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## Transcriber's Notes

With the exception of the addition of a Table of Contents and the typographical correction noted below, the text in this file is that presented in the original printed version. Some of the text was rearranged so that figures and tables do not split paragraphs.

## Typographical Errors

Page 92, Para. 4: plaes => [places](#)

## The Forest Habitat of the University of Kansas Natural History Reservation

Henry S. Fitch And Ronald L. McGregor

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————— **December 31, 1956** —————

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BY

**HENRY S. FITCH AND RONALD L. MCGREGOR**

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# The Forest Habitat of the University of Kansas Natural History Reservation

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## Introduction

In northeastern Kansas, before it was disturbed by the arrival of white settlers in the eighteen fifties, tall grass prairies and deciduous forests were both represented. These two contrasting types of vegetation overlapped widely in an interdigitating pattern which was determined by distribution of moisture, soil types, slope exposure and various biotic factors.

The early explorers who saw this region, and the settlers who came later, left only incomplete descriptions, which were usually vague as to the locality and the species of plants represented. As a result, there is but little concrete information as to the precise boundaries between the forests and grasslands, and opinions differ among ecologists. No representative sample of either type remains.

It may be assumed that the plant communities existing one hundred years ago and earlier were far more stable than those of the present that have resulted from man's disruptive activities. This stability was only relative, however. Within the last few thousand years since the final withdrawal of the Wisconsin ice sheet, fairly rapid and continual change must have occurred, as a result of changing climate, the sudden extinction of various large, dominant mammals, and finally the impact of successive aboriginal cultures.

The land north of the Kansas River had been a reserve for the Delaware Indians. This land was thrown open to settlement as a result of two separate purchases from the tribe, in 1860 and 1866. The alluvial bottomlands were fertile and soon were under cultivation.

## History

[\[↑ TOC\]](#)

Because the prairies and forests were soon destroyed or altered by cow, ax, plow and fire, knowledge of the region's ecology under the conditions that prevailed in the early nineteenth century and the centuries before must be gained largely from circumstantial evidence. Although there were no ecologists among the first settlers in Kansas, occasional glimpses of the region's ecology are afforded by the writings of early residents who mentioned native plant and animal life from time to time. However, such mention was usually casual and fragmentary.

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A brief early description of forest in northeastern Kansas, which is casual and incomplete, and perhaps misleading, since it differs from later accounts, was included in Major W. S. Long's report of the exploring expedition that passed through country now included in Johnson, Douglas, Shawnee, Wabaunsee, Riley, Pottawatomie, Jackson, Jefferson and Leavenworth counties in 1819. "The catalogue of the forest trees in this region is not very copious. The cottonwood and the plane tree [sycamore] everywhere form conspicuous features of the forests. With these are intermixed the tall and graceful acacia, the honey locust, and the bonduc, or coffee-tree, and carya [hickory] and fraxinus [ash] ..." (Taft, 1950:442).

A description of the country in northern Douglas County and adjacent Leavenworth County, while it was still in virtually undisturbed condition, was written by Mr. George S. Parks (1854). Travelling up the Kansas River from the Missouri state line he described the vegetation and

physiography with respect to specific landmarks that can be easily located at the present time. His descriptions of the areas he saw that were nearest the Reservation, are quoted below, in part.

[Travelling west from near the mouth of Stranger Creek 10 miles ESE Reservation.] "... bluff with open woods and high rolling prairie in background. On the south side of the river ... grass and scattering timber forming a green lawn back with high prairie. In this neighborhood the shore is rocky. We passed a bald bluff on the north, with a rich bottom on the south side, and a high open lawn in the rear. A little farther on the elevated prairies strike the river, giving a charming variety of scenery—while on the north are extended bottoms of rich timbered lands.

"In this vicinity we saw many Indians along the banks; we also passed a grape thicket, in the bottom, spread over several thousand acres—while just above, on our right, rose a rocky bluff, covered with open woods. A little above this Sugar Creek empties into the Kansas, from the right; and a little farther up, there is a low bluff—a short distance beyond, there being another fine grape thicket, and rich walnut bottom. On the right side of the river ... rises a beautiful undulating eminence ... open woods and a fine prairie about a mile back.

"On the left, a short distance above, the Wakarusa flows in—a considerable stream—with good timber for some way back.

"On both sides of the river, above the Wakarusa, there are excellent bottom lands; ... farther up on the south bank, the high prairie comes down to the water's edge... away as far as the eye could reach in a southwest direction, the prairies were high and rolling, like the waves of old ocean—southward, beautiful groves dot the prairie and the dark line of timber that stretches along the Wakarusa Valley—with the great Prairie-mound ... fixed there as a landmark of perpetual beauty—the meandering river with its dark skirting forests of timber on the north ... Proceeding north, high rich bottoms extend for many miles and we saw vast thickets of grapevines, pea-vines etc. and paw-paws. The timber was principally oak, walnut, ash, hickory, mulberry, hackberry, linden, cottonwood and coffee-bean.

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[Between the Reservation and the mouth of the Delaware River, 10 miles west.] "A few miles below the mouth of the Grasshopper [Delaware] on the north the prairie undulates gradually back from the river as far as the eye can reach ... between the Grasshopper and Mud Creek there is a prairie bottom where pioneers are making claims."

In 1855 Mrs. Sara T. D. Robinson, wife of Dr. Charles Robinson who was the first governor of Kansas, described in her diary the environs of Lawrence (1899). In part, the areas described by her overlap those described by Parks, and both writers impart similar impressions. Mrs. Robinson's writing was concerned chiefly with the social and political affairs of the territory and the occasional comments on the "scenery" in her voluble accounts must be regarded as impressions rather than purposeful and accurate descriptions, as certain inconsistencies are apparent. Excerpts from several of her more significant descriptive passages are quoted below. [Between Lawrence and Kansas City, April 17, 1855.] "... prairie stretching in all directions, noble forests marking the line of the rivers and creeks, ... tall oaks and walnuts grouped in admirable arrangement ... there were deep ravines ... skirted with graceful trees, while the water in their pebbly beds is limpid and clear." [North of Wakarusa Crossing.] "... stumps in every direction in the woods ..." [At Lawrence, April 18, 1855.] "The town reaches to the river, whose further shore is skirted with a line of beautiful timber, while beyond all rise the Delaware lands, which in the distance have all the appearance of cultivated fields and orchards.... A line of timber between us and Blue Mound marks the course of the Wakarusa, while beyond the eye rests upon a country diversified in surface, sloping hills, finely rolling prairies, and timbered creeks ... to the northwest there is the most delightful mingling together of hill, valley, prairie, woodland, and river ... fine grove about a mile west of town, one of Nature's grand old forests."

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[On trip to visit a neighbor four miles away from Lawrence.] "There were high, conical hills, bearing on their tops forest trees, with dense, thick foliage; at the next moment a little shady nook, with a silvery rivulet running over its pebbly bed...."

[On trip west toward Topeka.] "Timber was more abundant, not only marking the line of the creeks, but crowning the summit of many an elevation."

[At Lawrence.] "Lawrence and its surroundings, of river flowing beneath the dim forests two miles deep on the north bank...."

Parks' and Robinson's accounts seem to show that in general bottomlands and stream courses were wooded, and uplands were mainly prairie, but that local deviations from this pattern were numerous, with trees and groves isolated or partly isolated in a variety of situations. This condition suggests that prairies were then encroaching into formerly wooded areas. A climatic shift toward hotter and drier conditions, or a change in native practices, with more frequent burning, might have brought about the trend.

Further information concerning the distribution and composition of the forest is afforded by a series of letters from the settlers at Lawrence, Kansas, that were printed in various Boston newspapers and in the Milwaukee Daily Sentinel, in 1854, 1855, and 1856. In nine such letters which discuss, among other things, the availability of timber, several kinds of trees are listed. Oak (species not mentioned), black walnut, and cottonwood are each listed in seven of the nine letters, while elm, hickory and "white walnut" are each listed in two, and ash, hackberry, sycamore,

basswood, willow and locust are each mentioned only once. Copies of these letters are in the files of Dr. James C. Malin, to whom we are much indebted for the privilege of examining them, and for his critical reading of parts of the manuscript.

Early U. S. Government maps of northeastern Kansas show the distribution of forest in the late eighteen fifties, and in general the pattern agrees well with that indicated by the accounts of Parks and Robinson. Through the kindness of Dr. Malin, we have been permitted to examine his photostatic copies of a series of these early maps, covering the area discussed in our study, and made in the period extending from 1855 through 1860. A tracing taken from parts of two of these maps, showing the Kansas River north and east of Lawrence, and the area between the river and the north boundary of Douglas County, is reproduced in [Fig. 1](#). For comparison, a map of the same area showing the stream courses and the distribution of timber, as traced from recent U. S. Geological Survey maps, is reproduced in [Fig. 2](#).

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The early maps agree with Parks' and Robinson's descriptions in showing an extensive belt of timber in the flood plain north of the river, and narrower belts of timber along its tributary streams. In [Fig. 1](#) the courses of the Kansas River and of Mud Creek agree fairly well with those shown on modern maps, but there are gross errors in the minor drainage systems of the sections of land in the northeastern part. Other evidence indicates that the distribution of forest was much different than that shown in this part of the map. Field work by the map-makers in this marginal area must have been extremely sketchy. Dr. Malin explains that such inaccuracies are to be expected because the contracts for mapping were made on a political basis, with little or no regard for other qualifications of the applicant.

The University of Kansas Natural History Reservation is in the northeasternmost section (Section 4, Township 12S, Range 20E) of Douglas County, Kansas. Topographically, it is almost evenly divided into three parts: (1) peninsular extensions of the Kansas River Valley, sloping gradually up to a level approximately 100 feet above that of the flood plain; (2) hilltops 200 feet or more above the level of the flood plain; (3) steep slopes from the hilltops to the valley floor.

The land that is now the Reservation was part of a tract acquired in the eighteen sixties by former governor Charles Robinson, after the Delaware Reserve lands in the northeastern part of Kansas Territory were sold by the tribe. The section of land now comprising the Reservation was used primarily for grazing after Robinson acquired it. However, several squatters settled on the area and cultivated small acreages for periods of years in the eighteen seventies and eighteen eighties. In the eighteen nineties parts of the area including some of the hillsides were still covered with a mixed forest of virgin timber (*vide* Frank H. Leonhard in conversation, October 19, 1951). Mr. Leonhard, who was long in the employ of the Charles Robinson family, remembered the area as far back as the early eighteen nineties when he worked on it cutting timber. He remembered, especially, cutting large walnut trees as much as two feet in diameter, which were valuable timber, but he thought that elm also was abundant at that time. By then the area, separated into east and west halves by a rock wall, had already been heavily grazed, and the original prairie vegetation, presumably dominated by big bluestem, had been much altered. The open upland portions were dominated by blue grass.

[Pg 84]

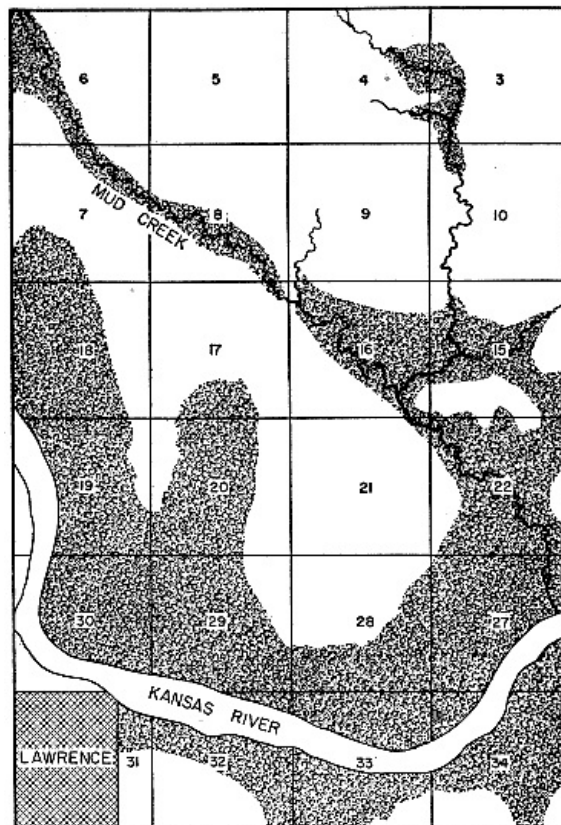


FIG. 1. Tracing from early (1855-60) U. S. Government maps of northeastern Douglas County, Kansas, and adjacent western edge of Leavenworth County, showing stream courses and approximate distribution of woodland before deforestation had occurred. Section 4 to right of center at upper edge of figure, is now mostly included in the University of Kansas Natural History Reservation. Note inaccuracies in drainage systems on this part of map as compared with [Fig. 2](#).

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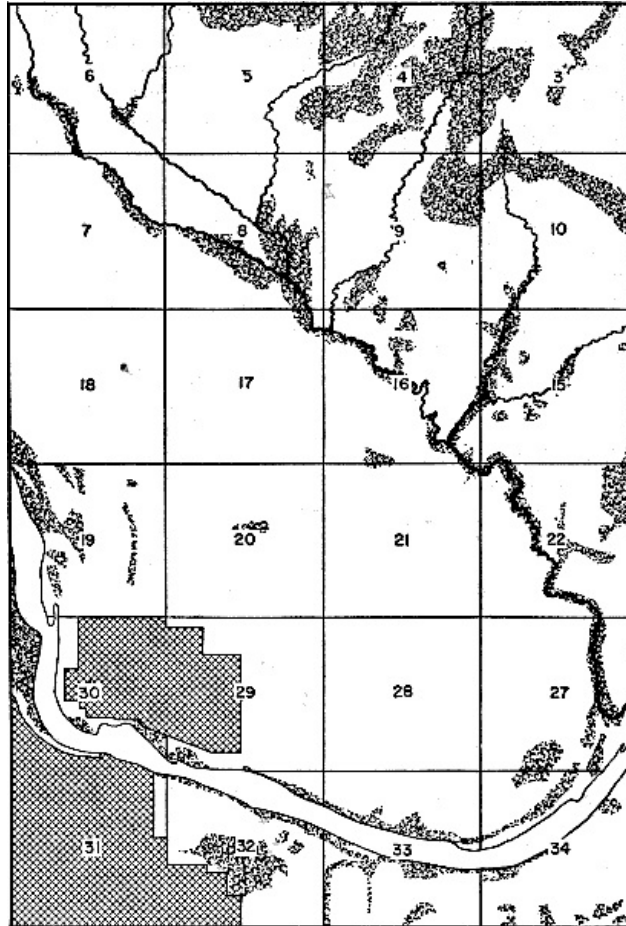


FIG. 2. Tracing from 1950 U.S. Geological Survey maps of same area shown in [Fig. 1](#), indicating present distribution of woodland, and the pattern of drainage systems.

By about 1900 control of the area had passed to the J. F. Morgan family. The homesteads had long since been deserted and the entire area was used for grazing (*vide* J. F. Morgan, in conversation, January 13, 1952). Parts of the bottomland were fenced and broken for cultivation in 1907, 1912, and 1915, and hilltop fields were first cultivated in 1909. Tree cutting was more or less continual. Many of the old stumps still present on the area are remnants of the trees cut in the "twenties" or even earlier. Several acres of hilltop and south slope in the northwest corner of the area were protected from livestock and maintained for harvesting of prairie hay. The hay was mowed annually, and the vegetation was burned at less frequent intervals, usually in early spring. This treatment served to kill encroaching woody vegetation and to maintain a prairie type.

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In the mid-thirties control of the area passed to the University of Kansas. At that time a program of development was launched by the University and the U. S. Soil Conservation Service with relief labor (*vide* C. G. Bayles in conversation, November 10, 1953). The work included: filling gullies, digging diversion ditches and building check dams and terraces to prevent erosion; clearing extensive thickets; bindweed eradication from the cultivated areas; and fencing off the wooded hillsides from the valley and hilltop pastures for protection from livestock. This work extended over several years, and one main objective was to utilize the area for growing timber. However, plans to make extensive plantings of walnut and other valuable timber never materialized. In the forties the check dams fell into disrepair. The area was leased to a farmer and was again heavily overgrazed. In this period there was some tree-cutting by the University's Department of Buildings and Grounds and by farmers, but this cutting was not on a commercial scale and was mainly for firewood and fence posts. One of the chief results of fencing off the wooded hillsides was that shrubs and young trees, formerly held in check by livestock, were



allowed to flourish. Understory thickets sprang up throughout most of the woodland, and especially in edge situations.

Late in 1948, after the area had been made a Reservation, livestock were excluded. In the years following, the parts of the closely grazed pastures adjacent to woodland passed through stages similar to those that had occurred 10 to 12 years earlier in the parts protected by fences. Young trees and shrubs sprang up in thickets, the numbers and kinds depending on amount of shade, seed sources, soil, moisture, and various other factors.

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Although most of the tree-cutting was done prior to 1934, annual growth rings are discernible on many of the old stumps, indicating the age of the tree at the time it was cut. Occasionally the stumps produced sprouts which had grown into sizable trees by 1954. In such instances the year that the tree was cut and the year that it originally began growing could be determined from a study of the annual growth rings. In 54 instances ring counts were obtained from stumps or logs, or from trees that had been split and fallen in wind storms.

Stumps that were otherwise intact often had small central cavities an inch or more in diameter. For these it was necessary to estimate the numbers of missing rings in order to obtain a figure for the approximate total age of the tree at the time it was cut. Many of the logs and stumps were so much decayed that growth rings were no longer distinct, and on most there were a few rings that were not clearly defined. In the majority of instances the time of cutting could not be determined accurately, but it is known that there was little tree-cutting after 1934 on most parts of the area. Probably most of the stumps on the Reservation that were well enough preserved to provide counts were from 20 to 30 years old. Most of the counts of growth rings on chestnut oaks were obtained on a hillside adjoining the Reservation where the trees were cut in the early nineteen forties.

Width of the annual growth rings reflects rapidity of growth in the tree and is determined, in part, by the amount of annual rainfall, especially in this region on the western edge of the deciduous forests where moisture is the chief limiting factor. Periods of drought or of unusually heavy rainfall may result in growth rings smaller or larger than average. Because the trees draw moisture from the deeper soil layer there is a lag in their response to precipitation, and a single year that is much wetter or much drier than those preceding or following it may not stand out clearly in the annual rings. In individual trees the effect of precipitation is often obscured by the effects of crowding and shading by competitors, injury or disease. None of the trees examined for growth rings reflected the annual precipitation accurately for long periods though some indication of known drought periods or of series of wet years were usually discernible.

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For 35 black oaks, chestnut oaks, and American elms, growth rings averaged 3.81 per inch of trunk diameter (according to size of the tree; 5.1 rings per inch in those trees 9 to 12 inches in diameter, 4.0 in those 13 to 15 inches, 3.6 in those 16 to 24 inches, and 2.8 in those of more than 24 inches). Data from a few complete counts and many incomplete counts indicate that in *Gleditsia triacanthos* growth is much more rapid, with only 2 to 3 rings per inch of trunk diameter, whereas in *Juglans nigra*, *Celtis occidentalis*, *Carya ovata*, and *Fraxinus americana* growth is much slower, with usually five or more growth rings per inch of trunk diameter. Individual trees deviate widely from the average for their species, and those in rich bottomland soil grow more rapidly than those in shallow soil of hilltops or those on rocky slopes. If such factors are taken into account the ages of trees may be estimated from the diameters of their trunks. In mature trees growth slows; age is likely to be underestimated rather than overestimated in those of exceptionally large size.

The belief that this and similar areas in northeastern Kansas were virtually treeless at the time of occupation by white settlers is shown to be wholly unfounded by the information obtained from growth rings. The ring counts show that many trees now growing on the area and others cut within the last 30 years, but still represented by stumps, were already present in the eighteen sixties when the area was first occupied. A few trees on the area probably are much older, dating back to the early eighteen hundreds. As there are no virgin stands of timber, and the more valuable trees have been removed by selective cutting at various times, it is to be expected that there are few or no trees on the area approaching the potential longevity for their species.

The many oaks and elms on the area that are more than two feet in trunk diameter mostly date back to the eighteen sixties or earlier. The distribution of the larger trees and stumps provides a clue as to the original distribution of forest and grassland on the area. There is no description available of the area that is now the Reservation in its original condition. However, Mrs. Anna Morgan Ward (1945) has recorded comments on the appearance of the country in the section of land adjoining the Reservation on the south, as it appeared when her family settled there in 1864. This land differed from that of the Reservation, as it consists of low rolling hills, well drained with predominately south exposure, and with sandy soil. It adjoins the present flood plain of the Kansas River, and consists partly of the old Menoken Terrace deposited in the Pleistocene. The following excerpts from Mrs. Ward's manuscript are selected as most descriptive of the original vegetation on this section of land.

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[In southwest part of section near the Morgan house.] "... some hills that were covered with Jack Oak trees ... Here we found wild strawberries on the hillsides. And along the creeks we located gooseberry bushes, wild grapes, both summer and winter grapes, plums, and paw paws in the fall. We found a crabapple tree ... Plenty of walnuts and hazel nuts."

[Hilly south-central part of section, the J. P. Whitney farm.] "... on a hill among many small trees ... especially on the east were many trees."

[Less hilly southeastern part of section.] "... Was open prairie and free grazing ground for many years...."

Much of the land in this section is now under cultivation but there are still hilltop groves of blackjack oak, probably in about the same places where Mrs Ward noticed them 90 years ago—south of the house that was formerly Robinson's residence, and west across the county road, beside the Oakridge School building, and on other knolls to the east and southeast.

The bottomland areas of the Reservation are mainly grassland and no old stumps remain to indicate that trees were formerly present. Nevertheless, it might be expected that under original conditions these bottomland areas supported forests, as the soil is deep and rich with abundant moisture. Also most of the early accounts agree that forests occurred mainly along stream courses in this region. Presumably these areas were cut over early, because they were most accessible, and because they supported the best stands of timber.

One of the best indications of the former vegetation on these bottomland areas is provided by old bleached shells of snails and certain other mollusks, brought to the surface by plowing in cultivated fields adjoining the Reservation on the south and west (Fitch and Lokke, 1956). A high proportion of the shells are of species limited to humus soil, decaying logs, or leaf litter in moist woodlands (*Stenotrema leai*, *Retinella electrina*, *Zonitoides arboreus*, *Vertigo ovata*, *Helicodiscus parallelus*), to wet places (*Lymnaea parva*, *Succinea avara*) or even to standing pools (*Physa hawni*, *Helisoma trivolvis*, *Pisidium compressum*). No living mollusks could be found in these fields and none could be expected to survive on land that is cultivated annually. As a whole the assemblage seems to be indicative of a humid, poorly drained forest habitat. Presumably most of the shells or all of them are more than 100 years old, antedating the time when the area was first disturbed by human activities, and also antedating the time when the creeks (now 15 feet or more below the fields) had begun to erode their channels. That the shell deposits are of no great antiquity, and represent conditions prevailing within the last few hundred years, is suggested by the fact that all are species still living in Douglas County, and with one exception, all still live on the Reservation.

[Pg 90]

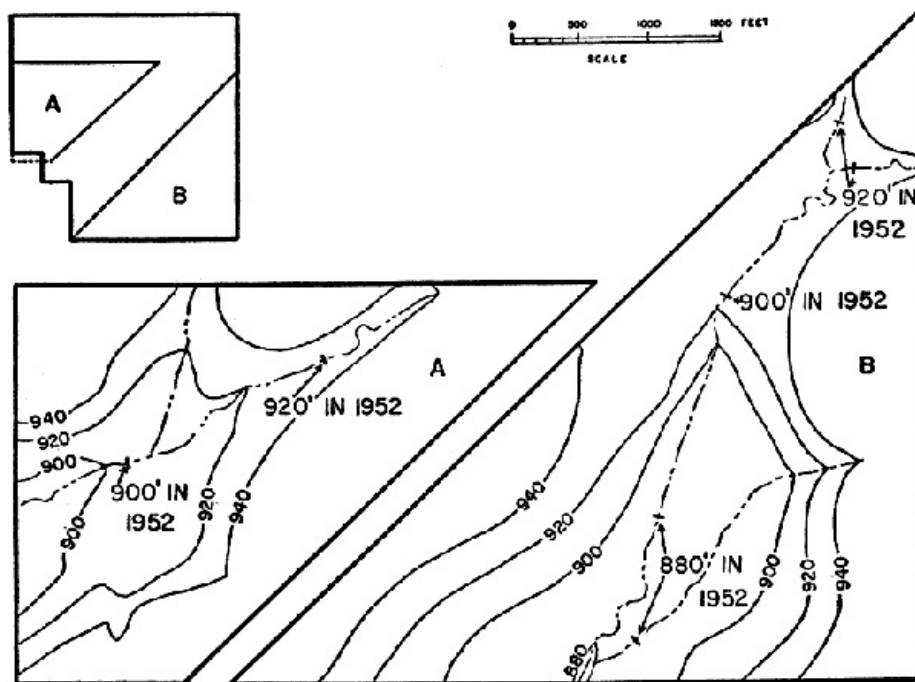


FIG. 3. Tracing from a contour map made in 1914, of the two small valleys on the Reservation, showing changed position of contour lines at gullies by 1952. As a result of overgrazing, and cultivation of part of the upland drainage area, there was relatively rapid erosion in the 38-year interval.

[Pg 91]



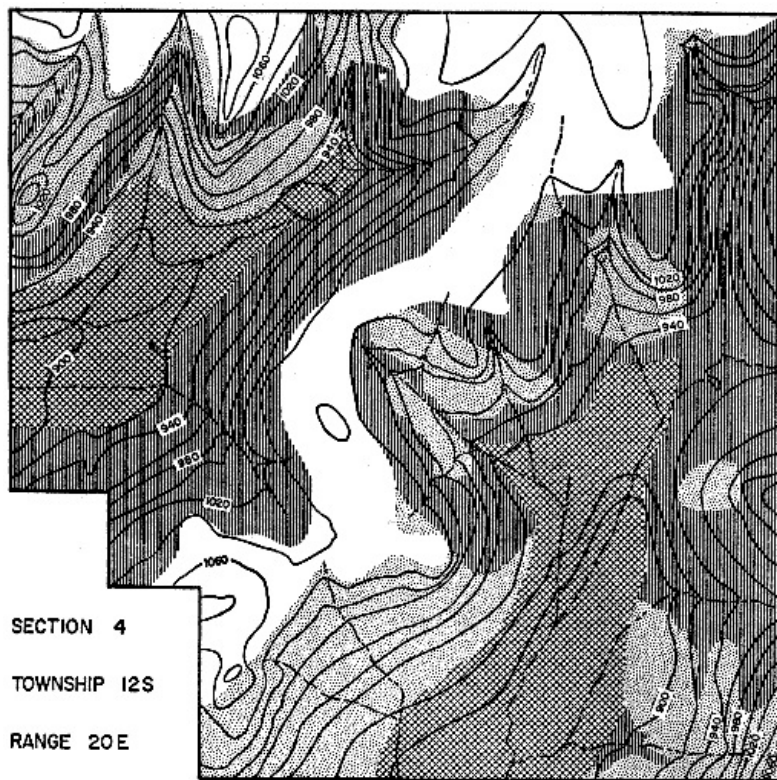


FIG. 4. Map of University of Kansas Natural History Reservation, with 20-foot contours, showing probable approximate distribution of forest in early eighteen hundreds (vertical lines show slopes and hilltops that are still wooded; grid pattern shows bottomlands that were formerly wooded but later cleared for pasture or cultivated crops). Stippled areas show those slopes and hilltops now wooded seemingly as a result of recent reinvasion, that probably were bluestem prairie earlier. Unshaded areas are relatively flat hilltops that are still grassland and are thought to have been bluestem prairie.

Mrs. Ward (*op. cit.*) in her manuscript concerning the early history of Grant Township, mentioned the small creek that drains the east part of the Reservation. Evidently in the sixties it had a more constant flow, usually with clear water. Later it eroded its channel, cutting a deep gully. Presumably the water table has been much lowered. In his verbal reminiscences of the area, Mr. J. F. Morgan told us that in the nineties this stream had eroded its channel but little within the present limits of the Reservation. In a period of years, 1902 to 1905 inclusive, when there was abnormally heavy rainfall, severe erosion occurred, and the saturated soil of several hillside areas slipped downhill to the extent of several feet vertical displacement. The ravine draining into the present pond from the north was known as "Sunken Canyon" because of such soil slips. However, a map of the Reservation and surrounding areas made by the University of Kansas Department of Civil Engineering in 1914, shows that by that time relatively little gullying had occurred. Comparison of this contour map with a more detailed one prepared in 1952 shows that the gullies had eroded their channels to depths more than 15 feet greater in some places, in the 38-year interval (Fig. 3). In June and July, 1951, when there was unusually heavy rainfall, gullies deepened perceptibly. Dozens of trees including many large mature elms, honey locusts, and osage orange, growing along the banks were undermined and fell into the gullies.

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## Composition of the Forest

[1 TOC]

Under present conditions, every one of the larger tree species dominates at least some small part of the area. For reasons that are usually obscure, locations that seem otherwise similar differ in the kinds, numbers, and sizes of trees they support. Probably most of these differences have arisen in the varying treatments under human occupation in the last 100 years.

In the two valley areas, presumably heavily wooded under primitive conditions, the trees growing at present seem to be secondary invaders. They include groves and isolated trees of elm, honey locust, walnut, and osage orange, and an occasional red haw, hackberry, or coffee-tree.

The hilltops likewise are chiefly open, but forest of the hillsides encroaches onto them for as much as 100 yards in some places. The slopes between the hilltops and the valleys are almost everywhere wooded, but the aspect of the woods changes from place to place. Subdivisions on a vertical scale, might be recognized as follows: the upper limestone outcrop (Plattsmouth member) at the hilltop; the usually steep slope strewn with rocks, between the upper and lower (Toronto)

limestone outcrop; the lower limestone outcrop; an almost level terracelike formation often approximately 50 feet wide a few feet below the level of the Toronto limestone; the slope below the terrace, variable in steepness, exposure, and soil type, and usually several times more extensive than the first four subdivisions combined. Along both the upper and lower outcrops, elm and hackberry are especially prominent. Chestnut oak is abundant along the outcrops and on the rocky slope between them in some situations. Ash grows abundantly on some upper slopes but there are few growing on the upper outcrop. On the terrace, elm, ash, hackberry, honey locust, coffee-tree and black oak are abundant. On the lower slopes grow most of the blackjack oaks, post oaks, red oaks and mulberries.

Even greater differences in the local aspect of woodland on the hillsides are caused by slope exposure. On south facing slopes, especially, the woodland is noticeably different from that in other situations, and of more xeric aspect. The climax species, *Quercus Muehlenbergii*, *Q. rubra*, *Q. velutina* and *Carya ovata* are almost totally absent. Such trees as are present are of small to medium size. They are mostly red elm, American elm, walnut, honey locust, hackberry, and osage orange, with dogwood (*Cornus Drummondii*) and plum (*Prunus americanus*) forming dense thickets. Occasional patches of prairie grasses remain in more exposed situations where they have not been shaded out. These, together with the small size of most of the trees, indicate that the south slopes have become wooded rather recently, and originally were prairie. Nevertheless, the small remaining groves of blackjack oak and post oak are on slopes that face south, southeast, or southwest, and probably under original conditions they occupied these situations, separate from the forests of other hardwoods. Slopes facing east, west, and north, are more similar in relative abundance of various kinds of trees, and they do not differ much from hilltop edges that are wooded. Chestnut oak and hickory are most abundant on north slopes, and ash occurs mainly on north slopes.

TABLE 1.—PERCENTAGES OF LARGER TREES (A FOOT OR MORE IN TRUNK DIAMETER) ON DIFFERENT SLOPE EXPOSURES.

	North slopes	Hilltops	West slopes	South slopes
Elm	35.7	38.6	25.8	51.4
Chestnut oak	22.0	18.3	17.8	2.9
Hickory	8.8	4.0	3.6	5.0
Walnut	8.8	5.8	19.6	12.1
Ash	7.1	.8		.4
Hackberry	8.2	1.6	2.4	6.9
Black oak	3.3	16.4		1.0
Red oak	2.2		23.8	
Locust	1.8	7.5	1.9	11.6
Osage orange	.5	1.5	.2	5.3
Sycamore	.5		2.1	.1
Coffee-tree		1.2	2.4	1.0
Cherry		2.4		.1
Red haw		.4		1.3
Ailanthus				.3
Mulberry		.5		.1
Cottonwood				.1
Redbud		.8	.2	.1
Boxelder		.1		.3
Blackjack oak			.2	
Total trees in sample	182	890	467	898

Table 1 shows the percentages of different kinds of trees a foot or more in trunk diameter on different slope exposures sampled. Elm is almost always the dominant tree, making up from one-fourth to one-half of the total stand. The other species dominate relatively small areas. Chestnut oak usually makes up a substantial part of the stand on hilltops and slopes of north, east, or west exposure. Black oak, red oak, and walnut may be prominent on the east and west slopes. Walnut and locust are prominent on south slopes.

Hickory usually has a trunk diameter of less than one foot, and, therefore, it is not prominent anywhere among the larger trees. Table 2, showing ratios of medium-small trees (more than 6 inches and less than one foot in trunk diameter) demonstrates that hickory is one of the more prominent trees on hilltops and on slopes other than those of south exposure.

## Invasion of Fields

In 1948 when the extensive open parts of the Reservation were grazed and cultivated, small trees were inconspicuous and few. Mature trees, with trunk diameters of 9 inches to more than two feet, were distributed over the pastured areas, however, with groves of American elm, honey locust, and walnut near the edges of the woods, and occasional scattered trees of these species and of osage orange, coffee-tree, red haw, hackberry, and ash.

TABLE 2.—PERCENTAGES OF DIFFERENT KINDS OF SMALL TREES (SIX INCHES TO A FOOT IN TRUNK DIAMETER) ON DIFFERENT SLOPE EXPOSURES.

	North slopes	Hilltops	West slopes	South slopes
Elm	29.6	29.9	34.6	57.9
Chestnut oak	29.6	17.5	15.5	.4
Hickory	11.1	25.4	28.4	.8
Walnut	5.6	.7	7.4	5.3
Hackberry	13.0	1.0	3.7	26.4
Black oak	1.9	16.3		
Red oak	1.9		6.8	
Locust		3.3		3.0
Osage orange		2.0		1.5
Coffee-tree	1.9	.7		1.1
Cherry				.4
Red haw		2.4		
Mulberry		.7		
Redbud	9.3		3.7	.8
Boxelder				2.6
Total trees in sample	54	295	162	266

In 1949 soon after the discontinuance of grazing and cultivation, a large crop of tree seedlings became established. Each year thereafter the numbers were augmented by new crops of seedlings, but conditions rapidly became less favorable for their establishment, as the ground cover of herbaceous vegetation became thicker. The numbers and kinds of young trees that became established differed markedly in different situations. The seedlings present in large numbers were those of elm, honey locust, boxelder, dogwood, walnut, osage orange and crab-apple. There was none of the climax species—oaks or hickories—in the sample.

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TABLE 3.—NUMBERS OF YOUNG TREES PER ACRE IN FIELDS OF THE RESERVATION, JUNE, 1952.

	Bottomland pasture	Hilltop pasture	Bottomland fallow field	Hilltop fallow field	Prairie
No. of 1/100 acre plots sampled	250	80	70	80	50
Honey locust	83.0	58.8		5.6	
Elm	80.0	72.5	138.8	230.0	150.0
Boxelder	1.6	1.2	22.9		200.0
Dogwood	18.8	18.8	11.4	51.2	44.0
Walnut	2.0	50.0	7.15		
Osage orange	16.0	48.7			
Crab-apple	7.2	93.8		1.2	
Red haw	5.2	17.5	2.8	2.5	4.0
Coffee-tree	4.8	1.2			
Hackberry	2.8				2.0
Cottonwood	.2				
Ash		8.8		3.7	
Plum	.8				
Peach	.2				
Cockspur thorn	.8	21.3			
Sycamore	.4			1.2	
Cherry		1.2			2.0

Total number counted	236	393	279	296	402
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[Table 3](#) shows the numbers of young trees counted in a total of 530 plots of 1/100 acre each, in June, 1952. The trees counted included all those approximately one foot high or larger. A few were up to 12 feet tall, but most were between one foot and five feet in height. Not included were the many smaller seedlings, which were mostly concealed beneath the dense layer of low herbaceous vegetation.

Of young trees there were most on the bluestem prairie area, less on the former pastures and least on the fallow fields. In both the pasture areas and the fallow fields, the bottomlands had fewer trees than the hilltops—60 per cent and 94.3 per cent, respectively. In every instance the abundance of young trees seemed to be inversely proportional to the amount of competing herbaceous vegetation. The bottomland fallow fields, which had the fewest tree seedlings, were dominated by a rank growth of giant ragweed and sunflower, often as much as ten feet tall, effectively shutting most of the light from the tree seedlings. By 1954, however, the sunflower was nearly eliminated, and the giant ragweed, though still abundant, was much stunted.

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The bluestem prairie on an area of hilltop and upper slope had not been burned over or otherwise disturbed for some years prior to 1948, and probably trees began to invade this area years before they invaded the fallow fields and pastures accounting, in part, for their greater abundance in 1952. Approximately half of the young trees on this prairie area were boxelders, which were relatively scarce on the other four areas. Elm was either first or second in abundance on each area. On both types of pasture areas honey locusts were appearing in abundance and osage orange seedlings were present in somewhat smaller numbers. However, these two kinds of trees were almost entirely absent from the other areas sampled, except that a few locusts were recorded on a hilltop fallow field. In 1948 honey locust seeds were noticed in great abundance in the droppings of cattle; their dispersal in this manner probably is in large part responsible for the abundance of young honey locusts throughout the former pastures. Osage orange may have been distributed in the same manner. Seedlings of dogwood were moderately numerous on each one of the areas sampled, and those of red haw were somewhat less abundant on each area. Crab-apple was the most abundant species invading the hilltop pastures but was scarce or absent in the other situations. The remaining species of trees, including coffee-tree, hackberry, cottonwood, ash, plum, peach, cherry, cockspur thorn, sycamore, and redbud, each made up only a small percentage of the tree crop in the situations where they occurred.

In late July and early August, 1954, counts of young trees were made again on the upland pasture area, with a total of 200 1/100-acre plot samples. This sample was taken at the end of one of the longest and most severe droughts in the history of the area. Both 1952 and 1953 had drought summers, and up to the end of July the summer of 1954 was exceptionally dry also. The conditions of the young trees at this time, in the relatively dry and shallow hilltop soil, was especially significant. As might have been anticipated, in this 1954 count, young trees were more numerous than they had been on any of the areas sampled in 1952. However, the data for 1952 and 1954 are not entirely comparable, because in 1952 none of the plots sampled was nearer than 50 feet to the edge of the woods, whereas in 1954, the sample was arranged to be representative of the entire field, including the parts adjacent to the woods. The numbers per acre of each kind of tree, and the percentages that were dead or dying, were as follows: crab-apple 167 (33.5 per cent dead); locust 98 (3 per cent dead); elm 69.5 (2.9 per cent dead); osage orange 63.5 (none dead); walnut 36.5 (4.1 per cent dead); red haw 25.5 (none dead); ash 19.5 (none dead); cockspur thorn 17 (17.6 per cent dead); wild plum 14 (3.6 per cent dead); dogwood 9.5 (none dead); prickly ash 2 (25 per cent dead); black oak 1.5 (none dead); boxelder .5 (none dead). Thus, of the species that were prominent invaders of the field, only crab-apple showed heavy mortality. In many instances the mortality in crab-apple was due wholly or in part to attack by cottontails (*Sylvilagus floridanus*), which had completely girdled many of the stems. In general, mortality in the young trees was light in this grassland area compared with the mortality in any part of the woodland.

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## Competition and Mortality

[\[↑ TOC\]](#)

The ratios of trees of different species and different size groups reflect, to some extent, the changes to which the area has been subjected. Under original conditions mature trees of oak and hickory dominated the forest. With the opening up of the forest that resulted from cutting most of these mature trees, other kinds of trees increased and spread. Species relatively intolerant of shading became established. Chinquapin oak, honey locust, osage orange, cherry, dogwood, red haw, and crab-apple, being especially intolerant of shading, cannot grow in close competition with climax species, and they become established only in fairly open situations. Their presence in thick woodland, along with climax competitors, usually is an indication that the woodland is either of recent origin or has been much disturbed in the past, permitting invasion by them.

About 1934 when approximately half of the Reservation, including nearly all the woodland



areas, was fenced against livestock, shrubs and young trees sprang up in great abundance, especially in more open woodland situations, and at the edge of the forest. Sumac (*Rhus glabra*) often dominated at first in such situations. Crab-apple, wild plum, red haw, chinquapin oak, prickly ash, dogwood, honey locust, and redbud also soon came into prominence. By 1954 thickets had grown up and the intense competition had killed much of the woody vegetation. Sumac, especially, had been almost entirely killed out by the shading. By then, however, the adjacent fields had been protected for eight years from grazing, and sparse sumac thickets were present on the field sides of the fences, the average sizes of the plants progressively declining farther from the edge of the woods. Much mortality had occurred also in all the other species mentioned, with only a few of the larger surviving in competition with elm, hackberry, ash and osage orange, and with reproduction practically stopped except near the edges of the thickets.

In 1954, after approximately 20 years of protection from livestock, the woodland had become much denser, with a thick understory of saplings and tall shrubs in most places. From a time soon after protection was initiated, there was little or no reproduction (except where the woodland originally was open) in blackjack oak, dwarf or chinquapin oak, red haw, honey locust, and osage orange. On one south slope, an open woods with well scattered trees of black oak, American elm, hackberry, honey locust and osage orange, had by 1954 become so dense that it was almost impassable except with the aid of a brush knife to cut or break through the thickets. Saplings of honey locust made up an important part of the understory vegetation on this slope. Those of the smallest size group, up to 1½ inches stem diameter, were mostly dead; in a strip 900 feet long and 50 feet wide there were 29 dead saplings and ten live ones of this size group. In the next largest size group, up to 2½ inches in stem diameter, there were 17 dead and 53 live saplings, while in the size group 2½ to 3½ inches stem diameter, there was one dead sapling and 51 were alive.

On another south slope, which had more large and medium-sized trees and less dense underbrush, 233 saplings six inches or less in stem diameter, counted on a sample strip 530 feet long and 40 feet wide, included elm 37.3%, dogwood 19.7%, hackberry 16.4%, coffee-tree 15.6%, honey locust 11.0%, plum 10.3%, chestnut oak 5.5%, crab-apple 3.4%, osage orange 2.1%, red haw 1.4%, hickory, redbud, mulberry and cockspur thorn each .7%. There was substantial mortality in the saplings of several of these species; plum 86.5%, dogwood 69.5%, elm 49.5%, locust 31.2%, chestnut oak 25.0%, coffee-tree 4.4%.

By 1954 several areas of hilltop-edge and north slope, which presumably had been wooded originally, but which had been subjected to heavy cutting, supported thriving stands of young hickories mostly two to six inches in trunk diameter. Most of these saplings seemed to have originated as stump-or root-sprouts. These numerous and closely spaced saplings produced a dense and almost continuous leaf canopy, shading and killing out many of the smaller trees of their own species as well as competing elms, redbuds, dogwoods, hackberries and others.

On a north slope in the southeastern part of the Reservation, many large stumps were found in late stages of decay, cut from 20 to 30 or more years before. Insofar as could be determined, these old stumps were mostly of oaks, but in 1954 the trees growing on this slope were chiefly elms and coffee-trees less than one foot in diameter.

## Effects of Livestock

Livestock importantly affected the trend of succession. The tendency of grazing animals to hold back the forest by stripping the foliage from young trees and killing them is selective, however; the several kinds of trees differ in their tolerance to browsing and in their palatability to animals. The kind of animal and the season and intensity of use also have important bearing on the ultimate effect. Several kinds of shrubs and small trees seem to be especially susceptible to damage by browsing; chinquapin oak, crab-apple, plum, hazel, dogwood, prickly ash, and paw paw were found to be either absent entirely from the parts of the woodland that were heavily used by stock, or much scarcer than they were on adjacent unbrowsed areas. Some woody plants that are even more susceptible may have been completely eliminated by browsing.

In the thirties when most of the woodland area was fenced off and protected from grazing, three wooded hillside areas of a few acres each, were maintained as connecting strips between the pastures of the hilltops and those of the bottomlands. These areas were utilized only at certain seasons, but by 1948 the effect of trampling and heavy browsing by livestock was conspicuous. Herbaceous ground vegetation was almost lacking and low woody vegetation was also scarce, in contrast to the parts of the woodland that were adjacent but separated by fences that excluded livestock. The contrast was perhaps heightened along the fences because the animals tended to follow along the fence lines and their effects were concentrated there.

TABLE 4.—NUMBERS OF YOUNG TREES OF VARIOUS KINDS AND SIZES IN 1954 ON A .919-ACRE AREA CONSISTING OF SIX HILLSIDE STRIPS EACH 20 FEET WIDE. EACH STRIP WAS EQUALLY DIVIDED BY A FENCE LINE, EXCLUDING LIVESTOCK FROM ONE SIDE DURING THE PERIOD 1934 (APPROXIMATELY) TO 1948.

	Less than ½-inch stem diameter		½-inch to 4-inch stem diameter		5-inch to 12-inch stem diameter	
	Total Number	Percentage in browsed half	Total Number	Percentage in browsed half	Total Number	Percentage in browsed half
Dogwood	556	52.1	1058	16.4		
Redbud	40	42.5	102	5.9		
Elm	30	76.7	189	27.6	99	47.5
Hackberry	131	39.7	206	13.1	5	20.0
Plum	26	77.0	35	22.8	1	100.0
Crab-apple	11	100.0	46	37.0		
Red haw	1	100.0	33	48.5	9	75.8
Walnut	7	28.6	32	43.7	26	61.5
Honey locust	2	100.0	20	15.0	11	27.3
Osage orange	1	100.0	7	57.1	2	50.0
Shagbark hickory	3	100.0	42	73.8	44	40.9
Chestnut oak			26	30.8	24	58.2
Chinquapin oak			12	100.0	1	100.0
Coffee-tree			11	18.1	8	12.5
Ailanthus	6	33.3	65	26.1	3	100.0
Black oak			5	40.0	7	16.6
American ash	21	100.0	3	33.3		
Paw paw	12		61	27.8		

In 1954 ten-foot wide strips were sampled on both sides of the fences. For both browsed and unbrowsed samples, the strips had a total length of 4000 feet, each representing an area of .919 acres. [Table 4](#) contrasts the number of young trees per acre on the browsed and unbrowsed areas, grouped in several size classes. In general the saplings up to one-fourth inch in diameter were those that had become established in the five growing seasons since browsing was discontinued and both areas were protected. For this size group the numbers were approximately equal, being slightly higher on the browsed strips. However, in the size group of ½ inch to 4 inches in stem diameter, the trees were nearly three times as abundant on the unbrowsed areas, and most trees within this size range must have become established within the time of differing treatments. The disparity in numbers was great for hackberry, redbud, elm and dogwood which made up the bulk of the saplings. In the size range 5 to 12 inches most trees antedated the fence, and the unbrowsed portion had only a few more than the portion that had been browsed.

On the formerly browsed areas clumps of gooseberry bushes were conspicuous and were computed to cover 3.81 per cent of the area sampled, versus 2.87 per cent on the unbrowsed area. These thorny bushes seem to be resistant to browsing, and elsewhere have been noted in abundance in woodlands heavily used by livestock. The elimination of competing undergrowth by browsers may be a factor favoring development of gooseberry clumps. The trend was just the opposite for fragrant sumac, which was computed to cover 1.94 per cent of the browsed sample versus 3.23 per cent of the unbrowsed sample. Greenbrier (*Smilax tamnoides hispida*) was most abundant on the unbrowsed strips, with seven large clumps, and 56 smaller clumps (10 stems or fewer) as contrasted with five large clumps and 32 smaller clumps on the browsed strips. There were 32 grapevines (*Vitis vulpina*) on the unbrowsed strips and only seven on those that were browsed.

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## Animal Associates

[1 TOC]

The invertebrates of the University of Kansas Natural History Reservation have not been intensively studied. Most of the species of vertebrates are characteristic of the deciduous forest of the eastern United States, or of the edge of woodland; relatively few kinds are characteristic of prairies.

Of birds, for example, some 23 species characteristic of the eastern deciduous forests have been found nesting on the Reservation, as have 14 additional species that are mainly eastern in their distribution but are most characteristic of forest-edge thickets, clearings, or marshy places. The ruffed grouse (*Bonasa umbellus*) and wild turkey (*Meleagris gallopavo*) are not present on the area, although they may have occurred there earlier. Other forest birds which occur in the general area, and which have been recorded from time to time on the Reservation, although they seem not to nest there, are: chuck-will's-widow (*Caprimulgus carolinensis*), scarlet tanager (*Piranga olivacea*), Acadian flycatcher (*Empidonax virescens*), veery (*Hylocichla fuscescens*), parula warbler (*Parula americana*), oven-bird (*Seiurus aurocapillus*), and orchard oriole (*Icterus*

*spurius*). For each of these, habitat conditions on the Reservation seem to be deficient in some respect. On the other hand, the only typical prairie bird that breeds on the Reservation is the dickcissel (*Spiza americana*). Others, including the Swainson hawk (*Buteo swainsoni*), greater prairie chicken (*Tympanuchus cupido*), upland plover (*Bartramia longicauda*), western kingbird (*Tyrannus verticalis*) and loggerhead shrike (*Lanius ludovicianus*), occur in the general area, and may even cross the Reservation at times, but they do not become established.

In the mammalian fauna, species typical of the deciduous forests include the opossum (*Didelphis marsupialis*), short-tailed shrew (*Blarina brevicauda*), eastern mole (*Scalopus aquaticus*), eastern gray squirrel (*Sciurus carolinensis*), and pine vole (*Microtus pinetorum*), but the eastern chipmunk (*Tamias striatus*) and southern flying squirrel (*Glaucomys volans*) are lacking. Also, the present fauna lacks large mammals that may have been present under original conditions: the white-tailed deer (*Odocoileus virginianus*), recorded on the area from time to time but not permanently established there, the wapiti (*Cervus americanus*), black bear (*Ursus americanus*), and bobcat (*Lynx rufus*). Other species on the area, that are characteristic of the deciduous woodlands, but that occur also far west into prairie regions, include the little short-tailed shrew (*Cryptotis parva*), raccoon (*Procyon lotor*), fox squirrel (*Sciurus niger*), white-footed mouse (*Peromyscus leucopus*), eastern woodrat (*Neotoma floridana*) and eastern cottontail. On the area, the only mammals that are sharply confined to grasslands, elsewhere as well as on the Reservation, are the plains pocket gopher (*Geomys bursarius*) and plains harvest mouse (*Reithrodontomys montanus*), both of which are rare on the area, and the hispid cotton rat (*Sigmodon hispidus*). The following species are typical of the plains, but they range eastward into the region of deciduous forests: western harvest mouse (*Reithrodontomys megalotis*), deer mouse (*Peromyscus maniculatus*), coyote (*Canis latrans*), and spotted skunk (*Spilogale putorius*). The following mammals, typical of grassland, are absent: black-tailed jack rabbit (*Lepus californicus*), black-tailed prairie dog (*Cynomys ludovicianus*), 13-lined ground squirrel (*Spermophilus tridecemlineatus*), Franklin's ground squirrel (*Spermophilus franklinii*), southern lemming-mouse (*Synaptomys cooperi*), and of course, the buffalo (*Bison bison*), and the prong-horned antelope (*Antilocapra americana*) long extinct in this part of their range.

Of amphibians and reptiles also, the majority are typical forest species, including: the American toad (*Bufo terrestris*), common tree frog (*Hyla versicolor*), brown skink (*Lygosoma laterale*), common five-lined skink (*Eumeces fasciatus*), worm snake (*Carphophis amoenus*), pilot black snake (*Elaphe obsoleta*), DeKay snake (*Storeria dekayi*), western ground snake (*Haldea valeriae*), copperhead (*Agkistrodon contortrix*), and timber rattlesnake (*Crotalus horridus*). Other typical forest species missing from the area include the spring peeper (*Hyla crucifer*), Carolina box turtle (*Terrapene carolina*), coal skink (*Eumeces anthracinus*), and red-bellied snake (*Storeria occipitomaculata*). Of typical prairie species only the Kansas ant-eating frog (*Gastrophryne olivacea*) and the ornate box turtle (*Terrapene ornata*) are common, and, curiously, each seems to prefer a forest habitat on this area, in the absence of their closely related eastern representatives, the eastern ant-eating frog (*G. carolinensis*) and the Carolina box turtle, respectively, which usually live in forests. The plains spadefoot (*Spea bombifrons*), garden toad (*Bufo woodhousii*), Great Plains skink (*Eumeces obsoletus*), prairie skink (*Eumeces septentrionalis*), slender tantilla (*Tantilla gracilis*), prairie rat snake (*Elaphe guttata*), bull snake (*Pituophis catenifer*), and blotched king snake (*Lampropeltis calligaster*) are all scarce on the area. The plains toad (*Bufo cognatus*), collared lizard (*Crotaphytus collaris*), except for an introduced colony, plains garter snake (*Thamnophis radix*), lined snake (*Tropidoclonion lineatum*), and massasauga (*Sistrurus catenatus*) seem not to occur on the area at all.

## Annotated List of Species

***Juniperus virginiana***.—Red cedar, the only native gymnosperm of northeastern Kansas, occurs in nearly all woodlands of the region, although individual trees are widely scattered. It has increased remarkably in the past few years. No mature cedar trees grow anywhere on the Reservation, but young trees, probably several dozen in all, are widely scattered in a variety of situations on the area. Probably in every instance the seeds have reached the area in droppings of birds. Approximately 15 miles south and a little east of the Reservation is a stand of cedars some of which are 100 to 300 years old. Near the southwest corner of the section, at the site of a former farm house there is a small grove of these trees, probably planted. These may have been the source for some of the young trees on the Reservation.

On several occasions cardinals (*Richmondena cardinalis*) were observed to have nested in the young cedars, whose thick foliage provided well sheltered nesting sites. This shelter was utilized especially in early nestings when foliage had only begun to appear on other trees and shrubs. However, two such nests in cedars, that were checked repeatedly, were eventually destroyed by predators.

***Salix nigra***.—Black willow is localized in the vicinity of the one small pond on the Reservation. The pond was made in 1936; at the upper end of a small valley a dirt bank 100 yards long was built across a ravine through which an intermittent creek drained. Hilltop fields draining into this ravine were then under cultivation. In the next few years heavy erosion occurred in the upland fields, and the soil carried downstream was deposited in the pond. Most of the pond was



filled up with a silt flat about an acre in area. On the higher part of this silt flat a dense thicket of saplings of elm, honey locust and osage orange sprang up. On the lower, wetter part of the silt bar a willow grove grew up, dominated by *S. nigra*, with *S. eriocephala*, *S. interior* and *S. amygdaloides* in smaller numbers. By 1955 some of these trees had attained a trunk diameter of eight inches and a height of thirty feet. Elsewhere on the Reservation, willow is represented only by a few scattered trees and bushes along the two intermittent creeks. The silty soil preferred by the willow is scarce as both streams are actively eroding their channels.

The moist, silty soil beneath the willow grove is covered with a dense mat of low vegetation including giant ragweed, carpenter's square, dayflower, and rice cutgrass. Short-tailed shrews, house mice (*Mus musculus*), harvest mice and cotton rats thrive in this habitat. Red-winged blackbirds (*Agelaius phoeniceus*), yellow-billed cuckoos (*Coccyzus americanus*), red-eyed vireos (*Vireo olivaceus*), catbirds (*Dumetella carolinensis*) and Kentucky warblers (*Oporornis formosus*) use it for nesting. The high humidity and dense vegetation in this grove render it favorable habitat for recently metamorphosed frogs and toads, especially the tree frog, which is sometimes extremely abundant there in summer.

***Populus deltoides*.**—Cottonwood is one of the less common trees on the area, but it attains a larger size than any of the other kinds. The larger of the two creeks on the Reservation is lined with mature cottonwoods along the lower part of its course. Along the smaller creek large cottonwoods are also present but they are more widely spaced. A few cottonwoods are present at well scattered points on slopes and hilltops, usually in forest edge situations or in woodland where other trees are sparse. By far the largest tree on the Reservation is a cottonwood of 15-foot circumference ([Plate 7](#)), growing on a hilltop near the south boundary of the Reservation, at the edge of woodland adjacent to a cultivated field.

The heavy rainfall of 1951 resulted in the establishment of hundreds of cottonwood seedlings, mostly in places remote from the mature trees. So far as observed, all these were in recent silt deposits. Many of them have survived the drought of 1952-1954.

Because of their great height, towering above the level of the surrounding tree-tops, cottonwoods are preferred look-out perches of certain of the larger birds, notably red-tailed hawks (*Buteo jamaicensis*), barred owls (*Strix varia*), and crows (*Corvus brachyrhynchos*). Flocks of robins (*Turdus migratorius*) and of rusty blackbirds (*Euphagus carolinus*) preparing to roost have been noted habitually to gather in the tops of tall cottonwoods. In spring, large wandering flocks of goldfinches (*Spinus tristis*) have been seen feeding on the leaf buds of cottonwoods. Baltimore orioles (*Icterus galbula*) and yellow-billed cuckoos often forage in cottonwoods. Red-bellied woodpeckers (*Centurus carolinus*) spend a disproportionately large amount of their time in cottonwoods. These woodpeckers have been observed nesting in the hollow branches on several occasions. Downy woodpeckers (*Dendrocopos pubescens*) also have been noticed foraging in cottonwoods on many occasions. Certain large isolated cottonwoods along creeks were favorite stopping places of blue jays (*Cyanocitta cristata*) which, on trips from one wooded hillside to another, usually perched briefly in the tops of these tall trees. Calling and looking about, the jays seemed to maintain contact with distant mates or members of the flocks by using these high perches. Often after a brief pause in the top of the cottonwood they flew off in a new direction.

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Both woodrats and opossums have been known to utilize hollow cottonwoods as dens. Fox squirrels have been seen climbing in cottonwoods occasionally.

***Juglans nigra*.**—Black walnut is one of the more prominent hardwoods. Under original conditions, evidently many of the larger trees were of this species. Being the most valuable timber species of the area, walnut has been subjected to heavy cutting over the past 85 years. Most of the walnut trees still present are small or medium-sized, but the species is still abundant over much of the area. Along certain hilltop edges there are groves of walnuts, growing in nearly pure stands, with an occasional elm, ash, coffee-tree or honey locust. Elsewhere walnut trees are more scattered, but are distributed throughout the woodland. Although the walnut trees growing in woods are of various sizes from those of mature size down to saplings, seedlings are to be found mainly in fields near the woodland edge. In these situations it is one of the more prominent of the woody species invading open lands. The seeds evidently are transported mainly by rodents, especially fox squirrels.

In autumn every walnut tree that is bearing nuts becomes a focal point of activity for squirrels. Over a period of weeks the squirrels concentrate their attention on the walnut crop, continuing until virtually every nut has been harvested. Walnut seems to be the one most important food source, for both the fox squirrel and the gray squirrel. Most of the nuts are stored for future use. Many buried separately and never retrieved by the squirrels, grow into new trees.

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White-footed mice often store the nuts in their nests, in burrows, beneath rocks or in crevices. In summer, groves and isolated trees of walnuts are favorite haunts of the yellow-billed cuckoo, which finds concealment in the thick foliage, and probably feeds upon the tent caterpillars that commonly infest these trees.

***Carya ovata*.**—Shagbark hickory is one of the more important hardwoods of the area. The trees are relatively small compared with the larger oaks, elms, ashes and hackberry. However, on several parts of the area this hickory is dominant. It grows mainly on north slopes and hilltops. The trees most frequently associated with it are black oak, American elm and chestnut oak.

Scattered through the woodlands are occasional mature hickories of DBH 18 inches or more. However, many of the trees are six inches or less DBH and a large proportion of these have originated as stump sprouts from trees cut in the early thirties or before.

Shagbark is especially tolerant of shading. Numerous young trees and seedlings noted all were growing in dense woods of larger hickories, oaks, or mature elms. None has been found in open fields or even in edge situations. This hickory is resistant to drought; relatively few died during the drought of 1952-1954, and these were mostly small trees in crowded stands.

In parts of the woodland dominated by shagbark hickory the trees are mostly 5 to 6 inches or even smaller in trunk diameter and 20 to 30 feet high, sometimes growing in nearly pure stands, and with a leaf canopy so dense that shrubs and herbaceous vegetation are sparse.

The mast crop produced by shagbark is an important food source for both fox squirrels and gray squirrels. Both kinds of squirrels often use these hickories as sites for their stick nests. White-footed mice also store the nuts as a winter food source.

Birds which are most often seen in groves of shagbark include the yellow-billed cuckoo, tufted titmouse (*Parus bicolor*), black-capped chickadee (*P. atricapillus*), blue jay, summer tanager (*Piranga rubra*), and red-eyed vireo. The Cooper hawk (*Accipiter cooperii*) has been recorded nesting in this hickory. In dead trees of this species that are still standing, the interiors may decay more rapidly than the armorlike bark plates. On several occasions tufted titmice and chickadees have been recorded as nesting in such cavities.

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***Quercus stellata***.—Post oak is relatively scarce on the Reservation. One area of approximately an acre on a south slope is dominated by it. There are several other small groves and scattered trees. All are on moderately steep south slopes in poor soil. Trees often found associated with it include red elm, chestnut oak, chinquapin oak, blackjack oak, hickory, and dogwood. It seems likely that under original conditions this species occupied about the same area as it does at present. It is not spreading, and there are few young trees anywhere on the area. In every instance the groves are limited to a rocky clay soil, and edaphic factors obviously are of major importance. Under original conditions fire was probably a limiting factor, and at the present time competition with other hardwoods may be even more important.

***Quercus macrocarpa***.—Less than a dozen individuals of mossycup oak have been noticed on the area, at well scattered points. Under original conditions, it probably grew chiefly in the bottomlands that have been completely cleared of timber for cultivation. The few now present are all on hillsides, and are medium to large trees.

***Quercus Muehlenbergii***.—Chestnut oak was perhaps the one most important tree species of the original climax forest on the area. Because of its slow growth, scanty seed production, and large heavy fruits with seeds lacking effective dispersal mechanisms, it has lost ground to other kinds of trees as a result of the unnatural disturbances which have occurred.

It still dominates on rocky upper slopes that have north, east or west exposures and forms nearly pure stands in limited areas. Nearly all the larger trees of this species now present have been cut one or more times and have regenerated from stump sprouts. Seedlings and young saplings of this oak are scarce even in parts of the woodland where the species is most common. It is evident that reproduction is slow, at least under present conditions. On the lower hill slopes these oaks are scarce and scattered, but some of the largest are in such situations. Chestnut oak seems to be relatively resistant to drought. In the summer of 1954 when elms, and especially black oaks of all sizes were dying in large numbers, the chestnut oaks growing among them showed little evidence of injury in mature trees and only a small percentage of mortality in saplings.

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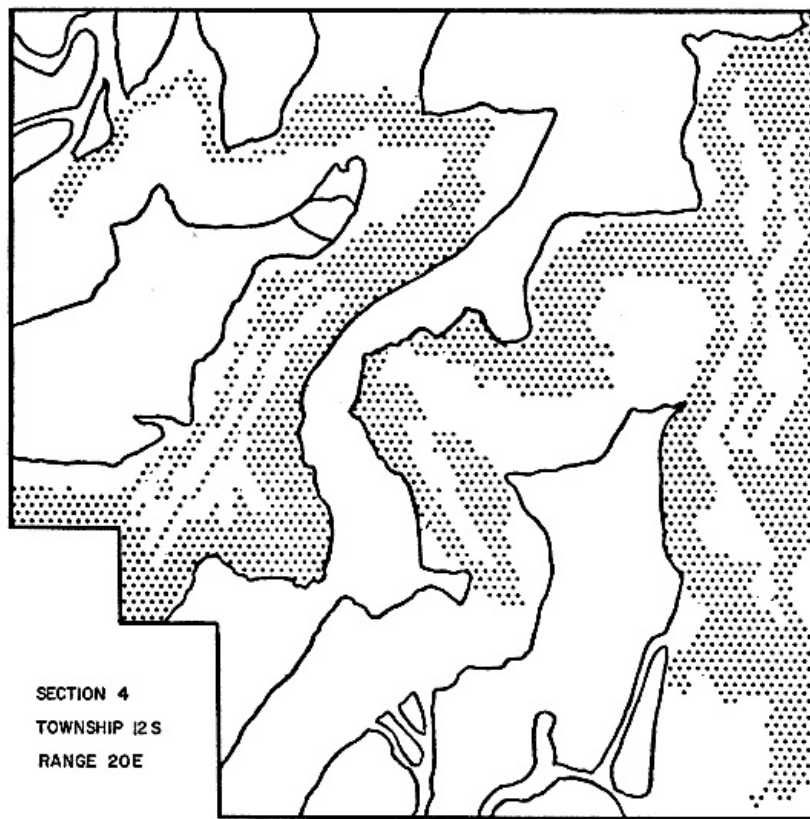


FIG. 5. Map of Reservation showing present distribution of chestnut oak (shaded). The species is not spreading and is thought to be largely confined to the area that was wooded before 1860. Except in minor details, shagbark hickory conforms to the same distribution pattern on this area.

Chestnut oak has a relatively slow growth rate. In 17 that were recorded, there were, on the average, 4.59 annual rings per inch of trunk diameter. Near Pigeon Lake, Miami County, Kansas, counts were obtained from five cut in 1952 from a virgin stand in a habitat similar to that on the Reservation. The five trees had trunk diameters of 16½ to 25 inches and ranged in age from 65 to 183 years. Several still growing on the Reservation are larger and presumably are well over 100 years old.

As this oak seems to be in process of being replaced by other trees, is slow-growing, and slow in dispersal, it seems probable that the areas now occupied by its stands supported stands of it under original conditions. Whether it can regain dominance under present conditions of protection from cutting, fire and grazing remains to be seen.

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The chestnut oak produces a mast crop which is utilized by many kinds of animals. Fox squirrels, gray squirrels, and white-footed mice feed upon the acorns and store them. Blue jays, red-headed woodpeckers (*Melanerpes erythrocephalus*), and red-bellied woodpeckers also eat them. The red-eyed vireo, summer tanager and tufted titmouse are among the birds that most frequently forage for insect food in chestnut oaks. Relatively few kinds of birds seem to use this tree as a nest site.

***Quercus prinoides.***—The chinquapin oak on this area is a small shrubby tree, usually not more than 15 feet high and more typically only six to eight feet. It occurs chiefly in dry rocky situations along hilltop edges and upper slopes, usually where the slope exposure is at least partly to the south. In such situations it may grow in nearly pure stands. Often it is associated with dogwood. The trunks are usually two to four inches in diameter, gnarled and twisted. The crowns are dense and spreading.

This oak is the dominant plant in certain small areas of its preferred habitat. In other areas of hilltop edge and upper slope it is being eliminated by stands of hickory, chestnut oak, black oak and elm, which shade it out. The species is tolerant of moderate to heavy browsing, but seemingly can be eliminated by more intensive utilization; even the higher foliage is often within reach of livestock. In "Horse Woods" one of the hillside areas that was open to livestock until 1949, this oak was almost absent, but it was abundant in adjoining parts of the woods that were fenced in the thirties to exclude livestock.

The thickets formed by this shrubby oak are frequented by cottontails, which feed upon the bark and foliage. The small acorns are used as food by rodents, especially the white-footed mouse. On several occasions, in winter, groups of long-eared owls (*Asio otus*) have been found roosting in thickets of chinquapin oak. Crows also utilize these thickets for roosting occasionally. The white-eyed vireo (*Vireo griseus*), gnatcatcher (*Poliotila caerulea*), and tufted titmouse, frequent the oak thickets.

***Quercus rubra.***—The red oak is one of the important climax species of the area. At present it is largely confined to a ravine in the northeastern part of the section. The woodland here is less disturbed than on most other parts of the Reservation, and red oak is the dominant species. There are large trees, rather evenly distributed, growing on east-facing and west-facing slopes. Just east of the Reservation, in the "Wall Creek" area, the small valley on either side of the creek and the adjacent lower slopes are dominated by giant red oaks larger than any now growing on the Reservation. Farther up the slope in the area of limestone outcrops, dominance shifts to chestnut oak. That red oaks of similar size, and even larger, formerly occurred on the Reservation, at least in the area still dominated by the species, is shown by the presence of a stump 49 inches in diameter, now in an advanced state of decay.

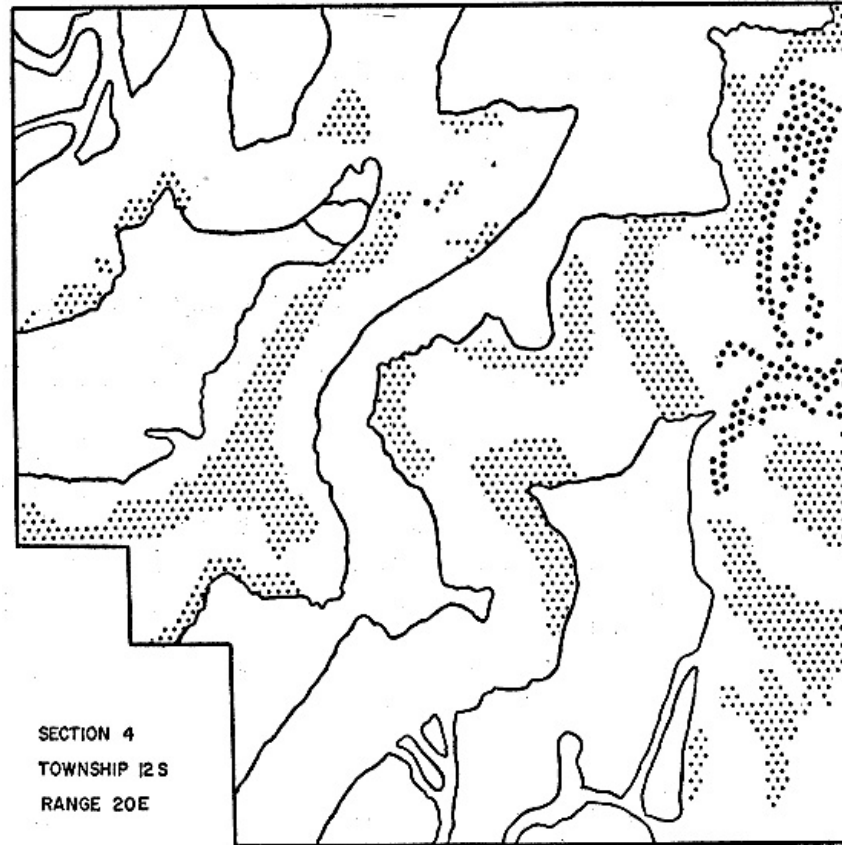


FIG. 6. Map of Reservation showing present distribution of black oak (smaller dots) and red oak (larger dots). Neither species is spreading and both are thought to be largely confined to the area that was wooded before 1860.

The large acorns of the red oak are a favorite food of the gray squirrel, which is most numerous on the parts of the Reservation where these trees are present. The red-headed woodpecker on the area tends to concentrate its activities where there are red oaks. The fox squirrel, white-footed mouse, and blue jay are important consumers of the acorns of red oak. A pair of barred owls resided in the deep woods formed by these oaks and the associated trees.

***Quercus velutina.***—Black oak is one of the dominant species of the original forest climax, and is still one of the more important trees of the woodland. Like chestnut oak it shows little tendency to spread beyond its present limits. Wherever there are small trees there are old mature trees or remains of them nearby. For this reason the present distribution of black oak on the area is thought to fall entirely within the area occupied by the original forest. At present it occurs throughout most of the woodland except in the warmer and drier situations, such as on south slopes. In some hilltop situations it is common, with occasional large mature trees. In some parts of the bottomland and lower slopes it is abundant also, but there are scarcely any on the upper dry rocky slopes that are the preferred habitat of chestnut oak.

Growth in the black oak is somewhat more rapid than in the chestnut oak, as the black oak usually grows on better soil. For 15 the average growth amounted to 3.21 annual rings per inch of trunk diameter.

In 1954 a study of annual rings in a large, long dead, black oak at the bottom of a north slope near the Reservation headquarters showed that the tree was 96 years old, and hence was growing before the area was settled. Within the period of this study black oak underwent reduction in numbers more severe than that noted in any other species of tree on the Reservation. The effect of drought may have been the primary factor, although undoubtedly disease was involved also. In 1953, the second successive drought year, mortality was noticeable. Precipitation continued below normal until August 1954. By then the oaks had been decimated. On a sample strip of hilltop where 29 were recorded, 21 had recently succumbed, and their leaves

were dry and withered; two were dying, though still having some green foliage, and only six were surviving, all evidently in critical condition. The mortality included trees of all sizes, even the largest and oldest. No further mortality was noted in 1955 when precipitation was only slightly below normal. On the Reservation there are many old logs, and snags still standing, of mature black oaks long dead. Earlier drought periods such as those of 1936-37 and 1925-26 possibly were also times of unusually heavy mortality. In any case it seems clear that this oak was originally more prominent in the woodlands than it is at present, and has been steadily losing ground. Even where the mature trees remain in greatest numbers the saplings are relatively scarce as compared with those of elm, ash, hackberry, and hickory. The westernmost limits of the range are nearly 100 miles west of the Reservation.

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Black oak provides a mast crop which is utilized by various small mammals, notably squirrels and white-footed mice. Gray squirrels have often been noticed in or about these trees. Hairy woodpeckers (*Dendrocopos villosus*), black and white warblers (*Mniotilta varia*), and brown creepers (*Certhia familiaris*) have often been noticed foraging on the trunks. Blue jays, myrtle warblers (*Dendroica coronata*), tufted titmice, and summer tanagers frequently forage through the crowns. Often black oak trunks are hollow and the cavities are utilized by various birds and mammals including the screech owl (*Otus asio*), barred owl, raccoon, opossum, fox squirrel, gray squirrel, woodrat, and white-footed mouse.

***Quercus marilandica***.—Black Jack oak is localized in four small compact groves on the Reservation. These sites, though well separated, are similar. All are on steep lower slopes, where there is dry rocky clay soil and the exposure is mainly south. Probably all four groves date back to the time when the area was still in an undisturbed state. Originally they were perhaps largely separated from the remainder of the woodland. Black Jack oak is more tolerant of heat and drought than most of the other hardwoods are. The species is intolerant of fire, but perhaps was partly protected under original conditions by the sparseness of herbaceous vegetation on the poor soil where the groves were situated.

These oaks are relatively slow-growing. One stump of 9-inch diameter, typical of the larger Black Jack trees, had approximately 60 annual rings. Under present conditions there is little or no reproduction and these trees are dying out as a result of competition by other hardwoods. Under protection from fire and browsing, elms, other oaks, locust and dogwood have closed in about the groves and seem to be shading them out.

There are several mature oaks of anomalous appearance, in different places within a few hundred feet at most of the groves of Black Jack. Most of these appear to be hybrids between the present species and *Q. velutina*, as they are somewhat intermediate in size, bark texture, and leaves.

This oak produces a mast crop used by various birds and mammals, and groves are frequented by blue jays, fox squirrels, white-footed mice and woodrats. In the mid-forties when the woodrat population was high, there were many of the rats' stick houses in the groves, built either at the bases of the trunks or among the dense branchlets in tops of fallen trees. By 1952 the population of woodrats was much reduced and had disappeared entirely from these groves. The houses were collapsed and decaying.

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Horned owls (*Bubo virginianus*) and barred owls often make their day roosts among the dense interlacing twigs of these trees, and red-tailed hawks have been known to roost for the night in the same kinds of situations.

***Ulmus americana***.—On most parts of the area American elm is the dominant tree. It occurs throughout the woodland, and most of the larger trees are of this species. In each of the fields that were formerly cultivated, and in the pasture areas, there are many saplings. More than one hundred elms of DBH two feet or more have been recorded. Presumably these mostly date back 90 years or more and were already growing on the area when it was relatively undisturbed. On the area the distribution of these large elms corresponds in a general way with the present distribution of the oak-hickory type. The coinciding distribution of the climax species and of the largest trees is believed to reflect the distribution pattern of the original forest, except that clearing was thorough in the bottomlands so that hardly any trees of the climax species, or large trees of any kind remain. Several elms of three feet or more DBH were recorded, and the largest one measured was 46 inches. The largest elms are in alluvial soil near small creeks in the two valleys. Also many large elms grow along the upper slopes, especially along the outcrops of the two main strata of the Oread Limestone. Such sites along the outcrops on open slopes are the first to be invaded. The rock strata are relatively impervious to water, which is held at a depth where it is readily available to the trees. Along rocky upper slopes between the two outcrops, where chestnut oak is abundant, elms are relatively scarce and seem unable to compete successfully. It is noteworthy that elm is not mentioned in several of the descriptions (Taft, 1950; Parks, 1854; Robinson, 1899) of the original forest, even in listings of the species present. It must have been much less prominent until favored by disturbed conditions.

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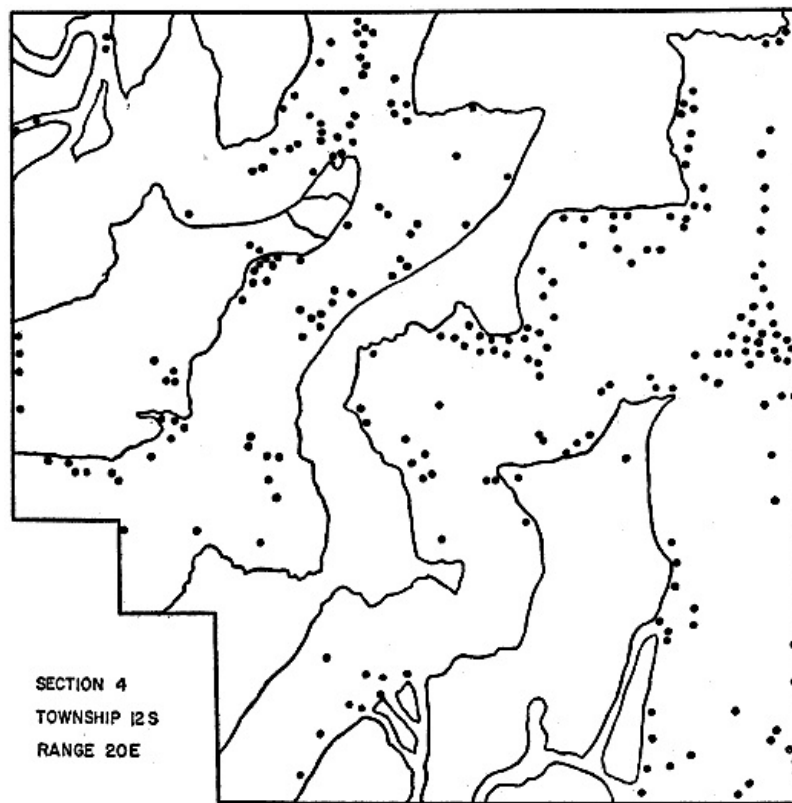


FIG. 7. Map of Reservation showing present distribution of the largest American elms, those more than two feet in trunk diameter. American elm is increasing and spreading on the area, and smaller trees are abundant even in former cultivated fields and pastures. Growth rate varies according to site, but these larger trees are, in many instances, 90 years or more in age and most of them are thought to be in the area wooded in the eighteen sixties and before.

In July and August, 1954, a large proportion of the elms on the area died. The die-off included trees of all sizes, and evidently the cumulative effect of drought in 1952 and 1953, continuing into the spring and summer of 1954, was the primary cause, although diseases such as phloem necrosis, and insect infestations, may have intensified its effect. In August of 1954 the bare dead elms stood out conspicuously in the mass of green foliage surrounding them. Most of them had survived the two dry summers of 1952 and 1953 with little evident loss in vitality. However, the continued lack of moisture as the 1954 growing season progressed, and the extremely hot weather of June and July caused heavy mortality. In the course of a few days the foliage of the upper branches would wither, die and turn brown. In some instances numerous sucker shoots grew from the trunk of the tree as the top was dying. Mortality was especially heavy on south-facing slopes. Certain ecologists believe that over the years, as trees deplete subsoil moisture and periodic droughts make their effects felt, other species also will die off and eventually prairie will replace them where the present forests are growing in dry and exposed situations.

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Infestations of the introduced bark beetle, *Scolytus multistriatus*, were common and probably contributed to death of many elms. In the winter of 1953-54 before much mortality had occurred, the bark beetle infestations had become conspicuous. Especially on south slopes elms of about six inches DBH were heavily infested. Woodpeckers, including the downy, hairy, and red-bellied, habitually resorted to the elm trunks to forage. As a result of their activities chips of bark accumulated sometimes to a depth of several inches around the bases of the trunks, and the exposed inner layers of brown bark caused the infested trees to contrast with the predominantly gray color of those that were still healthy and retained the outer layer of bark.

In April and early May seeds of the American elm constitute a major food source for birds, including the black-capped chickadee, tufted titmouse, junco (*Junco hyemalis*), red-eyed towhee (*Pipilo erythrophthalmus*), Harris sparrow (*Zonotrichia querula*), cardinal, goldfinch, tree sparrow (*Spizella arborea*) and field sparrow (*S. pusilla*). Birds recorded as nesting in the American elm include the mourning dove (*Zenaidura macroura*), Cooper hawk, red-tailed hawk, broad-winged hawk (*Buteo platypterus*), turkey vulture (*Cathartes aura*), screech owl, horned owl, barred owl, red-bellied woodpecker, downy woodpecker, tufted titmouse, black-capped chickadee, gnatcatcher, red-eyed vireo, summer tanager, indigo bunting (*Passerina cyanea*), field sparrow and cardinal.

Opossums, raccoons, fox squirrels and white-footed mice often live in cavities in elms.

Insectivorous birds that find their food on foliage and prefer elm or use it to a large extent are: yellow-billed cuckoo, tufted titmouse, black-capped chickadee, blue-gray gnatcatcher, red-eyed vireo, white-eyed vireo and warblers, including the myrtle, Audubon (*Dendroica auduboni*),

yellow (*D. petechia*), black-throated green (*D. virens*), black-poll (*D. striata*), Tennessee (*Vermivora peregrina*), orange-crowned (*V. celata*), Nashville (*V. ruficapilla*) and American redstart (*Setophaga ruticilla*).

***Ulmus rubra***.—The red elm (or slippery elm) is widely distributed over the area, but only a few trees with a trunk diameter of twelve inches or more are present. Throughout the woodlands of the Reservation the saplings of this species constitute a prominent part of the understory. However, few survive beyond the sapling stage. The red elm is never abundant in Kansas woodlands. It is intolerant of drought conditions, and is one of the first trees to die. This fact probably explains the scarcity of mature trees of this species on the Reservation.

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***Celtis occidentalis***.—Hackberry is widely distributed on the area, but is not dominant anywhere. Its favorite site is along hilltop limestone outcrops, especially where there is south exposure. There are few on hilltops away from the outcrops. Hackberries are scattered in small numbers over the wooded slopes. There are a few of unusually large size, along edges of the bottomlands. Hackberries are slow-growing. Counts of annual rings for four indicated an average of 7.1 rings per inch of trunk diameter. Young hackberries of all sizes are numerous throughout the woodland. Therefore it seems likely that this species is in process of spreading and probably has already extended beyond the situations which it originally occupied.

The fruits of hackberry provide a fall and winter food supply for various animals. Opossums are especially fond of them. Red-bellied woodpeckers have been seen storing them. Migrating flocks of robins may utilize them as a major food source temporarily. White-footed mice and woodrats store them and eat them.

***Morus rubra***.—Red mulberry is moderately common in certain heavily wooded areas, especially the lower parts of north slopes. A few are present on wooded hilltops. Most of the trees are between ten and twenty feet tall, and generally die before growing larger. Red mulberry is present in most woodlands of eastern Kansas and is seemingly distributed by birds. It is never an important component of woodlands in the area. Catbirds (*Dumetella carolinensis*) and wood thrushes (*Hylocichla mustelina*) especially have been noted frequenting the vicinity of mulberry trees in fruit. Probably many other kinds of birds utilize the fruits to some extent.

***Maclura pomifera***.—Osage orange was not a member of the original flora, but early settlers in Kansas valued it for windbreaks and fence posts, and they made extensive plantings. Presumably it was introduced onto the area of the present study in the eighteen sixties. At the present time it occurs throughout the woodland, with scattered mature trees and many young trees on the former pastures. This aggressive invader spread despite frequent cutting, and now plays an important part in the ecology of the area. Most of the larger trees have been cut one or more times, but have regenerated from stump sprouts with multiple stems and spreading habit. The tough and durable wood is useful for fence posts. The growth rate is slow, similar to that of oaks and elms.

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Osage orange is intolerant of fire and is easily killed by scorching. It is damaged by browsing, and cannot grow in deep shade. It is drought resistant. Mortality was light during the drought period of 1952-1954, although many of the trees were growing on poor soil in the hotter and drier sites.

Where there are stands of mixed hardwoods, osage orange is relatively scarce and tends to be on or near the edges of the stands. The osage orange trees growing in competition with oaks, elms and hickories may have tall, slender trunks and narrow crowns, in contrast with the spreading habit of those growing in more open sites. In the woodlands small and medium-sized trees are scarce and there is hardly any reproduction. Obviously the osage orange, like honey locust became established in the forests when the stands were more open, probably after cutting of the large trees. In contrast to the meager reproduction in shaded sites is the abundant crop of young saplings along edges of fields adjacent to woods or about isolated osage orange trees. Evidently the tree does not become established readily on bluestem prairie. On a hillside adjoining the northwest corner of the Reservation, long subjected to heavy grazing, osage orange dominates, but just across the fence on the Reservation side, it is almost absent. This area had been maintained as bluestem prairie until about 1934 by occasional burning and since then had partly grown up into thickets in which dogwood, and saplings of elm and hackberry were abundant.

The dense thorny branches provide shelter and nesting sites for many kinds of animals. On this area the cardinal utilizes it for nesting sites more frequently than any other kind of tree. Some nests were so well protected by the thorns that they could scarcely be reached. Indigo buntings, field sparrows, and yellow-billed cuckoos also use these trees or young saplings for nesting sites.

In the forties, when the woodrat was common on the area, its local distribution seemed to be determined mainly by the osage orange. Many houses of the woodrat were built around old stumps at the bases of large, spreading osage orange trees. Frequently the houses were in the main crotch of a tree two to eight feet from the ground. Characteristically the rats used horizontal or gently inclined, low branches of the tree as runways to and from the house. In summer and early autumn these rats stored foliage of the osage orange in large quantities in chambers adjacent to the nest. The seeds also provided an important food source. During the period 1948 to

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1951 the woodrat population steadily decreased, and one by one the houses in osage orange trees were deserted, until the small surviving population of woodrats was limited to hilltop rock outcrops not associated with osage orange trees.

The seeds are well liked by other rodents also. In late fall and winter after the "hedge balls" have fallen, fox squirrels visit the trees and shred the fruits to gain access to the seeds. Over periods of weeks heaps of the shredded refuse accumulate at the base of the tree trunk. The seeds probably constitute the one most important winter food of the fox squirrel. The tufted titmouse also relies to a large extent on the seeds for its winter food. Being unable to shred the bulky hedge balls itself, it depends almost entirely on the seeds in fruits torn open by the squirrel but not fully utilized by it. At times when the ground and trees are snow-covered, making unavailable most other food sources, the osage orange seeds gleaned from refuse heaps in the sheltered feeding places of the squirrels are probably of critical importance to the titmouse.

The cottontail and white-footed mouse also eat the seeds.

***Platanus occidentalis.***—Sycamores are few and scattered on the area, but those present seem to be holding their own if not gaining in numbers. They include some of the largest trees on the Reservation. The most typical habitat is along rocky ravines on wooded slopes. Occasional trees are scattered through the woods away from ravines on slopes of north, east, or west exposures, or on hilltop edges, providing strong evidence that these areas were more open at the time the sycamore seedlings became established. Cutting of the mature trees in the original forest and subsequent grazing might have created the conditions favorable for their establishment. Many saplings have sprung up in the fallow hilltop fields that were formerly cultivated.

Many of the larger sycamores have cavities and these are inhabited by various animals. A large sycamore in a ravine below a pond had a cavity in its base within which a raccoon reared its litter of young one summer. At other times this same cavity was inhabited by woodrats and by fox squirrels. Seemingly this cavity was the habitat of a certain chigger which was found on both the squirrels and the woodrat. Red-bellied woodpeckers excavated a cavity high on this same tree trunk, in which they reared their brood.

Several large sycamores died as a result of the cumulative effect of drought in the summers of 1952, 1953 and 1954, but many others survived.

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***Prunus americana.***—Wild plum is a small tree, usually not more than three inches in trunk diameter, nor more than twelve feet high. It tends to grow in dense thickets which are spotty in distribution. Several of these thickets are in edges of former pastures at the woodland edge. Other extensive thickets are in the following situations: along hilltop rock ledges and encroaching into adjacent prairie on upper south-facing slope maintained as bluestem prairie by mowing and burning, until 1934; along a ravine in formerly cultivated hilltop fields; along tops of steep creek banks at edge of old corn field. In a few situations within the woodland there are dead and dying thickets of wild plum, shaded out by the closing in of the tree canopy, as fast-growing trees such as elm, honey locust, and cherry sprang up in former clearings.

The woodrat lived in several plum thickets that provided the type of shelter from predators that it requires. The bark, fruit and foliage are used as food. In autumn the plums sometimes are the chief food of the opossum. Plum thickets provide the preferred habitat for the Bell vireo (*Vireo bellii*). The white-eyed vireo, field sparrow, tree sparrow, Harris sparrow, and white-throated sparrow (*Zonotrichia albicollis*) also frequently use these thickets.

***Prunus serotina.***—Isolated trees of black cherry six to fifteen inches in trunk diameter, have been noted on various parts of the Reservation at widely scattered points. On a flat hilltop at the southeastern corner of the Reservation there are many large trees of black cherry, which make up a major portion of the stand, and trunks of some are as much as 21 inches in diameter. Other trees in the vicinity are mostly elms and honey locusts, and seemingly the area was more open or perhaps entirely treeless in the recent past. The presence of black cherry in forest often can be interpreted as indicating more open conditions at the time the seedling became established. Black cherry prefers a rich soil and an open habitat; hence it is generally not common in woodlands of northeastern Kansas.

The fruits of black cherry are a favorite food of the opossum, and the seeds have often been noticed in the scats of this animal. White-footed mice store and eat the seeds. Two trees of black cherry well isolated from other trees except for saplings in low thickets, constituted the headquarters of a Bell vireo's territory each summer from 1951 through 1955.

***Pyrus ioensis.***—Crab-apple is a small tree, usually less than five inches in trunk diameter and less than 12 feet high. It grows both in woodlands and in former pastures, but chiefly along the line of contact. After removal of livestock in early 1949, crab-apple spread into the edges of hilltop pastures, from the adjacent protected woodland. Each year thickets of encroaching crab-apple have extended farther into the fields, until, in 1955, there were graded series from the trees along the fence, six feet high or more, to the seedlings 30 to 50 feet out in the fields. Dogwood, red haw, and smooth sumac are among the most common associates of crab-apple as they share its tendency to invade open land adjacent to the forest.

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Evidently the tree is intolerant of browsing by livestock, as few were growing in the pastured areas in 1948, but as soon as livestock were removed these areas were rapidly invaded.

The thickets formed by crab-apple provide shelter for many kinds of animals. Cottontails, especially, tend to stay in or near these thickets. In autumn the fruits are eaten by them, and in winter, when the ground is covered with snow, the bark is a major food source. Most mature or partly grown trees show old scars near their bases, where the rabbits have attacked them. Often the trees are completely girdled. In years when snow lies on the ground for long periods girdling is extensive and a substantial portion of the trees in the thickets may be killed, but this mortality has been insufficient to check the rapid spread of crab-apple.

The crab-apple is one of the trees preferred as a nesting site by the cardinal. Other birds that frequently use the crab-apple tree as a nest site include the field sparrow, towhee and indigo bunting. White-footed mice, prairie voles and pine voles eat the fruit and seed.

***Crataegus mollis.***—Red haw occurs over much of the Reservation, both in woodland and former pastures. The trees are scattered, and are not dominant, even on small areas. In the woodland, haw usually grows in the more open situations. Where there are haws in denser woods, they are usually large and old; seemingly they are survivors from a time when the woods were more open. Haw is intolerant of shading, and being of lesser height than any of the climax species, it cannot compete with them. The present wide distribution of haw on the area is secondary, resulting from the extensive cutting of the larger trees and opening up of the woodland. Haw trees are most numerous on south facing slopes that have grown up into thickets in the last 30 years. Here its associates are chiefly honey locust, osage orange, dogwood and elm.

Red haws have been recorded as nest trees of horned owls, yellow-billed cuckoos, cardinals, and fox squirrels. Cavities in the trunks are used by downy woodpeckers, titmice, chickadees and white-footed mice.

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***Cercis canadensis.***—Redbud is abundant in some parts of the woodland. Trees are up to nine inches in diameter and 25 feet high. They grow chiefly in rich soil on hillsides in moist situations. Redbud and dogwood are in part complementary in distribution, each forming an understory in parts of the woodland where the leaf canopy of larger trees is not too dense. However, redbud is more tolerant of shade. In general dogwood grows in the drier, more rocky situations and redbud in better soil and damper sites. In the southeastern part of the Reservation, on a west facing slope, redbud dominates, with smaller numbers of elm, blackjack oak, and dogwood.

Several times nests of yellow-billed cuckoos were found in redbuds. Titmice, chickadees, and red-eyed vireos forage in redbuds on many occasions. Brown creepers forage on the trunks. Titmice, chickadees, and downy woodpeckers used cavities in dead or dying redbuds. However, there is no evidence that this tree is especially attractive to any kind of vertebrate, or plays an important part in the ecology of the area.

***Gymnocladus dioica.***—Kentucky coffee-tree is one of the less important trees on the area but it is widely distributed. In general it is absent from the denser woods. On limited areas of certain slopes it is the dominant species. The groves sometimes are in nearly pure stands. Slope exposure evidently is not the determining factor in the local distribution as groves have been found on hillsides of varying exposure. The tree seems to flourish where the forest has been opened by cutting of the larger trees. Groves are mainly on the more gently sloping parts of the hillsides, or on the nearly level terrace. There are few coffee-trees more than 12 inches in trunk diameter. The largest tree examined was 27 inches.

In May, groups of orchard orioles (*Icterus spurius*) have been observed in coffee-trees, seemingly attracted by the blossoms. These concentrations never lasted more than a few days and seemed to involve individuals that were still migrating or newly arrived and not yet established on their territories.

In winter the large pods of this tree are used as food to a limited extent by cottontails. The large hard shelled seeds resist attack by most animals. Seemingly they are used by white-footed mice, as they have often been found stored in the nest cavities of these mice, beneath rocks or in logs.

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***Gleditsia triacanthos.***—Honey locust is at present one of the more important species of trees on the area. There are scattered locusts throughout most parts of the woodland. In the bottomland fields there are groves and scattered trees of medium to large size. On south slopes honey locust, osage orange and red elm form thickets. On hilltops, along woodland edges where fences were installed in the mid-thirties, young honey locusts have become established and are now abundant. Some have grown to a diameter of 8 inches or more. Honey locust is the fastest growing of the trees on the area and therefore has an early advantage in competing with other kinds. A locust of 25-inch diameter cut in 1950 was found to have 32 annual rings, an average of only 1.3 rings per inch as contrasted with an average of 3.8 for all the trees studied, and more than 9 for some of the slowest growing. In open fields, both those used for pasture and those formerly cultivated, young honey locusts have sprung up in abundance since the discontinuance of grazing in 1948. The species is resistant to drought. It seems to have been limited on the area mainly by grazing and shading. The locusts growing in the woods tend to be concentrated near its

edges. Those that are deeper in woodland evidently became established after heavy tree-cutting had opened clearings. Locusts in such situations, competing with other hardwoods are of much different form than those growing in the open; the trunks are long and slender and the crowns are narrow.

The south slopes that were originally prairie, were evidently only sparsely clothed with trees up until the thirties when livestock were fenced out. Then the abundant growth of shrubs and young trees formed thickets. Honey locust, growing rapidly tended to dominate. The younger locust saplings that were shaded beneath the leaf canopy died in large numbers.

Honey locust plays an important part in the over-all ecology of the area, providing both food and shelter for many kinds of animals. The foliage is well liked by livestock; consequently young trees have little chance of surviving in heavily grazed pastures. Rabbits like both the foliage, and the bark. Often they girdle or injure young trees, and eat the beans. Both the prairie vole and the pine vole often feed upon the inner bark and root crowns of small saplings, sometimes completely undermining them. These voles also store and eat the seeds. Beneath large mature locusts, runway systems and burrow sof the pine vole are sometimes much in evidence. As ground vegetation is scanty in these places it seems that the voles are attracted by the abundant supply of locust seeds.

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The spiny branches of locusts provide well protected nesting sites that are utilized by various kinds of birds; mourning dove, horned owl, yellow-billed cuckoo, gnatcatcher, cardinal and goldfinch have been recorded nesting in locusts. The wood is relatively soft. The hairy woodpecker has been recorded nesting in a cavity which it had dug in a living honey locust, while the black-capped chickadee and red-bellied woodpecker have been recorded nesting in cavities in dead limbs. The summer tanager prefers large locusts near the edge of woodland as singing stations.

Fox squirrels also often exploit the spiny protection provided by locust trunks, and build their stick nests in these trees, usually in a fork of the main trunk eight to twelve feet above the ground. Such nest trees often are either isolated or are in groves of other locusts. Presumably the squirrels are attracted to them by the supply of locust seeds.

***Acer Negundo.***—Boxelder probably was not a part of the original flora of the Reservation. The trees present now are few and scattered, and most are not more than eight inches in trunk diameter. The species seems intolerant of shade and does not grow in the denser woodlands. A few are present along the banks of the intermittent streams, and there are others in open woodlands of south slopes. The small patch of bluestem prairie remaining at the northwest corner of the Reservation is being invaded by a variety of shrubs and saplings, and boxelder is by far the most prominent of these invaders, with two hundred seedlings and saplings per acre.

***Ailanthus altissima.***—Tree-of-heaven is an Asiatic species that was introduced early into northeastern Kansas, and has become established locally in the woodland. Most of those on the Reservation are near the central part of the southwestern one-fourth. Concentrated about the site of an old homestead, occupied in the eighteen-seventies, within a few acres, there are dozens of mature trees, up to 22 inches in trunk diameter, and hundreds of saplings. Elsewhere on the Reservation the species is scarce and is represented by isolated trees and scattered clumps at a few places.

## EXPLANATION OF PLATE 7

[Pg 124]

Upper figure shows gully in southeastern part of Reservation, which has enlarged and deepened greatly in the past 40 years. Heavy precipitation in the summer of 1951 resulted in the undermining and collapse of many large and medium sized trees, as shown in this photograph taken in March, 1956, by H. S. Fitch.

Lower figure shows Cottonwood fifteen feet in circumference, growing on hilltop near south edge of the Reservation. This is the largest tree on the area. Several exceptionally large black oaks, chestnut oaks, and elms are present on the same hilltop. Photograph taken in December, 1954, by H. S. Fitch.

## PLATE 7



**PLATE 8**



Large American elm at edge of bottomland field in west part of the Reservation. Photograph taken on April 2, 1955, by H. S. Fitch.

***Cornus Drummondii.***—This dogwood is the most abundant tree on the area. However, it scarcely reaches the size of a tree. Most mature examples are 1½ to 3½ inches in trunk diameter, and rarely more than twelve feet high. Dogwood grows in greatest abundance on dry rocky slopes where other trees are scarce. In small areas it may be the dominant tree, often closely associated with chinquapin oak and red elm. In parts of the woodland where there are larger trees, dogwood may form an understory, its development depending largely on the amount of light passing through the upper leaf canopy. Where the canopy is dense and nearly continuous, dogwood tends to be eliminated by shading. In some situations where forest has recently closed in, most of the dogwoods are dead or dying. Especially on formerly cut-over north slopes, where oak and hickory have sprung up in a dense stand 20 feet high, with a thick canopy, most of the dogwoods have been eliminated.

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On the remaining hillside prairie near the northwest corner of the Reservation, dogwood is the most prominent of the trees and shrubs encroaching onto the area since it has been protected from fire—a period of approximately 20 years. There are dense thickets of dogwood along the borders of the prairie and the woodland edge.

The white-eyed vireo and Bell vireo both forage and nest in thickets of dogwood and other shrubs.

***Fraxinus americana.***—White ash is localized on the Reservation and most of the mature trees are within an area of perhaps three acres on a steep slope of northwest exposure. Several of the largest trees, well over a foot in trunk diameter, grow at the lower limestone outcrop. Ash is most abundant at this level and at the terrace just below it. On the one slope where it is concentrated, ash is one of the most common trees, growing in association with American elm, chestnut oak, black oak, and shagbark hickory. This area is one of the most mesic on the Reservation. The soil is usually damp, with thick leaf litter and rich humus. In hilltop fields, formerly cultivated or pastured, saplings of white ash are among the most prominent invaders.

The leaves of this tree and especially its saplings, are favorite foraging places for the tree frog. The groves of this tree provide favorable habitat for the opossum, short-tailed shrew, gray squirrel, and white-footed mouse. Birds that frequent the same habitat include the black-capped chickadee, tufted titmouse, blue jay, rose-breasted grosbeak (*Pheucticus ludovicianus*), yellow-billed cuckoo, red-eyed vireo, gnatcatcher, hairy woodpecker, Kentucky warbler, and crested flycatcher (*Myiarchus crinitus*).

The University of Kansas Natural History Reservation, in the northeastern corner of Douglas County, Kansas, is situated in an area that originally supported two types of climax vegetation, tall grass prairie, and hardwood forest. These associations were distinct and sharply defined. The present distribution of the different species of trees on the area, supplemented by the data from snails, indicates the approximate distribution of the two original climaxes. The principal climax trees of the original forest were mossy-cup oak (mainly in bottomlands), black walnut, shagbark hickory, hackberry, red oak, black oak (mainly on hillsides and hilltop edges), chestnut oak (mainly on rocky upper slopes). Subclimax trees characteristic of marginal situations include: American elm, red elm, white ash, honey locust, osage orange, coffee-tree, red haw, dogwood, redbud, cherry, wild plum and crab-apple. Others characteristic of hydrosere situations include sycamore, willow (of four species), and cottonwood.

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In the Kansas River flood plain and small tributary valleys, rich mesophytic forest of predominantly oak-hickory type was present. In somewhat stunted form, and with partial replacement of its species by those of more xeric habit, it extended up onto hillsides sloping north, east or west, and onto the adjacent hilltop edges. Slopes having poor shallow soil and exposures mainly to the south supported chiefly tall grass prairie, but also had compact clumps of blackjack oak and post oak, usually more or less isolated from other parts of the woodland. Hilltops were mostly treeless (except near their edges) and supported a tall-grass prairie vegetation. Shrubs and various kinds of small trees must have been a much less conspicuous part of the woodland flora than they are at present, and occurred in small ravines where shelter was inadequate for the larger forest trees, and also along the extensive line of contact between forest and open land.

One of the earliest changes was the destruction of the bottomland forest. With the rapid settlement of the region in the sixties and seventies, lumber was in demand and the supply was limited. The cleared land was productive as pasture. Heavy grazing combined with drought, gradually altered the original tall grass prairie; the bluestems and other perennial grasses were replaced by the introduced blue grass and by various weedy forbs. Prolonged protection from fire permitted encroachment of trees and shrubs into situations where they had not grown previously. Heavy grazing however, tended to hold in check the spread of the woody vegetation.

When the bottomlands had been cut over, lumbering operations were extended onto those hillsides where the better stands of trees were located. The cutting of large, mature oaks, walnuts, and hickories opened up the woodland and permitted large scale encroachment by subclimax species. American elm, especially, sprang up in thickets. Ash, honey locust, cherry, red haw, crab-apple, dogwood, and the introduced osage orange, thrived and spread in the situations to which they were especially adapted. These species largely replaced the original climax. Some of the trees cut, the oaks, sycamores, and hickories, usually produced fast-growing stump sprouts and competed vigorously with the invaders. At each successive cutting, however, the climax species lost ground. American elm, being tremendously prolific of seed, and only a little less tolerant of shading than its climax competitors, soon became the dominant tree of the woodlands.

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