

P1978-007

2

1978-
Herb. Armitage
from
E. P. Hall
copy 1 of 2

A 20-YEAR RECORD OF SUCCESSION ON
RESEEDED FIELDS OF TALLGRASS PRAIRIE
ON THE
ROCKEFELLER EXPERIMENTAL TRACT



By Henry S. Fitch
and
E. Raymond Hall

December 1978
Special Publication No. 4

UNIVERSITY OF KANSAS PUBLICATIONS
MUSEUM OF NATURAL HISTORY

Editor: E. O. Wiley

SPECIAL PUBLICATION No. 4

Pp. 1-15

Issued December 29, 1978

MUSEUM OF NATURAL HISTORY
THE UNIVERSITY OF KANSAS
LAWRENCE, KANSAS 66045

PRINTED BY
UNIVERSITY OF KANSAS PRINTING SERVICE
LAWRENCE, KANSAS

A 20-YEAR RECORD OF SUCCESSION ON
RESEEDED FIELDS OF TALLGRASS PRAIRIE
ON THE
ROCKEFELLER EXPERIMENTAL TRACT

By

HENRY S. FITCH¹ AND E. RAYMOND HALL²

In recent decades it has become generally recognized that the tallgrass prairie, once extending from Canada to the Gulf of Mexico on the eastern edge of the Grassland Biome, is a subclimax maintained by fire. Without periodic burning, the grass is rapidly invaded by trees and other woody plants (if there is a seed source for these) and eventually is shaded out, eliminated, and replaced by the climatic climax of oak-hickory forest (Shelford, 1963).

In 1956 the University of Kansas acquired a 65-ha (160-acre) upland tract for study of this process of succession. Objectives were to determine how best to maintain a tallgrass prairie and to investigate the plant-animal interactions involved in the maintenance of this type of fire subclimax. The area studied (Rockefeller Experimental Tract) is on the southern edge of Jefferson County, Kansas, adjoining the John H. Nelson Environmental Area to the east and north, and the Charles Robinson Pasture (= University of Kansas Natural History Reservation) to the south.

Much of the Rockefeller Tract had been under cultivation or pastured as a private farm prior to 1956, but a block of 4.6 ha (11.4 acres) on its western edge was still virgin prairie that had been maintained by annual mowing for hay, and burning of remaining stubble. In the spring of 1957 the cultivated and grazed parts were disked and sown to a seed mixture of Big Bluestem, Little Bluestem, Indian Grass and Switchgrass. The mechanical seeder used was filled several times in the course of operations, and was driven inward in a concentric course. The stand of grass that was subsequently established was not uniform, and it became evident that after each filling of the seeder the heavy rounded seeds of Switchgrass had fed through rapidly until used up, but the light and downy seeds of Little Bluestem were mostly retained by the seeder until the other three kinds had passed through (Fitch, 1965). As a result, the course of the machine could be traced from the bands of grass, with gradients from nearly pure Switchgrass where the seeder had started full to nearly pure Little Bluestem where it was emptying. This original zonation disappeared over a period of years. The

¹ Professor, Department of Systematics and Ecology, University of Kansas, Lawrence, KS 66045

² Director Emeritus, Museum of Natural History, University of Kansas, Lawrence, KS 66045

perennial tall grasses required several years to become well established and dominate early seral vegetation, which was especially prominent in the first two seasons.

The virgin prairie (Fig. 1, I) adjoined a reseeded area (Fig. 1, II) that was not subjected to experimental treatment. The virgin prairie, since the 1870s, had been maintained in something like its pristine state by annual mowing for hay in late summer, and burning of the remaining dry vegetation in early spring. This regimen was altered under management by the University of Kansas beginning in 1957. Thereafter the virgin prairie was burned off every third year until in the late 1960s it became obvious that woody vegetation was not being held in check. Then the expanding thickets on the area (Fig. 1, I) were removed in one year by means of a brush cutter. Thereafter the virgin prairie was burned annually or biennially except that in some years it was instead mowed or, in some years, both mowed and burned.

MATERIALS AND METHODS

Five years after the reseeding operations of 1957, a stand of perennial tall grasses had been re-established and was fairly dense on most parts of the reseeded area. During the five-year interval the only management was mowing of weeds in each of the first two years. In 1962, after the stand of grass was established, five comparable plots were marked off and differential treatments were begun. The easternmost strip (Fig. 1, VI) was burned off annually at the end of March or the first week of April. The fire was started in late afternoon when wind velocity was low and humidity was rising, and it burned upwind until a protective marginal strip was cleared of vegetation on three sides of the plot. Then fires were lit on the fourth side and allowed to sweep across the area downwind. When the burning was most effective all vegetation above ground was consumed, but on some occasions, after recent rains, a mat of dead vegetation adhering closely to the soil, retained enough moisture to resist the fire.

Cattle were placed on the grazed plot (Fig. 1, IV) in early June and, depending on amount of vegetation present and degree of usage, were removed at an appropriate time in August. Grazing pressure for the summer months usually amounted to about one animal per .4 ha (1 acre). The remaining plot (Fig. 1, III) was mowed in July. On one part of it the cut grass was removed as hay, but on the other part was left lying. Mowing was begun in 1963. Two of the plots used as controls (Fig. 1, II and V) were protected and received no special experimental treatments after the original reseeding of perennial grasses. The larger of these (Fig. 1, II) adjoined the original prairie, and there was opportunity for prairie

plants to invade this area where the perennial tall grasses had been re-established.

Comparisons of the areas subjected to different treatments were made from time to time over the 15-year period 1962-77 and especially in the spring and summer of 1977. Vegetation was analyzed on a series of circular plots of 10 m² (Table 1). Occurrence and relative density of each plant species on each plot was estimated. Animal populations on the plots were sampled by direct observation of the animals and their sign, by sweep-netting, and by various types of traps, including grids of live-traps for small mammals. The two largest native mammals, Elk (Wapiti) and Bison which were primary consumers of the prairie vegetation, were extirpated on the tract concerned more than a century ago.

In this account only vernacular names of plants and animals are used, but the scientific names of all species mentioned are listed (see appendix). The scientific names of plants follow the taxonomy of McGregor, Brooks and Hauser (1976).

RESULTS

Burned Plot (Fig. 1, VI) The program of annual burning resulted in maintenance of grassland virtually free from woody vegetation. Because of abundant nearby seed sources, large numbers of shrub- and tree-seedlings, notably Smooth Sumac, Rough-leaved Dogwood, American Elm and Boxelder appeared each year, but were eliminated or severely damaged by the fire and never became firmly established. Little Bluestem and Switchgrass dominated the area (see Table 1). The lower parts of the plot, at the north and south ends, had relatively deep soil with silt deposits which supported dense and almost pure stands of Switchgrass up to 1 m high, whereas Little Bluestem, growing in lower and sparser stands, dominated most of the area including the higher parts. In 1977 an east-west line along a central low ridge was discernible where a former fence separated what was once a pasture to the south from a formerly cultivated field to the north. Sheet erosion from the cultivated land had lowered the surface from .1 to .5 m, and reduced soil fertility. As a result, clumps of Little Bluestem were small and well separated and fire did not readily burn through them.

Animal life in general was scarce on the burned plot (Fig. 1, VI). The Deer Mouse seemed to be the only mammal that lived there permanently and the Eastern Meadowlark was the only nesting bird noted. No reptiles were found there, and the only amphibian was the Western Chorus Frog, which lives in ground cracks. In contrast, certain stem- and leaf-living insects and spiders were even more abundant than on the virgin prairie or any of the other experimental plots. These included the Mermiria Grasshopper, Orphulella Grasshopper, Long-bodied Jumping Spider, Striped

TABLE 1.—Percentage Composition in 1977 of Experimental Plots To Perennial Prairie Tall Grasses in 1957

	Untreated Control Plots II and V	Grazed Plot (IV)	Mowed Plot (III)	Burned Plot (VI)
Number of Samples 10m ²	50	52	38	100
Little Bluestem	18.2	45.1	34.2	69.0
Switchgrass	18.2	26.9	13.5	22.6
Missouri Goldenrod	17.9	9.0	1.3	—
Crassleaved Goldenrod	17.2	2.6	—	—
Kentucky Blue Grass	—	14.9	14.0	—
Big Bluestem	20.0	.6	15.2	4.7
Prairie Dropseed	2.8	4.5	6.5	—
Indian Grass	—	1.0	—	2.9
Japanese Chess	—	trace	3.8	—
Brome	—	trace	2.1	—
Sedge	—	trace	1.9	—
Other	2.7	3.5	1.1	1.0
Total	100	100	100	100

Lynx Spider and Prairie Crab Spider. Ground-living invertebrates included abundant large lycosid spiders (Tiger Wolf Spider, Rabid Wolf Spider, Lance Spider) and the ubiquitous Acrobat Ant.

Mowed Plot (Fig. 1, III) Mowing, like fire, proved to be highly effective in maintaining a prairie vegetation and eliminating invading woody plants. In 1977 after re-establishment of the four species of prairie grasses and 16 successive annual mowings, there were no trees or shrubs on the experimental plot. This plot differed from the burned plot in having far more diversity in both plants and animals. The part from which prairie hay was removed was more nearly homogeneous, with Little Bluestem by far the most abundant species and Switchgrass making up most of the remainder. In places there were scattered plants of Canada Wild Rye, and Plains Wild Indigo. In deep soil at the south edge Big Bluestem was fairly common.

Where the mowed vegetation was not removed, flora was much more diversified, with some typical prairie species (Canada Wild Rye, Prairie Dropseed, Compass Plant, Stiff Sunflower, Purple Coneflower, Common Breadroot Scurfpea) and some species characteristic of disturbed habitats including Ironweed, Dogbane, Smooth Brome, Kentucky Blue Grass (see Tables 1 and 2).

Animal species present include the Deer Mouse, Prairie Vole, Long-tailed Harvest Mouse, Hispid Cottonrat, Eastern Meadowlark, Mourning Dove, Ring-necked Snake, Red-sided Garter Snake, Prairie King Snake, Yellow-bellied Racer, Slender Glass Lizard, Western

TABLE 2.—Percentage of Frequency of Occurrence in 10m² Samples in 1977 Of Various Prairie Plants and Weeds, in Experimental and Untreated Plots Reseeded to Perennial Prairie Tall Grasses in 1957.

	Untreated Control Plots II and V	Grazed Plot (IV)	Mowed Plot (III)	Burned Plot (VI)
Number of Samples	50	52	38	100
Little Bluestem	66	98	98	92
Switchgrass	94	100	37	60
Indian Grass	44	10	50	54
Big Bluestem	88	8	90	58
Kentucky Blue Grass	—	39	48	—
Missouri Goldenrod	68	92	24	43
Grassleaved Goldenrod	64	52	48	—
Dogbane	50	46	63	7
Ironweed	14	19	50	2
Common Ragweed	34	10	10.5	5
Japanese Chess	—	—	24	—
Brome	—	—	10.5	—
Prairie Dropseed	30	38	36	—
Slender Mountain-mint	4	2	3	1

Chorus Frog and many of the invertebrates characteristic of tall-grass prairie.

Grazed Plot (Fig. 1, IV) Like the other experimental plots, this one was elongate from north to south. A pond on one side near the middle served as a watering place for the cattle and tended to concentrate their activities in the vicinity; the more remote areas at the northern and southern extremes were subject to relatively light use.

Like the untreated plots the grazed plot was subject to rapid invasion by woody plants, but trampling and feeding by the cattle tended to delay their establishment. By 1977 thickets and groves were extensive, with trees up to 6 m in height, mainly Shagbark Hickory, oaks of three species, American Elm in the parts adjacent to the forest, and with thickets of dogwood throughout, alternating with more open areas. Poison Ivy was almost absent from these thickets, whereas on the adjacent Control Plot it was fairly common.

In the open areas, patches of bare ground between clumps and individual plants were prominent, especially at the heads of small gullies in the most heavily grazed central portion. Little Bluestem dominated most samples (Table 1) and Switchgrass was scarcer. Throughout the grazed plot, prairie plants other than the reseeded grasses were almost absent, and seemingly were unable to establish themselves under grazing pressure. Notable exceptions were Prairie Dropseed and Slender Mountain-mint (Tables 1 and 2). Also, Blue Sage and Canada Wild Rye occurred in appreciable quantities. Kentucky Blue Grass, Smooth Brome and Japanese Chess were

prominent in the heavily used central part. In the parts that were relatively little used by the cattle Missouri Goldenrod and Grass-leaved Goldenrod were both common.

Many of the animal species found on the untreated areas were also present on the grazed plot. Lack of surface litter made the area unsuitable habitat for microtine rodents, and none was found there.

Untreated Plots An untreated plot (Fig. 1, V) nearly .8 km long was between the grazed and burned plots, but was bordered by woodland for nearly 30 percent of its perimeter. Another plot (Fig. 1, II) was irregular in shape having a lobe extending into woodland, and trees on more than half its perimeter. Thus in 1957 both plots adjoined forest which served as an abundant seed source for invading woody vegetation, but they also had extensive open areas; some points were as much as 200 m from a seed source. Invasion by woody vegetation began immediately along the edges bordering forest, but was delayed elsewhere. By 1977 both plots consisted of mixtures of prairie and woodland plants, and each assemblage dominated a comparable area. Where the experimental strips adjoined forests, trees including Shagbark Hickory, Northern Red Oak, Chinquapin Oak, American Elm, American Ash and Boxelder had grown up in dense stands as much as 8 m high, but with average height rapidly decreasing farther from the edge, and with Rough-leaved Dogwood, Eastern Redbud, Smooth Sumac and Buckbrush intermingled with the young trees where they were not dense enough and high enough to shade out such competition. Throughout both untreated strips there were thickets dominated by Rough-leaved Dogwood 2 m to 3 m high in lines and clumps, some isolated and some in contact with others. The vegetative samples from the untreated plots that were the basis for Tables 1 and 2 were taken from the remaining open areas between brush clumps, and the woody plants were not included.

Even on the parts of the untreated plots still dominated by herbaceous plants, the composition was extremely diversified in 1977. Some parts of the areas that were sloping and severely eroded had sparse stands of Switchgrass and Little Bluestem but not much else. In contrast, parts that had deeper and better soil, including an almost level hilltop and also lower parts, had a much greater diversity of grass and forbs. Big Bluestem, though making up only a small part of the total, was more prominent than anywhere else on the reseeded plots. Prairie Dropseed and Slender Mountain-mint, two species that are part of the virgin prairie flora, were both found frequently (usually in trace quantities) on the untreated plots II and V but were scarcely represented on plots III, IV and VI (see Fig. 1).

Both Missouri Goldenrod and Grassleaved Goldenrod were prominent on many parts of those plots, and often one or both

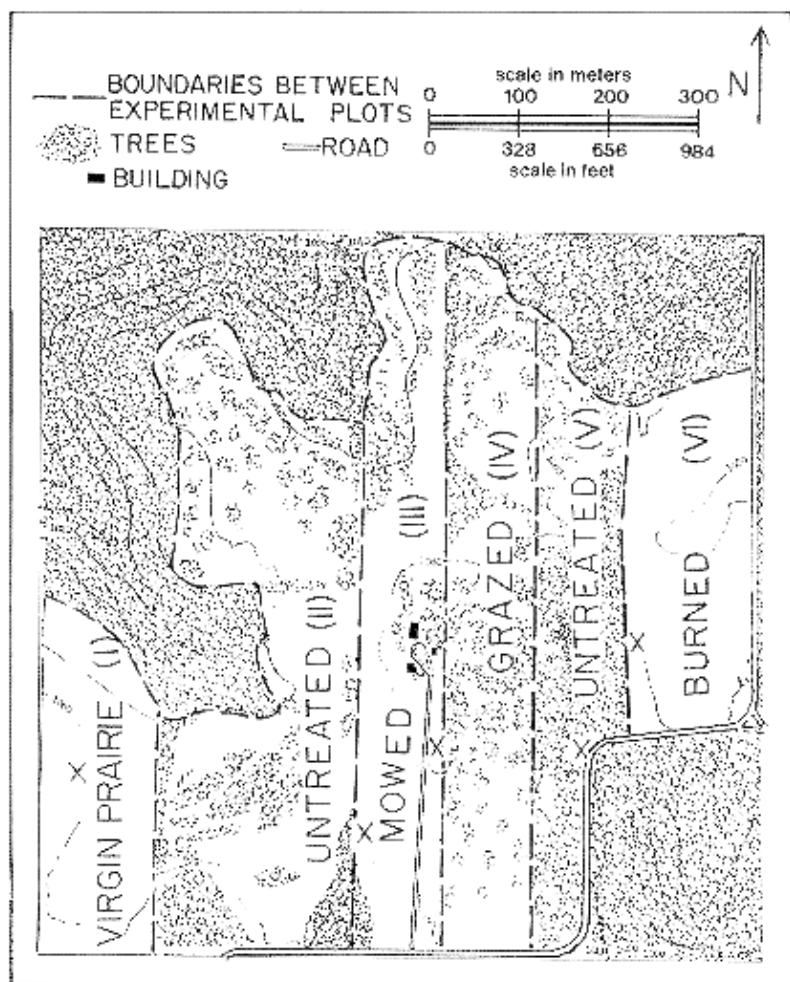


Fig. 1.—Rockefeller Experimental Tract (SW 1/4 sec. 33, T. 11 S., R. 20 E., Jefferson Co., Kansas) showing numbered areas discussed in text. X's mark locations of cameras when the photographs on Figs. 2 and 3 were taken.



Fig. 2.—*Upper*: Virgin prairie (I) of Rockefeller Experimental Tract, free of woody plants after four consecutive years of annual burning, and mowing in the next (1976) year. View from near center toward northwest corner. H. S. Fitch in foreground; E. R. Hall in distance; each ca. 5' 8" tall. *Lower*: South edge of untreated plot (V) showing dense woody vegetation after 20 years of protection subsequent to sowing of prairie grass seeds. (Photos by Willbur D. Hess 27 April 1977. X's on Fig. 1 of page 7 mark locations of camera.)

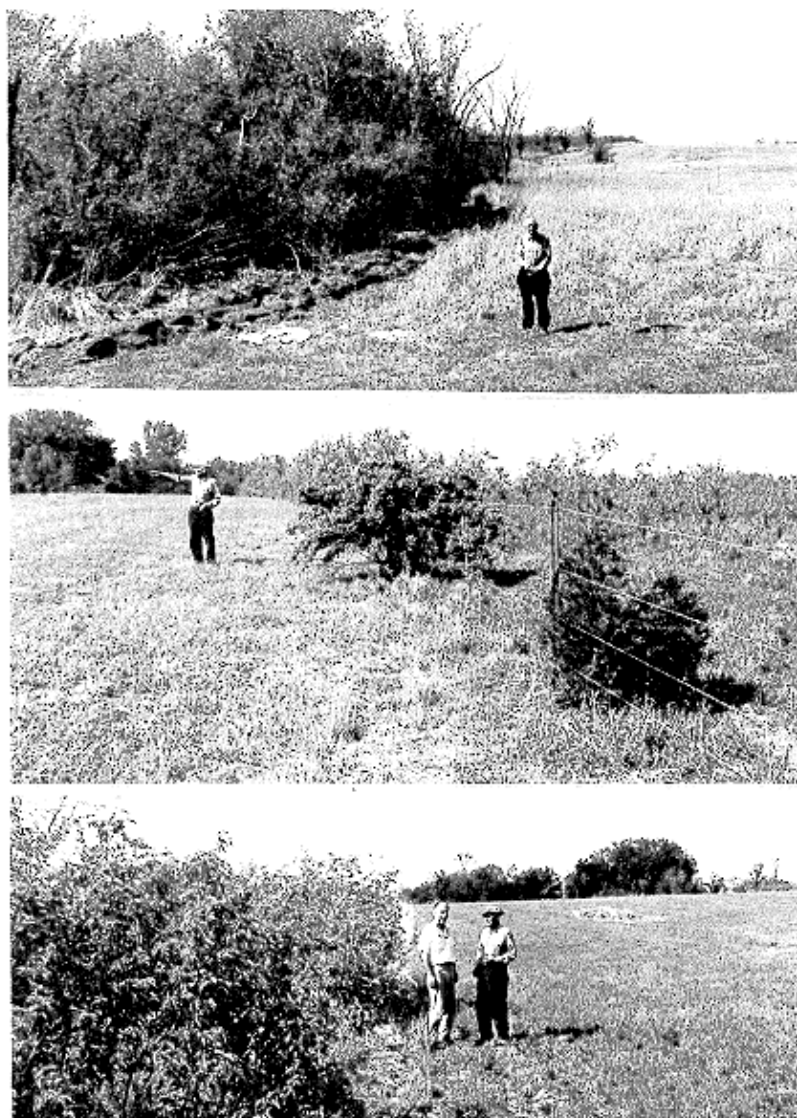


Fig. 3.—Upper: Experimental plot No. VI (right) subjected to annual burning, resulting in freedom from woody vegetation, and untreated plot No. V (left) with dense growth of woody vegetation after 20 years of protection. Middle: Experimental plot No. III mowed annually in summer (left) showing freedom from woody vegetation, and grazed strip No. IV (right) showing moderate invasion of woody vegetation after 20 years. Lower: Experimental mowed plot No. III (right) showing freedom from woody vegetation, and untreated plot No. II (left) showing encroachment of brush and trees after 20 years of protection. (Photos by Willbur D. Hess 27 April 1977; all views toward north—X's on Fig. 1 of page 7 mark locations of camera.)

dominated a sample. Where goldenrods were common, grass was sparse and unthrifty and often the dead and crumbling remains of former large grass clumps were noticed, suggesting that the presence of goldenrod in abundance was harmful to the grass. Weedy forbs including Devil's Beggarticks, Common Ragweed, Ironweed and Dogbane, were more prominent on the untreated plots than elsewhere on the reseeded area.

Animal life was especially abundant on the untreated plots. White-tailed Deer spent much time there. Eastern Cottontails were moderately common. Small mammals that were regular residents included the Hispid Cottonrat, Prairie Vole, Southern Lemming-mouse, Woods Mouse, Long-tailed Harvest Mouse, Short-tailed Shrew and Least Shrew. Breeding birds include Bobwhite, Mourning Dove, Yellow-billed Cuckoo, Brown Thrasher, Yellow-breasted Chat, Cardinal, Field Sparrow, Eastern Meadowlark, and Bell Vireo. Reptiles included the Copperhead, Yellow-bellied Racer, Ring-necked Snake, Prairie King Snake, Red-sided Garter Snake, Black Rat Snake, Slender Glass Lizard and Great Plains Skink.

DISCUSSION

Our study confirms observations that tallgrass prairie in eastern Kansas is dependent on recurrent fire, which destroys competing woody plants and actually stimulates growth of the dominant grasses. These grasses, and most other plants of the prairie, are perennials with underground parts that ordinarily are not damaged by fire, even though all plant material above the surface of the ground is consumed. The biota of this type of prairie consists of species that are highly resistant to fire or are able to escape it by high mobility or by retreat to underground shelters that are sufficiently insulated. Those animals which escape incineration have the further problem of surviving on the charred soil surface where food and shelter have been almost entirely removed. Under these constraints the tallgrass prairie fauna is considerably impoverished, and many of its animal species are somewhat marginal, living where gullies, streamcourses or rock outcrops provide some protection against the fire.

The annual burning off of our experimental plot was always at approximately the same date and was timed to minimize destruction of wildlife; it took place just before new growth appeared in the spring, when soil was damp, and when many kinds of animals were still dormant underground. Natural prairie fires must have been far more variable in their seasonal incidence, making it more difficult for animals to avoid their effects.

Mowing parallels burning in eliminating woody vegetation, but is much less destructive of animal life in general, though at times it causes high mortality in certain species. After the cutting, some

food and cover remain. The timing of mowing is critical to both plants and animals. Mowing on any given date affects each species somewhat differently according to the seasonal timing of its growth and reproduction. Mowing either earlier or later in the season might have had important effects on the plant composition and the productivity of the experimental strip.

Our experimental treatments demonstrate that a tallgrass prairie of sorts (dominant grasses only) can be readily re-established by reseeding and can be maintained by either annual burning or annual mowing, but that, without these treatments, both natural and regenerated prairie undergo rapid degradation ending in disappearance of the prairie biota and its replacement by forest species. The rate of replacement depends on the situation, especially the availability of seed sources for the forbs, shrubs and trees that are invading the grassland. For a large and continuous block of grassland the process would begin slowly, with most invasion at the edges.

Four overlapping stages can be recognized in the process of degradation and replacement of tallgrass prairie. In *STAGE 1*, various broad-leaved forbs, notably Missouri Goldenrod and Grass-leaved Goldenrod spread through the prairie, increase in abundance over a period of years, compete with the grass, and produce substances that inhibit its growth. The grass becomes progressively more sparse and stunted. In *STAGE 2* low woody plants appear and spread. Rough-leaved Dogwood, Smooth Sumac, Northern Dewberry, and Buckbrush are prominent in approximately that order. From a dogwood seed, dropped on the open prairie, a plant may, over several years, grow 2-3 m high and meanwhile its lateral roots may produce new stems. Eventually there is a brush clump several m in diameter, with stems tallest in the center and lowest at the edges, where it is fringed with lower shrubs such as Smooth Sumac and Buckbrush, and with the Northern Dewberry Vine. Such clumps spring up throughout the grassland, and they gradually expand and merge, shading out the prairie grasses and other herbaceous plants. Meanwhile, *STAGE 3* has begun—the establishment of trees. American Elm, American Ash and Boxelder, because of their minute, winged seeds are early invaders, and become established within and between the clumps of brush. The area becomes a mosaic, having patches of prairie grass and the associated fauna alternating with woodland species. In *STAGE 4* the climax oaks and hickories of the deciduous forest become established and gradually gain dominance over the herbs, shrubs, and trees mentioned above as characteristic of preceding seral stages.

Although our efforts to re-establish a tallgrass prairie were superficially successful plantwise, it must be emphasized that in diversity of species of plants, as well as of animals, this regenerated prairie was extremely depauperate. Two species of perennial grasses made up most of the biomass. A few other prairie species and weeds

were sparsely represented, but most of the characteristic tallgrass prairie species were totally absent. Their absence was the more remarkable because the regenerated prairie on one side for a distance of 270 m contacted the block of virgin prairie with its large assemblage of characteristic species. No obvious barrier to the dispersal of any of these species existed, and it seemed reasonable to expect them to spread over a period of years throughout the block reseeded to grass. Yet in 1977, after 20 years, few species of prairie plants could be found anywhere in the reseeded area. Compass Plant, Blue Sage, Yucca-leaved Eryngo, Plains Wild Indigo, and Slender Mountain-mint occurred mostly in sparse and scattered stands on the experimental strips. However, from their pattern of distribution, it seemed evident that the seeds had occurred as contaminants in the grass seed sown, and isolated plants from such seeds had produced the scattered colonies observed. Along the line of contact between the virgin prairie and the reseeded grassland, remarkably little penetration could be observed; it was limited to few species and usually the distances involved were short.

SUMMARY

In the spring of 1957 on an upland area of 43 ha (160 acres) in Jefferson County, northeastern Kansas, seeds were sown of four native grasses, Big Bluestem (*Andropogon gerardii*), Little Bluestem (*Andropogon scoparius*), Switchgrass (*Panicum virgatum*), and Indian Grass (*Sorghastrum avenaceum*). Within five years these native perennials were re-established, causing the area to resemble the original prairie superficially, but the plant cover consisted mostly of Little Bluestem and Switchgrass with much smaller amounts of Indian Grass and Big Bluestem, and few other prairie plants. The re-established tall grasses were successfully maintained on plots that were either burned or mowed annually. Conversely, on plots not subject to those treatments, but either grazed or protected, rapid degradation of the grass stands occurred over a 14-year period. Weedy forbs, especially goldenrods, invaded and competed, and more gradually shrubs and tree saplings followed, first as isolated plants but later as expanding clumps replacing the grass. Along a 270-m front where a block of virgin prairie contacted the area reseeded to tall grasses, invasion of the grass stands by the native prairie flora was almost negligible, demonstrating that once the native prairie is destroyed or drastically altered, the prairie community as a whole cannot readily be restored. Certain insects and spiders characteristic of tallgrass prairie were abundant on the burned plot, but vertebrates were scarce there both in species and in individuals; they were progressively more numerous and diversified on the mowed plot, the grazed plot, and especially the untreated plots.

HISTORY AND ACKNOWLEDGEMENTS

Alone at a window table for an early breakfast in April of 1956 at the Campus Club in Washington, D.C., I [R. H.] welcomed Mr. Horace M. Albright's "Ray Hall, may I join you?" with a "please do."

H. A.: "What special project has your attention now?"

R. H.: "When you spoke I was thinking about the 11 acre tract of Tallgrass Prairie on an otherwise worn-out 160 acre upland farm which adjoins the University of Kansas Natural History Reservation. More precisely, I was speculating on how to acquire that tract of prairie which might reveal whether its persistence depended on mowing, grazing, or burning. One wonders also whether the native prairie plant- and animal-life could be re-established by seeding adjoining parts of the worn out cultivated land."

H. A.: "Tell me more."

I [R. H.] outlined the plan which Henry Fitch and I had made to test mowing versus grazing and occasional burning of the prairie vegetation in its dormant period as a means of preserving the tallgrass prairie which was threatened by invasion of woody vegetation from three sides.

H. A.: "Could I have an outline of that plan in writing?"

R. H.: "Yes. I'll send you one."

Then we talked of other things.

Two and a half months later at Lawrence, Kansas, a letter from Mr. Albright came. It read: "I was at dinner . . . last night [in New York] and sat next to Mr. [Dana S.] Creel who is Mr. [John D.] Rockefeller's chief of staff so far as consideration of projects is concerned. . . . Mr. Creel indicated very great interest in your little native prairie . . . he brought up the subject himself."

Soon thereafter an envelope postmarked New York arrived at Lawrence. It contained two items: a check signed by John D. Rockefeller, Jr. for \$17,000, and a paste-down flap from a used envelope bearing in longhand the words "for the prairie tract."

For three decades in this century Mr. John D. Rockefeller, Jr. (aided by Laurance S. Rockefeller and his brothers) surpassed all others in preserving scenic and natural areas ranging in size from huge to small (Newhall, 1957) and Mr. Horace M. Albright had much to do with most of those areas.

We acknowledge the assistance of Virginia Fitch in obtaining precise data recorded in tables 1 and 2 herewith.

In the 22 years since 1956, faculty members of the University of Kansas and their advanced students have recorded in scores of articles in technical journals a tremendous amount of new information in the broad field of Ecology as a result of experiments and observations on the Rockefeller Experimental Tract, and the adjoining Nelson Area and Natural History Reservation. The end of new findings is not in sight.

LITERATURE CITED

- FITCH, H. S. 1965. The University of Kansas Natural History Reservation in 1965. Univ. Kansas Mus. Nat. Hist., Misc. Publ. No. 42, 60 pp.
- MCGARCOB, R. L., R. E. BROOKS and L. A. HAUSER. 1978. Checklist of Kansas vascular plants. State Biol. Surv. Kansas, Tech. Pub. No. 2, 168 pp.
- NEWHALL, N. 1957. A contribution to the heritage of every American. Alfred A. Knopf, New York. 179 pp.
- SORRESON, V. E. 1963. The ecology of North America. Univ. Illinois Press, Urbana. 610 pp.

*Manuscript completed
December 30, 1977*

APPENDIX I.—LIST OF PLANTS

- American Ash *Fraxinus americana* L.
 American Elm *Ulmus americana* L.
 American Plum *Prunus americana* Marsh.
 Big Bluestem *Andropogon gerardii* Vitman
 Black Oak *Quercus velutina* Lam.
 Blue Sage *Salvia pitcheri* Torr.
 Boxelder *Acer negundo* L.
 Buckbrush *Symphoricarpos orbiculatus* Moench
 Canada Wild Rye *Elymus canadensis* L.
 Chinquapin Oak *Quercus muehlenbergii* Engelm.
 Common Breadroot Sculpin *Psoralea esculenta* Pursh
 Common Ragweed *Ambrosia artemisiifolia* L.
 Compass Plant *Silphium laciniatum* L.
 Devil's Beggarticks *Bidens frondosa* L.
 Dogbane *Apocynum cannabinum* L.
 Eastern Redbud *Cercis canadensis* L.
 Flowering Spurge *Euphorbia corollata* L.
 Grassleaved Goldenrod *Solidago tenuifolia* (L.) Salisb.
 Hackberry *Celtis occidentalis* L.
 Honey Locust *Gleditsia triacanthos* L.
 Ironweed *Vernonia baldwini* Torr. var. *interior* (Small) Schub.
 Indian Grass *Sorghastrum avenaceum* (Michx.) Nash
 Japanese Chess *Bromus japonicus* Thunb.
 Kentucky Blue Grass *Poa pratensis* L.
 Kentucky Coffee Tree *Gymnocladus dioica* (L.) K. Koch
 Leadplant *Amorpha canescens* Pursh
 Little Bluestem *Andropogon scoparius* Michx.
 Missouri Goldenrod *Solidago missouriensis* Nutt.
 Narrow-leaved Gayleather *Liatris punctata* Hook.
 Northern Dewberry *Rubus flagellaris* Willd.
 Northern Red Oak *Quercus borealis* Michx. var. *maxima* (Marsh.) Ashe
 Osage Orange *Maclura pomifera* (Raf.) Schneid.
 Plains Wild Indigo *Baptisia leucophylla* Nutt.
 Poison Ivy *Toxicodendron radicans* (L.) Ktze.
 Prairie Dropseed *Sporobolus heterolepis* Gray
 Prairie Rose *Rosa setigera* Michx.
 Purple Coneflower *Echinacea pallida* Nutt.
 Rough-leaved Dogwood *Cornus drummondii* C. A. Meyer
 Slagbark Hickory *Carya ovata* (Mill.) K. Koch
 Slender Mountain-mint *Pycnanthemum tenuifolium* Schrad.
 Smooth Brome *Bromus inermis* Leys.
 Smooth Sumac *Rhus glabra* L.
 Stiff Sunflower *Helianthus rigidus* (Cass.) Desf.
 Switchgrass *Panicum virgatum* L.
 Yucca-leaved Eringo *Eryngium yuccifolium* Michx.

APPENDIX II.—LIST OF ANIMALS

Acrobat Ant <i>Crematogaster lineolata</i> (Say)	Mermiria Grasshopper <i>Mermiria maculipennis</i> (Bruner)
Bell Vireo <i>Vireo bellii</i> Audubon	Mourning Dove <i>Zenaida macroura</i> (Linnaeus)
Black Rat Snake <i>Elaphe obsoleta</i> (Say)	Orphulella Grasshopper <i>Orphulella speciosa</i> (Scudder)
Bison <i>Bison bison</i> (Linnaeus)	Prairie Crab Spider <i>Philodromus prairieae</i> (Scheffer)
Yellow-bellied Racer <i>Coleber constrictor</i> (Linnaeus)	Prairie King Snake <i>Lampropeltis calligaster</i> (Hadan)
Bolwhite <i>Colinus virginianus</i> (Linnaeus)	Prairie Vole <i>Microtus ochrogaster</i> (Wagner)
Brown Thrasher <i>Toxostoma rufum</i> (Linnaeus)	Rabid Wolf Spider <i>Lycosa rabida</i> Walckenaer
Cardinal <i>Cardinalis cardinalis</i> (Linnaeus)	Red-sided Garter Snake <i>Thamnophis sirtalis</i> (Linnaeus)
Copperhead <i>Agkistrodon contortrix</i> (Linnaeus)	Ring-necked Snake <i>Diadophis punctatus</i> (Linnaeus)
Deer Mouse <i>Peromyscus maniculatus</i> (Wagner)	Short-tailed Shrew <i>Blarina brevicauda</i> (Say)
Eastern Cottontail <i>Sylvilagus floridanus</i> (J. A. Allen)	Slender Glass Lizard <i>Ophisaurus attenuatus</i> (Baird)
Eastern Meadowlark <i>Sturnella magna</i> (Linnaeus)	Southern Lemming-mouse <i>Synaptomys cooperi</i> (Baird)
Elk (Wapiti) <i>Cervus canadensis</i> Exlehen	Western Chorus Frog <i>Pseudacris triseriata</i> (Wied)
Field Sparrow <i>Spizella pusilla</i> (Wilson)	Striped Lynx Spider <i>Oxyopes salticus</i> (Hentz)
Great Plains Skink <i>Eumeces obsoletus</i> (Baird and Girard)	Tiger Wolf Spider <i>Lycosa aspersa</i> (Hentz)
Hispid Cottonrat <i>Sigmodon hispidus</i> (Say and Ord)	White-tailed Deer <i>Dama virginiana</i> Zimmermann
Lance Spider <i>Schizocosa avida</i> (Walckenaer)	Woods Mouse <i>Peromyscus leucopus</i> (Rafinesque)
Least Shrew <i>Cryptotis parva</i> (Say)	Yellow-billed Cuckoo <i>Coccyzus americanus</i> (Linnaeus)
Long-bodied Jumping Spider <i>Marpissa pikei</i> (Peckham and Peckham)	Yellow-breasted Chat <i>Icteria virens</i> (Linnaeus)
Long-tailed Harvest Mouse <i>Reithrodontomys magalotii</i> (Baird)	

