rest rotation.
III. All subunits grazed more than twice a year.	Rotational grazing.

1. Variations of systems are discussed in the cited literature source.

SECTION 4 *Intensive Early Stocking*

Results of Kansas Research

Rate-of-stocking studies near Manhattan on Flint Hills bluestem range grazed May 1 to October 1 showed that yearling steers made approximately two-thirds of their total gain during the first half (May 1 to July 15) of the growing season from 1950 to 1967 (Table 10). Stocking heavier increased total beef production per acre but reduced individual animal gains during the five months or the summer grazing season. Gains per head, however, were not reduced by any increases in stocking rate from start of grazing until July 15; heavier stocking rates after July 15 decreased animal gains.

Research on intensive early stocking Flint Hills bluestem range compared season-long stocking (3.3 acres per yearling steer, May 1 to October 1, on both unburned and late-spring-burned range) with twice the normal season-long stocking rate (1.67 acres per yearling steer on late-spring-burned range) May 1 to July 15. In contrast with season-long grazing, intensive early stocking increased beef production 35 pounds per acre over gains from unburned range and 22 pounds per acre over gains from burned range (Table 11). During the first 10 weeks of the forage growing season, steers grazing intensively early-stocked range and those grazing all season on burned range gained the same up to July 15; so individual performance was not reduced by doubling the stocking rate the first half of the growing season.

The large increase in livestock gain per acre from intensive early stocking resulted from steers averaging 1.83 pounds per head daily for two and one-half months compared with only half as many animals averaging 1.30 pounds daily on burned range and 1.07 pounds daily on unburned range stocked season-long for five months (Table 12).

Perennial grass yields were slightly higher (Tables 13 and 14) and forb and brush production lower on range stocked intensively early in the growing season than on ranges grazed at the normal rate all season (Table 15).

Grass-stand composition steadily improved on range stocked intensively early and remained stable or deteriorated on ranges stocked all season (Tables 16, 17, and 18); forbs increased in the plant cover more under season-long stocking than under intensive early stocking (Tables 19 and 20).

Grazing distribution was more nearly uniform on range stocked intensively early in the season than on burned range stocked all season. Fuel for burning was distributed more uniformly on intensively early stocked range than on range grazed season long. Livestock concentration, shortness of grazing season, and evenness of burning probably interacted favorably to improve grazing distribution.

By the end of growing season, food reserves in big bluestem (a major constituent of Flint Hills bluestem range) did not differ between ranges stocked intensively early in the season and those stocked all season (Figure 18). That is, heavier-than-normal grazing each spring, followed by summer-fall resting, did not reduce range-plant vigor after three years.

Results of Colorado Research

Intensive early stocking (May 10 to August 11) and intensive late-season stocking (August 11 to November 11) on deferred range were compared with continuous stocking (May 10 to November 11) relative to livestock performance and range-plant production of major forage groups in a grazing experiment on the Central Plains Experimental Range, Nunn, Colorado, from 1943 to 1953 (Kipple 1964). Average monthly gains of yearling cattle per head (Figure 19) and beef production per acre (Figure 20) showed that intensive early stocking can be used on shortgrass range.

Herbage yields were essentially the same on all ranges except during the first year of the study, when the intensively early stocked one outyielded ranges stocked all season or intensively late in the season (Table 21).

Although concern was expressed about livestock trampling effects on vegetation and soils around the usual high-concentration points under intensive early-spring stocking (Klipple 1964), the results would appear to recommend intensive early stocking on shortgrass range of eastern Colorado. By taking proper steps to control possible blow-outs on highly unstable sandy soils, one could reasonably expect the system to apply throughout the central United States grasslands.

Recommendations

- ***Use stocker-type grazing animals for intensive earthy stocking: the system is suited for weaned livestock that is still growing, but it is not practical for reproductive stock.***
- ***In eastern Kansas, burn range in late spring (about May 1). Stock two times the normal seasonal rate for yearling animals from the beginning of the forage growing season to July 15, then move the livestock to other high-quality forage or to a feedlot.***
- ***On central and western Kansas ranges, where prescribed burning is not practiced, stock ranges at twice the normal rate for young animals at the***

beginning of the growing season. Start grazing in March or early April if western wheatgrass and annual grasses predominate; start in late April to early May if only warm-season species are present. Remove livestock about July 15; rest range until after fall dormancy. After November 1 to start of forage growth the next spring, use the carry-over old growth as a holding area for stockers as they are accumulated to be ready for intensive early stocking during the spring growing season. Graze winter range moderately (the range should have a patchy grazed appearance at the start of new growth) and supplement old growth by feeding livestock protein equivalent to five pounds per head daily of good-quality alfalfa hay.

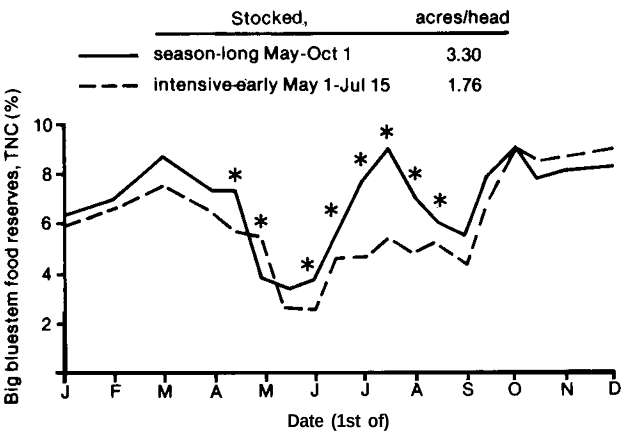
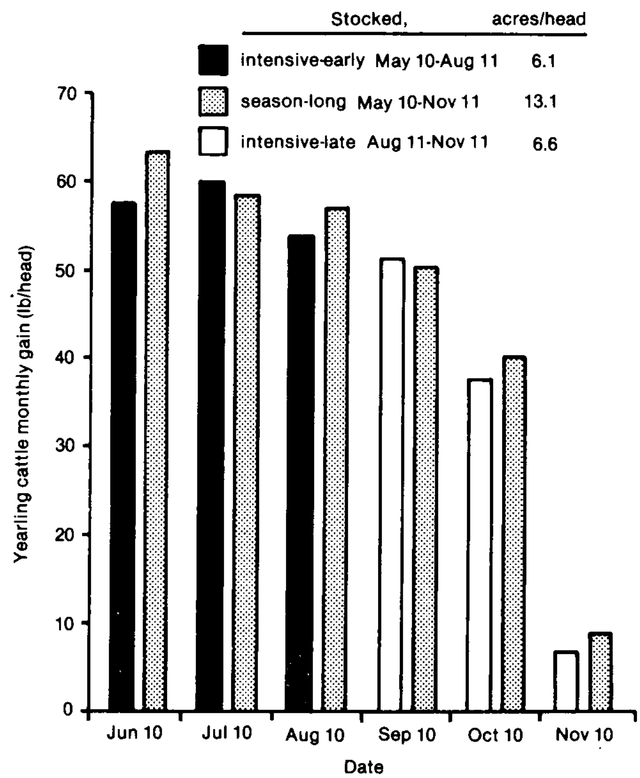
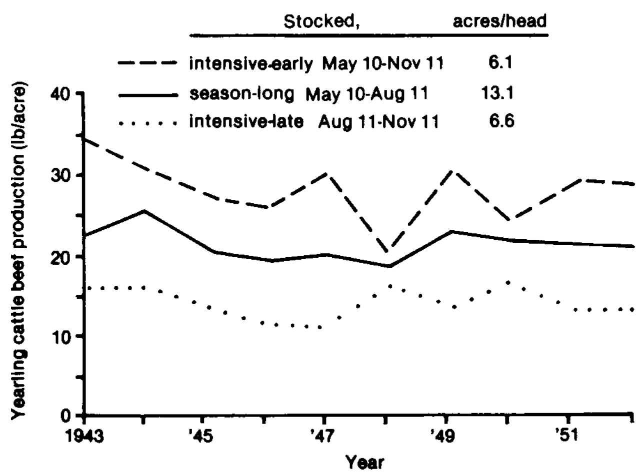


*Figure 18 (above). Percentage of average food reserves (total nonstructural carbohydrates, TNC) in big bluestem bases, 2 inches above the plant crowns, and attached rhizomes (underground stems), at dates indicated, on Flint Hills bluestem range under intensive-early or seaon-long stocking, 1972 to 1975. (Range burned annually in late spring, May 1.) * = Percentages of food reserves on those dates differ significantly ($p < 0.05$).*





Figures 19 and 20 (right; top and bottom, respectively). Average monthly gains (Fig. 19) and average beef production (Fig. 20) of yearling cattle on native range near Nunn, Colorado, under intensive-early, season-long, or intensive-late stocking. 1943 to 1953. (Adapted from Klipple 1964.)

Table 10. Average monthly gains of yearling steers on Flint Hills bluestem range near Manhattan stocked lightly, moderately, and heavily May 1 to October 1, 1950 to 1967.

Range stocked		Month					May-Oct total gain
		May	Jun	Jul	Aug	Sep	
May l-Oct l	Acres/head	Yearling steer monthly gain (lb/head)					
Lightly	5.00	62	51	42	38	40	233
Moderately	3.30	57	52	49	38	43	239
Heavily	1.75	58	52	40	36	33	219

Table 12. Daily gains of yearling steers (lb/head) on Flint Hills bluestem range under season-long and intensive-early stocking and indicated late-spring burning treatments, 1972 to 1977.

Year	Stocking system		
	Season-long May l-Oct 1, 3.30 acres/head		Intensive-early May 1-Jul 15, 1.67 acres/head
	Range not burned	Range burned May 1	Range burned May 1
	Yearling steer daily gain (lb/ head)		
1972	0.84	1.23	1.72
1973	0.90	1.06	1.51
1974	1.30	1.69	2.11
1975	1.17	1.18	1.78
1976	1.14	1.34	2.03
Average	1.07	1.30	1.83

Table 14. Average yields of perennial grass for three major Flint Hills bluestem range sites under season-long and intensive-early stocking with yearling steers. 1972 to 1975.

Range site	Stocking system	
	Season-long May 1-Oct 1, 3.30 acres/steer	Intensive-early May 1-Jul 15, 1.67 acres/steer
	Perennial grass yield (lb dry matter/acre)[1]	
Loamy upland	2480	2860
Limestone breaks	2190	2440
Clay upland	2270	2000
Average	2310	2500

1. Rangelate-spring burned annually May 1.

Table 1l. Beef production per acre by yearling steers on Flint Hills bluestem range under season-long and intensive-early stocking and indicated late-spring burning treatments, 1972 to 1977.

Year	Stocking system		
	Season-long May l-October 1, 3.30 acres/head		Intensive-early May l-July 15, 1.67 acres/ head
	Range not Burned	Range burned May 1	Range burned May 1
	Yearling steer beef production (lb/acre)		
1972	30	56	79
1973	41	48	72
1974	61	79	94
1975	48	49	70
1976	54	63	93
Average	47	59	82

Table 13. Yields of perennial grass averagedfor three major Flint Hills bluestem range sites and for years indicated, under season-long and intensive-early stocking with yearling steers, 1972-1975.

Year	Stocking system	
	Season-long May 1 -0ct 1, 3.30 acres/steer	Intensive-early May 1-Jul 15, 1.67 acres/steer
	Perennial grass Yield (lb dry matter/acre)[1]	
1972	2150	2280
1973	2540	2490
1974	2250	2730
Average	2310	2500

1. Rangelate-spring burned annually May 1

Table 15. Combined yields of major perennial forb and brush species on grazed and ungrazed areas averaged for three major Flint Hills bluestem range sites and, for years indicated, under season-long and intensive-early stocking with yearling steers, 1972 to 1975.

Area	Year	Stocking system	
		Season-long May 1-Oct 1, 3.30 acres/ steer	Intensive-early May 1-Jul 15, 1.67 acres/ steer
		Perennial forb + brush yield (lb dry matter/acre)[1]	
Grazed	1972	310	140
	1973	290	270
	1974	280	370
	Average	290	260
Not grazed	1972	430	210
	1973	570	320
	1974	410	520
	Average	470	350

1. Range late-spring burned annually May l.

Table 16. Percentage of ground covered by big bluestem living-plant bases (basal cover) averaged for three major Flint Hills bluestem range sites before grazing treatments were started in 1971; and in 1975, after four grazing seasons under season-long and intensive-early stocking with yearling steers, 1972 to 1976.

Year	Stocking system: Season-long May 1-Oct 1, 3.30 acres/steer	Stocking system: Intensive-early May 1-Jul 15, 1.67 acres/steer
	Big bluestem basal cover(%)[1]	
1971	1.10	1.31
1975	1.66	2.71
Change	+ 0.56	+ 1.40

1. A major desirable Flint Hills grass. Range late-spring burned annually May 1

Table 17. Relative percentages of big bluestem and little bluestem in the total plant ground cover (species composition) averaged for three major Flint Hills bluestem range sites before grazing treatments were started in 1971; and in 1975, after four grazing seasons under season-long and intensive-early stocking with yearling steers, 1972 to 1976.

Grasses[1]	Year	Stocking system: Season-long May 1-Oct 1, 3.30 acres/steer	Stocking system: Intensive-early May 1-Jul 15, 1.67 acres/steer
		Species composition (%)[2]	
Big bluestem	1971	28.9	26.0
	1975	21.7	30.8
	Change	- 7.6	+ 4.8
Little bluestem	1971	15.5	11.9
	1975	11.0	10.8
	Change	- 4.5	- 1.1

1 Major desirable Flint Hills grasses.
2. Range late-spring burned annually May 1

Table 18. Percentage of ground covered by living plant bases (basal cover) of Kentucky bluegrass on each of three Flint Hills bluestem range sites before grazing treatments were started in 1971; then in 1975, after four grazing seasons under season-long and intensive-early stocking with yearling steers, 1972 to 1976. (Range late-spring burned annually May 1.)

Range site	Year	Stocking system: Season-long May 1-Oct 1, 3.30 acres/steer	Stocking system: Intensive-early May 1-Jul 15, 1.67 acres/steer
		Basal cover of Kentucky bluegrass(%)	
Loamy upland	1971	0.18	0.60
	1975	1.01	0.86
	Change	+ 0.83	+ 0.26
Limestone breaks	1971	0.12	0.20
	1975	0.17	0.14
	Change	+ 0.05	- 0.06
Clay upland	1971	0.37	0.76
	1975	1.10	0.64
	Change	+ 0.73	- 0.12

Table 19. Ground covered by perennial forb living-plant bases (basal cover) averaged for three major Flint Hills bluestem range sites before grazing treatments were started in 1971; then in 1975, after four grazing seasons under season-long and intensive-early stocking with yearling steers, 1972 to 1976. (Range late-spring burned annually May 1.)

Year	Stocking system: Season-long May 1-Oct 1, 3.30 acres/steer	Stocking system: Intensive-early May 1-Jul 15, 1.67 acres/steer
	Forb basal cover (%)	
1971	0.21	0.23
1975	0.89	0.50
Change	+ 0.68	+ 0.27

Table 20. Relative percentages of perennial forbs in the total plant ground cover (species composition) on each of three Flint Hills bluestem range sites before grazing treatments were started in 1971; then in 1975, after four grazing seasons under season-long and intensive-early stocking with yearling steers, 1972 to 1976. (Range late-spring burned annually May 1.)

Range site	Year	Stocking system: Season-long May 1-Oct 1, 3.30 acres / steer	Stocking system: Intensive-early May 1-July 15, l.67 acres / steer
		Perennial forbs in species composition (%)	
Loamy upland	1971	4.1	6.9
	1975	13.3	5.8
	Change	+ 9.2	- 1.1
Limestone breaks	1971	5.1	3.9
	1975	9.4	5.7
	Change	+ 4.3	+ 1.8
Clay upland	1971	8.5	4.3
	1975	11.4	5.0
	Change	+ 2.9	+ 0.7

Table 21. Yields of major forage groups on native range near Nunn, Colorado, under intensive-early, season-long, and intensive-late stocking with yearling cattle, 1943 to 1953. (Adaptedfrom Klipple 1964.)

Forage group[1]	Year	Stocking system: Intensive-early May 10-Aug 11, 6.1 acres/head	Stocking system: Season-long May 10-Nov 11, 13.1 acres/head	Stocking system: Intensive-late Aug 11-Nov 11, 6.6 acres/head
		Forage yield (lb/acre, air-dry)		
Short grasses and sedges	1943	712	498	743
	1949	514	381	467
	1950	460	305	499
	1951	601	403	481
	1953	535	602	653
	Average	564	438	569
Mid grasses	1943	206	231	230
	1949	137	171	183
	1950	83	128	173
	1951	99	133	193
	1953	20	92	88
	Average	109	151	173
Total forage	1943	918	729	973
	1949	651	552	650
	1950	543	433	672
	1951	700	536	674
	1953	555	694	741
	Average	673	589	742

1. Short grasses and sedges: blue grama, buffalograss, and fine-leaf sedges. Mid grasses: western wheatgrass, needle-and-thread, sand dropseed, alkali sacaton, inland saltgrass. little bluestem. prairie sandreed, and sideoats grama.

SECTION 5 *Prescribed Burning*

Fire has always occurred on grasslands; in recent times it has been used as a management practice to increase livestock production and maintain high-quality rangeland. Prescribed burning has been researched on Flint Hills bluestem range near Manhattan since the early l900s, on various range sites in central Kansas since 1971, and on clay upland shortgrass range near Hays since 1975.

Burning bluestem range May 1, after spring growth had started, had no major effects on forage quality or the chemical composition of yearling steer diets from May 1 to October 1 (Table 22). Although yearling steers selected forage higher in crude protein and lower in lignocellulose than in samples hand-clipped (on both burned and unburned range), they also took in larger proportions of lignin and relatively indigestible cell-wall constituents. There was little difference in apparent digestibility of steer diets on unburned or burned range, yet animals on range burned in late spring gained approximately 11 percent more than did those on unburned range (Figure 21). The differences in livestock performance, despite similarities in diet composition, indicated that forage intake by yearling steers was greater on burned than on unburned range.

On grazed areas, forage yields were similar on unburned range and grassland burned in late spring (May l), but yields were reduced by burning in mid spring (April 10) or early spring (March 20) (Figure 22); forb yields were lower on range burned in late spring than on range unburned or burned earlier in the spring (Figure 23).

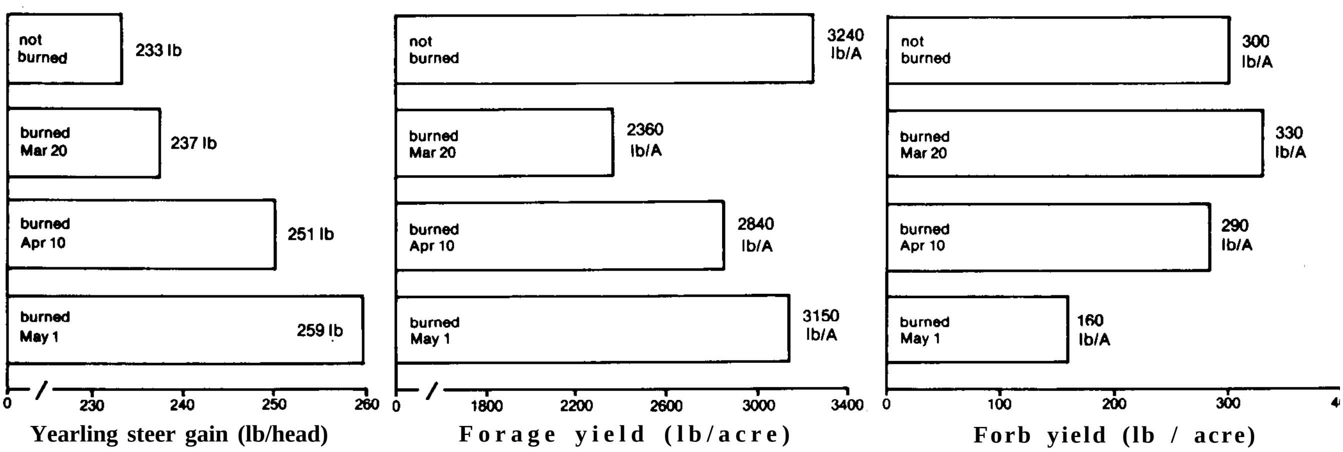
Amounts of soil moisture in the upper five feet of a loamy upland range site correlated well with range forage production (Figure 24). Areas not burned and those burned in early or mid spring generally had less soil moisture than did those burned in late spring (May 1), the ideal time to bum considering range forage production and livestock gains.

Burning ungrazed Flint Hills bluestem range annually in early winter to mid spring for 46 years tended to increase pH, organic matter, and exchangeable elements (calcium, magnesium, and potassium) of the soil, but late-spring burning (May 1, the optimum date) annually for that long had no important effect on soil chemical properties (Table 23). Annual late-spring burning under season-long moderate grazing for 22 years, however, caused increases in soil pH and decreases in organic matter, exchangeable magnesium, available phosphorus, and total nitrogen (Table 24). Such slow rates of chemical change suggested that late-spring burning annually probably never would result in irreversible adverse effects on Flint Hills bluestem range.

Late-spring burning consistently produced a more desirable plant-species composition than did burning earlier or not burning (Table 25). Ground covered by living plant bases of big bluestem and indiangrass was greater on late-spring burned range than on range burned earlier or not burned; ground cover of little bluestem was unchanged except by early-spring burning, which reduced it (Figure 25). Low-producing Kentucky bluegrass (Figure 26) and naturalized annual species (Figure 27)-cool-season grasses-were essentially eliminated on burned sites, as indicated by reduced ground cover regardless of time rangeland was burned. Basal cover of perennial forbs was reduced by late-spring burning (Figure 28).

Late-spring burning effectively controlled eastern redcedar, buckbrush, and most other undesirable woody plants except smooth sumac, which maintained itself regardless of date range was burned (Section 8, **Woody Plant Control).**

Late-spring burning of Flint Hills bluestem range also improved grazing distribution, because livestock sought vegetation that developed after the fire in preference to vegetation on areas heavily grazed the previous season but not burned because of insufficient grass left for fuel.



Figures 21, 22, 23. Average gains per head of yearling steers (Fig. 21, left), average yields of forage (Fig. 22, center), and average yields of forbs (Fig. 23, right) on Flint Hills bluestem range; unburned and burned annually in early spring (March 20), mid spring (April 10), or late spring (May 1); range stocked moderately with yearling steers (3.3 acres/head) May 1, 1950 to 1967.

Precautions

Frequent range burning is recommended for the Flint Hills and other areas in eastern Kansas. Currently, prescribed burning of ranges in central and western Kansas is for special purposes or is still experimental. (See Sections 7 and 8.)

- ***Carefully plan prescribed burning and have the utmost respect for maintaining control of vegetation fires. Sufficient fire-control equipment is a must: at least two spray rigs (one along each fire line) are necessary. Fire***

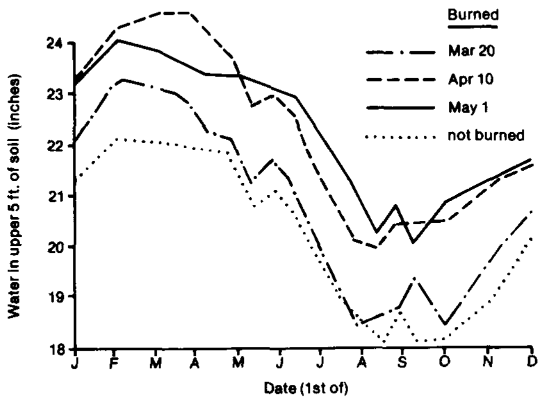


Figure 24. Year-long changes in average soil moisture (in the upper 5 feet of soil) of a Flint Hills bluestem. loamy, upland range site; unburned and burned annually in early spring (March 20) mid spring (April 10), or late spring (May 1) and stocked moderately with yearling steers (3.3 acres/head) May 1 to October 1, 1961 to 1967.

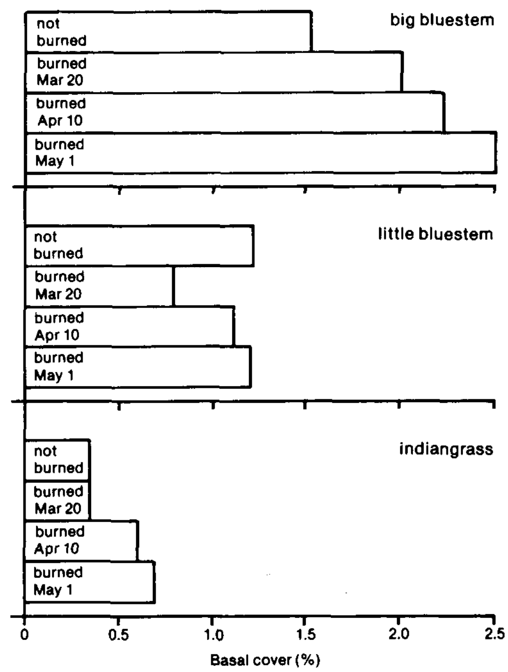
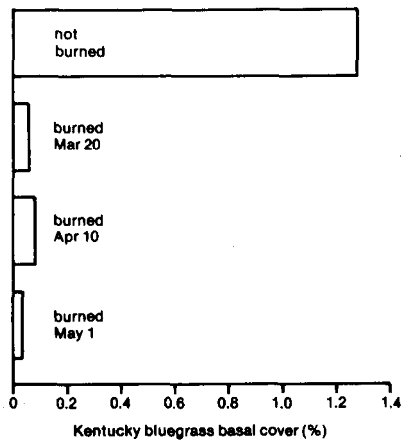
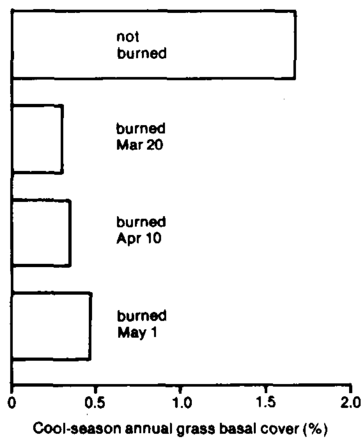
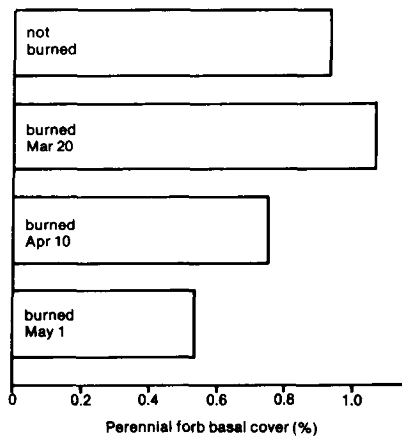


Figure 25 (right, above) and Figures 26, 27, 28 (below, left to right). Percentages of ground covered by living plant bases (basal cover): (Fig. 25) of big bluestem, little bluestem, and indiangrass: (Fig. 26) of cool-season Kentucky bluegrass: (Fig. 27) of cool-season annual grasses: and (Fig. 28) of perennial forbs-all on Flint Hills bluestem range, unburned and burned annually in early spring (March 20), mid spring (April 10). or late spring (May 1). Range stocked moderately with yearling steers (3.3 acres/head) May 1 to October 1, 1950 to 1967.







can be spread uniformly along fire lines most efficiently by using 'drip torches " that distribute a mixture of gasoline and dieselfuel. (Dieselfuel in the mixture produces residual flames, generally needed to ignite vegetation under controlled burning conditions.)

- *Notify all neighbors and the ruralfire district of your intention to burn.*
- *If smoke might present a traffic hazard, notify the proper law-enforcement agencies.*
- *Obtain from your local county extension agent the latest State Department of Health rules and regulations pertaining to agricultural burning.*
- *Monitor weather reports several days before the tentative date of burning; obtain both short- and long-range forecasts.*

Time of burning

- *Burn range concurrently with start-of-growth of the major warm-season perennial grasses, which generally is late April in northern Kansas and mid-to-late April in southern Kansas.*
- *Burn range under as ideal conditions as possible-when there is a moist mulch, winds are steady at 5 to 20 miles per hour, and the day is clear and air temperatures are mild.*
- *DO not start broadcast burning on a calm day or when there are only intermittent shifting breezes. In addition to difficulties in getting a fire to move and generate heat, burns started under those conditions are subject to being blown out of control if a wind should come up suddenly from an unexpected direction. Furthermore, temperatures too cool or too hot will retard the fire or increasefire intensity beyond control.*

Method of burning

- *Use natural firebreaks, including roads, trails, and cowpaths along fence rows, when possible.*
- *In open grassland, spread fire slowly and extinguish the flames outside the fire lines with motorized water-spraying equipment.*
- *Use appropriate means to remove woody vegetation along fire lines and preburn it under low, wildfire-hazard conditions.*
- *Follow the steps illustrated in Figure 29.*

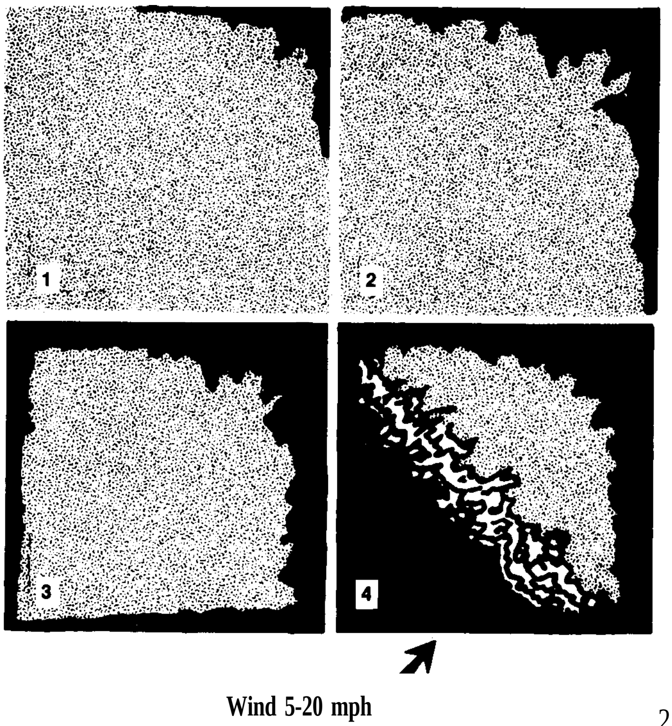


Figure 29. Proper method to burn rangeland:

1. *Start a backfire at the farthest point downwind.*
2. *Spread fire simultaneously each direction from starting point along downwind sides.*
3. *After the backfire has burned 50 to 100 feet into the wind, bring fire around windward sides and ignite at a quickened, steady pace.*
4. *Allow the fire to sweep with the wind across the major part of the area.*

For grassland fires use natural firebreaks including roads. trails, and fenceline cowpaths; or create firebreaks while burning by spreading fires slowly from point of origin and extinguishing flames outside the intended firelines with motorized water-spraying equipment.

Avoid woody vegetation along downwind firelines, or remove trees and shrubs mechanically and bum safe firebreaks under low wildfire-hazard conditions before broadcast burning entire area.

Spread fire with drip torches to increase ease and continuity of ignition along firelines.

Table 22. Percentages of chemical constituents of forages, averaged over five months (May to October), in diets selected by yearling steers (fitted with esophageal fistulas) and in samples clipped by hand to simulate diets selected by the steers on unburned Flint Hills bluestem range, compared with late-spring burned range, 1972.

Chemical composition of forage sample	Method of collecting forage sample on range: Selected by steers: Not burned	Selected by steers: Burned May 1	Clipped by hand: Not burned	Clipped by hand: Burned May 1
Partial analysis	% of dry matter[1]			
Least digestible				
Neutral detergent fiber (cell-wall constituents)	80.70	82.41	77.74	74.99
Acid detergent fiber (lignocellulose)	52.97	51.39	81.70	76.57
Lignin	12.75	11.35	7.05	6.24
Most digestible				
Crude protein	10.24	10.95	5.30	5.86
Neutral detergent solubles (cell contents)	31.37	29.99	51.12	52.48
Hemicellulose	24.50	28.08	31.80	31.97
Cellulose	35.14	34.49	34.77	32.56
Apparent digestibility				
Total dry matter	49.76	49.16	- -	- -

1. Percentages. within each method of collecting forage samples, underscored by the same line do not differ significantly (P< 0.05).

Table 23. Average soil reaction, organic matter, exchangeable calcium and magnesium, and available phosphorus in the top 3 feet of soil, plus total nitrogen and exchangeable potassium and bulk density in the top 3 inches of soil for Flint Hills bluestem range, unburned and burned annually on dates indicated and protectedfrom livestock grazing, 1926 to 1972.

Range burned: Season	Date	3 feet: Soil reaction	Organic matter	Exchangeable Ca	Exchangeable Mg	Available P	3 inches: Total N	Exchangeable K	Bulk density
		pH	Parts/million				Parts/million		Grams/cc
Early winter	Dec 1	6.07	25,100	2,510	534	1.15	2,160	965	1.082
Early spring	Mar 20	6.02	25,700	2,210	473	1.15	2,360	929	1.037
Mid spring	Apr 10	6.05	23,000	1,910	454	1.24	2,210	930	1.051
Late spring	May 1	5.85	23,100	2,000	479	1.09	2,010	839	1.093
Not burned		5.83	23,300	2,040	443	1.14	2,360	862	1.093

Table 24. Average soil reaction, organic matter, exchangeable calcium, magnesium and potassium, available phosphorus, and total nitrogen, in the top 3 feet of soil in Flint Hills bluestem range, unburned and late-spring burned annually and stocked moderately with yearling steers (3.3 acres/head) May 1 to October 1, 1950 to 1972.

Range burned		Depth of soil samples, 0-3 feet						
		Soil reaction	Organic matter	Exchangeable Ca	Exchangeable Mg	Exchangeable K	Available P	Total N
Season	Date	pH	Parts/million					
Late spring	May 1	6.66	30,000	4,048	741	593	2.21	1,460
Not burned		6.41	34,000	3,774	548	638	3.31	1,690

Table 25. Relative percentages of principal decreaser and increaser grasses in the total plant ground cover (species composition) averaged for three major Flint Hills bluestem range sites under unburned and annual burning treatments indicated and moderate stocking with yearling steers (3.3 acres/head), May 1 to October 1. 1950 to 1967.

Reaction of plants to grazing	Plants	Spring burned: Early, Mar 20	Spring burned: Mid, Apr 10	Spring burned: Late, May 1	Not burned
		Average species composition (%)[1]			
Decreasers	Big bluestem	23.0	23.6	28.4	16.0
	Little bluestem	9.4	11.5	13.9	13.0
	Indiangrass	4.0	5.8	4.5	3.7
	Switchgrass	0.8	0.6	1.5	0.7
	Other decreasers	1.2	0.6	0.2	0.0
	All decreasers	38.4	42.1	48.5	33.4
Increasers	Sideoats grama	11.5	8.6	9.5	8.4
	Blue & hairy grama	19.3	15.7	12.6	3.1
	Buffalograss	8.3	13.1	11.7	11.6
	Kentucky bluegrass	0.4	0.5	0.4	10.8
	Other increasers	0.4	4.7	0.8	4.7
	All increasers	42.9	42.6	35.1	38.6

1. Average species composition on loamy upland, limestone breaks, and clay upland (including clay pan) range sites combined.

SECTION 6 *Wildfire*

Each year throughout Kansas untimely accidental range fires occur, generally from late fall to mid spring when vegetation is dormant, humidities are low, soil surfaces are dry, and wind velocities are above average. Some grass crowns and tillers may be killed by heat or combustion under smoldering organic material, but major detrimental effects appear to be associated with exposure of dormant plant-regenerative tissue to winter weather extremes, soil moisture evaporation, and the puddling action of early-spring rains especially on bare, fine-textured soils.

Near Hays in 1959, all plants that grew on range burned by wildfire in early spring were shorter than plants on nearby unburned range (Table 26) - which indicated that reduced soil-moisture intake on early-burned range, coupled with exposure, lowered plant vigor and hence forage yields (Figure 30). Timely range burning generally favors native perennial grasses and decreases other kinds of plants (see Sections 7 and 8), but fall to mid-spring fires may interact with spring weather conditions to increase less desirable plants. Contiguous wildfires near Hays, one in November and the other in March, resulted in yield differences of western ragweed the next growing season (Hopkins et al. 1948).

Management of ranges burned from late fall to mid spring, whether planned or accidental and regardless of location, may require adjustments in stocking rates for one or more seasons - because of reduced forage yields - (Table 27). Livestock grazing range only partly burned, avoid unburned sites and concentrate on burned areas. To circumvent that, the remaining old growth should be burned at the proper time (late spring, after new growth has started), mowed closely from mid to late April, or fenced and grazed separately one to three seasons. Another alternative is to reduce stocking to what the burned areas will carry until grazing distribution from the fire is no longer a problem. If one of those choices is not used, the heavy grazing for several seasons after the fire may result in further, long-lasting damage to the parts of the range burned by wildfire.

Recommendations

- ***Wildfires frequently do not take in an entire range unit. Prevent livestock from concentrating on burned parts of range by burning or mowing significant "missed" areas from mid to late April (in southeastern Kansas) to late April-early May (in northwestern Kansas), or by adjusting stocking rates to the carrying capacity of the burned area untilfire-caused livestock-grazing - distribution problems no longer exist (one to three seasons), or by separating burned from unburned areas with cross fencing for one to three seasons (if that is practical with regard to fencing requirements and livestock water supplies) and grazing the resulting fenced units independently (if necessary, fence lanes of access to water supplies).***
- ***Reduce stocking rates on burned areas 25 to 75 percent the first season and 25 to 50 percent the second season, depending on season in which the range is burned and on soil texture. The closer the date of burning is to the start of spring growth and the coarser the soil texture, the less will be soil puddling from raindrops, reductions in soil-moisture intake, and decreases in herbage yields.***
- ***Graze burned range moderately during the growing season (see section 1), not only for optimum livestock production but to help control forb increases that may result from conditions peculiar to an individual wildfire and subsequent growing-season conditions.***

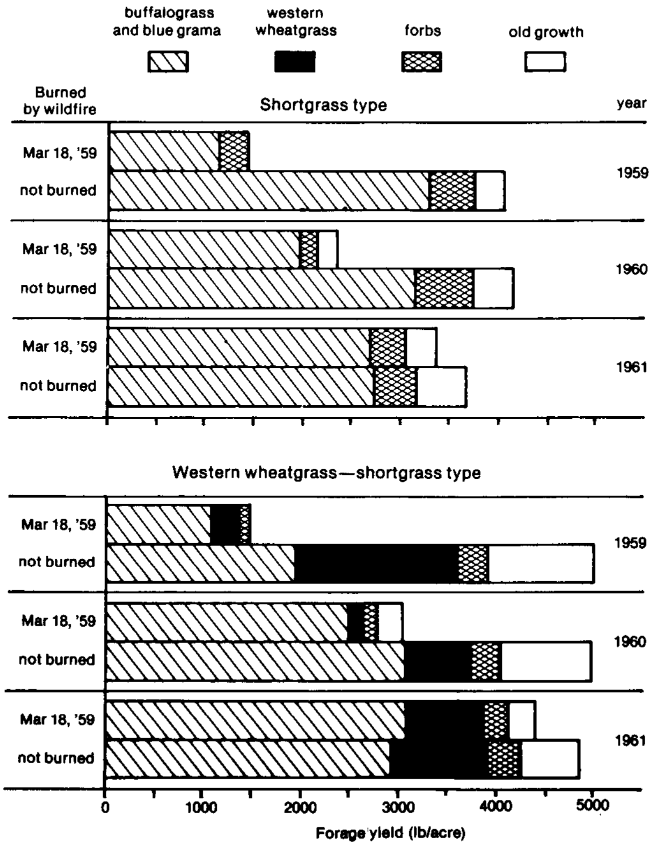


***Figure 30.** Yields of major forage groups on October 1 for three growing seasons on clay upland shortgrass range with two vegetation types; near Hays, in areas protected from livestock grazing after a wildfire on part of the range March 18, 1959. Production on burned and unburned sites compared.*

Table 26. Average heights of major plants on clay upland shortgrass range near Hays October 1, 1959, in areas protected from livestock grazing after a wildfire on part of the range March 18, 1959.

Major plants	Range treatment: Wildfire Mar 18,1959	Range treatment: Not burned
	Plant height (inches) Oct 1, 1959	
Western wheatgrass	11.0	17.0
Blue grama	6.7	11.9
Buffalograss	4.1	6.9
Western ragweed	6.1	9.7
Horseweed	10.3	14.2
Average	7.6	11.9

Table 27. Average yields of forage on Flint Hills bluestem range, unburned and burned annually on dates indicated, 1950 to 1967. Burning bluestem range earlier than the latest date in spring when vegetation will still carry a fire, whether intentionally or by wildfire, reduces forage yields.

Item	Range burned: Mar 20	Range burned: Apr 10	Range burned: May 1	Not burned
	Yield (lb dry matter/acre)			
Total forage	2360	2840	3150	3240

SECTION 7 *Managing Secondary Grasses and Perennial Forbs*

In years with favorable conditions for spring growth, dominant range grasses may be obscured by secondary cool-season annual grasses and warm-season perennial forbs, particularly under conservative stocking. Although in many years some native forbs, including broom snakeweed and slimflower scurfpea (a legume), seem to take over native ranges (except under continuous grazing at heavy stocking rates), actual production of species that create a weedy appearance may be relatively small.

Japanese brome, the commonest "naturalized" cool-season annual grass, and certain perennial native forbs are "opportunistic" in that they depend on soil moisture in excess of that used by the dominant grasses. Thus, in shortgrass range near Hays, from 1956 through 1965, yields of opportunistic plants were greatest during years most favorable for plant growth (when grazed lightly season long) and their yields were least during dry years (particularly under season-long heavy grazing) (Tables 28 and 29).

Little barley and upright prairieconeflower were most abundant on heavily stocked summer range during some years of high rainfall early in the growing season. Regardless of stocking rate on clay upland shortgrass range, however, western ragweed and upright prairieconeflower were nearly absent some years, largely because precipitation and resulting soil-moisture regimes were less favorable than in other years.

Soil-moisture surpluses in spring favor the growth of most opportunistic plants. Prairie threeawn-a noxious warm-season annual grass-increases in eastern Kansas ranges, hay meadows, and abandoned cultivated areas when surface mulch accumulations and late-spring soil moisture are favorable. Grass production on a loamy lowland range site near Hays that had western ragweed stands dense enough to nearly obscure the grasses benefited from forb control in a year of high precipitation early in the growing season (Table 30). A herbicide treatment June 1 increased grass production more than did mowing on that date. Although mowing reduced forb production, compensating increase in grass production was minor compared with the increase after herbicide treatment.

Stands of western ragweed with yields ranging from nothing to nearly 3,000 lbs. of dry matter per acre under moderate-to-light season-long stocking did not reduce grass yields on a clay upland range site near Hays in a year of high rainfall throughout the growing season (Figure 31); in ragweed stands of 7,000 lbs. of dry matter per acre, perennial grass yields were still within 50 percent of maximum.

Western ragweed stands averaging about 1,200 lbs. dry matter per acre appeared to be beneficial to grass production on a clay upland range site in the semi-arid climate near Hays (Figure 32). A reasonable explanation is that native perennial range grasses, as the dominants, exert their control of the habitat by having 75 to 80 percent of their root systems in the first one and a half to two and a half feet of soil (Figure 33). To compete, most subdominant forbs have root systems that use moisture below the major extraction zone of grass roots. Also, the taller growing broadleaf plants moderate microclimatic factors-wind velocities, temperatures, and evaporation rates near the ground-and thereby reduce environmental stress on the perennial grasses.

The role of native legumes in adding nitrogen to range soils has not been clearly defined. Many legumes, along with other forbs, however, have much higher protein content than do the grasses, and the most palatable ones are sought out and grazed by livestock. Livestock gain more on ranges with mixtures of grasses and forbs than on grasses alone (Costello 1944), so most broadleaf plants, maintained at tolerable levels, are desirable on native range.

Grazing Flint Hills bluestem range season long at conservative stocking rates for 17 years reduced perennial forb yields (Table 31). On clay upland shortgrass range near Hays, forb and annual grass yields were reduced by season-long continuous moderate and heavy stocking rates compared with light stocking (Table 32).

Abundance of pricklypear and thistle probably is associated with weather and site effects and not overgrazing (Table 33). Continuous season long or year long heavy grazing ultimately will kill many forbs, but that is not a profitable way to manage native range.

Recommendations

Secondary grass and forb control in general

- ***Use and manage most secondary grasses and forbs by grazing ranges during the growing season of those plants, especially early in the season when they are most palatable. Because of relative locations and heights of growing points, broadleaf species are weakened more than are grasses by continuous grazing. Broadleaf plants are more likely to remain in "grazeable"growth forms than are similar but more mature forbs protectedfrom grazing early in their development.***
- ***Refer to Tables 34 and 3.5 for preferred and alternative measures for reducing secondary grasses and forbs in eastern and western Kansas. Ex-***

cept for spectfic procedures to control certain undesirable range plants that cannot be maintained at tolerable levels by grazing management alone, conservative season-long or year-long stocking, combined with appropriate supplemental practices, appear to be the way to manage the dominant grasses and nearly all the opportunistic plants that grow among them.

- *Restrict weedy-plant control (by chemical or mechanical methods) to the most highly productive range sites, such as lowlands and meadows.*
- *Direct noxious weed-eradication procedures toward eliminating specific plants. Avoid broadcast treatments that may remove desirable species indiscriminately.*

Secondary grass and forb control in eastern Kansas

- *Combine grazing management with prescribed burning.*
- *Graze continuously during the growing season or stock ranges intensively early, and combine either system with late-spring prescribed burning to manage stand densities of annual brome, Kentucky bluegrass, and broadleaf plants (western ragweed, Louisiana sagewort, ironweed, and goldenrod).*
- *To control prairie threeawn, combine prescribed burning eve y three to five years (mid-to-late November) with moderate, continuous grazing.*
- *Stock ranges season long or year long at conservative rates to restore vigor of desirable plants and to minimize production of annual broomweed and snow-on-the-mountain.*

Secondary grass and forb control in western Kansas

- *Stock ranges in spring, before warm-season perennials are ready, to use Japanese brome, which tolerates close defoliation before heading (Hulbert 1955). Cool-season annual grasses seldom produce substantial amounts of forage without nitrogen fertilization. (See Section 9 for method of increasing Japanese brome, a desirable cool-season annual grass, for improved livestock production.)*
- *Graze ranges season long or year long continuously at moderate stocking rates for optimum use of western ragweed and broom snakeweed. Ranges that normally have dense forb stands should be stocked at the start of the growing season so that livestock will have access to the forbs in their most grazeable form.*

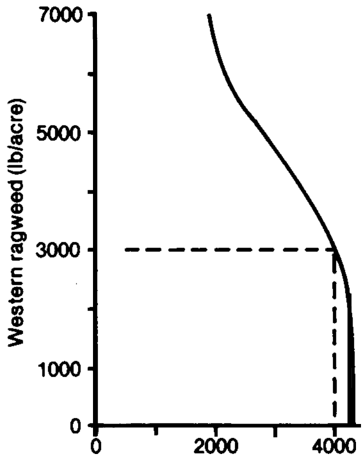


Figure 31. Yield's of blue grama and buffalograss (combined) as related to production of western ragweed on clay upland shortgrass range near Hays, 1958: range protectedfrom livestock use for one season after 12 years of light grazing during the growing season (5 acres/yearling steer, May 1 to November 1, 1946 to 1956; and May 1 to October 1, 1956 to 1959). Curve derived by separating - on October 1, 1958 - grass and forbs on areas yielding from 0 to 7,000 lb (dry weight) of western ragweedper acre.

In the example, 4,000 lb per acre of blue grama and buffalograss, along with 3,000 lb per acre of western ragweed, were produced in 1958. For that year, yields of grass were 4.000 lb or more per acre from range areas that produced 0 to 3,000 lb of western ragweed per acre; and were never less than 2,000 lb per acre from sites that produced 7,000 lb of ragweed per acre.

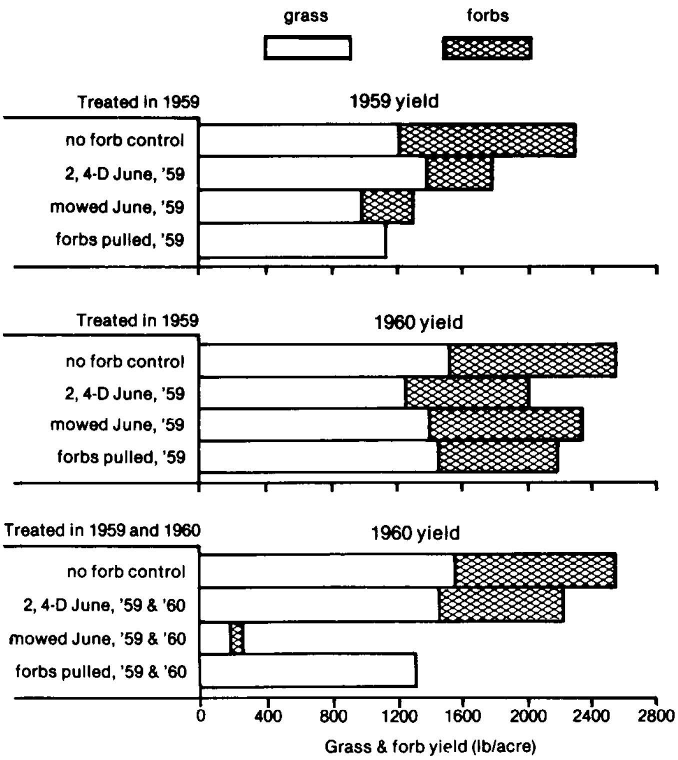


Figure 32. Yields of native grasses and forbs on clay upland shortgrass range near Hays October 1, 1959 and 1960, after forb-control treatments one year only and two consecutive years: (1) No forb control; (2) ester of 2, 4-D sprayed at 1 lb per acre June 10: (3) grass mowed at a 2-inch height June 10; and (4) forbs pulled as necessary May to October. One set of plots was treated only in 1959 (yields were taken in 1959 and again in 1960 to measure residual effects): another set was treated in both 1959 and 1960. Grasses were mainly buffalograss and bluegrama; western ragweed was the major forb.

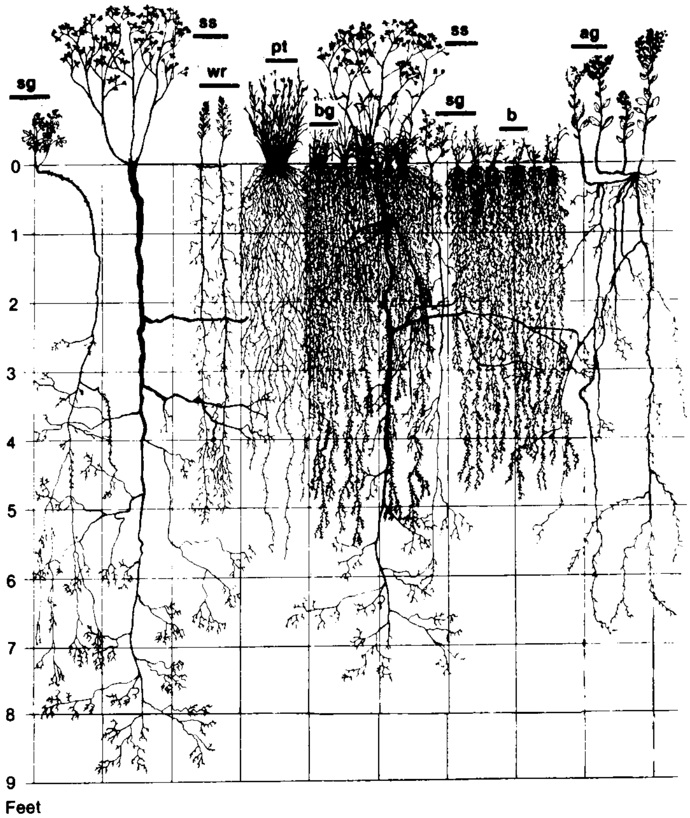


Figure 33. Root and top layering of native grasses and tall forbs on a typical clay upland range site at Hays. sg = scarlet globemallow, ss = slimflower scurfpea, wr = western ragweed, pt = purple threeawn. bg = blue grama, b = buffalograss, ag = ashy goldenrod. (Adapted from Albertson 1937.)

Table 28. Yields of annual grasses on clay upland shortgrass range near Hays stocked heavily, moderately, and lightly with yearling steers May 1 to October 1, 1956 to 1966.

Year	Range stocked: Heavily 2.0 acres/head	Range stocked: Moderately 3.5 acres/head	Range stocked: Lightly 5.0 acres/head	Average
	Annual grass yield (lb dry matter/acre)[1 2]			
1956	200	370	600	390
1957	250	220	770	410
1958	90	30	120	80
1959	10	90	250	120
1960	40	230	670	310
1961	10	70	670	250
1962	70	150	380	200
1963	10	10	10	10
1964	0	60	290	120
1965	10	80	290	130
Average	70	130	410	200

1. Mostly little barley at 2.0 acres/head; primarily Japanese brome at 3.5 and 5.0 acres/head.
2. Yields underscored by the same line did not differ significantly ($P < 0.05$) that year.

Table 29. Yields of perennial forbs on clay upland shortgrass range near Hays stocked heavily, moderately, and lightly with yearling steers May 1 to October 1, 1956 to 1966.

Year	Range stocked: Heavily, 2.0 acres/head	Moderately, 3.5 acres/head	Lightly, 5.0 acres/head	Average
	Perennial forb yield (lb dry matter/acre) [1,2]			
1956	90	30	160	90
1957	160	130	920	400
1958	370	1310	1610	1100
1959	50	1140	1850	1010
1960	350	1340	1590	1090
1961	1060	1400	1100	1190
1962	530	1610	2590	1570
1963	10	10	30	20
1964	20	20	180	70
1965	40	140	190	120
Average	270	710	1020	670

1. Mostly upright prairie coneflower at 2.0 acres/head; primarily western ragweed at 3.5 and 5.0 acres/head.
2. Yields underscored by the same line did not differ significantly ($P < 0.05$) that year.

Table 30. Yields of perennial grasses and forbs on loamy lowland shortgrass range near Hays October 13. 1960, after indicated forb-control treatments June 1, 1960.

Vegetation group	Forb-control treatment, Jun 1, 1960: Mowed, 2-inch height	Sprayed, 1 lb/acre ester 2,4-D	No forb control
	Yield (lb dry matter/acre) Oct 13, 1960		
Grass [1]	820	2570	650
Forbs [2]	280	1510	4370

1. Mostly buffalograss and blue grama.
2. Nearly all western ragweed

Table 31. Average yields and disappearances of perennial forbs on two major Flint Hills bluestem range sites, burned on dates indicated and unburned, and grazed moderately by yearling steers (3.3 acres/head) May 1 to October 1, 1950 to 1967.

Range stocked: Season	Date	Forb — Loamy upland: Yield, lb/acre air-dried	Disappearance, lb/acre air-dried	Disappearance, %	Limestone breaks: Yield, lb/acre air-dried	Disappearance, lb/acre air-dried	Disappearance, %
Early spring	Mar 20	340	120	35	430	160	37
Mid spring	Apr 10	290	140	48	270	100	37
Late spring	May 1	160	50	31	110	20	18
Not burned		300	120	40	340	110	32
Average		270	110	41	290	100	34

Table 32. Average yields and disappearances of perennial forbs and annual grasses on clay upland shortgrass range near Hays, grazed by yearling steers May 1 to October 1, 1956 to 1966, at the stocking rates indicated. (Ranges were grazed by yearling cattle May 1 to November 1, 1946 to 1956. at the same stocking rates indicated.)

Range stocked: May 1-Oct 1	Acres/head	Perennial forb [1]: Yield, lb dry matter/ acre	Disappearance, lb dry matter/acre	Disappearance, %	Annual grass [2]: Yield, lb dry matter/acre	Disappearance, lb dry matter/acre	Disappearance, %
Heavily	2.0	270	200	74	70	60	86
Moderately	3.5	710	350	49	130	100	77
Lightly	5.0	1020	410	40	410	250	61

I. Mostly upright prairie coneflower at 2.0 acres/head; primarily western ragweed at 3.5 and 5.0 acres/head.
2. Mostly little barley at 2.0 acres/head; primarily Japanese brome at 3.5 and 5.0 acres/head.

Table 33. Plants per acre of pricklypear and "pasture" thistle July 15, 1956, on clay upland shortgrass range near Hays stocked with yearling cattle at rates indicated May 1 to November 1, 1946 to 1957.

Range stocked		Species	
		Pricklypear [1]	Thistle [2]
May 1 - Nov 1	Acres/head	Plants/acre	
Heavily	**2.0**	**92**	**99**
Moderately	**3.5**	**117**	**38**
Lightly	**5.0**	**140**	**192**

1. Mostly common pricklypear, with scattered plains pricklypear; plants generally distributed over the range.
2. Largely yellowspine thistle and occasionally wavyleaf thistle; populations dense in small areas and sparse to absent elsewhere.

Table 34. Recommended methods for reducing stands of secondary grasses and forbs in eastern Kansas.

Species	Preferred control measures	Alternative control measures [1]
Japanese brome	Late-spring or mid-to-late fall burning.	
Kentucky bluegrass	Combined moderate, continuous grazing and periodic late-spring burning.	
Western ragweed Louisiana sagewort Ironweed Goldenrod	Combined moderate, continuous grazing and periodic late-spring burning.	2,4-D, 1-2 lb a.e./acre. Use 2 lb a.e./acre 2,4-D ester on ironweed. Treat when problem weed is in early growth stage, just before or during early bud stage; usually May 15 (south)-July 1 (north).
Prairie threeawn	Burn in November. Hot fire and complete mulch removal are necessary for control	
Annual broomweed Snow-on-the-mountain	Moderate, continuous grazing	Mow in prebloom stage.

1. Herbicides noted here were registered for uses suggested as of May 1, 1978. **Do not use a herbicide unless directions for applying it to your kind of vegetation are given on the label.** For most effective plant control and least effect on nontarget organisms, **apply each herbicide or herbicide mixture according to all directions, warnings, and precautions on the label.** For aerial application, see label. (Note: a.e. = acid equivalent, the weight used in the suggested herbicide rates.)

Table 35. Recommended methods for reducing stands of secondary grasses and forbs in western Kansas.

Species	Preferred control measures	Alternative control measures [1]
Japanese brome Little barley Six weeks fescue	Moderate, continuous grazing.	Periodic late-spring burning.
Western ragweed	Moderate season-long or year-long grazing to control most stands.	2,4-D amine, ester, or low volatile ester. 1-2 lb a.e./acre in 4 gal water for aerial; 15-25 gal for ground broadcast. Treat during active growth. usually June 1-20.
Broom snakeweed	Open, thin stands do not require treatment.	2,4-D amine, ester, or low volatile ester. 1-2 lb a.e./acre in 4 gal water for aerial; 15-25 gal for ground broadcast. Treat during active growth, usually June 1-20.

1. Herbicides noted here were registered for uses suggested as of May 1, 1978. **Do not use a herbicide unless directions for applying it to your kind of vegetation are given on the label.** For most effective plant control and least effect on nontarget organisms, **apply each herbicide or herbicide mixture according to all directions, warnings, and precautions on the label.** For aerial application, see label. (Note: a.e. = acid equivalent, the weight used in the suggested herbicide rates.)

SECTION 8 Controlling Woody Plants

Woody vegetation invades range and increases when such natural controls as fire and year-long conservative grazing are absent. On properly stocked range, woody-plant seedlings and sprouts are stunted by livestock browsing them, but cattle do not consume large amounts of most mature woody species on Kansas grasslands. Hence, unless controlled, shrubs and trees gradually increase in size and number on rangeland and reduce livestock-carrying capacity. Prescribed burning or other periodic control measures are necessary to maintain desired amounts of open range.

Woody plants generally are not completely eradicated by control measures, nor would it be economically sound to do so. A point is reached at which the cost of eliminating remaining woody plants would exceed benefits.

Trees and shrubs left to grow along water courses, in ravines, and in difficult-to-control areas have little influence on livestock-carrying capacity, yet they are important as shade and winter protection for domestic stock. They also provide wildlife habitat, watershed, and other multiple-use benefits. Manageable amounts of woody plants are compatible with profitable livestock production when in practical balance with proper stocking and grazing distribution. Reducing brush and trees to stands that can be maintained easily with prescribed burning likely is the least-cost, maximum-benefit way to control most woody vegetation; some require other control measures. On Flint Hills bluestem range, woody plants were controlled most effectively by top killing when burning or mowing was properly associated with regrowth characteristics of each species.

Eastern redcedar, which does not root sprout after its tops have been killed, is susceptible to prescribed burning. As demonstrated on bluestem range (Table 36), degree of control depends on tree height, amount and distribution of herbaceous material that serves as fuel, backfire or headfire, and whether or not weather conditions favor generating a fire front necessary to ignite tree crowns. Backfires eliminated eastern redcedar seedlings overtopped by grass fuel, but headfires running with a 5- to 20-mph wind were necessary to create flames that would engulf the lower parts of large trees enough to set them ablaze.

Species that would root sprout after their tops had been killed were adequately controlled on Flint Hills bluestem range by burning or mowing the range two or more consecutive years when plant food reserves were low. Low ebb in buckbrush food reserves, reached at the first indication of full-leaf stage, was between mid April and late May (Table 37). Early-May mowing, which coincided with low food reserves, reduced buckbrush stem numbers more than did cutting on other dates (Table 38). Late-spring burning two to three successive years satisfactorily controlled buckbrush (Figure 34).

Smooth sumac was not controlled by late-spring burning (Figure 35) because its food reserves were lowest fully a month later than the latest possible date the range would burn (Table 39). Smooth sumac was most effectively controlled, therefore, by mowing from late May to early June (Table 40).

Proper management of sites with highly concentrated brush stands may require spot treatment with one of several control measures to prevent extensive, unmanageable brush problems on rangeland. Treatments to consider for spot application, extensive control, and maintenance of compatible grass and woody plant stands include fire and mechanical, biological, and chemical means (Tables 41 and 42).

Recommendations

General

- ***Adopt woody-plant-control procedures that result in practical and economical compromises between "no control" and eradicating all woody plants.***
- ***Focus control measures on sites with greatest potentials for producing desirable range forage: give least attention to sites with brush that will not respond economically to treatment.***
- ***Control new infestations or reinfestations of woody plants, after initial control measures have reduced stands to manageable levels, with procedures applied periodically for maintaining acceptable amounts of woody species.***

Prescribed burning

- ***Control scattered clumps of susceptible woody species by burning range in late spring when enough dead grass is available to carry the fire through stands of woody plants. Controlling brush requires intense heat, which can be generated with headfires when humidity is low and winds are from 5 to 20 mph.***
- ***In preparation, burn fireguards through brush and tree stands under less***

hazardous conditions of high humidity and low wind velocity.

- *Before starting any burning, notify fire departments, neighbors, and-if roadways downwind are near enough for smoke to be a hazard-appropriate authorities who control traffic.*
- *Monitor immediate and long-range weatherforecasts.*

Mowing or cutting

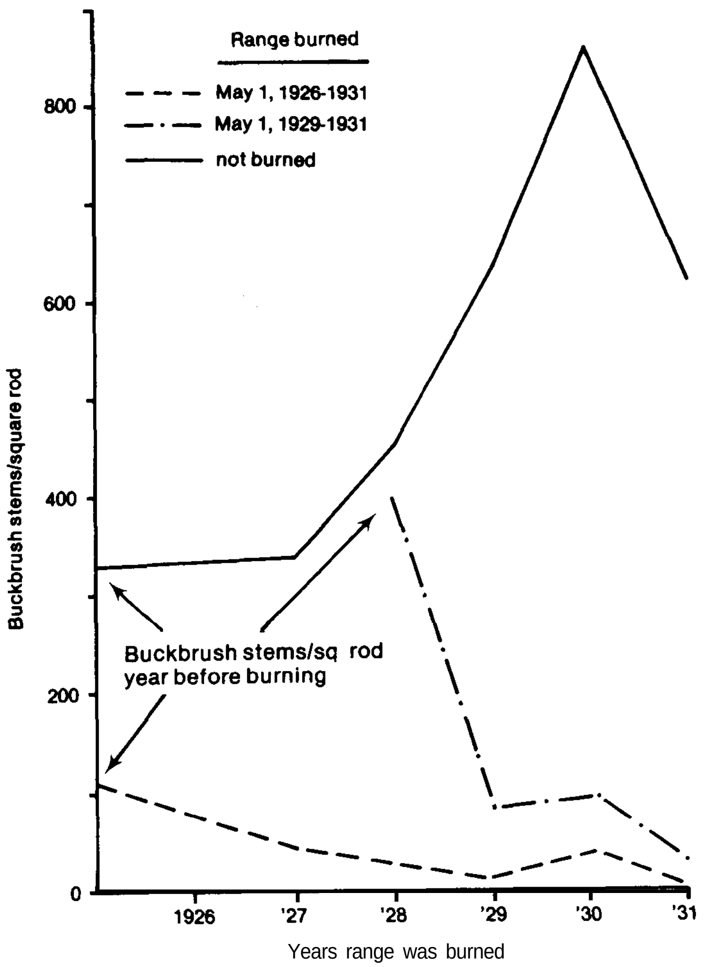
- *Consider mowing range as an option to control woody species, particularly those not controlled effectively with fire. Root-sprouting species, however, must be mowed when theirfood reserves are low and the treatment must be used two to three successive years.*
- *Kill eastern redcedar. especially trees that escape controlled burning, anytime with a single cutting to remove all green material. Although redcedar is a nonsprouter, any green branches left after cutting will produce regrowth.*

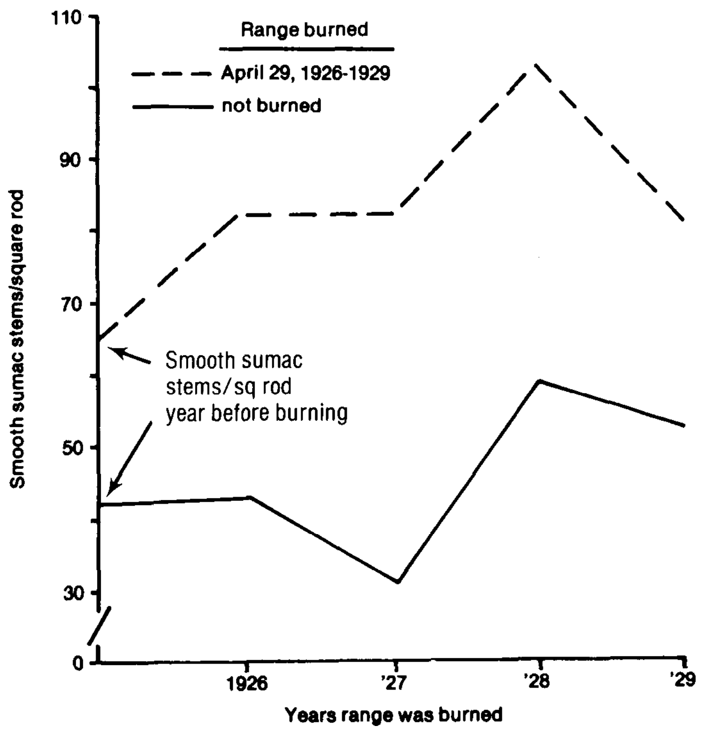
Chemical control

- *For best control of woody plants, use herbicides that are translocated to roots.*
- *Apply herbicides at the proper time and calibrate sprayers to insure the desired application rate.*
- *Do not use a herbicide unless its label includes directions for applying it on rangeland, and be absolutely certain to apply each herbicide or herbicide mixture according to all directions: heed all warnings and precautions given on the label.*
- *After heavy stands of woody plants have been reduced to manageable levels, switch from broadcast to spot treatment and basal applications of herbicides. Broadcasting chemicals repeatedly eventually eliminates desirable forbs that make up "natural" protein complements to the low-quality range grasses.*
- **When brush colonies do not contain enough grass or dead stems to carry a** *fire through the clumps, use herbicides, followed by prescribed burning to prevent reinfestation. Do not apply translocated herbicides and burn range the same season.*

Biological control

- *Once woody vegetation is under control from prescribed burning, mechanical cutting, or chemical application, maintain regrowth, sprouts, and seedlings in grazeable browse forms as long as possible through continuous grazing, especially during the growing season. Livestock can thus benefit from increased dietary selection: at the same time competition of woody vegetation with desirable grass will be reduced.*
- *Reduce or eliminate stands of small soapweed by two-to-three consecutive years of continuous, moderate winter grazing (November to March) with cows (Jensen 197.5). Although it is not necessary to starve cattle as an inducement for them to use small soapweed on winter range, overfeeding high-quality roughages and protein concentrates as range supplements could reduce their effectiveness as control agents.*





Figures 34 and 35 (top and bottom, respectively). Buckbrush stems (Fig. 34) on Flint Hills bluestem range, unburned and burned in late spring (May 1). 1926 to 1932 and 1928 to 1932; and smooth sumac stems (Fig. 35) on Flint Hills bluestem, unburned and burned in late spring (April 29). 1926 to 1930.

Table 36. Effectiveness of prescribed burning of Flint Hills bluestem range (April 24, 1971) to control eastern redcedar in three size classes.

Eastern redcedar	Live trees before range burning April 24	Tree kill 4 months after range burning: Partial to complete kill of tree crown area	Tree kill 4 months after range burning: Dead trees
Height class	Number/acre		
Seedlings, under 2 ft	25	22	18
Small trees, 2-6 ft	25	21	12
Medium trees, over 6 ft	10	4	2

Table 37. Food reserves in buckbrush roots from Flint Hills bluestem range on dates indicated, 1928 to 1932.

Date		Average total starch and sugars in buckbrush roots
		% of total dry matter
Mar	15	13.45
Apr	10	9.02
	24	8.77
May	12	7.36
	23	11.75
Jun	7	12.27
	21	11.29
Jul	2	13.56
	16	12.35
Aug	1	13.26
	14	12.84
Sep	10	14.25
	28	14.44
Oct	3	15.73
	24	15.13

Table 38. Average stem numbers of buckbrush and increases or decreases as a result of mowing Flint Hills bluestem range on dates indicated, 1928 to 1932.

Mowing date		Buckbrush stem number: Before mowing	After mowing: Increase or decrease	After mowing: Decrease
		Stems/square rod		%
Apr	27	127	+ 29	
May	10	218	- 191	87
	25	369	- 193	53
Jun	9	138	- 32	24
	22	144	+ 38	
Jul	6	265	+ 48	
	18	218	- 8	10
Aug	1	143	+ 7	
	15	104	+ 1	
Sep	8	132	+ 90	
	22	140	+ 71	
Oct	5	185	+ 122	

Table 39. Food reserves in smooth sumac roots from Flint Hills bluestem range on dates indicated, 1928 to 1932.

Date		Average total starch and sugars in smooth sumac roots
		% oft total dry matter
Mar	15	23.28
Apr	10	16.86
May	12	17.87
	23	13.69
Jun	7	9.45
	21	12.92
Jul	2	17.25
	16	17.13
Aug	1	24.23
	14	20.22
	28	19.84
Sep	10	24.71
	24	20.47

Table 40. Average stem numbers of smooth sumac and increases or decreases as a result of mowing Flint Hills bluestem range on dates indicated, 1928 to 1932.

Mowing date		Smooth sumac stem number: Before mowing	After mowing: Increase or decrease	After mowing: Decrease
		Stems/square rod		%
Apr	27	21	+ 45	
May	10	86	+ 48	
	25	75	- 34	45
Jun	8	61	- 37	60
	10	73	- 24	33
Jul	6	94	- 28	30
	18	116	- 23	19
Aug	1	140	+ 3	
	15	109	+ 31	
	24	36	+ 59	
Sep	8	26	+ 41	
	22	40	+ 59	
Oct	5	33	+ 44	

Table 41. Recommended methods for controlling woody species in eastern Kansas.[1]

Species	Preferred control measures	Alternative control measures
Eastern redcedar	Mid-late spring burning (April 15-May 1) with follow-up cutting of surviving trees.	Cutting any time of the year, remove all green material.
Buckbrush	2-3 successive years of late-spring burning, April 15-25 (south); April 20-May 1 (north)[2]	Mowing 2-3 consecutive years, April 25-May 10 (south); May 1-15(north). 2,4-D low volatile ester at 1-2 lb a.e./acre. Treat at full leaf stage while actively growing, usually April 15 (south)-June 1 (north).
Smooth sumac	2.4-D low volatile ester at 1-2 lb a.e./acre. Treat at full leaf stage, while actively growing, usually June 1 (south)-July 15 (north).	Mowing 2-3 consecutive years, Mav 20-June 5 (south); May 25-June 10(north).
Roughleaf dogwood	2-3 consecutive years of late-spring burning, April 15-25 (south); April 20-May 1 (north).	2,4,5-T low volatile ester at 2-4 lb a.e./100 gal water. Drench thoroughly during active growth (full-leaf stage), usually May 15 (south)-June 15 (north) for 2-3 years. Combine burning after 1st year of chemical control.
Osageorange	Foliage application of 2,4,5-T low volatile ester at 2-4 lb a.e./100 gal water. Drench thoroughly during active growth (full leaf stage), usually May 15 (south)-July 15 (north).	Basal and stump treatment with 2,4,5-T at 10-20 lb a.e./100 gal number 2 or 3 fuel oil. Apply anytime during year. Spray lower 12-24 inches of trunk or freshly cut stump to runoff.
Blackberry	Late-spring burning for 2-3 consecutive years. April 15-25 (south); April 20-May 1 (north).	2,4,5-T low volatile ester at 2-4 lb a.e./100 gal water. Drench thoroughly during active growth (full leaf stage), usually June 1 (south)-June30 (north).

1 .Herbicides noted here were registered for uses suggested as of May 1, 1978. **Do not use a herbicide unless directions for applying it to your kind of vegetation are given on the label.** For most effective plant control and least effect on non-target organisms, apply **each herbicide or herbicide mixture. according to all directions, warnings, and precautions on the label.** For aerial application, see label. (Note: a.e. = acid equivalent, the weight used in the suggested herbicide rates.)

2. When brush colonies do not contain enough grass and dead brush to carry a fire through buckbrush clumps, alternative control measures may be needed, followed by controlled burning to prevent reinfestation. Herbicides that are translocated to roots should not be used during the same season that controlled burning is used.

Table 42. Recommended methods for, controlling woody species in western Kansas.[1]

Species	Preferred control measures	Alternative control measures
Broom snakeweed	Thin stands do not require treatment other than continuous, moderate grazing to reduce undesirable increases.	2,4-D amine, ester, or low volatile ester, 1-2 lb a.e./acre in 4 gal water for aerial; 15-25 gal for ground broadcast. Treat while actively growing, usually June 1-20.
Pricklypear	Continuous, moderate grazing permits range use consistent with control by insects during growing seasons with higher-than-average relative humidities.	2,4,5-T low volatile ester or silvex low volatile ester, 2 lb a.e./acre ground broadcast in 25-30 gal oil-water emulsion (5 gal diesel + water to make 25-30 gal/acre). Before spraying dense stands bruise pads with rotary hoe. Apply herbicide during early bloom, in overlapped swaths of ½ normal swath width to wet all pads to point of runoff. Treat scattered plants individually to runoff with 8 lb herbicide a.e./100 gal diesel fuel.
Small soapweed	2-3. consecutive years continuous, moderate winter grazing (Nov-Mar) by cattle; use only required supplemental feed. Rotary mow dense stands and graze moderately during the growing season, if winter grazing is riot practical.	Silvex low volatile ester, 1-2 lb a.e./acre in 4 gal oil-water emulsion for aerial (1 qt diesel oil + water to make 4 gal/acre). Treat in mid-bloom stage. Apply 25-30 gal/acre of carrier in ground broadcast application.
Sand sagebrush	Open stands may be maintained in tolerable densities with moderate year-long grazing to use terminal buds and reduce seedling numbers. Spring burning at grass greenup to kill brush tops may be practical in combination with moderate continuous grazing to retard sprouts and seedlings.[2]	In dense stands use 2,4-D low volatile ester 1-2 lb a.e./acre in 4 gal oil-water emulsion for aerial (1 gal diesel + water to make 4 gal/acre), or 15-25 gal oil-water emulsion for ground broadcast (1 gal diesel + water to make desired gal/acre). Apply May l-June 15 in active growth stage.

1. **See, footnote 1 to Table 41.**

2. Spring burning may not be practical on unstable sandy sites where brush stands are so dense grass understory is insufficient to protect the soil from wind erosion. Before burning, use alternative chemical control methods in those places to reduce sand sagebrush stands and permit increases in understory grasses.

SECTION 9 *Range Fertilization*

Among the three major elements--nitrogen, phosphorus, and potassium--used to fertilize Flint Hills bluestem range in the early 1950s, only nitrogen increased forage yields significantly (Mader 1956). In later fertilization comparisons on the same site, with and without residual and added phosphorus, nitrogen alone still was the only nutrient to increase yields of bluestem range significantly (Table 43). In addition, nitrogen fertilization improved the efficiency of soil-moisture use by bluestem range (Table 44).

Applying 40 pounds of N per acre late each spring from 1972 to 1976 increased carrying capacity of grazed bluestem range 50 percent (Table 45). Livestock performance, however, was more efficient on burned, fertilized range than on fertilized, unburned range (Tables 46 and 47).

Comparing forage samples clipped from treated ranges indicated that burned, fertilized bluestem range produced slightly lower-quality forage than did unburned, nonfertilized range (Table 48). Comparing forage samples collected from esophageal fistulated steers that had grazed on the two treatments, however, showed that except for crude protein, the animals selected diets similar in composition from both ranges. Other than close similarities in relative amounts of cellulose and hemicellulose in samples clipped by hand and those from esophageal fistulated animals, steers selected diets that differed greatly in chemical composition from the clipped samples. Nitrogen-fertilized Flint Hills bluestem ranges had to be burned in late spring to prevent shifts to undesirable plants in the vegetation (Table 49).

Nitrogen fertilizer was applied annually during spring for four years at different rates on two contrasting range sites near Hays. N increased forage yields up to two or three times those on range without N (Figure 36). Applying 40 pounds of N per acre May 1 annually (for four years) on shortgrass range near Hays increased carrying capacity for yearling steers approximately 50 percent compared with that of unfertilized range (Table 50). Although steer gains per head on the fertilized and unfertilized ranges were comparable (Table 51), beef production per acre on the fertilized range was increased more than 50 percent (Table 52). Japanese brome and western wheatgrass were major forages during spring and early summer on fertilized range. Those species gave way to blue grama, buffalograss, and forbs during summer and early fall.

Recommendations

Flint Hills region

- ***Burn fertilized range when big bluestem has an inch of new growth, usually in late April.***
- ***Apply 40 pounds of N per acre about May 1. Aerial application may be necessary on rough topography: otherwise, conventional ground rigs may be used.***
- ***Increase stocking rates on nitrogen-fertilized ranges approximately 50 percent above normal, conservative stocking rates for unfertilized ranges.***

Mixed prairie and shortgrass regions

- ***Apply 40 pounds of N per acre from early to late April and stock range when grasses begin spring growth. Sites with western wheatgrass and Japanese brome start to grow two to four weeks earlier than does vegetation on sites with all warm-season perennial grasses and forbs.***
- ***Increase stocking rates approximately 50 percent above normal, conservative stocking rates for unfertilized ranges.***

General for all regions

- ***Use the lowest-priced nitrogen fertilizer per unit of N that is compatible with type of application equipment required for the site: profit depends largely on the market prices of livestock and fertilizer.***
- ***If range vegetation fails to respond to 40 pounds of N per acre, add the most readily available form of phosphorus (40 to 60 pounds of P per acre) with nitrogen to small areas protected from livestock grazing: observe the treatment compared with nitrogen alone for a growing season before making major applications of fertilizer. On southeastern Kansas range, include potassium (60 to 80 pounds of K per acre) in small-scale trials. Nor-***

mally, however, available phosphorus and potassium in Kansas range soils are adequate.

- *Take advantage of increased production and palatabliity of forage on fertilized range by stocking early in the growing season. Compensate for overstocking during drought years by removing livestock earlier than usual during the grazing season.*

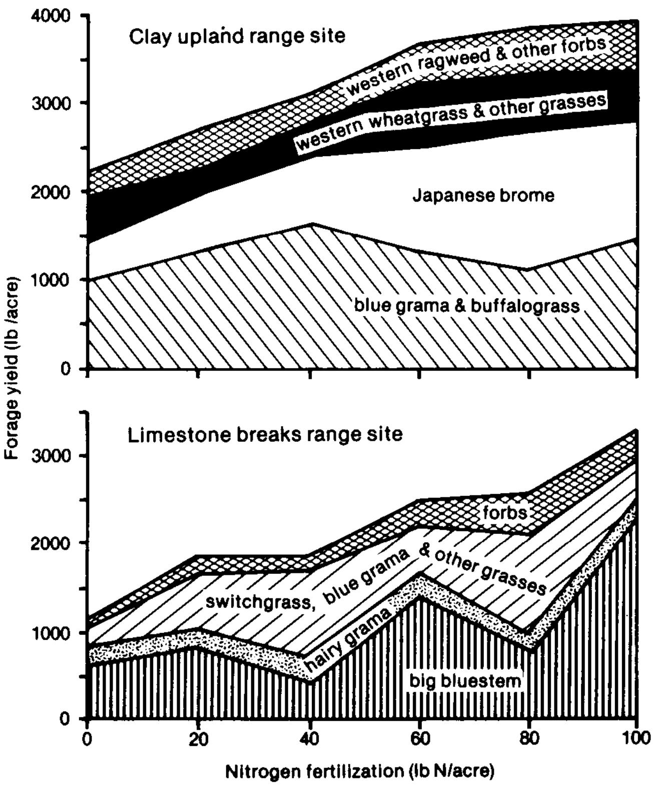


Figure 36. Average yields of major forage groups on two important range sites in mixed prairie, near Hays, fertilized annually on May 1, 1969 to 1973, with indicated rates of nitrogen.

Table 43. Yields of forage in 1963 on Flint Hills bluestem range fertilized that spring with phosphorus and nitrogen at rates indicated on sites that had not received phosphorus before 1963 compared with sites having residual P from annual applications, 1951 to 1955.

Fertilizer applied, spring 1963			Phosphorus added annually, 1951 to 1955	
Phosphorus	**Nitrogen**		**None**[1]	**44 lb P/A**[2]
			Forage yield in 1963 (lb dry matter/A)	
lb P/acre	lb N/acre			
0	0		4030	3980
0	33		4600	4410
0	67		4660	5310
		Average	4430	4570
20	0		4540	4160
20	33		4890	5190
20	67		4560	5770
		Average	4660	5040

1. Plots with no phosphorus added from 1951 to 1955 contained 12 lb P/A in the upper six inches of soil before fertilization in 1963.
2. Plots that received phosphorus from 1951 to 1955 contained 90 lb P/A in the upper six inches of soil before fertilization in 1963.

Table 44. Moisture-use efficiency of vegetation on Flint Hills bluestem range fertilized with 0 and 50 pounds N/acre, 1965 to 1969.

Nitrogen fertilization rate	Year				Average
	1965	**1966**	**1967**	**1968**	
lb N/acre	Dry matter yield (lb/inch of precipitation)				
0	**101**	**115**	**183**	**112**	**128**
50	**157**	**130**	**183**	**163**	**158**

Table 45. Nitrogen fertilization and stocking rates on unburned or late spring burned Flint Hills bluestem range, grazed by yearling steers May 1 to October 1, 1972 to 1976.

Nitrogen fertilization rate	Year				Average
	1972	1973	1974	1975	
lb N/acre	Stocking rate (acres/yearling steer May 1 - Oct 1)				
0	3.30	3.30	3.30	3.30	3.30
40	2.18	2.18	2.18	2.18	2.18
80	1.43	1.43	1.84	1.84	1.64

Table 46. Beef production per acre on late spring burned and unburned Flint Hills bluestem range fertilized with nitrogen at rates indicated and grazed with yearling steers May 1 to October 1, 1972 to 1976.

Range burning treatment	Year	Nitrogen fertilization rate (lb N/acre)		
		0	40	80
		Beef production (lb/acre)		
Burned May 1	**1972**	**56**	**99**	**137**
	1973	48	68	69
	1974	80	95	104
	1975	48	69	63
	Average	58	83	93
Not burned	1972	39	68	84
	1973	41	54	58
	1974	61	69	75
	1975	48	54	57
	Average	47	61	68

Table 47. Average daily gains of yearling steers May 1 to October 1 on late spring burned and unburned Flint Hills bluestem range fertilized with nitrogen at rates indicated, and grazed 1972 to 1976.

Range burning treatment	Year	Nitrogen fertilization rate (lb N/acre)		
		0	40	80
		Yearling steer average daily gains (lb/head)		
Burned May 1	1972	1.23	1.42	1.27
	1973	1.06	0.99	0.84
	1974	1.69.	1.48	1.19
	1975	1.18	1.16	0.95
	Average	1.29	1.26	1.06
Not burned	1972	0.84	0.99	0.77
	1973	0.90	0.80	0.69
	1974	1.30	0.99	0.99
	1975	1.17	0.96	0.90
	Average	1.05	0.94	0.84

Table 48. Chemical constituents of range forages averaged over 5 months (May to October, 1972) in the diets selected by yearling steers (fitted with esophageal fistulas) and in samples hand clipped from similar forages to simulate grazing on late spring burned Flint Hills bluestem range, unfertilized andfertilized with 40 pounds of N per acre May 17, 1972.

Chemical composition of forage sample	Method of collecting forage sample on range			
	Clipped by hand		Selected by steers	
	Burned May 1	40 lb N/A & burned May 1	Burned May 1	40 lb N/A & burned May 1
Partial analysis	% of dry matter[1]			
Least digestible				
Neutral detergent fiber (cell-wall constituents)	76.35	76.38	82.41	83.09
Acid detergent fiber (lignocellulose)	79.79	79.37	51.39	50.78
Lignin	6.51	6.78	11.35	11.73
Most digestible				
Crude protein	5.57	5.59	10.95	11.15
Neutral detergent solubles (cell contents)	52.39	51.20	29.99	28.85
Hemicellulose	32.01	31.76	28.08	29.30
Cellulose	33.77	33.56	34.49	34.07
Apparent digestibility				
Total dry matter	- -	- -	49.16	48.27

1. Percentages underscored by the same line in the same row-comparing the two columns under "Clipped by hand" separately from the second two columns under "Selected by steers"-do not differ significantly (P<0.05).

Table 49. Relative percentages of important plants and forage groups in the total ground cover (species composition) averaged for unburned and burned Flint Hills bluestem (combined loamy upland and limestone breaks range sites) before nitrogen-fertilization treatments were started (1971) and after four grazing seasons (1975). under season-long continuous grazing with yearling steers, May I to October 1, 1972 to 1976.

Individual plants and vegetation group	Range burning treatment	Years composition measured[1]	Nitrogen fertilization rate (lb N/acre) 0	40	80
			Species composition (%)		
Big bluestem	Burned May 1	1971	31.2	39.6	27.6
		1975	23.4	28.8	15.4
		Change	- 7.8*	- 10.8*	- 11.2*
	Not burned	1971	35.8	24.8	33.4
		1975	18.1	12.2	13.0
		Change	- 17.7*	- 12.6*	- 20.4*
Little bluestem	Burned May 1	1971	18.0	14.6	12.6
		1975	13.8	8.2	4.5
		Change	- 5.2*	- 6.4*	- 8.1*
	Not burned	1971	11.1	13.2	8.2
		1975	18.2	7.3	9.4
		Change	+, 7.1*	- 5.9*	+ 1.2
Indiangrass	Burned May 1	1971	17.2	17.4	18.2
		1975	13.8	12.9	4.3
		Change	- 3.4*	- 4.5*	- 13.9*
	Not burned	1971	20.0	17.4	15.0
		1975	8.0	7.0	5.2
		Change	- 12.0*	- 10.4*	- 9.8*
Sideoats grama	Burned May 1	1971	9.0	8.6	7.6
		1975	10.0	9.9	16.1
		Change	+ 1.0	+ 1.3	+ 8.5*
	Not burned	1971	7.4	4.3	11.0
		1975	8.9	9.5	9.2
		Change	+ 1.5	+ 5.2*	- 1.8
Kentucky bluegrass	Burned May 1	1971	3.7	0.2	4.5
		1975	7.3	1.9	5.6
		Change	+ 3.6*	+ 1.7	+ 1.1
	Not burned	1971	2.4	6.2	0.2
		1975	12.6	20.6	29.8
		Change'	+10.2*	+ 14.4*	+29.6*
Grass-like plants	Burned May 1	1971	5.9	4.5	4.3
		1975	9.1	9.9	12.6
		Change	+ 3.2*	+ 5.4*	+ 8.3*
	Not burned	1971	5.3	4.8	6.6
		1975	11.4	19.8	10.6
		Change	+ 6.1*	+15.0*	+ 4.0*
Perennial forbs	Burned May 1	1971	4.6	4.0	8.0
		1975	10.1	9.7	13.3
		Change	+ 5.5*	+ 5.7*	+ 5.3*
	Not burned	1971	5.9	8.0	6.4
		1975	13.2	16.0	-14.3
		Change	+ 7.5*	+ 8.0*	+ 7.9*

1. Changes in species composition between 1971 and 1975 followed by (*) are significant (P <0.05)

Table 50. Nitrogen fertilization and stocking rates on clay upland shortgrass range near Hays, grazed with yearlingsteers May 1 to October 1, 1973 to 1977.

Nitrogen[1] fertilization rate (lb N/acre)	Yearling steer stocking rate measured in:	Year				Average
		1973	1974	1975	1976	
0	Acres/ head	3.16	3.51	3.51	3.16	3.34
	Steer days/acre	53	46	45	51	49
40	Acres/ head	2.43	2.10	2.10	2.10	2.18
	Steer days/acre	69	77	74	72	73

1. Ammonium nitrate 1973-74; urea 1975-76. Broadcast applications May 1.

Table 51. Gains of yearling steers May 1 to October 1 on clay upland shortgrass range near Hays, fertilized with 0 and 40 pounds of N per acre annually May 1, 1973 to 1977.

Nitrogen fertilization rate	Year				Average
	1973	1974	1975	1976	
lb N/acre	Yearling steer summer gain (lb/head)				
0	229	149	226	188	198
40	232	170	199	197	200

Table 52. Beef production per acre on clay upland shortgrass range near Hays, fertilized with 0 and 40 pounds of N per acre annually (May 1) and grazed with yearling steers May 1 to October 1, 1973 to 1977.

Nitrogen fertilization rate	Year				Average
	1973	1974	1975	1976	
lb N/acre	Beef production (lb/acre)				
0	73	42	64	59	60
40	96	81	94	93	91

SECTION 10 *Reestablishing Range Grasses*

Reestablishing range grasses in undisturbed "preparatory crop residue" became virtually standardized in the 1950s, particularly under semi-arid conditions where clean-tilled seedbeds frequently erode and planted grasses sometimes fail to produce satisfactory stands (Cooper 1957). Although undisturbed crop residues reduce erosion and result in firm seedbeds, grass stands in Kansas Soil Bank plantings of the early 1960s were influenced greatly by climatic factors-stand success was lowest in the arid western counties and highest in the subhumid central counties (Table 53).

Studies in Kansas have been directed at maximizing benefits of the preparatory crop residue method of providing a seedbed for planted grasses. Major findings support grass-establishment recommendations regarding: (1) Preparatory crop-harvesting treatments (Table 54); (2) effects of amount and condition of preparatory crop residue on moisture-holding capacity of grass seedbeds, on seedbed temperatures, on competitive weed numbers, and on first-year grass stands (Figure 37, and Tables 55, 56, and 57); (3) optimum grass-planting dates (Tables 58 and 59); (4) effects of first-year competitive weed-control treatments (including grazing) on first- and second-year grass stands (Figure 38); (5) effects of nitrogen and phosphorus fertilization on reestablished range (Tables 60 and 61); and (6) nitrogen fertilization of planted switchgrass for grazing by yearling steers (Tables 62, 63, and 64).

Recommendations

Seedbed preparation and grass planting

- ***The year before grasses are planted, establish forage or grain sorghum types in rows one to three feet apart, preferably in east-west rows at right angles to prevailing southerly and northerly winds that dessicate the grass seedbed or cause erosion.***
- ***Avoid sudangrass and other hard-seeded sorghums with high volunteer potential when selecting cultivars for preparatory crop residues on grass seedbeds.***
- ***Leave a 12- to 18-inch stubble of preparatory crop residue by cutting forage types for hay or silage and combine harvesting grain types, or leave stubble of comparable heights by grazing in the fall after a killing frost. Base harvesting method on the practicality of removing a part of the preparatory crop. Site and weather conditions may dictate leaving the total crop for grass seedbed cover.***
- ***Do not disturb soil or preparatory crop residue with tillage equipment.***
- ***Plant grass seedfrom regionally adapted sources, at 15 to 25 pure live seeds (PLS) per square foot, from late March to early May, with a standard grass drill (equipped with double-disc furrow openers, depth bands, separate hoppers for smooth and non-free flowing seed, and presswheels instead of drag chains to improve seed and soil contact).***
- ***Although authorities disagree, fertilizing grass the year it is planted generally is not advantageous to developing seedlings. "Starter rates" of nitrogen may be too low; higher rates may intensify competition from unwanted grasses and broadleaf weeds.***

Species to plant

- ***For reclamation plantings on low-fertility, highly erodable, undifferentiated soil parent materials, use mixtures of grasses deemed superior for site conservation, wildfire, and esthetics. Give livestock grazing low priority until sites become stabilized.***
- ***Revegetate marginal cropping areas-those with complex mosaics of soils, range sites, and degrees of soil erosion-with mixtures of the most productive native species, considering (in order): grazing potential, site conservation, wildlife, and esthetics.***
- ***Plant waterways to desirable cool- or warm-season hay-type perennial***

grasses.

- *To establish grass as an alternative to cultivated crops on highly productive farmland, plant single species or simple mixtures of warm-season tall grasses that respond efficiently to nitrogen fertilization, are palatable, have inherently high livestock carrying capacity, and resist encroachment by less-productive vegetation.*

Managing first-year grass plantings

- *Keep in mind that moisture and temperatures that favor grass-seed germination and seedling emergence also favor competing weeds that grow much faster than the planted grasses.*
- *Be aware that conventional weed-control measures (mowing or herbicides) are expensive and usually ineffective in controlling competing vegetation enough to improve grass establishment significantly.*
- *Consider the weed "crop" in first-year grass plantings as a grazing resource that would otherwise be lost if not used by livestock.*
  1. *Begin grazing when weeds are two to four inches tall and sufficiently abundant to furnish a practicalforage supply, usually late spring to early May.*
  2. *Regulate stocking rates for optimum animal performance.*
  3. *Disperse livestock grazing as evenly as possible using conventional distribution aids.*
  4. *Remove livestock when necessary to prevent soil puddling during periods of high rainfall.*
  5. *Avoid high intensity-low frequency grazing strictly for weed control unless livestock are physiologically adjusted to radical changes in diet.*
- *If first-year plantings are not grazed, allow them to develop with a minimum of time and money invested; stands will establish at about the same rate with or without conventional, mechanical, or chemical weed control.*

Managing reestablished range

- *From the time reestablished ranges are planted, manage them as grazing resources.*
- *Because it is impossible to duplicate native grassland in the revegetation process, livestock may or may not use reestablished range most efficiently if given free access to both seeded and native vegetation.*
  1. *Graze reestablished range concurrently with native range when water development and fencing make separate management uneconomical.*
  2. *Manage reestablished range separately from native range if practical, and especially if differences in grazing cause inefficient use of either native or reestablished range.*
  3. *Use reestablished range as a complement to native range by concentrating livestock on one or the other or allowing simultaneous grazing.*
  4. *When fertilizer cost-livestock price relationships appear favorable, apply 40 lb of N per acre about May 1 and increase stocking rates approximately 50 percent above normal rates for unfertilized reestablished range. Increased forage production from nitrogen fertilization of reestablished range depends largely on inherent soil fertility and kinds of grasses the site supports. Thus, yield increases of tall grasses on highly productive sites are greater per unit of N than are increases from the same grasses or shorter ones on less productive sites.*

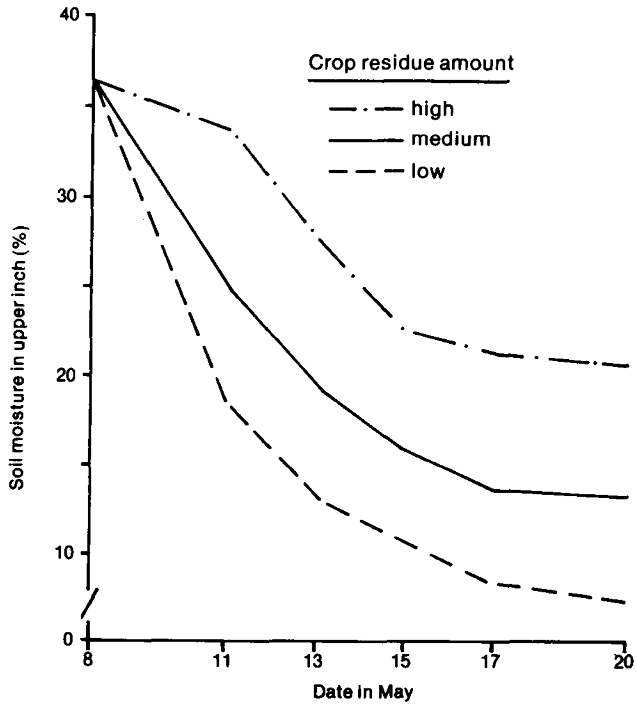


Figure 37 (above). Moisture in the top inch of soil under high, medium, and low amounts of preparatory crop residue on seedbeds for planting grasses near Hays between rains (May 7 to May 21, 1961). Medium amounts of standing sorghum stubble, 12 to 18 inches tall, appeared optimum for controlling wind erosion and establishing grass seedlings.

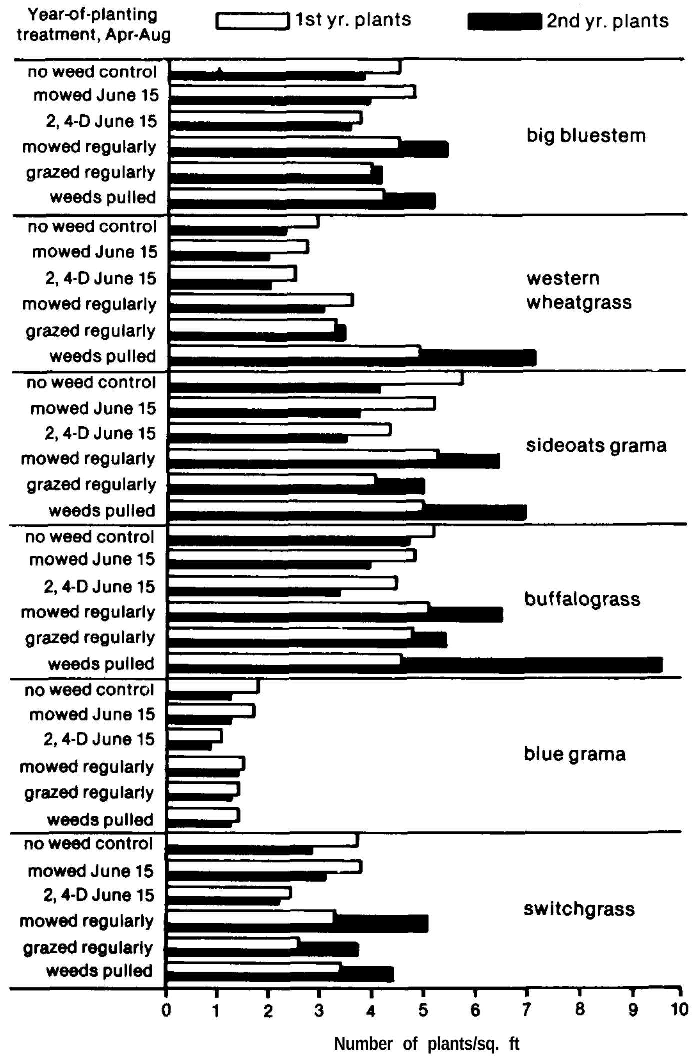


Figure 38 (above, right). Average numbers of first-year grass seedlings and second-year established plants for six native species from 25 live seeds per square foot of each-planted April 15, 1971 to 1975, near Hays and given the following treatments the year planted: (1) No weed control; (2) grass, mowed once, June 15, at a 3-inch height: (3) ester of 2, 4-D applied at 3/4 lb per acre June 15; (4) grass mowed twice weekly, from late April to mid August, at a l-inch height: (5) range grazed twice weekly with yearling steers from late April to mid August (equivalent to 50 steer days per acre): and (6) all weedy plants pulled from mid April to early August.

Table 53. Success of Kansas Soil Bank plantings (1960 to 1963). evaluated on first-year average seedling numbers per squarefoot.

Part of state		Grass stand success standards		
		Successful, more than 1 seedling/sq ft	Borderline, ½ to 1 seedling/sq ft	Failure, less than ½ seedling/sq ft
Zone	Counties	% of grass plantings		
Western	21	38	15	47
West-central	22	78	15	7
East-central	20	71	18	11

Table 54. Harvesting treatments of closely spaced forage sorghum in IO-inch rows used as preparatory crop for grass seedbeds, and average amounts of residues on dates indicated, near Hays, 1959 to 1963.

Preparatory crop	Amount of preparatory crop residue		
	High	Medium	Low
	lb dry matter/acre		
Harvested for hay in Oct	0	3010	6370
Residue left in Oct	7220	4210	850
Residue remaining the following June	3620	2460	580
	Condition of grass seedbed cover		
Height in Oct	48 to 60 inches	12 to 18 inches	2 to 4 inches
Condition the following June	Lodged plants	Standing stubble	Standing stubble

Table 55. Temperatures in the top inch of soil and 4 feet above the ground at 2:00 PM two successive clear days (May 29 and 30, 1961) under three amounts of preparatory crop residue on seedbeds for planting grasses near Hays.

Air temperature	Amount of sorghum residue		
	High 48- to 60-inch lodged plants	Medium 12- to 18-inch standing stubble	Low 2- to 4-inch standing stubble
F	Temperature, upper 1 inch of soil (F)[1]		
80	85	87	88
91	96	104	110

1. When soil moisture is optimum in the shallow placement zone of planted grasses, high soil temperatures increase seed germination and seedling emergence. Low soil temperatures at optimum soil moisture favor soil pathogens that destroy emerging seedlings or attack grass seeds before they germinate.

Table 56. Average numbers offirst-year competitive weedy plants in native grass plantings April 15, 1959 to 1963, on seedbeds with three amounts of preparatory crop residue near Hays.

Plants of:	Amount of sorghum residue[1]		
	High 48- to 60-inch lodged plants	Medium 12- to 18-inch standing stubble	Low 2- to 4-inch standing stubble
	Weedy plants (number/sq. ft.)		
Kochia, horseweed, pigweed	1.06	1.81	1.67
Tumblegrass, windmillgrass	0.30	0.70	0.74
Total weedy plants	1.36	2.51	2.41

1. High quantities of preparatory crop residues that suppress weedy species also may suppress emergence of planted grasses much more than medium or low amounts of residue do.

Table 57. Average numbers of first-year grass seedlings for four native species from 25 live seeds per squarefoot of each, planted April 15, 1959 to 1963, on seedbeds with three amounts of preparatory crop residue near Hays.

Grass planted April 15 (25 live seeds/sq. ft.)	Amount of sorghum residue[1]		
	High 48- to 60-inch lodged plants	Medium 12- to 18-inch standing stubble	Low 2- to 4-inch standing stubble
	First-year seedlings (number/sq. ft.)		
Big bluestem	1.10	.97	.53
Sideoats grama	.91	.65	.68
Switchgrass	1.17	1.00	1.29
Western wheatgrass	1.45	1.05	.69

1. When economically practical, harvest preparatory crops and leave a 12- to l8-inch stubble. That is the optimum amount considering value of harvested fraction, seedbed protective cover, and acceptable grass stands.

Table 58. Average numbers of first-year grass seedlings and second-year established plants for four native grasses from 25 live seeds per square foot of each, planted on the 15th of every month, 1959 to 1963, near Hays. First-year counts were November 2; second-year counts were July 1.

Species	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
	Date of planting (15th of each month)												
Warm-season grasses	First-year seedlings (number/sq. ft.)												
Big bluestem	.07	.09	.65	.54	.59	.77	.93	.56	1.12	1.04	.24	.00	6.60
Sideoats grama	.22	.42	.98	.75	.73	.85	.72	1.04	1.35	1.11	.23	.00	8.40
Switchgrass	.12	.22	.53	.26	.38	.67	1.45	.71	.98	1.33	.13	.00	6.78
Average	.14	.24	.72	.52	.57	.76	1.03	.77	1.15	1.16	.20	.00	7.26
Cool-season grass													
Western wheatgrass	1.14	1.52	1.09	1.33	1.25	.98	.88	.34	.60	1.29	.23	.00	10.65
Warm-season grasses	Second-year plants (number/sq. ft.)[1]												
Big bluestem	.07	.09	.64	.53	.59	.76	.86	.45	.48	.15	.00	.00	4.62
Sideoats grama	.22	.41	.88	.75	.69	.80	.66	.87	.65	.25	.00	.00	6.18
Switchgrass	.12	.22	.48	.26	.35	.65	1.33	.48	.35	.07	.00	.00	4.31
Average	.14	.24	.67	.51	.54	.74	.95	.60	.49	.16	.00	.00	5.03
Cool-season grass													
Western wheatgrass	2.10	2.23	2.05	2.90	2.73	1.80	1.40	.29	.42	.73	.11	.00	16.76

1. Losses of first-year seedlings (planted from May through October) as indicated by second-year surviving plants were caused by winter killing of late-emerging grass seedlings, which was consistant over years. Increases of western wheatgrass second-year plants over first-year seedling numbers in plantings from November through May resulted from vegetative spread of underground stems of first-year plants.

Table 59. Average stands of first-year plants from 15 live seeds per square foot each for six grasses sown on fall, winter, and spring dates, 1958 to 1963, near Manhattan. Stand evaluations made in October.

Species	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	Mar 1	Mar 15	Apr 1	Apr 15	May 1	May 15	Jun 1
	Date of grass planting											
	First-year stand I% of full stand)[1]											
Warm-season grasses												
Big bluestem	3	16	12	28	27	39	38	32	41	49	29	29
Little bluestem	11	15	11	37	26	24	46	43	37	45	22	22
Switchgrass	5	28	21	34	33	24	34	50	39	44	27	25
Sideoats grama	6	25	27	43	49	48	45	52	49	59	32	29
Average	6	21	18	35	34	34	41	44	42	49	28	26
Cool-season grasses												
Western wheatgrass	3	9	11	15	30	15	15	4	10	2	1	tr
Smooth brome	47	51	55	52	45	41	52	42	17	11	6	tr
Average	25	30	33	34	38	28	34	23	14	7	4	tr

1. In full grass stands plants are close enough together in the row that leaves of one plant touch leaves of adjacent plants. In semi-arid to arid regions a full stand, thus defined, may be more than is practical to obtain.

Table 60. Yields of vegetation on range reestablished in 1949 on a previously cropped, gently sloping, moderately eroded clay upland range site near Hays, fertilized with nitrogen and phosphorus broadcast in April, 1957 and 1959, at rates indicated.

Major elements combined and alone	1957 80 lb N/acre 60 lb P/acre	1958 response to carry-over N+P	1959 80 lb N/acre 60 lb P/acre	1960 response to carry-over N+P	Average
	Year, rate, and kind of spring-applied fertilizer[1]				
	Forage yield (lb dry matter/acre)[2]				
NP	5030	3060	3800	1660	3390
N	4920	3040	3550	1550	3260
P	3380	2590	1620	1190	2200
0	3520	2670	1600	1250	2260
LSD (P < 0.05)	740	NS	370	220	
(P < 0.01)	1070	NS	540	310	

1. Ammonium nitrate and treble superphosphate.
2. Mostly switchgrass and relatively small amounts of blue grama, buffalograss. sideoats grama, little bluestem, and Japanese brome without fertilization or fertilized with P alone; coo-season Japanese responded most to N and NP

Table 61. Yields of vegetation on range reestablished in 1949 on a previously cropped, gently sloping, severely eroded limy upland range site near Hays, fertilized with nitrogen andphosphorus broadcast in April, 1957 and 1959, at rates indicated.

Major elements combined and alone	Year. rate. and kind of spring-applied fertilizer [1] 1957 80 lb N/acre 60 lb P/acre	1958 response to carry-over N + P	1959 80 lb N/acre 60 lb P/acre	1960 response to carry-over N + P	Average
	Forage yield (lb dry matter/acre) [2]				
NP	1200	480	1430	390	870
N	720	410	720	420	570
P	230	210	110	80	160
0	270	250	160	130	200
LSD (P < 0.05)	240	100	150	70	
(P < 0.01)	350	140	220	100	

1 Ammonium nitrate and treble superphosphate.

2. More than 90% sideoats grama; the remainder blue grama, little bluestem. buffalograss. and less than 1% forbs

Table 62. Gains ofyearling steers at stocking rates indicated, 1974 to 1977, on Blackwell switchgrass pastures planted in 1972 on a previously cropped, highly productive clay upland range site near Hays, fertilized annually (May Z) with 0 or 40 pounds of N per acre.

Nitrogen fertilization rate	Yearling steer stocking rate (May 1-Oct 8)		Year 1974	1975	1976	Average
lb N/acre [1]	Acres/head	Steer days/acre	Steergain(lb/head)			
0	2.9	56	107	197	176	160
40	1.8	91	162	220	205	196

1. Urea

Table 63. Beef production per acre by yearling steers at stocking rates indicated, 1974 to 1977, on Blackwell switchgrass pastures planted in 1972 on a previously cropped, highly productive clay upland range site near Hays, fertilized annually (May Z) with 0 or 40 pounds of N per acre.

Nitrogen fertilization rate	Yearling steer stocking rate (May 1-Oct 8)		Year 1974	1975	1976	Average
lb N/acre [1]	Acres/1 head	Steer days/acre	Beef production (lb/acre)			
0	2.9	56	35	70	63	56
40	1.8	91	81	138	121	113

1. Urea

Table 64. Forage left at the end of the grazing season by yearling steers at stocking rates indicated, 1974 to 1977, on Blackwell switchgrass pastures planted in 1972 on a previously cropped, highly productive, clay upland range site near Hays, fertilized annually (May 1) with 0 or 40 pounds of N per acre.

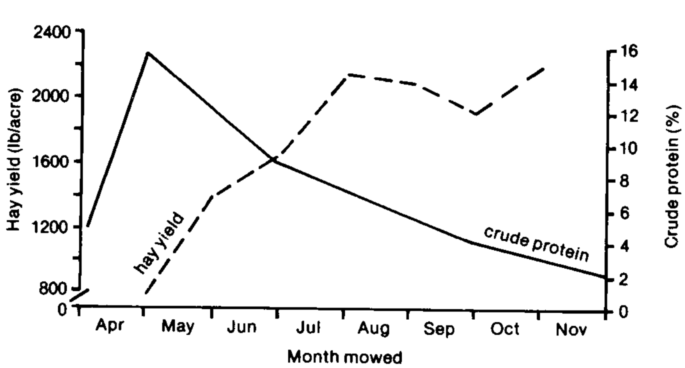
Nitrogen fertilizer rate	Yearling steer stocking rate (May 1-Oct 8)		Year 1974	1975	1976	Average
lb N/A [1]	Acres/ head	Steer days/acre	Forage left Oct. 7(lb dry matter/acre) [2]			
0	2.9	56	3730	2780	3060	3190
40	1.8	91	3450	2510	2520	2830

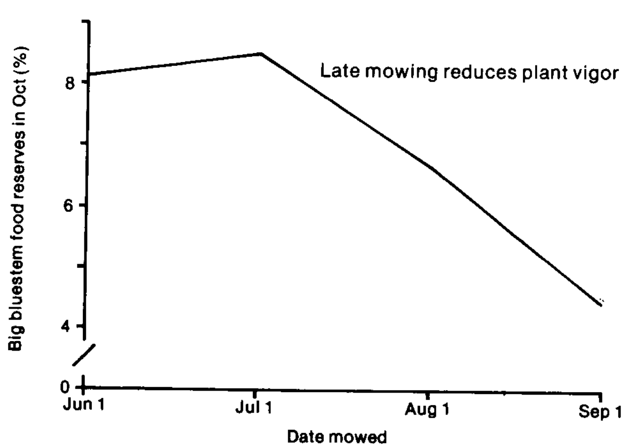
1. Urea.

2. Although amounts of forage left at the end of the summer grazing season do not suggest either treatment was overstocked, the large differences in steer gains per head (comparing fertilizer rates, Table 62) indicate that lower animal performance on unfertilized switchgrass was caused by less high-quality forage for steers to select from in choosing diets comparable to those on fertilized switchgrass. Thus, the unfertilized treatments probably were overstocked.

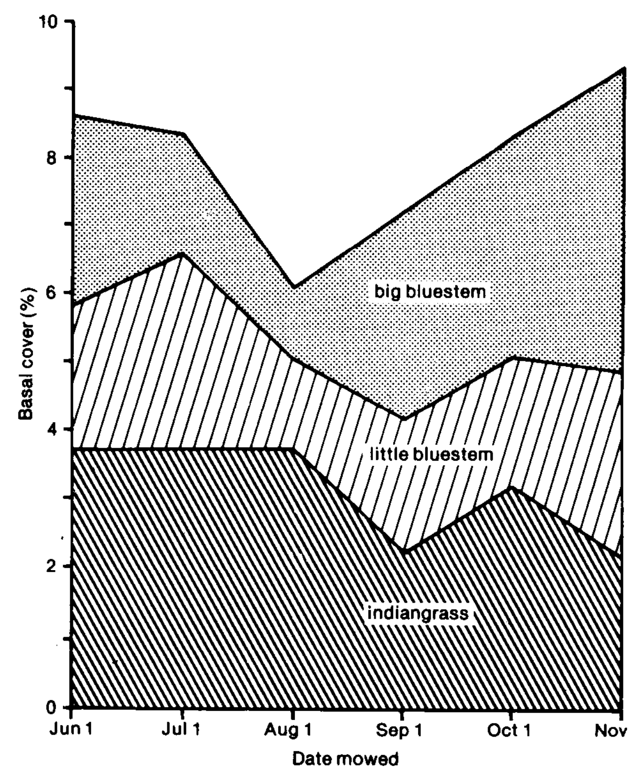
Harvest date is the most important operator-controlled factor in producing native hay. It can affect hay yield, forage quality, stand composition, and usable regrowth.

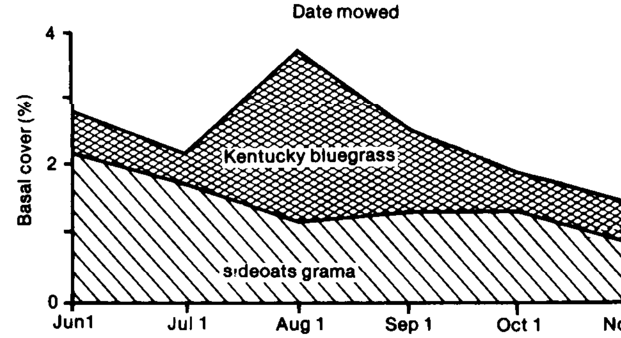
Near Manhattan, during an eight-year period, the best quantity-quality relationship for native hay came from harvesting in mid July (Figure 39). Hay quality was also affected by cutting date. As the growing season progressed, indigestible plant tissue increased as plants translocated nitrogen compounds to stem bases and underground stems (rhizomes). It was not possible to obtain maximum quantity and quality hay in the same cutting. The compromise cutting stage near Manhattan was early-to-mid July. Reduced plant-food reserves decreased hay yields the next year when harvest was later. After being cut, active hay plants produced new top growth. That drew on stored food in the crowns and roots. When time between harvesting and grass dormancy was not adequate for replenishing reserves, plants went into winter with low food reserves (Figure 40). Hay production was lowered the next season. Haying in August and September also changed stand composition; as desirable warm-season perennial grasses became less abundant, undesirable vegetation increased (Figures 41 and 42). After eight years of being cut September 1, a bluestem





Figures 39 and 40 (top and bottom, respectively). ***(Fig. 39)*** *Average hay yield and crude protein content of Flint Hills bluestem meadow mowed annually from 1960 to 1968 during months indicated: and (Fig. 40) percentage of food reserves (average total stored carbohydrates in October) in big bluestem bases 2 inches above plant crowns and in attached rhizomes (underground stems) on Flint Hills bluestem hay meadow mowed annually from 1960 to 1968 on dates indicated.*





Figures 41 and 42 *(top and bottom, respectively). Ground covered* ***(Fig. 41)*** *by desirable warm-season hay plant bases (basal cover) and* ***(Fig. 42)*** *by undesirable cool- and warm-season hay plant bases (basal cover) in November 1967, after 8 years of mowing Flint Hills bluestem meadow annually from 1960 to 1968 on dates indicated.*

meadow was dominated by showywand goldenrod, a weedy forb of low value for hay (Figure 43).

Clipping (to simulate grazing of plant regrowth after hay had been cut) reduced yields, tiller numbers, and food reserves the next season (Figures 44, 45, and 46). The same would hold true for cutting a meadow more than once during the growing season or cutting grazed pastures late in the growing season.

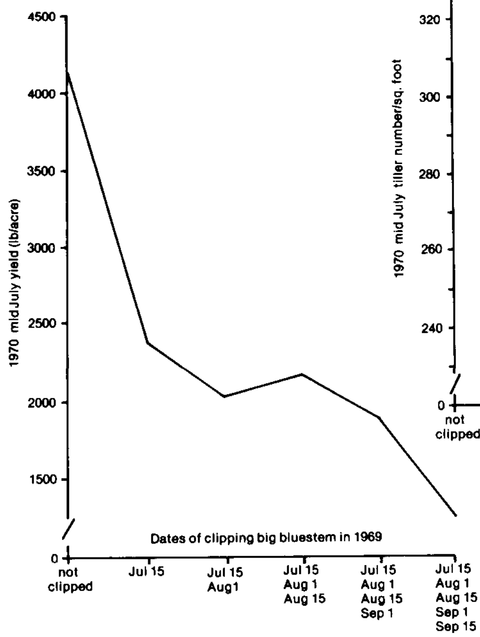
Nitrogen appeared to be the only fertilizer that increased herbage yields enough to warrant using it on native hay meadows. Applying 33 to 67 pounds of N per acre increased hay yields 0.75 to 1.00 ton of dry matter per acre; adding phosphorus to the extent of increasing the amount of available P seven- to eightfold in the top six inches of soil had no consistently significant effect on hay yields (Table 65). Crude protein of early- and late-cut hay also was increased by nitrogen fertilization; but again, phosphorus had no important effect (Table 66).

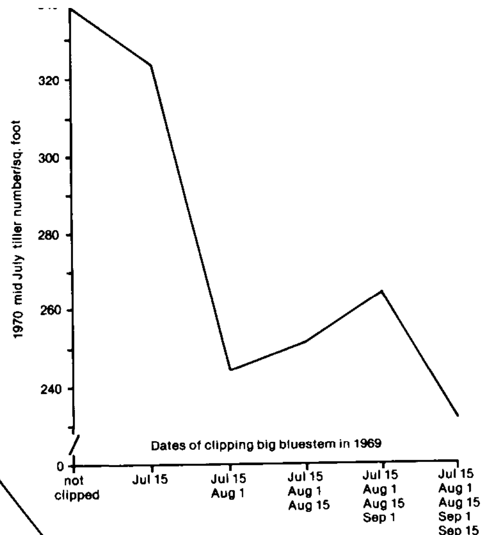
Nitrogen fertilization of a Flint Hills bluestem hay meadow several years in a row caused an increase in cool-season Kentucky bluegrass (Table 67). Such a composition change negated benefits of N fertilization. Late-spring burning controlled that shift, so meadows fertilized with nitrogen must be burned in late spring. Otherwise, too much of the hay produced will be low-producing weedy plants.

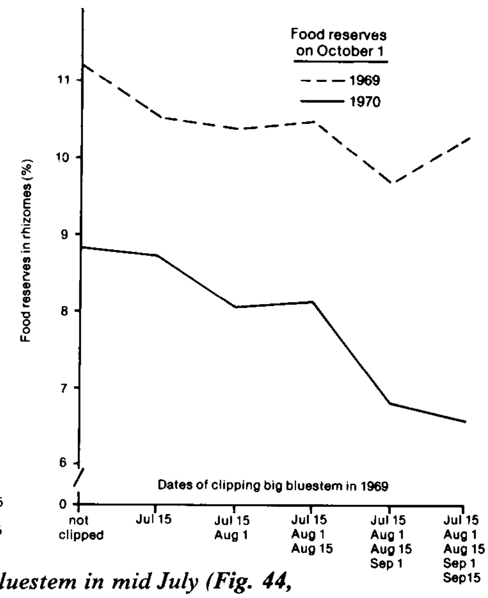
Recommendations

- ***Cut native hay in early-to-mid July in northern parts of Kansas and slightly earlier in southern Kansas.***
- ***Do not allow livestock to graze regrowth until afterfrost; late summer-early fall grazing lowers meadow productivity the next growing season.***
- ***Apply 30 to 40 pounds of N per acre about May 1, depending on cost of nitrogen application, anticipated increase in tonnage, and price of hay.***
- ***In eastern Kansas, burn fertilized meadows in late spring (April 15 in southeast; May 1 in northeast) to control increases in undesirable weedy vegetation. If regrowth is grazed after frost, enough grass must remain as fuel to carry a late-spring fire.***

Figure 43 (left). A hay-meadow experimental plot, dominated by the weedy forb showywand goldenrod, in Flint Hills bluestem vegetation after 8 years of mowing annually September 1, 1960 to 1968.







Figures 44, 45, 46. Yield of big bluestem in mid July (Fig. 44, left); shoots of big bluestem per square foot in mid July (Fig. 45, center): andpercentage of food reserves (starch and sugars) on October 1, 1969 and 1970, in big bluestem rhizomes (underground stems) (Fig. 46, right). All calculations after plants in the Flint Hills bluestem hay meadow had been clipped in 1969 on dates and number of times indicated.

Table 65. Yield of hay harvested in mid July 1963, on Flint Hills bluestem meadow fertilized that spring with phosphorus and nitrogen at rates indicated (yields from sites that had not received phosphorus before 1963 are compared with yields from sites having residual P from annual applications of phosphorus from 1951 to 1955).

Fertilizer applied, spring 1963			Phosphorus added annually, 1951 to 1955	
Phosphorus	**Nitrogen**		**None[1]**	**44 lb P/A[2]**
lb P/acre	lb N/acre		Hay yield mid July, 1963 (lb dry matter/A)	
0	0		4070	4050
0	33		4700	4520
0	67		4800	6340
		Average	4520	4970

1. Plots with no phosphorus added from 1951 to 1955 contained 12 lb P/A in the upper 6 inches of soil before fertilization in 1963.
2. Plots that received phosphorus from 1951 to 1955 contained 90 lb P/A in the upper 6 inches of soil before fertilization in 1963.

Table 66. Average crude protein content of big bluestem cut for hay in mid July, 1963, compared with that cut in mid September on Flint Hills bluestem meadowfertilized in spring with phosphorus and nitrogen at rates indicated.

Spring applied, 1963			Hay cut in:	
Phosphorus	**Nitrogen**		**Mid July**	**Mid September**
lb P/acre	lb N/acre		Crude protein content (%)	
0	0		4.9	3.3
0	33		5.5	4.0
0	67		5.7	4.0
		Average	5.4	3.8
20	0		5.2	3.5
20	33		5.3	3.5
20	67		6.2	4.3
		Average	5.6	3.8

Table 67. Ground covered by plant bases (basal cover) of Kentucky bluegrass, an undesirable grass on Flint Hills bluestem range and hay meadows, fertilized with 0 and 50 pounds of N per acre from 1965 to 1969.

	Nitrogen fertilization rate (lb N/acre)	
Year	**0**	**50**
	Kentucky bluegrass basal cover (%)[1]	
1965	0.50	0.69
1966	2.31	2.00
1967	1.94	5.50
1968	2.62	5.12

1. Percentages underscored by the same line in a given year do not differ significantly ($P<0.05$)

COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED IN THIS PUBLICATION

Common Name	*Scientific Name*
Grasses	***Grasses***
alkali sacaton	***Sporobolus airoides*** **(Torr.) Torr.**
big bluestem	***Andropogon gerardi*** **Vitman**
blue grama	***Bouteloua gracilis*** **(H.B.K.) Lag. ex Steud.**
bluestem	***Andropogon L.***
buffalograss	***Buchloe ductyloides*** **(Nutt.) Engelm.**
grama	***Bouteloua*** **Lag.**
hairy grama	***Bouteloua hirsuta*** **Lag.**
indiangrass	***Sorghastrum nutans*** **(L.) Nash**
inland saltgrass	***Distichlis stricta*** **(Torr.) Rydb.**
Japanese brome	***Bromus japonicus*** **Thunb.**
Kentucky bluegrass	***Poa pratensis*** **L.**
little barley	***Hordeum pusillum*** **Nutt.**
little bluestem	***Andropogon scoparius*** **Michx.**
needleandthread	***Stipa comata*** **Trin. & Rupr.**
prairie sandreed	***Calamovilfa longifolia*** **(Hook.) Scribn.**
prairie threeawn	***Aristida oligantha*** **Michx.**
purple threeawn	***Aristida purpurea*** **Nutt.**
sacaton	***Sporobolus*** **R. Br.**
saltgrass	***Distichilis*** **Raf.**
sandreed	***Calamovilfa*** **Hack.**
sand dropseed	***Sporobolus cryptundrus*** **(Torr.) A. Gray**
sideoats grama	***Bouteloua curtipendula*** **(Michx.) Torr.**
smooth brome	***Bromus inermis*** **Leyss.**
sorghum	***Sorghum bicolor*** **(L.) Moench**
switchgrass	***Panicum virgatum*** **L.**
tall dropseed	***Sporobolus asper*** **(Michx.) Kunth**
tall fescue	***Festuca arundinacea*** **Schreb.**
western wheatgrass	***Agropyron smithii*** **Rydb.**
Other Plants	***Other Plants***
ashy goldenrod	***Solidago mollis*** **Bartl.**
blackberry	***Rubus*** **L.**
broom snakeweed	***Gutierrezia sarothrae*** **(Pursh) Britt. & Rusby**
broomweed	***Gutierrezia dracunculoides*** **(DC.) Blake**
buckbrush	***Symphoricarpos orbiculatus*** **Moench**
bulrush	***Scirpus*** **L.**
common pricklypear	***Opuntia humifusa*** **Raf.**
fine-leaf sedges	***Carex*** **L.**
goldenrod	***Solidago*** **L.**
hickory	***Carya Nutt.***
horseweed	***Conyza canadensis*** **(L.) Cron.**
ironweed	***Vernonia baldwini*** **Torr.**
Louisiana sagewort	***Artemisia ludoviciana*** **Nutt.**
oak	***Quercus*** **L.**
osageorange	***Maclura pomifera*** **(Raf.) Schneid.**
plains pricklypear	***Opuntia polycantha*** **Haw.**
pricklypear	***Opuntia*** **Mill.**
redcedar	***Juniperus virginiana*** **L.**
roughleaf dogwood	***Cornus drummandi*** **Meyer**
sandsage	***Artemisia filtfolia*** **Torr.**
scarlet globemallow	***Sphaeralcea coccinea*** **(Pursh) Rydb.**
showywand goldenrod	***Solidago mollis*** **Bartl.**
slimflower scurfpea	***Psoralea tenuiflora*** **Pursh**
small soapweed	***Yucca glauca*** **Nutt.**
smooth sumac	***Rhus glabra*** **L.**
snow-on-the-mountain	***Euphorbia marginata*** **Pursh**
upright prairieconeflower	***Ratibida columnifera*** **(Nutt.) Woot. & Standl.**
wavyleaf thistle	***Cirsium undulatum*** **(Nutt.) Spreng.**
western ragweed	***Ambrosia psilostachya*** **DC.**
yellowspine thistle	***Cirsium ochrocentrum*** **Gray**

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