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THE UNIVERSITY  
OF KANSAS  
NATURAL HISTORY  
RESERVATION



The University of Kansas  
Natural History Reservation  
in 1965

BY

HENRY S. FITCH

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UNIVERSITY OF KANSAS  
MUSEUM OF NATURAL HISTORY

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EDITOR: E. RAYMOND HALL

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# The University of Kansas Natural History Reservation in 1965

## INTRODUCTION

In 1947, at the suggestion of Professor E. Raymond Hall of the Department of Zoology, Chancellor Deane W. Malott proposed to the State Board of Regents that a tract of 590 acres of the University's "Robinson Farm" land be set aside as a reservation where native plants and animals might be protected and studied under natural conditions. This action was taken and on July 1, 1948, the writer came to The University of Kansas, Department of Zoology, and began field work as first superintendent and resident naturalist of the newly created natural history reservation. In the following years a residence and small laboratory were completed and the writer and his family moved onto the area on March 1, 1950. As anticipated, the Reservation has provided a valuable adjunct to the several departments of biological science of the University, providing a place for field work to supplement the types of instruction carried on in classrooms, laboratories and museums. The Reservation is administered by the Department of Zoology.

Early in 1952 a pamphlet was published (Fitch, 1952) briefly describing the Reservation and its plant and animal life, its objectives, the research program during its first three years, and the work planned for later years. The publication is now much outdated and has long been unavailable. The present report incorporates the more essential material included in the earlier report, presents some of the more general findings, and traces the trend of the numerous investigations already completed or in progress on the area in the 17 years since it was made a reservation.

In the present report attempt has been made to avoid scientific names except in the formal lists of species. For most groups, except those of some invertebrate animals, widely accepted vernacular names are available. The reader is referred to the following authoritative works for both the scientific names and the vernacular names used here: Fernald, 1950, for flowering plants; Hall, Ander-

son, Jones and Packard (1957) for mammals; Johnston (1960) for birds; Smith (1956) for reptiles and amphibians; Harlan, Speaker and Reece (1956) for fish.

Much of the information in this report is not new but is compiled from previous publications—many of them based on field studies carried on partly or wholly on the Reservation. These publications are all included in the Bibliography section. A large number of persons have contributed to the information used herein.

The writer is especially indebted to those persons who have donated large amounts of time to the study and identification of specimens. Dr. Ronald L. McGregor and Dr. Worthie H. Horr identified most of the plants. Mr. A. Noel McFarland identified all the moths or submitted them to specialists for identification. My former research assistants, Mr. William N. Berg, the late Robert M. Hedrick, and Dr. Allen Brady, identified many insects and spiders. Other persons who have identified many specimens include: Dr. George W. Byers, Mr. J. B. Karren, Mr. Bruce Harrison and Mr. H. L. Willis (insects), Dr. Paul R. Ehrlich (butterflies), Mr. Charles D. Miles (snails), Dr. William Murchie (earthworms), Dr. Frank Kurczewski (wasps), Dr. M. R. Smith (ants), and Dr. Robert L. Gering, Dr. Willis J. Gertsch, Dr. T. B. Kurata, Dr. Herbert W. Levi, Mr. Wilton Ivie, and Dr. M. H. Muma (spiders), and Dr. Jerry Tash (crustaceans).

The photographs included in this report are intended to illustrate the vegetation and the general habitats on the area as they existed in 1964 and 1965, but also are intended to illustrate ecological succession. Most of these photographs had their predecessors, taken from the same spot at the same season but years earlier, and published in one of the earlier reports concerning the plants and animals of the Reservation. These earlier photographs are not reproduced in the present report, but the publication of each is cited, so that the interested reader may compare the scenes and judge the extent of successional change in the interval of years elapsed between the photographs of each pair.

#### OBJECTIVES

The objectives of the University of Kansas Natural History Reservation are: to accomplish research in ecology; to teach biology, with emphasis on natural history; and to conserve a sample of the Kansas flora and fauna. It is intended that the Reservation be maintained permanently as a natural area and a research station, with a long-term program of study, concerning the inter-

relations of native animals and plants with their physical and biotic environments, and their population dynamics under natural conditions. Continued collaborative effort by various specialists working on this limited area will ultimately provide unusual insight into these interrelations.

Another function is to promote a better appreciation of the land and of living plants and animals by the public in general. The area provides practical demonstration of the benefits to be derived by protection of the land from abuse and exploitation, showing, for example, the control of erosion by natural vegetation after cultivation and grazing are stopped, and gradual restoration of fertility and disappearance of noxious weeds after discontinuance of overgrazing. This is one of the few areas within the state of Kansas where native plants and animals are rigidly protected from disturbance by humans and where primitive conditions are to some degree approximated, so that the natural interrelations of species are revealed. Constantly expanding human populations, agriculture and industry encroach everywhere except in the few such places that are maintained by constant effort. The animals protected on the Reservation include species of native game such as deer, rabbits, squirrels, and quail, which propagate naturally, attain high population densities on the area, and tend to disperse into depleted surrounding areas and restock them, to the benefit of local sportsmen.

Another major function of the Reservation is that of providing a place conveniently near the University campus where classes in the biological sciences may carry on field work. Each year hundreds of students in many different classes visit the area on organized field trips. Traditionally these have included the large class in Biology I, of students experiencing their first contact with a life science. Early in their training these students thereby gain some grasp of ecological principles, and on the field trips each student is required to use field equipment, and to find and study animal life on his own. Many other classes and groups not connected with the University visit the Reservation each year. Among these are classes in biology and ecology from various colleges and universities in Kansas, high school biology classes and science clubs, elementary schools, groups interested in bird study, and Boy Scouts. Many interested individuals of the general public, and research workers from other states or from foreign countries visit the area from time to time.

The nearness (6½ miles by road) of the Natural History Reservation to the campus of the University of Kansas in Lawrence strengthens the teaching function of the Reservation over what it would be if the Reservation and Campus were farther apart. The 590-acre Reservation comprises all but the southwestern 50 acres of the northeasternmost section (see Fig. 1) in Douglas County and is only four and a half miles north and one and a half miles east of the City Hall at 11th and Massachusetts streets, Lawrence, Kansas.

#### THE CONCEPT OF A NATURAL AREA

In recent decades unprecedented growth of industry and population in the United States has been accompanied on the one hand by the rapid and progressive destruction of remaining natural communities of plants and animals as they formerly existed by a public callous and largely unaware of them and, on the other hand, by an increasing sense of outrage and urgency concerning this trend by more enlightened segments of the citizenry. Through the efforts of the latter, channeled and directed into effective action by the Nature Conservancy and kindred organizations, hundreds of "natural areas," large and small, in all parts of the country, have been acquired and turned over to the custodianship of institutions or agencies interested in their preservation.

Some of the best examples of natural areas are in the larger national parks. Through the far-sightedness of the policy-makers in the National Park Service, such areas were to be preserved unimpaired for posterity. Nevertheless, in national parks and in all other natural areas there has been some compromise between the ideal of preservation of natural conditions and the practical considerations of obtaining some short-term benefits to mankind.

In late years the provision of recreation on a large scale has been emphasized by the National Park Service; more than 170 areas principally for that purpose now (1965) are administered by the Service, in addition to the 32 National Parks *per se* in which preservation of natural conditions unimpaired (and therefore naturally occurring changes) was the primary and prescribed aim. A degree of dilution of National Park policy, and more especially practice, has permitted massed humanity in such popular places as Yosemite Valley, the basin containing Old Faithful Geyser in Yellowstone, and Clingman's Dome in the Great Smoky Mountains, thereby so greatly altering the plant and animal communities locally that these places do not qualify as natural areas. Although these

are extreme examples, ecosystems everywhere including all so-called natural areas, have been more or less altered from their natural condition by man.

The University of Kansas Natural History Reservation is no exception in this regard. In approximately 95 years prior to 1949 the area was grazed by domestic livestock and substantial parts of it were cultivated at one time or another. In administering the area since 1949 the policy has been "hands-off" allowing nature to take its course with no interference, but several notable exceptions have been made. In the first place, fire has not swept over the area in more than 20 years. In the second place large primary consumers, bison and elk (*wapiti*), have been absent. In the third place the decision to build a dwelling and laboratory near the center of the area, with associated well and pumphouse, garage, small lawn, sewage disposal field, access road, parking area, power lines, and clotheslines has changed a small part of the area eliminating some species but rendering conditions favorable for those which require an edificarian habitat. In 1949 soon after the Reservation was set aside as such, an eroded barren upland field in its northeast quarter was sown to native tall-grasses, and in 1953 a silted pond was deepened and an outlet pipe installed to provide a permanent water supply, and assure the continued presence of certain aquatic plants and animals.

While picnicking and camping *per se* are not encouraged because of potential destruction or disturbance of plant and animal life, visitors who are interested in the flora or fauna, or the area itself, are welcome. Attempt is made to impress visitors with the fact that *all* plants and animals are protected, even those which are considered undesirable elsewhere.

Harvesting of wild crops such as grapes, mushrooms, berries, or nuts, is not allowed. As a general policy plants and animals are neither introduced to the Reservation nor removed from it and effort is made to exclude activities that unnaturally influence populations. Nevertheless, limited collecting, for study purposes, of plants and small animals has been permitted when the kinds involved were sufficiently abundant that it seemed no appreciable effect would result on their populations or on the ecosystem as a whole. In this regard a somewhat arbitrary distinction has been made in permitting the collecting of insects by classes and individuals but not permitting such collecting of small vertebrates, even those of the more abundant and prolific species.

Visitors and workers on the area are admonished to avoid any

activities that might alter or destroy habitats—notably tearing apart decaying stumps or logs, stripping of loose bark from trees, or careless turning of rocks or logs. Live-trapping constitutes an important means of studying small vertebrates, and has been done on a large scale, sometimes with the use of bait, even though it is recognized that such operations may alter the numbers and behavior of the animals being studied, and perhaps of other kinds. Domestic animals are rigorously excluded from the area.

A major policy decision involving the philosophy of a natural area was that concerning exclusion of fire; the Reservation lies in an area of fire subclimax and the tall-grass prairie found in the region by explorers and early settlers was fire-dependent. Fires started by lightning or set by aboriginal human inhabitants in accordance with long-established custom often swept unchecked over hundreds of square miles, destroying the plants and animals except those specially adapted to escape or withstand fire. Preservation of the remaining remnants of this prairie type and the return of other areas to a like condition could have best been accomplished by periodical controlled burning. But the effects of fires under primitive conditions probably could not be precisely duplicated with any program of controlled burning. The policy of protection from fire allows areas that were formerly fire subclimax to develop into the "climatic climax" of deciduous forest with its rich associated fauna. The 160-acre Rockefeller Experimental Tract adjacent to the Reservation but not committed to the same policy of protection, even from experiments, provides an excellent situation for manipulation of fire as a tool in maintaining a typical tall-grass prairie subclimax.

#### HISTORY

The University of Kansas Natural History Reservation is situated in the broad belt of the ecotone or transition from the eastern hardwood forests to the grasslands of the Great Plains. Its original condition is not well known, but before the coming of the White Man, this area probably consisted, as it still does to-day, of mixed woodland and grassland, with each type dominating in the local situations more favorable to it. Some ecologists, aware of the rapid invasion of woody vegetation in grassland areas protected from fire, have adopted the extreme view that the entire area was virtually treeless, but there is much evidence to the contrary.

In Major W. S. Long's report of an 1819 exploring expedition

through the area that is now in Douglas County, Kansas, and nearby counties, various forest trees of kinds still common in the area were mentioned (Taft, 1950:442). Early residents of Lawrence, Kansas, have described the countryside about the recently settled town and between the town and the present Reservation as it appeared in the early eighteen-fifties (Robinson, 1899; Parks, 1854). The late Mrs. Anna Morgan Ward, daughter of a pioneer family which settled in 1864 on the section of land adjoining the Reservation on the south, has set in writing her girlhood memories of the area (Ward, 1945). A U. S. Government map prepared sometime in the eighteen-fifties showed distribution of forest in Douglas County. Surveying records of the section lines bounding the Reservation are also available and have provided information about the vegetation at regular intervals along these transects, in different soils and slope exposures. Finally, numerous core borings of large trees on the Reservation made in the early nineteen-fifties have indicated approximate ages of the trees and possible minimum ages of the groves where they occur.

This evidence has been set forth in some detail in earlier publications (Fitch, 1952:4-6; Fitch and McGregor, 1956:79-86). In brief, it may be stated that parts of the flood plain of the Kansas River supported a forest with a climax vegetation of many species of large trees. The forest had oaks, hickories, elms, walnut, linden, ash, hackberry, Kentucky coffee tree, honey locust and cottonwood. The broad bottomland forest had attenuate peninsular extensions along tributary streams, but elsewhere, even on some of the bottom land, tall-grass prairie dominated the landscape. Where soil, moisture, and slope exposure were favorable, groves extended up onto hillsides or hilltop edges in a sparser, less luxuriant type of forest than that which grew in the bottomlands. Some groves were isolated and surrounded by prairie. Usually in autumn, prairie fires burned the dry grass from extensive areas and any woody vegetation beginning to encroach was killed. On the Reservation two small valleys draining to the west and south, respectively, were both heavily timbered, but they were cleared early and used for cultivation of crops and for grazing. North-facing slopes also were sparsely wooded and hilltop edges had at least a thin line of trees along the rock outcrops. Elsewhere, notably on hilltops and slopes of predominantly southward exposure, there was tall-grass prairie, except for occasional open groves of blackjack oak and post oak.

For centuries prior to the settlement in the eighteen-fifties and

sixties, this region was under the influence of a succession of aboriginal cultures. Relatively rapid succession of aboriginal groups resulted from the progressive colonizing of European settlers, fanning out from the Atlantic seaboard with resultant westward displacement of native tribes. Frequent changes in population density, and varying practices in agriculture, keeping of domestic animals, hunting and burning, must have had pronounced effect on the plant and animal community. From time to time stone-age artifacts have been found on the Reservation attesting to the former presence of primitive man, but as yet none of the artifacts found has been definitely identified with any specific culture or period. In 1829 the Delaware Indians were moved from Ohio to the land granted to their tribe by the Federal Government between the Missouri and Kansas rivers, including the tract that is now the Natural History Reservation. They occupied this land until 1868, when, at their own request, they were moved again to Oklahoma. Having absorbed much of the White Man's culture in nearly 200 years of contact prior to their move to Kansas, these Indians lived much as did other frontiersmen who were their contemporaries.

Earlier the Kansa Indians were in possession of the lower Kansas River Valley, but they too were of more eastern origin. They were a small tribe (estimated at 800, and by another traveler at 1750, in the early eighteen hundreds) of Siouan affinities, most closely related to the more southern Osage. In the seventeen hundreds known village sites of the Kansa were near the present towns of Atchison and Leavenworth, but five villages that were known in the interval 1804 to 1836 (mentioned in the accounts of Lewis and Clark, and later travelers) were all situated beside or near the Kansas River between the present cities of Topeka and Manhattan. Economy of the tribe was based to a large extent on primitive agriculture. However these Indians also depended on the buffalo for part of their subsistence, and almost up to the time of their removal to Oklahoma in 1873 they continued to make an annual buffalo hunt, following a regular route to hunting grounds in central Kansas far to the west of their villages. By 1811 the tribe had acquired many horses and mules, rendering them more mobile in their hunting, and this may have hastened the extirpation of the buffalo and elk from northeastern Kansas. In 1825, by treaty with the United States, the Kansa relinquished claim to the part of northeastern Kansas where the Natural History Reservation is located, and from

1847 to 1873 the tribe occupied three villages along the Neosho River near Council Grove (Wedel, 1959:50-54; Chapman and Chapman, 1964:81).

With the disappearance of the buffalo, elk and deer no grazers above woodchuck size remained and the annual crop of prairie grass was largely unused. As a result "primary consumers" of the vegetation became relegated to a secondary role and "reducers" and decay organisms became relatively more important. In the absence of effective grazers the accumulation of dead and dry vegetation over intervals of years might have intensified the effects of fire. At any rate the accounts written in the eighteen-fifties, describing a savannah type with isolated groves of trees surrounded by prairie, seem to suggest a recent encroachment of prairie at the expense of a formerly more extensive woodland.

In a more remote period, perhaps before the influence of the White Man had affected the region, even indirectly, Indians of the so-called "Nebraska" Culture occupied northeastern Kansas and lived by primitive agriculture, probably with much less effect on the ecology than the later cultures that utilized the horse and firearms. Attempts to trace ecological trends in the area still farther back in time must be largely speculative. Major ecological changes must have been wrought by: 1. The Hypsithermal Period, from about 3000 to 8000 years before the present, with a climate much warmer than that now prevailing (and drier in its late stages) resulting in widespread displacement of biota; 2. Relatively sudden extinction in the Great Plains region in late glacial (Wisconsinan) or postglacial time of various species of large herbivorous mammals including buffaloes different from those now living, and native horses and elephants. It has been speculated on the basis of some circumstantial evidence that early human hunters played some part in this extinction (Wormington, 1957; Martin, 1958; MacGowan and Hester, 1962:196).

Dr. Charles Robinson, first governor of Kansas, acquired his farm of more than 1200 acres (in Douglas County) in 1864. The portion that is now the Reservation was long known as the Robinson Pasture and up to the time when it was acquired by the University was used mainly for grazing. However, four separate homesteads were made on the area, each occupied for a few years, mainly in the eighteen-seventies and eighteen-eighties. A peach orchard was planted at one site. Small acreages were cultivated

by the homesteaders, who also grazed livestock. Rocks and boulders were piled into walls marking the boundaries of the separate farms. Parts of these walls have been torn down and removed; the remaining parts, now in a state of collapse, are the only remaining evidence of the former farmsites. Usually the homesteader failed to profit from his small scale marginal farming operations, and eventually lost possession of the land, which reverted to pasture under control of the original owner. In the eighteen-nineties parts of the area including some of the hillsides still supported a mixed forest of virgin timber. In 1951 the late Frank H. Leonhard remembered harvesting this timber some 60 years before, especially large walnut trees.

Dr. Robinson bequeathed his entire farm to The University of Kansas, but the transfer of title did not take effect until the death of his widow in 1910, and for some years thereafter the University administration did not have any active interest in the area. Several farmers on neighboring land leased it at different times for grazing their livestock. Heavy overgrazing caused deterioration of the forage crop, originally dominated by a luxuriant cover of native grasses, to a condition in which coarse and unpalatable weeds were prominent. Severe erosion with gullying occurred. About 1900 use of the area now constituting the Reservation had passed to the J. F. Morgan family and the entire area was used for grazing. Sheep were pastured on parts of the area, and a corral for them was situated a short distance northeast of the present Reservation headquarters. By 1964 this old corral area had grown up to an almost impenetrable thicket of brush and young trees, especially dogwood, elm, honey locust and osage orange, and with vines of poison ivy, Virginia creeper, grape and bittersweet.

Parts of the bottomland were fenced and broken for cultivation in 1907, 1912 and 1915 and hilltop fields were first cultivated in 1909. Throughout this period there was intermittent tree-cutting. Several acres of hilltop and south slope in the northwest corner of the section were protected from livestock. There prairie hay was mowed annually and the remaining dry vegetation was burned off at less frequent intervals, thereby maintaining a prairie type.

In the mid-thirties control of the area finally passed to the University. At that time a program of development was launched by the University and the U. S. Soil Conservation Service with relief labor. 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.

Much of the northwestern part of the Reservation is drained by a small intermittent creek which leaves the section at the mid-point of its west side. A somewhat larger intermittent creek drains approximately the southeastern half of the section. Both creeks have deeply incised channels; that of the larger is more than 15 feet below bank level in some places. The verbal and written accounts of old-time residents, comparison of early and later maps, and known changes in the fauna, all provide evidence that the creeks formerly flowed in shallow meandering channels only a few feet below bank level, and that their flow was more constant than at the present time. Erosion occurred as a result of cultivation and heavy grazing. In a period of years from 1902 to 1905 when rainfall was unusually heavy, saturated soil of several hillside areas slipped downward with a vertical displacement of several feet. According to the evidence, gully-cutting was most severe between 1915 and 1948. Even after cessation of cultivation and the removal of livestock, permitting regeneration of vegetation in formerly bare areas, erosion and gully-cutting was severe in the summer of 1951 as a result of unusually heavy rainfall. Incision of deep gullies in the

two small valleys has lowered the water table, hastened run-off after storms, and thereby rendered conditions more xeric. Minnows (fatheads and stone rollers) and mollusks (*Vertigo ovata*, *Lymnaea parva*, *Heliosoma trivolvis*, *Physa anatina*, *Pisidium compressum*) which formerly abounded in or near the then more sluggish and more nearly permanent creeks have now completely disappeared or have become scarce and localized.

In 1948 when the policy of protection was finally put into practice on the area, some longtime trends resulting from cultivation, overgrazing, erosion, and the harvesting of trees, wild crops, and game animals were in part reversed. Responses to the changed treatment were immediate and in some instances they were striking. The closely grazed pastures became covered with high grass and weeds and by the end of the first growing season accumulated a ground litter of dead vegetation. Small mammals including the prairie vole, cotton rat, harvest mouse, and jumping mouse had become abundant after two growing seasons. Reptiles including the glass "snake," blue-racer, prairie king snake and garter snake, made corresponding gains but with a longer lag. By the fourth growing season the luxuriant weedy vegetation of the pastures, in which ironweed, vervain, germander, nightshades, milkweeds and spurges were prominent, had been largely replaced by grasses (especially awnless brome and Kentucky blue-grass). Concurrently with this shift to a more homogeneous vegetation type, populations of the dominant small rodents, the prairie vole, cotton rat and harvest mouse, trended downward and have never again approached the maximum levels attained in 1951. Numerous small vertebrates that prefer open situations, notably the lark sparrow, kingbird, pocket gopher, Plains harvest mouse, ornate box turtle, six-lined racerunner, Great Plains skink and collared lizard became scarcer, more localized or entirely absent. The ruby-throated hummingbird once common in summer, became rare as weedy flowering species, especially germander, declined. Concurrently with the increase in grass, small trees and shrubs were springing up in great numbers. By 1954 brushy thickets of mixed elm, crab apple, dogwood, sumac, honey locust, Osage orange and red haw, had sprung up in former pastures, cultivated fields, and prairie, and especially in the edges of these areas where they adjoined woodland. Animals preferring this type of habitat including the white-footed mouse, cottontail, indigo bunting, cardinal, cuckoo and brown thrasher, increased. Scattered trees of medium to large size, mostly elm, honey locust, Osage orange, ailanthus and Kentucky coffee tree, occurred through-

out most of the pasture areas and provided seed sources. In 1949 when the effect of grazing livestock in holding in check the growth of tree seedlings was eliminated, the former pastures in both bottomland and hilltop entered a stage similar to that which had occurred 10 to 12 years earlier on most hillsides of the Reservation when the hillsides were fenced to exclude livestock.

In the summer of 1952 a systematic survey of the vegetation on the Reservation was made. Series of plots of 1/100 acre each were examined in most of the open parts of the Reservation, and the percentage of the total vegetative cover made up by each species was estimated. The trend of the records showed striking changes when compared to a more general survey made in 1948 and 1949. The detailed survey of vegetation was repeated in the summer of 1964. Table I shows the trends in the more important kinds of plants—those that comprised at least two per cent in one or more of the series. A much larger number of species were represented each of which separately made up less than two per cent, but combined they made up appreciable percentages in some of the series, and have been included under the heading of "miscellaneous." For the sake of brevity groups of species that are similar ecologically, and closely related, have been combined under the same heading in the table in some instances: for example, "thistle" includes *Cirsium altissimum* and *C. canadensis*; "goldenrod" includes *Solidago altissima*, *S. lindheimeriana*, *S. nemoralis*, *S. ulmifolia*, and *S. rigida*; and perennial tall-grasses include big bluestem, little bluestem, Indian grass, side-oats gramma and switchgrass.

Over the 12-year period from 1952 to 1964, some of the main trends were: (1) the reduction of weedy vegetation on the formerly pastured areas and its replacement by grass, (2) reduction of ragweeds and other annual pioneer weeds on the old-field areas and their replacement by perennials, especially goldenrods, (3) increase in woody vegetation, especially young trees of elm, dogwood, Osage orange and honey locust on all the areas.

The woodland areas of the Reservation, especially those parts having climax species, have changed much less rapidly than the fields. However in 1953 and 1954 a high proportion of black oaks died from the combined effects of drought and disease. Also in 1954 heavy mortality of American elms was noted and the die-off (probably resulting from attacks of introduced bark beetles and phloem necrosis) has continued with increasing severity up to 1965. The prospect is that this most important kind of tree in the

TABLE 1.—VEGETATION ON UNFORESTED AREAS OF THE UNIVERSITY OF KANSAS NATURAL HISTORY RESERVATION, SAMPLED ON 1 100 ACRE PLOTS, SHOWING CHANGES IN PERCENTAGES FROM 1952 TO 1964.

Kind of vegetation	Hilltop pastures (Upper, Reithro and Ridge fields)		Bottomland pastures (Cow, Gully, Dike, House, Horse and Picnic fields)		Bottomland old-fields (Corn, Oat and Square fields)		Regenerated prairie (Road and High fields)	
	1952	1964	1952	1964	1952	1964	1952	1964
grasses								
awnless brome	44.3	68.8	60.6	72.6				
Japanese chess	5.7		7.4			10.7		
bluegrass	14.9	12.4	10.9	5.3				
panic							3.4	
three-awn							2.6	
perennial tall- grasses							47.9	61.0
seral weeds								
aster					2.7		14.4	
saw-tooth								
sunflower					3.1	3.0		
bindweed							10.2	
carex	3.9	2	1.9					
fleabane					9.1			
germander	4.5	1	1.9					
horseweed					6.7	5		
legumes								
( <i>Desmanthus</i> <i>Lespedeza</i> , <i>Melilotus</i> )		1.1				2.4	1.0	
hemp					2.0			
ironweed	10.6	2.8	2.9			1.2	1.8	
nightshades			4			2.5		
polygonum	2.2				2.2			
ragweeds	1	1.8	1.5		46.5	1.2		
thistle					10.0			
goldenrod					2.5	40.3	13.9	10.4
trees and shrubs								
elm				1.2		6.1		4.9
dogwood			1.1			9.1		12.8
Osage orange				2.4				1.2
locust				3.1				
walnut				2.4				
grape						5.2		
sumac				1.2		6		9
coralberry	10.3	.9	5.8	2.2			3.4	1.6
miscellaneous	3.5	11.9	5.6	9.6	15.2	16.8	.5	6.7
Number of plots	80	68	193	123	100	100	50	61

local woodland will be largely eliminated. Already the general aspect of the woodland on most parts of the area is greatly changed; the dying of elms has been accompanied by an opening up of the canopy which has permitted large scale encroachment of brushy and weedy species.

In 1954, 200 elms that were approximately two feet or more in trunk diameter were recorded on the Reservation. A recheck of these same trees in November, 1964, showed that 54 percent were then dead or dying, and most of those remaining appeared to be in poor condition, obviously diseased. In smaller elms the incidence of mortality was even higher. In 1948 there was little decaying woody material on the ground, as the forest consisted mostly of young trees, but in 1964, there was an abundance of decaying logs and of dead snags still standing, creating conditions favorable for the flora and fauna of this type of microsere.

Approximately 8.3 acres of bluestem prairie in the northwestern corner of the Reservation was rapidly invaded by woody vegetation after cessation of burning and annual mowing; by 1964 parts of this area had grown up to an almost impenetrable tangle of brush and little of the prairie vegetation remained.

Certain major changes noted in the animal populations of the area are due primarily to factors other than ecological succession. The white-tailed deer, for example, has gradually increased. In the first year of field work on the Reservation no deer or signs of them were noticed but in the following years they were seen with increasing frequency, and by 1964 deer sign had become conspicuous and deer were seen often, sometimes in groups of ten or more. The trend reflects increase in the population of deer over the entire eastern part of Kansas. In 1963 and 1964 the southern bog lemming was caught frequently in traps set for small mammals, and had become moderately common on the Reservation, Rockefeller Tract and other areas of northeastern Kansas, whereas none at all had been recorded in 14 years of field work previously. Despite fairly intensive but variable collecting efforts in northeastern Kansas by mammalogists, the bog lemming has seldom been recorded. However, the striking increase in numbers in 1963 and 1964 was not unprecedented; in 1925 and 1926, 87 were trapped in Douglas County by students from the University interested in mammals, 20 others were caught in the years 1924, 1927, 1928, and 1929, and one each in 1894 and 1937 (Cockrum, 1952:194). The reason for the increase is still unexplained.

The eastern woodrat was phenomenally abundant on the Reservation in 1947 and 1948 but underwent drastic reduction in a period of years thereafter. Although from time to time its population has made gains over periods of years, it has never again approached the high level of the late nineteen forties. The muskrat has been present in small but variable numbers each year at the pond, but the colony has not been continuous. In autumn as a result of low water level and reduced food supply the rats have usually been eliminated by predators but in early spring new immigrants arrive to recolonize the area if habitat conditions are favorable. The hispid cotton rat, formerly unknown at the latitude of the Reservation, extended its range northward and reached the area in the early nineteen-hundreds but in this northern part of its range it is subject to decimation by severe winter storms. At times its numbers have reached remarkably high levels, of several dozen per acre, but at irregular intervals of several years, at times of severe and prolonged low temperatures, it has died off except for a small percentage of survivors in unusually favorable habitat situations. The Carolina wren also is unable to withstand unusually low temperature, and twice in a sixteen year period it has been eliminated from the Reservation in severe winters. After its disappearance several years are required for it to return to the area from unknown refugia and to regain its former numbers. The chuck-wills-widow is a common nesting species some years, but in other years it is much scarcer or absent, and the Reservation is near the northern edge of its breeding range.

In late May and June, 1964, there was a mass emergence of a periodical cicada (*Magicicada cassini*) on the Reservation and for a time these large insects with populations of tens of thousands per acre, dominated the aspect of the habitat and created an abundant food supply for insectivorous animals in general. A more lasting effect was created by the cylindrical soil tunnels extending vertically from feeding places on tree roots to the surface and excavated by the mature nymphs preparing to emerge. Besides aerating the soil and rendering it more porous these tunnels offered ready-made shelters for various small subterranean animals. In 1949 the late Dr. Paul B. Lawson showed the writer extensive damage to honey locust twigs still remaining from the mass ovipositing of periodical cicadas of the 1947 brood. The next major emergence is to be expected in 1981.

The "spring cankerworm," the larva of a geometrid moth, varies greatly in abundance from year to year but it is a primary con-

sumer of major importance ecologically. In late April and May the larvae are growing rapidly and feed voraciously on new leaves, especially those of American elm, crab apple and a few other kinds of trees. The larvae are at times sufficiently numerous to cause extensive defoliation. Arboreal birds of many species, as well as insectivorous small mammals, lizards, and arthropods are provided with an abundant food supply until the larvae mature.

Species that prefer tall grass—the eastern cottontail, Hudsonian jumping mouse, western harvest mouse, cotton rat, marsh hawk, slender glass lizard, blue racer, common garter snake, and prairie king snake—have all increased, as have some brush-loving species, notably the long-tailed chat and least vireo. Other species that prefer open situations—the Plains harvest mouse, Plains pocket gopher, killdeer, lark sparrow, collared lizard, Great Plains skink, prairie skink, six-lined racerunner and ornate box turtle—have disappeared from the Reservation or have become relatively scarce and localized.

Species of birds not regularly present on the Reservation, but which sometimes come in large numbers, and have important effect on the ecology, are the starling, the grackle, the red-wing black-bird, the robin and the flicker. The crop of wild grapes constitutes a major food source upon which large visitant flocks of the robin subsist for periods of weeks in late autumn.

Although thousands of species of plants and animals occur on the Reservation, a relatively few species are so much more abundant than others that they are the kinds usually noticed by the casual observer; they make up most of the biomass and control the flow of energy through the ecosystem. Some of the most important are the following:

#### *Producers*

American elm	crab apple	flowering aster
black walnut	wild currant	Kentucky blue-grass
honey locust	coralberry	fox grape
osage orange	redbud	Japanese chess
shagbark hickory	avens	switchgrass
chestnut oak	white snakeroot	little bluestem
black oak	awnless brome	Indian grass
dogwood	Missouri goldenrod	

#### *Primary Consumers*

white-tailed deer	katydid	moths
eastern cottontail	( <i>Oecanthus niveus</i> )	( <i>Apantesis phalaerata</i> )
cottonrat	( <i>Orchelimum vulgare</i> )	( <i>Orthosia alurina</i> )
prairie vole	( <i>Orchelimum nigripes</i> )	( <i>Orthosia hibisci</i> )

deer mouse	( <i>Neoconocephalus</i>	( <i>Orthosia rubescens</i> )
wood mouse	<i>robustus</i> )	( <i>Palaeacrita vernata</i> )
harvest mouse	( <i>Conocephalus</i> )	( <i>Melanolophia</i>
junco	camel cricket	<i>signataria</i> )
tree sparrow	( <i>Ceuthophilus</i>	termites
mourning dove	<i>pallidus</i> )	( <i>Reticulitermes</i>
grasshoppers	cicadas	<i>claripennis</i> )
( <i>Melanoplus</i>	( <i>Magicicada cassini</i> )	leafhoppers
<i>bivittatus</i> )	( <i>Tibicen pruinosa</i> )	( <i>Erythroneura</i> sp.)
( <i>M. differentialis</i> )	roach	( <i>Exitianus</i>
( <i>M. femur-rubrum</i> )	( <i>Parcoblatta bolliana</i> )	<i>obscurinervis</i> )
crickets	beetles	( <i>Agallia constricta</i> )
( <i>Gryllus assimilis</i> )	( <i>Scolytus</i>	earthworm
( <i>Nemobius fasciatus</i> )	<i>multistriatus</i> )	( <i>Allolobophora</i>
	( <i>Phyllophaga</i> sp.)	<i>caliginosa</i> )

*Secondary Consumers*

eastern mole	ground beetles	( <i>Argiope trifasciata</i> )
short-tailed shrew	( <i>Calosoma scrutator</i> )	( <i>Neoscona benjamina</i> )
downy woodpecker	( <i>Pasimachus</i> sp.)	( <i>Micrathena</i> sp.)
black-capped chickadee	( <i>Harpalus caliginosus</i> )	( <i>Singa pratensis</i> )
tufted titmouse	ants	( <i>Tetragnatha</i>
red-eyed vireo	( <i>Camponotus</i>	<i>laboriosa</i> )
yellow-billed cuckoo	<i>herculeus</i> )	( <i>Agelenopsis naevia</i> )
ornate box turtle	( <i>Lasius niger</i> )	( <i>Dapanus mirus</i> )
five-lined skink	( <i>Crematogaster</i> sp.)	( <i>Lycosa aspersa</i> )
ring-necked snake	wheel-bug	( <i>Lycosa rabida</i> )
bullfrog	( <i>Arius cristatus</i> )	( <i>Schizocosa crassipes</i> )
cricket frog	spiders	( <i>Frontinella</i>
chorus frog	( <i>Argiope aurantia</i> )	<i>pyramitela</i> )

*Dominant Predators*

coyote	opossum	marsh hawk
red fox	horned owl	black rat snake
raccoon	barred owl	copperhead
	red-tailed hawk	

THE ROCKEFELLER EXPERIMENTAL TRACT

In 1956, through the generosity of the late Mr. John D. Rockefeller, Jr., an upland tract of 160 acres in Jefferson County, contiguous on its south edge with the western half of the Reservation, was acquired by the University as the Rockefeller Experimental Tract, which is administered through the Museum of Natural History. Need for such an area on which experimentation was permissible, had been acutely felt. Along its west edge the Rockefeller Tract contains an 11.4 acre strip of virgin tall-grass prairie, and an additional 107 acres now is regenerated prairie, but with impover-

ished and eroded soil because of former abuse by cultivation and overgrazing. The northern part of the quarter-section, on hilltops and north slopes, has about 27 acres of forest, somewhat different from any on the Reservation. Two species of climax hardwoods found there, mossy-cup oak and basswood, are almost absent from the Reservation. The southeastern part of the quarter-section, a hilltop and south-facing slope, has a brushy and scrubby woodland.

In the spring of 1957 the formerly cultivated and pastured parts of the Rockefeller Tract were sown to seeds of four native prairie grasses, namely big bluestem, little bluestem, Indian grass and switchgrass. The seed was obtained from several sources but was thoroughly mixed, and applied with a mechanical seeder. After several years the tall grass clumps had become well established over the area, but not in uniform stands as anticipated. After each filling of the seeder, the relatively heavy rounded seeds of switchgrass had fed through rapidly, while the light fluffy seeds of little bluestem passed through much more slowly with Indian grass and big bluestem somewhat intermediate. As a result, these kinds of grasses tended to be arranged in strips with almost pure stands of switchgrass or little bluestem in some places. Big bluestem did not thrive on the impoverished and eroded old fields and its stands were sparse from the start. Indian grass also was much less abundant than switchgrass and little bluestem. Differences in limiting factors between the latter two grasses became increasingly apparent, in the nineteen-sixties; in low areas where soil was deeper, with silt deposits, switchgrass grew in tall dense stands, to the exclusion of most other vegetation, whereas on sloping ground especially where the soil was poor and eroded, little bluestem dominated, but in relatively sparse stands. In 1961 and 1964 the tract of original prairie was burned off. In 1962 the eastern part of the regenerated prairie was divided into four parallel north-to-south experimental strips of approximately 15 acres each, and the easternmost strip was burned off in early April. A second strip was maintained as a control and a third was fenced and lightly grazed in summer. These same treatments were repeated in 1963 and 1964, and in these years a fourth strip was mowed in July.

By 1964 the experimentally burned strip was almost a pure stand of the dominant prairie grasses, with increasing percentages of big bluestem. The mowed strip was somewhat similar. The grazed strip and especially the control had brush encroaching, mostly dogwood and sumac.

In 1957 several species of animals characteristic of open places,

including the Plains pocket gopher, Plains harvest mouse, horned lark, lark sparrow, loggerhead shrike, and sparrow hawk were prominent on the Rockefeller Tract. In the following years as tall prairie grasses became reestablished, each of these animals became scarcer and eventually disappeared from the area. Meanwhile prairie loving animals formerly scarce or absent came into prominence on the area—notably the dickcissel, yellowthroat, marsh hawk, prairie vole, blue-racer and prairie king snake.

Although the Rockefeller Experimental Tract is administered with somewhat different policy than the Natural History Reservation, the two areas supplement each other in some respects, and many field studies encompass parts of both areas.

#### RESEARCH

Over the past 16 years dozens of research projects covering a wide range of subjects have been carried on at the Reservation. Most research has been done by staff members and graduate students in the departments of Zoology, Botany, Entomology, Geography and Geology. Many graduate students have carried on research on the area for doctoral or master's dissertations. In some instances persons not directly connected with the University of Kansas, have carried on research—either as individuals or representing organizations such as the Soil Conservation Service. Several undergraduate students from the University and even high school students have, with guidance, carried on research projects on the area.

Although nearly all studies on the Reservation have been concerned with "pure research," many may eventually have practical applications, sometimes unforeseen. Kinds of animals that are most abundant and conspicuous have been given most attention and often these are species which have important effects on human affairs. Some are important as game (the cottontail, gray squirrel, fox squirrel), some are agricultural pests (voles, cotton rat), some are involved in public health problems (mosquitoes, chiggers, and venomous snakes), and some are destroyers of pests (red-tailed hawk, blue-racer). All of these kinds have been intensively studied on the Reservation. With the accumulation and synthesis of data over periods of years, findings that have practical applications emerge. For instance, the roles of certain kinds of animals as carriers and transmitters of human diseases are clarified, and means of "biological control" of certain undesirable species, such as weeds or rodent pests, are revealed.

Most of the studies by the writer and his co-workers have been autecological, that is to say the studies have been concentrated on particular species in attempts to determine interrelationships of those species with their physical environment and with their plant and animal associates. Vertebrate animals have been given the most attention. An important aspect of a study of this type is the capture and distinctive marking of individual animals, which thereby may be recognized if they are recaptured, or even seen again on a later occasion. From one to 4000 individuals of each of 97 species (10 amphibians, 23 mammals, 26 reptiles, and 38 birds) have been marked. The method of marking varies, of course, according to the kind of animal being studied. Information regarding the growth, movements, and longevity of individuals representative of their species are thereby obtained.

One of the simplest and most effective methods of marking is by clipping toes to half length, sometimes in combination with ear-clipping. Ordinarily no more than two toes (these on different feet) are clipped on each individual. After amputation healing occurs rapidly and without noticeable handicapping of the animal in most instances, but the method needs to be used with discretion on some kinds of animals that have toes specialized for climbing or digging. Thousands of small mammals, lizards and frogs have been marked by toe-clipping. Birds have been marked with serially numbered metal leg bands issued by the U. S. Fish and Wildlife Service, sometimes supplemented by color bands for sight recognition without recapture. Certain kinds of mammals, notably rabbits and raccoons, have been marked with numbered metal ear tags. Snakes have been marked by clipping the serially arranged subcaudal and ventral scales, leaving permanent scars to yield distinctive formulas.

One of the major research efforts by the writer and his graduate students has been directed to a study of small mammals. Grids of live-traps spaced at intervals of 10 to 75 feet have been established on various parts of the Reservation and Rockefeller Tract and some of these have been maintained as much as ten years. Mammals captured have been individually marked by toe- and ear-clipping and many have been recaptured from one to 50 times revealing much concerning their natural history. For a few such as the eastern wood rat and pine vole it was found far more effective to set traps in carefully selected sites, rather than in grids. Table 2 summarizes the information accumulated from many thousand catches for several of the most common species.

In the autumn of 1949 and for the following 14 years, wire funnel traps were set along hilltop limestone outcrops to catch snakes where they concentrated in search of suitable hibernacula, and all those captured were marked individually by clipping the subcaudals and certain other scales. In 1957 and each summer thereafter, lines of funnel traps were maintained also in grassland and brush on various parts of the Reservation and Rockefeller Tract. The following table summarizes the information gained from thousands of records including hundreds of recaptures for six of the common species. For all but the ring-necked snake "Number of individuals recorded" refers almost entirely to individuals marked and released, but the majority of the 4846 ring-necked snakes were measured, sexed and released without marking, and some of these ring-necked snakes were caught on neighboring areas rather than on the Reservation or Rockefeller Tract.

Seven species of lizards are known from the Reservation; five of these have been intensively studied on the area, by use of funnel traps similar or identical to those employed for snakes along with other special types of traps and capture techniques, and with individual marks based chiefly on toe-clipping. Table 4 shows some of the findings concerning these common lizards. It is noteworthy that three of these five species have been almost or entirely eliminated by successional changes on the area; the five-lined skink and glass snake are abundant.

Studies by Greenberg (1952), Kardos (1954), Loomis (1956) and Wolfenbarger (1953) have revealed the extensive chigger fauna of the Reservation (22 species in all) and clarified their taxonomy, life histories, and possible bearing on public health problems. Chiggers are the larvae of trombiculid mites, all of them ectoparasites of vertebrate hosts although in the nymphal and adult stages they are free-living predators. The many genera and species differ in habitats, seasonal timing of life cycles and type of host preferred. They differ in host specificity; for instance, the common pest chigger that annoys man, *Trombicula alfreddugèsi*, has been recorded from 83 species of vertebrates in Kansas whereas some other kinds are more or less specific to bats (*T. twentei*), squirrels (*T. fitchi*), lizards (*Acomatocarus arizonensis*), and frogs (*Hannemania eltoni*).

Studies on several genera and many species of the native bee fauna by Professor Charles D. Michener and his students, H. V. Daly, Alvaro Willie, Alvin Shinn, and Ellen G. Ordway, and by Professor Karl Stockhammer, have revealed a wide array of life

TABLE 2.—SUMMARY OF FINDINGS CONCERNING SEVERAL KINDS OF SMALL RODENTS ON THE NATURAL HISTORY RESERVATION

	Western harvest mouse	Deer mouse	White-footed mouse	Prairie vole	Pine vole	Eastern wood rat
Habitat .....	tall grass	pastures and fallow fields	woodland, woodland edge, and brush	prairie and pastureland	chiefly woodland, edge, grass beneath trees	open, scrubby woodland, ravines, rock ledges, hedges, old buildings
Breeding season .....	late Feb. to early Nov.	year-round (low Dec.-Jan.)	year-round (low Dec.-Jan.)	year-round (peak in spring)	year-round (low in winter)	Feb. to Nov.
Litters per season .....	several	several	several	several	several	3
Size of litter .....	3.55(2-5)	4.12(2-7)	4.4(3-5)	3.18±.24	2.4(2-3)	2.7(1-5)
Size of adults total length, mm.	124 (107-155)	143 (135-158)	172 (157-206)	160 (150-175)	135 (105-148)	♂ 374 (305-450) ♀ 369 (300-399)
weight, grams .....	10.9 (7-14)	18.3 (13-24)	27.1 (22-33)	44.2 (32-58)	39.2 (31-49)	♂ 258 (170-350) ♀ 210 (172-251)
Home range (acres) .....	.52	1.0 (males) .6 (females)	.40 (males) .42 (females)	.09	.07	.07
Maximum longevity in field .....	15 months	16 months	15 months	23 months	17 months	33 months*
Principal food source .....	grass, seeds, insects	seeds, insects	seeds, insects	grass, seeds, roots	tubers, roots, seeds, herbage	seeds, flowers and herbage, esp. Osage orange
Number of individuals recorded .....	1489	754	869	4000	189	256
Total number of records .....	3889	1777	1695	15521	1763	1107

\* Span of records for an individual that was already adult when first marked.

TABLE 3.—SUMMARY OF FINDINGS CONCERNING SEVERAL COMMON SNAKES ON THE UNIVERSITY OF KANSAS NATURAL HISTORY RESERVATION.

	Ring-necked snake	Red-sided garter snake	Blue racer	Black rat snake	Copperhead
Habitat.....	open woodland, grassland and edge	forest edge, brush and grassland in damp places	prairie and pastureland	deciduous forest	deciduous forest, edges and brush
Season of activity.....	late Mar. to late Oct.	late Mar. to mid-Nov.	mid-April to early Nov.	mid-April to late Oct.	mid-April to early Nov.
Breeding season.....	spring and fall	early spring and fall	May	May	chiefly May
Time of appearance of young.....	Sept.	late July	late Aug., Sept.	Sept., Oct.	early Sept.
Principal food sources.....	earthworms	frogs, earthworms	orthopterous insects, small vertebrates	birds (eggs, nestlings), rodents	voles, mice
Brood size.....	4.03(1-7)	14.5(4-29)	11.8(5-26)	14.5(6-44)	5.02(2-14)
Length of hatchlings (mm. snout-vent)...	119(88-134)	168(134-191)	214.5(186-244)	327(290-381)	223(209-247)
Weight of hatchlings, grams.....	.92(.5-1.3)	1.88(.7-2.5)	4.67(2.3-6.1)	12.5(8.0-15.3)	10.6(8.2-13.2)
Age at breeding maturity (months).....	19	21	21	44	22 (males) 32 (females)
Length of adults (mm. snout-vent)					
males.....	242(170-305)	524(387-678)	746(542-900)	1130(831-1530)	725(420-936)
females.....	271(200-368)	677(504-950)	836(640-1088)	1003(829-1465)	662(515-720)

Adult weight, grams						
males.....	4.89(3.3-8.1)	53.9(14-110)	124.2(57-287)	390(104-1005)	170.8(54-400)	
females.....	6.19(3.6-10.3)	164.6(21-410)	174.7(63-390)	346(138-1270)	140.5(75-247)	
Home range, acres						
males.....	(probably has	35	26	29	24	
females.....	none)	23	24	24	8.5	
Maximum longevity in field (years).....	5	9	12	16 (at least)	12	
Optimum body temp., degrees C.....	28	29	34	28	27-28	
No. individuals recorded.....	4846	1097	1020	359	1664	
Total number records.....	4888	1354	1688	516	2715	

TABLE 4.—SUMMARY OF FINDINGS CONCERNING SEVERAL KINDS OF COMMON LIZARDS ON THE UNIVERSITY OF KANSAS NATURAL HISTORY RESERVATION.

	Five-lined skink	Great plains skink	Collared lizard	Six-lined racerunner	Class "snake"
Habitat.....	open woodland and edge	rocky, short-grass areas	open, rocky places	open areas, especially sandy places	tall-grass prairie
Season of activity.....	late March through Oct.	mid-April to Oct.	late April to early Oct.	Late April to early Oct.	late April to early Nov.
Breeding season.....	early May	May	late May and June	late May, June, early July	late May
Time of appearance of young.....	early July	late July or early Aug.	Aug.-Sept.	Aug.	Sept.
Principal food source.....	spiders, insects	spiders, insects	grasshoppers	insects	grasshoppers and crickets; beetles
Brood size.....	9.13(4-15)	11.4(7-17)	7.55(2-20)	3.1(1-6)	3 to 16
Length of hatchlings (mm. snout-vent).....	23	36	41	32	56
Weight of hatchlings (grams).....	.4	1.0	2.5	1.0	1.0
Age at breeding maturity (months).....	22	34½	9½	10	32
Length of adults (mm. snout-vent).....	73(62-83)	120(115-128)	98(88-109)	71(55-82)	232(215-285)
Adult weight (grams).....	7.45(4.4-10.7)	37(24-50)	37(26-50)	8.2(5.8-10.6)	61(40-100)

Home range (acres).....	more than .5( $\sigma$ ) to less than .07( $\varphi$ )	.59( $\sigma$ ) .22( $\varphi$ )	.2( $\sigma$ ) .25( $\varphi$ )	.55
Maximum longevity in field (years).....	10	6	6	9
Optimum body temperature (degrees Centigrade).....	34	38	40	32
No. of individuals recorded.....	1580	61	230	512
Total number of records.....	2465	900	581	656

histories, with various stages from those that are truly solitary to those that have developed a social organization of some complexity.

Dr. A. Ralph Barr and his student, Harlan L. MacMillan, made a survey of the mosquito fauna on one part of the Reservation—the headquarters' area. Their studies revealed a surprisingly large number of species (several dozen), and also revealed a succession of species during the season, with each common species prominent for a relatively brief span of days or weeks.

Professor Robert E. Beer and his students have studied the mite fauna of the Reservation, by taking extensive samples with Berlese funnels from various parts of the area. As in most other areas mites have here been shown to play an important role in the overall ecology, by feeding as primary consumers, scavengers, predators and parasites.

In a survey of the Reservation's spider fauna undertaken by the present writer in 1948 and completed in 1963, with the generous assistance of several leading araneologists, including Dr. Willis J. Gertsch, Dr. Herbert Levi, Mr. Wilton Ivie and Dr. Allen Brady, who identified specimens, a list of 192 species of 114 genera and 21 families was compiled from the area. Spiders as a group are important predators on small animals, especially on the insects. The common large orbweavers, wolf spiders, and funnel-web weaver destroy the larger kinds of insects in great numbers. However, other smaller kinds of spiders, which are less conspicuous but far more abundant, and especially some of the minute erigonids, may have even more important effects on the area's ecology through their destruction of insects.

Mr. John George has studied the taxonomy, seasonal cycles, habitats and hosts of the kinds of ticks occurring on the Reservation. The cottontail rabbit is an important carrier of ticks on the area.

Mr. Alwan J. El-Wailly studied the fleas of the Reservation and found 15 species, with some kinds of mammalian hosts carrying several species.

Dr. James Chilicott, as a graduate student, studied the arthropod fauna in nests of the prairie vole. These nests, situated several inches underground in damp soil, harbor many species of invertebrates, some of which are parasites on the voles, whereas others are scavengers feeding on the decaying vegetation of the nest, and still others are predators that feed upon species of the two groups mentioned first. Dipterous flies are especially prominent in the nest fauna.

Dr. John M. Legler from 1953 to 1957 studied the ecology and population dynamics of the box turtle, *Terrapene ornata*, at the Reservation and at Damm Farm 12 miles west of Lawrence. The turtles were found to prefer shortgrass areas that were heavily grazed. Females lay clutches averaging 4.7 eggs. Late May and June is the principal nesting season, but some females lay second clutches in July. Males become sexually mature in eight to ten years, on the average, and females in ten to eleven years, but the total growing period extends over 15 to 20 years and the longevity is estimated as approximately 50 years. Box turtles are active for approximately six and one-half months, in the warmer part of the year. They prefer a body temperature of approximately 30° C. Insects that are associated with cow dung, especially scarabaeid and carabid beetles, are the chief food source, but larvae of noctuid and arctiid moths, and grasshoppers (*Melanoplus*) were also frequent items, and some plant food, especially mulberries, were eaten. Box turtles have home ranges averaging 5.6 acres, and in their season of activity usually travel 200 to 300 feet daily. In a period of years following 1948 box turtles became much less conspicuous on the Reservation, and by 1964 they were rarely found although they remained common on adjoining areas of pastureland. The removal from the area of cattle and other livestock, and the increase in rank herbaceous vegetation were factors which rendered the habitat less favorable for them.

Dr. R. W. Frederickson surveyed the myriapod fauna of the Reservation and recorded 54 kinds of millipedes and centipedes. The former play an important role as scavengers reducing decaying vegetation, while the latter are important as predators on insects and other small animals.

The molluscan fauna of the Reservation was surveyed by Leonard and Goble (1952) in 1948 and 1949 soon after the policy of protection was inaugurated, and was reexamined several years later by Fitch and Lokke (1956). A total of 25 species of snails and two clams were found, but some of these were represented only by old shells, their populations having been eliminated by the successional changes that have taken place. The terrestrial and freshwater mollusks of the area are sensitive indicators of environmental conditions, and also play significant roles as primary consumers in their ecosystems.

It is intended that the Reservation be maintained permanently as a natural area and a research station for ecological studies. Each study that is completed provides background for further

studies by which the complex web of ecological interrelationships between species in the local biotic community may be worked out. A large number of species are involved, and no end is in prospect for the studies. For insects especially there are hosts of species to be dealt with, most of them still not studied ecologically either on the Reservation or elsewhere. For vertebrates the situation is somewhat different, as the number of kinds present is relatively small, and of these some are present irregularly, or are so uncommon that they are not suitable subjects for autecological studies. Many of those that are most common and most important in the local ecology have already been the subject of intensive investigation.

This is not to imply that opportunities for research on vertebrates have decreased. Every species studied merits further more intensive investigation, but new approaches and more refined techniques are needed. Undoubtedly future studies will rely to a greater extent on instrumentation. A beginning in this direction was made in the winter of 1964-65, in a collaborative study by Dr. Hampton W. Shirer and the writer, by attaching thermistors on or within various reptiles hibernating under natural conditions, in order to ascertain their tolerances for low temperatures and the normal temperature ranges within their hibernacula.

#### DESCRIPTION OF THE AREA

The University of Kansas Natural History Reservation is situated on the northern edge of the Kaw River Valley, where level or gently sloping bottomland interdigitates with plateaulike upland. The "cuesta" (Schoewe, 1949:282) is a prominent physiographic feature created by a nearly horizontal stratum of limestone, approximating the 1,040-foot contour. It underlies the shallow glacial till soil of the hilltops, but with an exposed edge occurring as a more or less continuous escarpment, below which the terrain slopes, steeply at first, and then more gradually, to the level of the valley floor. The upper stratum of the limestone is the Plattsmouth member of the Oread limestone, of late Pennsylvanian age, in the Shawnee group of the Virgilian Series (Moore, Frye and Jewett, 1944:181-182). Its exposed edge is in places almost covered and concealed by deposited soil, but for most of its length it may be seen as an outcrop from 18 inches to three feet, or in places more than six feet, high. The face of this outcrop is deeply fissured and cracked, with numerous jagged boulders and small rocks, in process of breaking away or strewn over the steep slope below.

Overhanging rocks of the ledge shelter the soil beneath from rain and snow, and partly shade it with the result that it is nearly devoid of vegetation. Many kinds of animals depend on this ledge more or less for shelter. Another member of the Oread limestone, the Toronto limestone, is a conspicuously hard lower stratum about 20 feet below the level of the hilltop and its exposed edge also occurs more or less continuously along the upper slope. Upper and lower outcrops are separated by usually 50 to 300 feet of steep wooded slope, with a soil mantle, but with quantities of loose rock. The lower outcrop often appears as a dark brown, smooth, vertical rock face, from several inches to three feet or more in height. Below this lower outcrop the hillside continues to slope steeply for a few yards, but then in most places, levels off to a natural terrace. The terrace follows the contour of the hillside and is often 30 to 50 feet wide. In places there are other terracelike formations farther down the hillsides, and these may be nearly horizontal, or may slope gently to join the upper terrace. Both upper and lower outcrops total approximately 4.5 miles in length on the Reservation, and 1.1 mile on the Rockefeller Experimental Tract. Below the lower outcrop the hillsides slope at more gradual gradients to the valley floor. Virtually all the hillsides, from the cuesta top to the valley floor, and small areas of upland adjacent to the upper ledge are wooded. On the Reservation this woodland comprises approximately 338 acres. The remaining 252 acres of the Reservation are open land of which about 116 acres was formerly under cultivation.

#### PLANT AND ANIMAL LIFE

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.

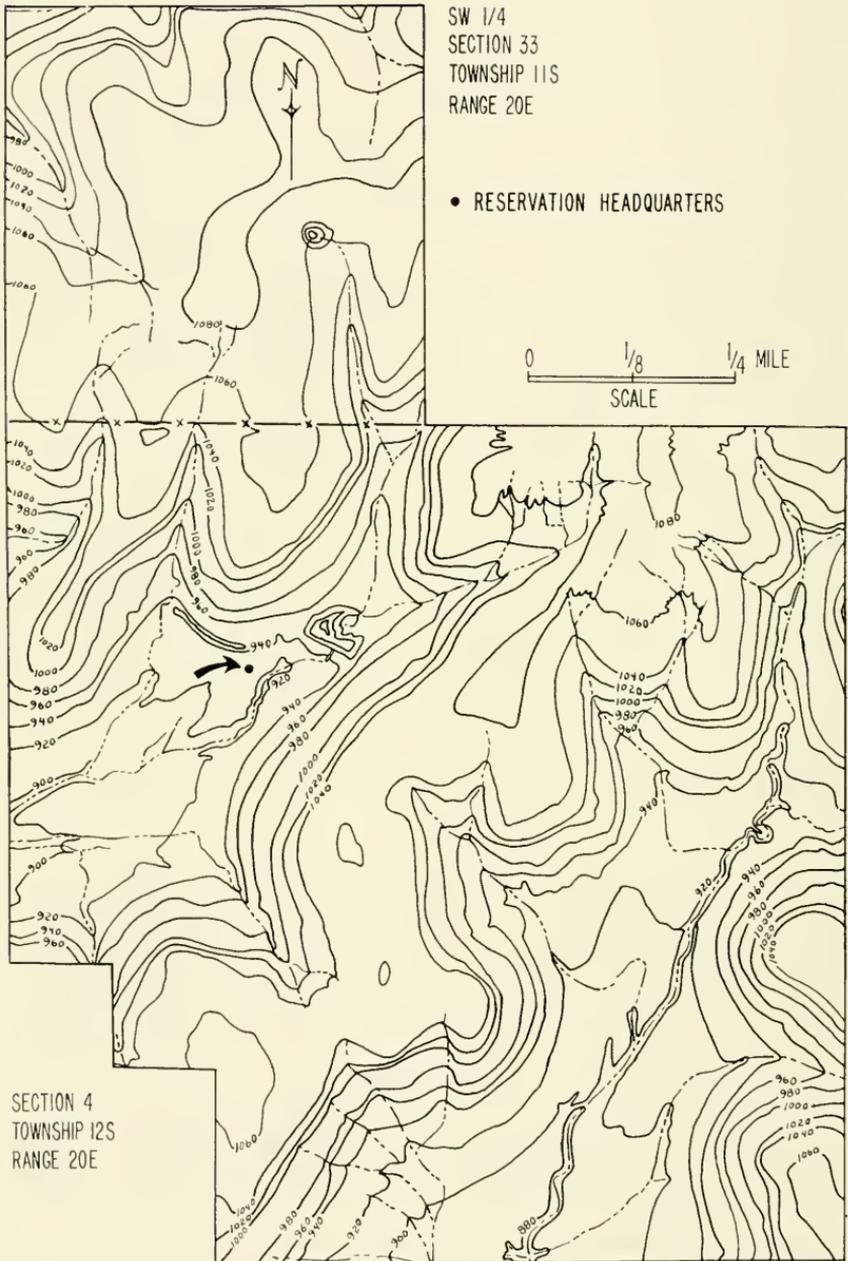


FIGURE 1. Contour map of The University of Kansas Natural History Reservation and the Rockefeller Experimental Tract.

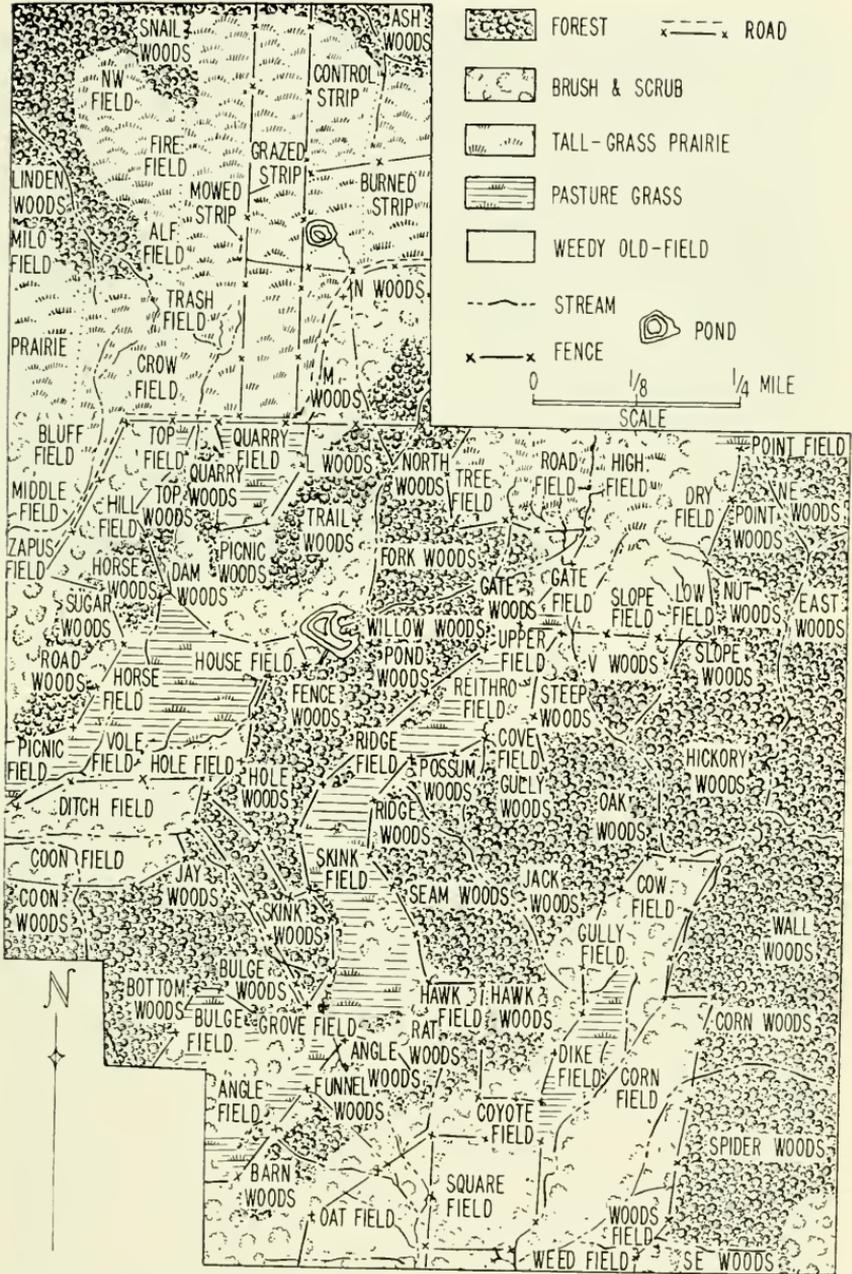


FIGURE 2. Map of The University of Kansas Natural History Reservation and the Rockefeller Experimental Tract showing named subdivisions of these areas, and showing the distribution of each of several major types of vegetation.

## PLATE I



FIG. 1. Stump of large cottonwood on hilltop at southeast corner of Bottom Woods on April 1, 1965. At the time of a previous photograph, taken from the opposite side of the tree in December, 1954 (see Fitch and McGregor, 1956, pl. 7, lower figure) the tree was living and was the largest on the Reservation. Hollows in the trunk sheltered many kinds of animals.



FIG. 2. South part of pond looking east from dike on January 16, 1965, when surface was frozen to a depth of several inches. Cattails and other succulent riparian or shallow water plants, abundant at the time of a previous photograph November 1, 1951 (Fitch, 1958b, pl. 5, fig. 1), had been almost entirely removed by muskrats, but small willow trees had appeared in the water, changing the aspect of the pond.

## PLATE II



FIG. 1. Large American elm at northeast corner of Ditch Field, still thriving on January 15, 1965, although many others had died presumably as a result of introduced diseases. Since April 2, 1955 (see Fitch and McGregor, 1956, pl. 8) the tree had become noticeably more massive, and the thicket around it (an open field in 1948) became denser.

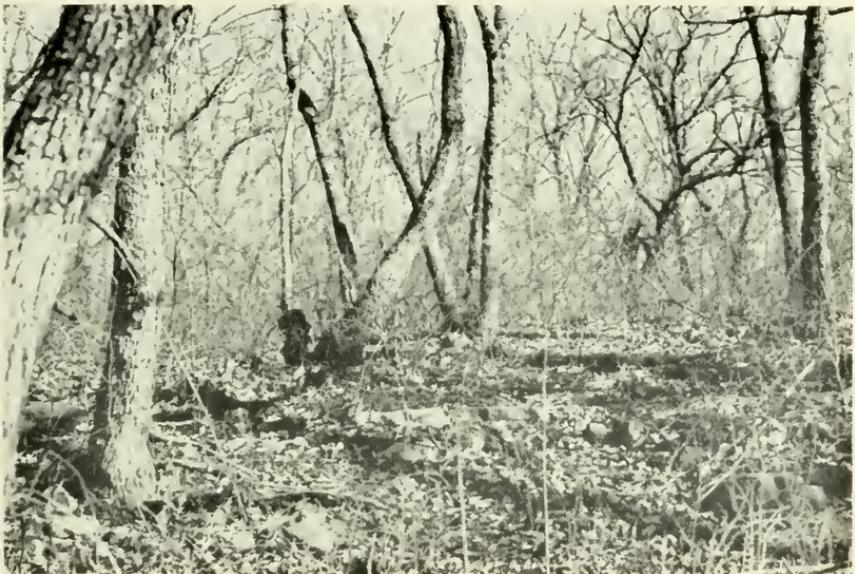


FIG. 2. Scene on west-facing slope of Skink Woods on January 15, 1965, from outcrop of Toronto Limestone, looking east up rocky hillside dominated by chestnut oaks. The scene remained similar to that in a photograph taken July 22, 1950 (Fitch, 1954a, pl. 1, fig. 2; 1958b, pl. 3, fig. 1) except that a large oak log in the foreground on the earlier date had completely disintegrated by the latter date and become incorporated in the soil.

## PLATE III



FIG. 1. Diversion ditch at edge of woodland 100 yards north of Reservation headquarters, looking west. The formerly barren eroded banks of the ditch provided favorable habitat for species that prefer open spaces (see Fitch, 1958b, pl. 2, fig. 2) but by January 15, 1965, as shown here, the bottom and banks of the ditch had grown up to thickets of woody vegetation.



FIG. 2. Gully in regenerated tall-grass prairie of formerly cultivated and eroded area of Road Field and High Field, looking north, on April 1, 1965. An earlier photograph from almost the same spot, taken on November 9, 1954 (see Fitch, 1958b, pl. 4, fig. 1) shows the young trees much smaller and less prominent, especially the three cottonwoods in center. Woody vegetation has spread rapidly onto this grassland area and has dominated some parts of it, and erosion has almost stopped in the gully, now choked with dense grass.

## PLATE IV



FIG. 1. Northwestern corner of the Reservation, from county road, looking north on January 15, 1965. The pale-colored central triangular area is thick brush, which has encroached onto a slope that was still dominated by big bluestem and other prairie grasses at the time of a previous photograph in the summer of 1951 (Fitch, 1963a, pl. 22, fig. 2), after cessation of burning and cessation of mowing in 1947.



FIG. 2. View of Dry Field looking east down gully toward edge of Point Woods on April 1, 1965. Vegetation in the field is sparse and consists of such weedy plants as three-awn grass, common lespedeza, and goldenrod. In the interval since November 9, 1954 (Fitch, 1958b, pl. 4, fig. 2) erosion had largely ceased in the gully but little successional change had occurred.

## PLATE V



FIG. 1. Reservation headquarters viewed from north on January 15, 1965. Since the time of a previous photograph on October 13, 1951 (see Fitch, 1952, pl. 1, fig. 1) several large elms around the buildings died and fell, and brushy vegetation appeared in the field in foreground.



FIG. 2. House Field looking WSW toward Reservation headquarters on January 15, 1965. Since the time of a previous photograph on March 3, 1956 (see Janes, 1959, pl. 45, fig. 1) much brush had sprung up in the field.

## PLATE VI



FIG. 1. K. U. zoology class studying the home life of small animals, October 13, 1951. Photograph by Robert Rose.



FIG. 2. Professor and student mark a Hudsonian jumping mouse for release October 13, 1951. Photograph by Robert Rose.

## PLATE VII



FIG. 1. Gully in southeastern part of Reservation on April 10, 1963. Since the time of an earlier photograph in March, 1956 (see Fitch and McGregor, 1956, pl. 7, upper figure) the gully eroded more deeply, and a large elm that had been undercut and had fallen, disintegrated and disappeared.



FIG. 2. Same gully as shown above, from a point several hundred yards farther south, looking north, upstream, on April 11, 1965. Since the time of a previous photograph, from approximately the same point, on November 7, 1949 (see Fitch, 1958b, pl. 6), configuration of the banks and gully bottom changed somewhat; erosion slowed and banks gained more brushy vegetation, and had less extensive bare areas.

## PLATE VIII

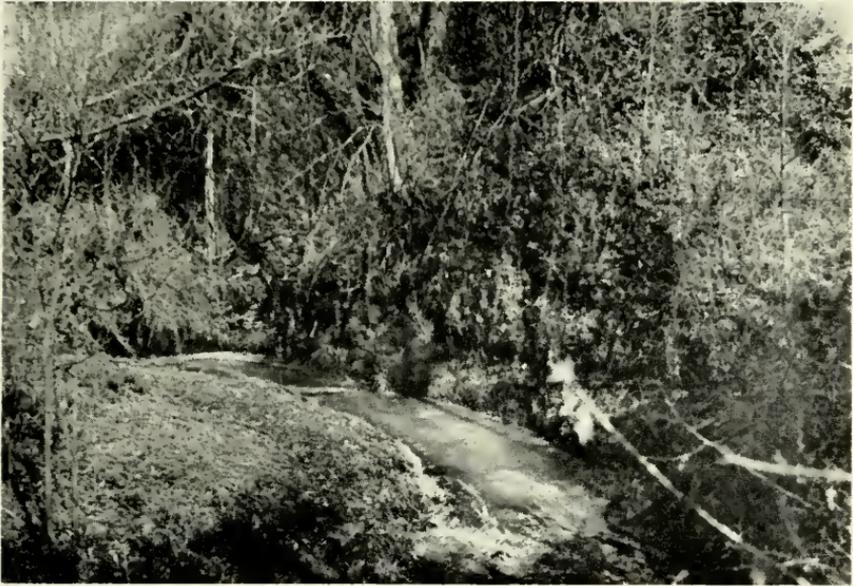


FIG. 1. Same gully as shown in Plate 7, viewed from south boundary of Reservation on January 15, 1965. Since the time of a previous photograph from approximately the same point in November, 1950 (see Leonard and Goble, 1952, pl. 99, f), the channel deepened, banks became more brushy, and a part of the bank enclosed in a loop of the creek (left center) was partly eroded away, so that trees in background were better exposed to view.



FIG. 2. Small cedar tree on hilltop (Grove Field), which by January 15, 1965, when this photograph was taken, had the upper part of its trunk girdled and killed by deer rubbing their antlers against it. By 1965 such sign of the activities of deer had become conspicuous on the area.

Subdivisions on a vertical scale, might be recognized as follows: the upper limestone outcrop at the hilltop; the usually steep slope strewn with rocks, between the upper and lower 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 of oaks and hickories 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 and plum 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 nearly alike 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.

In the following alphabetical lists scientific names are grouped in several major categories that in general correspond with taxonomic groupings. Nevertheless, for the plants it seemed desirable to separate the trees and other woody species from the herbaceous types. All the species listed have been definitely identified. For some, notably the birds and a few other vertebrates, sight records are the sole basis for inclusion, but all such sight records were

made by well-trained and competent observers and hence there can be little doubt that the species actually occur on the area. For most of the plants and invertebrates listed, the records are substantiated by preserved specimens in the small museum collection at the Reservation headquarters. In some respects the records for different species are not strictly comparable. Of the birds, for instance, relatively few are permanent residents, some are present only in winter, others only in summer, others on migration, and some only as accidental wanderers, perhaps recorded only on one occasion. For each of several species of birds the sole record is based on an individual flying over the Reservation but not known to have stopped there. Status of each of the vertebrates is discussed in a previous publication (Fitch, 1958b).

The lists represent the combined data from the Reservation and the Rockefeller Tract. A few species, notably the large conspicuous woodland snails, *Triodopsis albolabris* and *Anguispira alternata*, and the spider, *Loxosceles reclusa*, occur on the Rockefeller Tract but stop short of the Reservation. Many other species have been recorded on the Reservation but not on the Rockefeller Tract. It may be expected that most of the lists will be enlarged as a result of further fieldwork adding previously undetected species. But in some instances species formerly present have been eliminated (notably certain aquatic mollusks whose habitat has deteriorated as a result of erosion), and other instances may be expected.

Some groups of invertebrates, notably the chiggers, mollusks, moths and spiders, have been made the subjects of intensive investigations on the area and specimens have been submitted to leading specialists for authoritative determinations. For other groups such as orthopterans and beetles, study has been more casual and determinations have been by research assistants, comparing material with the reference collection in the Snow Entomological Museum, with only occasional help from specialists. Also, some determinations were made several years before the present report was prepared. Hence, some of the names used may not be in line with the most recent taxonomic revisions.

Some major groups of invertebrates on the area, such as the hemipteran bugs, wasps, leafhoppers, mites (other than chiggers), crustaceans and nematode worms have been given little attention or none at all, and hence no lists are available for these groups. To this extent, the treatment herein is unbalanced, and major synecological investigations on the area must await detailed studies of such neglected groups.

*Trees, shrubs and woody vines*

Acer negundo	Menispermum	Rhus glabra
Acer saccharinum	canadense	Rhus radicans
Ailanthus altissima	Morus rubra	Ribes missouriense
Ampelopsis cordata	Parthenocissus	Rosa arkansana
Asimina triloba	quinquefolia	Rosa setigera
Ceanothus ovatus	Platanus occidentalis	Rubus argutus
Carya ovata	Populus deltoides	Rubus flagellaris
Celastrus scandens	Prunus americana	Salix amygdaloides
Celtis occidentalis	Prunus angustifolia	Salix eriocephala
Cercis canadensis	Prunus hortulana	Salix interior
Cornus drummondii	Prunus nana	Salix nigra
Cornus amomum	Prunus persica	Sambucus canadensis
Corylus americana	Pyrus ioensis	Smilax hispida
Crataegus crus-galli	Quercus macrocarpa	Staphylea trifolia
Crataegus mollis	Quercus marilandica	Symphoricarpos
Diospyros virginiana	Quercus muehlenbergii	orbiculatus
Euonymus	Quercus prinoides	Tilia americana
atropurpureus	Quercus borealis	Ulmus americana
Fraxinus americanus	Quercus stellata	Ulmus rubra
Gymnocladus dioica	Quercus velutina	Vitis cinerea
Juniperus virginiana	Rhamnus lanceolata	Vitis vulpina
Maclura pomifera	Rhus aromatica	Xanthoxylum
	Rhus copallina	americanum

*Flowering plants (herbaceous dicotyledons)*

Abutilon theophrasti	Baptisia leucantha	Desmodium illinoense
Acalypha virginica	Baptisia leucophaea	Echinacea pallida
Achillea lanulosa	Bidens bipinnata	Ellisia nyctelea
Agastache nepetoides	Bidens frondosa	Erigeron philadelphicus
Agrimonia parviflora	Bidens polylepis	Erigeron strigosus
Agrimonia pubescens	Cacalia atriplicifolia	Eupatorium altissimum
Amaranthus hybridus	Campanula americana	Eupatorium purpureum
Amaranthus tamariscina	Capsella bursa-pastoris	Eupatorium rugosum
Amaranthus torreyi	Cassia fasciculata	Euphorbia corollata
Ambrosia artemisiifolia	Cassia marilandica	Euphorbia dentata
Ambrosia trifida	Chenopodium album	Euphorbia heterophylla
Ammannia coccinea	Chenopodium	Euphorbia maculata
Ampelamus albidus	boscianum	Euphorbia marginata
Amorpha canescens	Chenopodium hybridum	Euphorbia missurica
Amorpha fruticosa	Chrysanthemum	Euphorbia serpens
Amphiachyris	leucanthemum	Fragaria virginiana
draunculoides	Circaea canadensis	Galium aparine
Androsace occidentalis	Cirsium altissimum	Galium circaeazans
Anemone canadense	Cirsium discolor	Galium tinctorium
Anemone virginicus	Comandra richardsiana	Gaura biennis
Antennaria campestris	Commelina communis	Gaura parviflora
Apocynum cannabinum	Convolvulus arvensis	Geum canadense
Arctium minus	Conyza canadensis	Geum vernum
Arisaema dracontium	Corydalis flavula	Geum virginianum
Arabis canadensis	Croton capitatus	Geranium carolinianum
Arabis perstellata	Croton monanthogynus	Gnaphalium
Aselepias meadii	Cycloloma	obtusifolium
Aselepias purpurascens	atriplicifolium	Hedeoma hispida
Aselepias stenophylla	Cynoglossum officinale	Helienium autumnale
Aselepias syriaca	Dasystoma macrophylla	Helianthus annuus
Aselepias tuberosa	Datura stramonium	Helianthus laetiflorus
Aselepias verticillata	Delphinium virescens	Helianthus
Aster ericoides	Descurainia sophia	grosseserratus
Aster simplex	Desmanthus illinoensis	Helianthus tuberosus
Aster drummondii	Desmodium glutinosum	Hypericum perforatum

*Flowering plants (concluded)*

Ipomoea hederacea	Parietaria	Salvia azurea
Iva ciliata	pennsylvanicus	Salvia reflexa
Kuhnia eupatorioides	Penthorum sedoides	Sanicula canadensis
Lactuca canadensis	Penstemon cobaea	Scrophularia marilandica
Lactuca floridana	Petalostemon candidus	Sida spinosa
Lactuca scariola	Phlox divaricata	Silene stellata
Lamium amplexicaule	Physalis heterophylla	Silphium laciniatum
Laportea canadensis	Physalis longifolia	Silphium perfoliatum
Lappula echinata	Physalis macrocarpa	Solanum carolinense
Lepidium densiflorum	Physalis missouriensis	Solanum nigrum
Lespedeza capitata	Physalis pumila	Solanum rostratum
Lespedeza striata	Phytolacca americana	Solidago altissima
Liatis aspera	Phryma leptostachya	Solidago angusta
Liatis squarrosa	Plantago major	Solidago nemoralis
Linum sulcatum	Plantago virginica	Solidago rigida
Lithospermum arvense	Podophyllum peltatum	Solidago ulmifolia
Lithospermum canescens	Polanisia trachysperma	Specularia perfoliata
Lithospermum incisum	Polygonum aviculare	Stenosiphon linifolius
Lobelia siphilitica	Polygonum coccineum	Taraxacum
Lobelia spicata	Polygonum hydropiper	erythrospermum
Lomatium	Polygonum	Teucrium canadense
foeniculaceum	hydropiperoides	Thlaspi arvense
Ludwigia palustris	Polygonum	Tridacantha bracteata
Lycopus americanus	lapathifolium	Tragia urticifolia
Lythrum alatum	Polygonum	Tragopogon pratensis
Medicago lupulina	pennsylvanicum	Trifolium pratense
Melilotus alba	Polygonum punctatum	Trifolium repens
Melilotus officinalis	Polygonum scandens	Triosteum aurantiacum
Mentzelia oligosperma	Potentilla simplex	Triosteum perfoliatum
Mimulus alatus	Potentilla norvegica	Urtica procera
Mirabilis nyctaginea	Potamogeton foliosa	Verbascum blattaria
Mollugo verticillata	Potamogeton nodosus	Verbascum thapsus
Monarda fistulosa	Prenanthes aspera	Verberna baldwini
Najas guadalupensis	Prunella vulgaris	Verberna canadensis
Nepeta cataria	Psoralea esculenta	Verberna hastata
Oenothera biennis	Ranunculus abortivus	Verberna stricta
Oenothera speciosa	Ratibida pinnata	Verberna urticifolia
Onosmodium occidentale	Rhamnus lanceolata	Viola rafinesquii
Opuntia humifusa	Ruellia humilis	Viola papilionacea
Osmorhiza longistylis	Ruellia strepens	Viola pedatifida
Oxalis dillenii	Rumex altissimus	Viola sororia
Oxalis stricta	Sagittaria latifolia	Xanthium strumarium
		Zizia aurea

*Grasses, rushes, sedges, lilies (monocotyledons)*

Agrostis alba	Carex gravida	Glyceria striata
Andropogon gerardi	Carex hyalinolepis	Hypoxis hirsuta
Andropogon scoparius	Carex vulpinoidea	Juncus interior
Andropogon virginicus	Cyperus ferruginescens	Koeleria cristata
Andropogon ternarius	Dactylis glomerata	Leersia oryzoides
Aristida oligantha	Diarrhena americana	Muhlenbergia schreberi
Bouteloua curtipendula	Digitaria ischaemum	Muhlenbergia sylvatica
Bromus inermis	Digitaria sanguinalis	Panicum capillare
Bromus japonicus	Echinochloa crusgalli	Panicum clandestinum
Bromus purgans	Eleocharis macrostachya	Panicum lanuginosum
Carex annectens	Elymus virginicus	Panicum latifolium
Carex bicknellii	Eragrostis capillaris	Panicum virgatum
Carex blanda	Eragrostis ciliaris	Phalopus ciliatifolium
Carex brevior	Eragrostis spectabilis	Pheum pratense
Carex emoryi	Erythronium albidum	Poa pratensis

*Grasses, rushes, sedges, lilies (concluded)*

Polygonatum canaliculatum	Setaria faberii	Spartina pectinata
Scirpus atrovirens	Setaria glauca	Tridens flava
Scirpus lineatus	Setaria viridis	Tripsacum dactyloides
Scirpus validus	Sisyrinchium campestre	Typha angustifolia
Scleria triglomerata	Sorghastrum nutans	Typha latifolia

*Lichens*

Allarthonia caesia	Lecanora subfusa	Physcia stellaris
Amphilonia lanuginosum	Lecanora versicolor	Psora demissa
Bilimbia trachona	Lecidia botryosa	Psora russellii
Candelaria concolor	Parmelia borteri	Rinodia dakotensis
Caloplaca aurantiaca	Pertusaria lecanina	Sarcogyne pruinosa
Cladonia capitata	Physcia adglutinata	Verrucaria calcisida
Graphis scripta	Physcia caesia	Verrucaria calkinsiana
Lecanora dispersa	Physcia obscura	Xanthoria candelaria
Lecanora iowensis	Physcia orbicularis	

*Mosses*

Amblystegiella confervoides	Brachythecium salebrosum	Hygroamblystegium irriguum
Amblystegiella serpens	Bynum argenteum	Hygroamblystegium orthocladum
Amblystegiella varium	Chamberlainia acuminata	Leptodictyum trichopodium
Anomodon attenuatus	Entodon cladorrhizans	Leskea gracilescens
Anomodon rostratus	Entodon compressus	Minum cuspidatum
Astomum muhlenbergianum	Entodon seductrix	Orthotrichum pumilum
Atrichum angustatum	Eurhynchium serrulatum	Orthotrichum pusillum
Barbula cruegeri	Fabronia wrightii	Physcomitrium turbinatum
Brachythecium oxycladon	Fissidens taxifolius	Thelia asprella
	Grimmia apocarpa	
	Homomallium adnatum	

*Liverworts*

Frullania eboracensis	Frullania riparia	Riccia lamellosa
Frullania inflata	Riccia hirta	

*Ferns*

Botrychium obliquum	Ophioglossum engelmannii	Woodsia obtusa
Botrychium virginianum		
Cystopteris protrusa		

*Mammals*

Blarina brevicauda	Myotis sp.	Scalopus aquaticus
Canis latrans	Neotoma floridana	Sciurus carolinensis
Cryptotis parva	Odocoileus virginiana	Sciurus niger
Didelphis marsupialis	Ondatra zibethicus	Sigmodon hispidus
Geomys bursarius	Peromyscus leucopus	Spermophilus franklini
Lasiurus borealis	Peromyscus maniculatus	Spilogale putorius
Marmota monax	Procyon lotor	Sylvilagus floridanus
Mephitis mephitis	Rattus norvegicus	Synaptomys cooperi
Microtus ochrogaster	Reithrodontomys	Urocyon cinereoargenteus
Microtus pinetorum	megalotis	Vulpes vulpes
Mus musculus	Reithrodontomys montanus	Zapus hudsonius
Mustela frenata		

## Birds

Accipiter cooperii	Dumetella carolinensis	Pipilo erythrophthalmus
Accipiter gentilis	Empidonax flaviventris	Piranga olivacea
Accipiter striatus	Empidonax minimus	Piranga rubra
Aetitis macularia	Empidonax traillii	Podilymbus podiceps
Agelaius phoeniceus	Eremophila alpestris	Poliophtila caerulea
Aegolius acadicus	Ereunetes mauri	Poocetes gramineus
Aix sponsa	Euphagus carolinus	Porzana carolina
Ammodrammus savannarum	Falco columbarius	Progne subis
Anas acuta	Falco mexicanus	Quiscalus quiscula
Anas carolinensis	Falco sparverius	Rallus limicola
Anas discors	Fulica americana	Regulus calendula
Anas platyrhynchos	Geothlypis trichas	Regulus satrapa
Anser albifrons	Grus canadensis	Richmondia cardinalis
Aquila chrysaetos	Guiraca caerulea	Riparia riparia
Archilochus colubris	Haliaeetus leucocephalus	Sayornis phoebe
Ardea herodias	Hirundo rustica	Seiurus aurocapillus
Asio otus	Hylocichla fuscescens	Seiurus motacilla
Aythya affinis	Hylocichla guttata	Seiurus noveboracensis
Aythya collaris	Hylocichla minima	Setophaga ruticilla
Bartramia longicauda	Hylocichla mustelina	Sialia sialis
Bombycilla cedrorum	Hylocichla ustulata	Sitta canadensis
Botaurus lentiginosus	Icteria virens	Sitta carolinensis
Branta canadensis	Icterus galbula	Spatula clypeata
Bubo virginianus	Icterus spurius	Sphyrapicus varius
Buteo jamaicensis	Junco hyemalis	Spinus pinus
Buteo lagopus	Lanius ludovicianus	Spinus tristis
Buteo lineatus	Larus pipixcan	Spiza americana
Buteo platypterus	Megasceryle alcyon	Spizella arborea
Butorides virescens	Melanerpes erythrocephalus	Spizella pallida
Capella gallinago	Melospiza georgiana	Spizella passerina
Caprimulgus carolinensis	Melospiza lincolni	Spizella pusilla
Caprimulgus vociferus	Melospiza melodia	Stelgidopteryx ruficollis
Carpodacus purpureus	Micropalama	Strix varia
Cathartes aura	himantopus	Sturnella magna
Centurus carolinus	Mimus polyglottos	Sturnella neglecta
Certhia familiaris	Mniotilta varia	Sturnus vulgaris
Chaetura pelagica	Muscivora forficata	Telmatodytes palustris
Charadrius vociferus	Myiarchus cineritus	Thryomanes bewicki
Chen caerulescens	Nuttallornis borealis	Thryothorus ludovicianus
Chen hyperborea	Nycticorax nycticorax	Totanus flavipes
Chondestes grammacus	Oporornis formosus	Toxostoma rufum
Chordeiles minor	Otus asio	Tringa solitaria
Circus cyaneus	Pandion haliaetus	Troglodytes aedon
Cistothorus platensis	Parula americana	Troglodytes troglodytes
Coccyzus americanus	Parus atricapillus	Turdus migratorius
Coccyzus erythrophthalmus	Parus bicolor	Tyrannus tyrannus
Colaptes auratus	Passer domesticus	Tyrannus verticalis
Colinus virginianus	Passerculus sandwichensis	Tyto alba
Columba livia	Passerella iliaca	Vermivora celata
Contopus virens	Passerherbulus	Vermivora peregrina
Corvus brachyrhynchos	caudacutus	Vermivora ruficapilla
Cyanocitta cristata	Passerina ciris	Vireo bellii
Dendrocopos pubescens	Passerina cyanea	Vireo flavifrons
Dendrocopos villosus	Pelecanus	Vireo gilvus
Dendroica coronata	erythrorhynchos	Vireo griseus
Dendroica fusca	Petrochelidon	Vireo olivaceus
Dendroica petechia	pyrrhonota	Vireo solitarius
Dendroica striata	Pheucticus ludovicianus	Wilsonia canadensis
Dendroica virens	Philohela minor	Wilsonia pusilla

*Birds (concluded)*

Xanthocephalus xanthocephalus	Zenaidura macroura Zonotrichia albicollis	Zonotrichia leucophrys Zonotrichia querula
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*Reptiles*

Agkistrodon contortrix	Elaphe guttata	Ophisaurus attenuatus
Carphophis amoenus	Elaphe obsoleta	Pituophis catenifer
Chelydra serpentina	Eumeces fasciatus	Scincella laterale
Chrysemys picta	Eumeces obsoletus	Storeria dekayi
Cnemidophorus sexlineatus	Eumeces septentrionalis	Tantilla gracilis
Coluber constrictor	Lampropeltis calligaster	Terrapene carolina
Crotalus horridus	Lampropeltis doliata	Terrapene ornata
Crotaphytus collaris	Lampropeltis getulus	Thamnophis sirtalis
Diadophis punctatus	Natrix sipedon	Virginia valeriae

*Amphibians*

Aceris crepitans	Bufo woodhousei	Rana catesbeiana
Ambystoma tigrinum	Gastrophryne olivacea	Rana pipiens
Bufo americanus	Hyla versicolor	Spea bombifrons
	Pseudacris nigrita	

*Fishes*

Camptostoma anomalum	Ictalurus melas Lepomis cyanellus	Notropis lutrensis Pimephales promelas
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*Beetles*

Acalymma vittata	Calosoma scrutator	Cryptocephalus quadruplex
Acanthocinus sp.	Cantharis bilineatus	Cryptorhynchus tristis
Achmaeodera pulchella	Cantharis carolinus	Cycloneda sp.
Adalia frigida	Carabus sylvosus	Deloyala guttata
Agabus disintegratus	Casnonia pennsylvanica	Dermestes sp.
Agabus stagninus	Cassida sp.	Desmocerus palliatus
Agonoderus pallipes	Ceratoma punctata	Diabrotica
Agroiconota bivittata	Ceratoma trifurcata	duodecimpunctata
Alaus oculatus	Ceratomegilla fuscilabris	Diabrotica longicornis
Alobates pennsylvanica	Ceratomegilla maculata	Diabrotica vittata
Anisoclavia quatuordecimguttata	Chauliognathus marginatus	Dineutes sp.
Anomoea laticlavia	Chelymorpha cassidea	Disonycha glabrata
Anomola marginata	Chion cinctus	Disonycha sp.
Anoplum cinerascens	Chirida guttata	Disonycha xanthomelaena
Anthonomus signatus	Chlaenius bicolor	Dorchaschema alternatum
Aphodius concavus	Chrysochus auratus	Eburia quadrigeminata
Aphodius distinctus	Cicindela belfragei	Elaphrus sp.
Aphodius stercorosus	Cicindela punctulata	Enochrus perplexus
Aphodius terminalis	Cicindela repanda	Enoclerus sp.
Araecerus sp.	Cicindela scutellaris	Epicaerus imbricatus
Astenus cognatus	Cicindela sexguttata	Epicaerus sericata
Bassareus clathratus	Clivinia bipustulosa	Epicaerus unicolor
Batyleoma suturale	Clivinia dentipes	Epicauta occidentalis
Bembidion sp.	Colaspis sp.	Epicauta pennsylvanica
Berosus sp.	Collops sp.	Epicauta sericans
Brachynus alterninus	Coniontellus sp.	Epicauta unicolor
Buprestis rufipes	Conotrachelus seniculus	Eucanthus lazarus
Calligrapha scalaris	Copelatus glypticus	Eumolpus colossus
Calligrapha similis	Cotinus nitida	Euphoria fugida
Calosoma calida	Cryptocephalus venustus	

*Beetles (concluded)*

Galerita atripes	Megacephala virginica	Poecilus chalcites
Galerita janus	Melanocytes piceus	Popilius disjunctus
Haltica foliaceae	Metachroma	Prionus imbricornis
Harpalus caliginosus	interruptum	Prometopia sexmaculata
Hemierana marginata	Metriona bicolor	Pseudamphasia sericea
Heterocerus brunneus	Metriona bivittata	Pseudolucanus capreolus
Heterocerus pallidus	Monocrepidius	Pyrota concinna
Hippodamia	vespertinus	Rhodobaenus
tredecimpunctata	Necrophorus orbicollis	tredecimpunctatus
Hippopsis lemniscata	Necrophorus pustulatus	Sandalus sp.
Hydrophilus obtusatus	Odontocorynus	Saperda tridentata
Hypera punctata	denticornis	Scaphinotus elevatus
Hyperodes sp.	Oedionychis gibbitansa	Scarites subterraneus
Ischyurus	Orthosoma brunneum	Silpha americana
quadripunctatus	Panagaeus fasciata	Silpha inaequalis
Lebia analis	Pantomorus sp.	Silpha surinamensis
Lebia atriceps	Paria canella	Tetraopes
Lebia grandis	Paria sp.	quinquemaculatus
Lebia pulchella	Pasimachus californicus	Tillus sp.
Lebia scapularis	Pasimachus elongatus	Triplectrus carbonarius
Lebia viridis	Pasimachus punctulatus	Tropisternus lateralis
Leiocnemis avida	Pelidnota punctata	Tropisternus sp.
Leptostylus transversum	Photinus pyralis	Trox sp.
Leucanus sp.	Photurus divisa	Typocerus sinuata
Lina interrupta	Phyllophaga fervida	Typophorus
Lina lapponica	Physocnemum	viridicyaneus
Lina scripta	brevilineum	Xylotrechus colonus
Listronotus nebulosus	Pinotus carolinus	Zygomma suturalis
Lucidota atra	Podabrus flavicollis	

*Crickets, grasshoppers, katydids, roaches (Orthoptera)*

Amblycorypha inastea	Melanoplus	Paratettix cucullatus
Arphia simplex	femurrubrum	Paratylotropidia
Ceuthophilus pallidus	Melanoplus glaucipes	brunneri
Chortophaga	Melanoplus mexicanus	Parcoblatta bolliana
viridifasciata	Melanoplus scudderi	Schistocerca americana
Conocephalus	Melanoplus walshii	Schistocerca obscura
brevipennis	Microcentrum	Scudderia furcata
Dissosteira carolina	rhombifolium	Scudderia texensis
Gryllotalpa hexadaetyla	Nemobius fasciatus	Sphargemon equale
Melanoplus bivittatus	Neoconocephalus	Stegomantis religiosa
Melanoplus blatchleyi	robustus	Syrbula admirabilis
Melanoplus differentialis	Orchelimum nigripes	Tetrix angustus
	Orchelimum vulgare	Tetrix arenosus

*Ants, bees, wasps (Hymenoptera)*

Apis mellifera	Camponotus herculeanus	Neivamyrmex nigrescens
Ammophila sp.	Cerceris sp.	Neivamyrmex
Anophius atrox	Chalybion californicum	opacithorax
Anophius sp.	Crematogaster	Paratrechina
Anthophora sp.	(Aerocoelia) sp.	(Nylanderia) sp.
Aphaenogaster	Formica fusca	Polistes fuscatus
tennesseensis	Iridomyrmex analis	Polistes metricus
Augochlora sp.	Lasioglossum	Priocnemoides sp.
Augochlorella aurata	inconspicuum	Pseudomethoca frigida
Augochlorella persimilis	Melissodes sp.	Stictia sp.
Augochlorella striata	Myrmilloides grandiceps	Stizus uncinatus
Bombus sp.	Myrmosula parvala	Trachites sp.
Camponotus castaneus		Trypoxylon politum

*Moths*

Abbotana clemataria	Cyenia inopinatus	Hypsorophora hormos
Acontia aprica	Cyenia tenera	Ichthyura albosigma
Acronyeta connecta	Dasylophia anguina	Isia isabella
Acronyeta hastulifera	Deidamia inscriptum	Isogona tenuis
Acronyeta impleta	Deilinia quadrifasciaria	Isogramma hageni
Acronyeta longa	Delta ramosula	Itame latiferrugata
Acronyeta morula	Dichorda irridaria	Lacinipolia anguina
Acronyeta oblonga	Diptergia scabriuscula	Lacinipolia renigera
Acronyeta paupercula	Dyspteris abortivaria	Lascoria ambigualis
Actias luna	Ectropis crepuscularia	Legna perditalis
Adelocephala bicolor	Elaphria festivooides	Leucania
Agriopodes teratophora	Elaphria grata	phragmitidicola
Agrotis ypsilon	Epienaptera americana	Leucania ursula
Amathes c-nigrum	Epizeuxis americanis	Leuconyeta diptheroides
Ampeloeca myron	Epizeuxis lubricalis	Lithophane antennata
Anacamptodes	Erastria bellicula	Lobocleta ossularia
defectaria	Erastria carneola	Lophodonta angulosa
Anagrapha falcigera	Erastria muscosa	Lycia ypsilon
Anavitrinella	Erastria musta	Marathyssa inficita
pampinaria	Erastria synochitis	Matigramma
Anepia capsularis	Estigmene acraea	pulverilinea
Anorthodes tarda	Euacidalia sericeata	Melalopha apicalis
Apantesis arge	Euagrotis illapsa	Melalopha inclusa
Apantesis nais	Euchaetias egle	Melanolopia signataria
Apantesis phalaerata	Euchaetias oregonensis	Melipotis indomita
Apicia confusaria	Euchlaena pectinaria	Melipotis jucunda
Argyrostromis anilis	Euclidean cuspidea	Mellilla xanthometata
Autographa biloba	Eudeilina herminiata	Metanema inatomaria
Baileya australis	Eugonobapta nivosaria	Metarranthis duaria
Baileya dormitans	Euparthenos nubilis	Metarranthis homuraria
Baileya ophthalmica	Euphyia centrostrigaria	Misogoda unicolor
Balsa malana	Eupithecia herefordaria	Mocis texana
Bapta vestaliata	Eupithecia swetti	Morrisonia confusa
Bendis detrahens	Eupsilia morrisoni	Morrisonia distincta
Biston cognataria	Eutolype electilis	Nadata gibbosa
Bleptina caradrinalis	Eutolype grandis	Neorastria apicosa
Bomolocha albaliensis	Faronta diffusa	Nerice bidentata
Bomolocha bijugalis	Galgula partita	Ogdoconta cinereola
Bomolocha sordidula	Gluphisia septentrionalis	Oligocentria lignicolor
Caenurgina crassiuscula	Haematopsis grataria	Orthodes crenulata
Caenurgina erectea	Halyssidota tessellaris	Orthosia alurina
Callizzia amorata	Haplon lecontei	Orthosia garmani
Calothyssanis amaturlaria	Heliothis zea	Orthosia hibisci
Catabena lineolata	Hemaris diffinis	Orthosia rubescens
Catopyrrha coloraria	Heterocampa bilineata	Palaeacrita merriccata
Celery lineata	Heterocampa guttivitta	Palaeacrita vernata
Cerastis tenebrifera	Heterocampa sp.	Palthis angulalis
Ceratomia sp.	Heterocampa umbrata	Panopoda carneicosta
Cerna cora	Heteropacha rileyana	Panopoda rufimargo
Chamyris cerintha	Heterophleps refusata	Parallela bistrariis
Chlorochlamys	Heterophleps	Paonias myops
chloroleucaria	triguttaria	Percnoptilota obstipata
Chorizagrotis	Himella intraetata	Peridroma margaritosa
auxiliaris	Homohadena infixa	Perigea xanthioides
Chytolita morbidalis	Horisme intestinata	Pero honestarius
Cissusa spadix	Homorthodes lindseyi	Phalaenophana
Cleora sublunaria	Hydriomena pluviala	pyramusalis
Coryphista meadi	Hypena humuli	Phalaenostola
Crambodes talidiformis	Hyperaeschra georgica	larentioides
Cressonia juglandis	Hyperetis amicarua	Phigalia olivacearia
Crocigrapha normani	Hyphantria cunea	Phigalia titea

*Moths (concluded)*

Philobia aemulataria	Raphia abrupta	Synchlora aerata
Phiprosopus	Salia interpuncta	Tarachidia candefacta
callitrichoides	Scopsis fulvicollis	Tarachidia erastrionides
Phoberia atomaris	Schizura apicalis	Telea polyphemus
Phosphila miselioides	Schizura ipomoeae	Tetracis crocallata
Plagodis phlogosaria	Schizura unicornis	Tornos abjectarius
Plathypena scabra	Scopula inductata	Tornos scolopacinaris
Platysenta vecors	Scopula limboundata	Trachea delicata
Platysenta videns	Semiothisa continuata	Trichoplusia ni brassicae
Plusia aerea	Semiothisa dislocaria	Ulolonche culea
Plusiodonta	Semiothisa guophosaria	Xanthoptera
compressipalpis	Semiothisa ocellinata	nigrofimbria
Polia adjuncta	Sericaglaea signata	Xanthotype sospeta
Prodenia ornithogalli	Simyra henrici	Xystrota
Proxenus miranda	Smerinthus jamaicensis	rubromarginaria
Psaphida grotei	Sphinx drupiferarum	Zale galbanata
Pscudaletia unipuncta	Spiloloma lunilinea	Zale minerea
Psychomorpha epimenis	Spilosoma virginica	Zanclognatha cruralis
Pyrrhia umbra	Stiriodes obtusa	

*Butterflies*

Anaea andria	Libytheana bachmannii	Polygonia comma
Asterocampa celtis	Melitaea nycteis	Polygonia
Cercyonis pegala	Nathalis iole	interrogationis
Colias eurytheme	Papilio glaucus	Precis lavinia
Danaus plexippus	Papilio marcellus	Speyeria cybale
Eurema lisa	Papilio polyxenes	Speyeria idalia
Eurema nicippe	Phyciodes phaon	Vanessa atalanta
Everes comyntas		

*Spiders*

Acacesia hamata	Castianeira variata	Enoplognatha
Acanthepeira stellata	Centromerus latidens	marmorata
Achaearanea porteri	Ceraticelus micropalpis	Eperigone maculata
Achaearanea	Ceraticelus minutus	Eperigone praecursa
tepidariorum	Ceratinella brunnea	Erigone autumnalis
Agelenopsis naevia	Chiracanthium inelusum	Euryopsis limbata
Agelenopsis oklahoma	Cicurina arcuata	Eustala anastera
Agelenopsis	Cicurina ludoviciana	Eustala cepina
pennsylvanica	Colpchepeira catawba	Evarcha hoyi
Antrodiaetus	Conaranea juniperi	Frontinella pyramitela
lincolnianus	Coras lamellosus	Gea heptagon
Anyphaena fraterna	Coriarachne lenta	Geolycosa missouriensis
Araeus marmoreus	Cornicularia indirecta	Gertschia scorpionia
Araeus solitarius	Clubiona kastoni	Habrocestum pulex
Araniella displicata	Clubionoides excepta	Habronattus coronatus
Aretosa funerea	Crustulina altera	Habronattus sabulosus
Aretosa noctuabunda	Cyclosa caroli	Habronattus viridipes
Aretosa sublata	Dapanus mirus	Haplodrassus bicornis
Argiope aurantia	Dictyna foliacea	Hentzia ambigua
Argiope trifasciata	Dictyna formidolosa	Hentzia mitrata
Atypus niger	Dictyna sublata	Herpyllus vasifer
Atypus sp.	Dictyna volucripes	Icius hartii
Aysha gracilis	Dolomedes sexpunctatus	Latrodectus variolus
Callilepis imbecilla	Dolomedes tenebrosus	Lepthyphantes
Castianeira cingulata	Dolomedes urinator	appalachia
Castianeira descripta	Drassodes auriculoides	Lepthyphantes sabulosa
Castianeira longipalpis	Drasyllus aprilinus	Leucauge venusta
Castianeira trilineata	Drasyllus gynosaphes	Linyphia marginata

*Spiders (concluded)*

Loxosceles reclusa	Neoscona pratensis	Singa pratensis
Lycosa aspersa	Origanates rostratus	Singa truncata
Lycosa avara	Oxyopes salticus	Sisicus penifisiferus
Lycosa carolinensis	Oxyopes scalaris	Souessoula parva
Lycosa gulosa	Oxyptila monroensis	Sosticus insularis
Lycosa helluo	Paraphidippus aurantius	Spermophora
Lycosa punctulata	Paraphidippus	meridionalis
Lycosa rabida	marginatus	Sphyrotinus imparatus
Maevia inclemens	Pardosa lapidicina	Spirembolus sp.
Mangora gibberosa	Pardosa milvina	Steatoda americana
Mangora ornata	Pardosa saxatilis	Steatoda borealis
Mangora placida	Peckhamia americana	Steatoda triangulosa
Marpissa bina	Pelopatis undulata	Synema varians
Marpissa pikei	Phidippus apacheanus	Tapinocyba sp.
Meioneta micaria	Phidippus fraudulentus	Tegenaria domestica
Meriola decepta	Phidippus pius	Tetragnatha elongata
Metacyrba undata	Phidippus princeps	Tetragnatha laboriosa
Metepeira labyrinthea	Phidippus putnami	Thanatus formicinus
Metaphidippus	Phidippus rimator	Theridion differens
castaneus	Phidippus variegatus	Theridion murarium
Metaphidippus	Phidippus whitmani	Thiodina iniquies
galathea	Philodromus marxi	Thiodina puerpera
Metaphidippus	Philodromus pernix	Tibellus oblongus
protervus	Philodromus pratariæ	Titanoeca americana
Micaria longipes	Pholeus sp.	Tmarus angulatus
Micrathena gracilis	Phrurotimpus alarius	Trachelas tranquillus
Micrathena mitrata	Phrurotimpus borealis	Tutelina elegans
Micrathena sagittata	Pirata arenicola	Uloborus glomus
Mimetus puritanus	Pirata insularis	Ummidia sp.
Mimognatha foxi	Pirata maculatus	Verrucosa arenata
Misumena vatia	Psilochorus pullulus	Wulflia saltabunda
Misumenoides	Sassacus papenboei	Xysticus bicuspis
formosipes	Schizocosa avida	Xysticus lemniscatus
Misumenops asperatus	Schizocosa bilineata	Xysticus pella
Misumenops delphinus	Schizocosa crassipes	Xysticus texanus
Misumenops oblongus	Schizocosa saltatrix	Xysticus transversatus
Myrmarachne hentzi	Scotinella redempta	Xysticus triguttatus
Neoscona arabesca	Scylaceus pallidus	Xysticus tumefactus
Neoscona benjamina	Sergiolus capulatus	Zelotes hentzi
		Zygoballus bettini

*Chiggers*

Eutrombicula diversa	Neoschongastia	Trombicula guerneyi
Eutrombicula jonesi	americana	Trombicula kansensis
Eutrombicula peromysci	Pseudoschöngastia	Trombicula lipovskiana
Eutrombicula setosa	farneri	Trombicula lipovskyi
Eutrombicula trigenuala	Pseudoschöngastia	Trombicula myotis
Hannemania eltoni	hungerfordi	Trombicula sylvilagi
Hannemania	Trombicula alfreddugéi	Trombicula tristetica
multifemoralis	Trombicula cynos	Trombicula whartoni
	Trombicula fitchi	Walchia americana

*Crustaceans (cladocerans, copepods, crayfish, sowbugs)*

Allona sp.	Macrocylops albidus	Scapholeberis kingi
Armadillidium vulgare	Mesocyclops edax	Simocephalus serrulatus
Chydorus sp.	Orconectes nais	Trophocyclops prasinus
	Pleuroxus denticulatus	

*Earthworms (Annelida)*

Allolobophora caliginosa

## Mollusks

## Clams

Pisidium compressum                      Sphaerium sp.

## Snails and slugs

Anguispira alterna	Hawaiiia minuscula	Succinea concordialis
Bulimulus dealbatus	Helicodiscus parallelus	Stenotrema hirsutum
Derocheras laeve	Helisoma trivolvis	Stenotrema leai aliciae
Euconulus chersinus	Lymnaea bulimoides	Strobilopsis labyrinthica
Gastrocopta armifera	Lymnaea parva	Triodopsis albolabris
Gastrocopta contracta	Physa hawni	Quickella vagans
Gastrocopta holzingeri	Pupoides albilabris	Vertigo ovata
Gastrocopta pentodon	Retinella electrina	Vallonia parvula
Gastrocopta procera	Retinella indentata	Zonitoides arboreus
Gyraulus parvus		

## BIBLIOGRAPHY

The following list contains: 1) titles that are cited in the text as general references because they contain material that is pertinent to the discussion; 2) titles (those marked with asterisks) that are based upon field research carried on, in part at least, on the Reservation although some are not cited in the text of preceding pages.

- ° ATKINS, M. D., and WERTZBERGER, M.  
1955. Plant the "go-back land" to grass. Jour. Soil and Water Cons., 10:233-235.
- ° ATYEO, W. T.  
1960. A revision of the mite family Bdellidae in North and Central America (Acarina:Prostigmata), Kansas Sci. Bull., 40:345-499.
- CHAPMAN, C. H. and CHAPMAN, E. F.  
1964. Indians and archeology of Missouri. Univ. Missouri Press. Missouri Handbook No. 6, 161 pp.
- COCKRUM, E. L.  
1952. Mammals of Kansas. Univ. Kansas Publ. Mus. Nat. Hist., 7(1):1-303.
- ° CROSS, EARLE, A.  
1965. The generic relationships of the family Pyemotidae (Acarina: Trombidiformes). Kansas Sci. Bull., 45:29-275.
- ° CROSSLEY, D. A., JR.  
1960. Comparative external morphology and taxonomy of nymphs of the Trombiculidae (Acarina). Kansas Sci. Bull., 40:135-321.
- FERNALD, M. L.  
1950. Gray's manual of botany. American Book Co., N. Y. lxiv + 1632 pp.
- ° FITCH, H. S.  
1952. The University of Kansas Natural History Reservation. Univ. Kansas Mus. Nat. Hist., Misl. Publ. 4:1-38.  
1954a. Seasonal acceptance of bait by small mammals. Jour. Mamm. 35:39-47.  
1954b. Life history and ecology of the five-lined skink (*Eumeces fasciatus*). Univ. Kansas Publ., Mus. Nat. Hist. 8:1-156.  
1955. Habits and adaptations of the Great Plains skink (*Eumeces obsoletus*). Ecol. Monogr. 25:59-83.

- 1956a. A field study of the Kansas ant-eating frog (*Gastrophryne olivacea*). Univ. Kansas Publ., Mus. Nat. Hist. 8:275-306.
- 1956b. An ecological study of the collared lizard (*Crotaphytus collaris*). Univ. Kansas Publ., Mus. Nat. Hist. 8:213-274.
- 1956c. Temperature responses of free-living amphibians and reptiles in northeastern Kansas. Univ. Kansas Publ., Mus. Nat. Hist. 8:417-476.
1957. Aspects of reproduction and development in the prairie vole (*Microtus ochrogaster*). Univ. Kansas Publ., Mus. Nat. Hist. 10:129-161.
- 1958a. Natural history of the six-lined racerunner, *Cnemidophorus sexlineatus*. Univ. Kansas Publ., Mus. Nat. Hist. 11:11-62.
- 1958b. Home ranges, territories, and seasonal movements of vertebrates of the Natural History Reservation. Univ. Kansas Publ., Mus. Nat. Hist. 11:63-323.
1960. Autecology of the copperhead. Univ. Kansas Publ., Mus. Nat. Hist. 13:85-288.
- 1963a. Natural history of the racer, *Coluber constrictor*. Univ. Kansas Publ., Mus. Nat. Hist. 15:351-468.
- 1963b. Natural history of the black rat snake (*Elaphe o. obsoleta*) in Kansas. Copeia, 1963(4):649-658.
- 1963c. Spiders of the University of Kansas Natural History Reservation and Rockefeller Experimental Tract. Univ. Kansas Mus. Nat. Hist., Misc. Publ. no. 33:1-202.
1965. An ecological study of the garter snake, *Thamnophis sirtalis*. Univ. Kansas Publ. Mus. Nat. Hist., 15:493-564.
- ° FITCH, H. S., and FITCH, V. R.  
1955. Observations on the summer tanager in northeastern Kansas. Wilson Bull., 67:45-54.
- ° FITCH, H. S., and LOKKE, D. H.  
1956. The molluscan record of succession on the University of Kansas Natural History Reservation. Trans. Kansas Acad. Sci. 59(4): 442-454.
- ° FITCH, H. S., and MCGREGOR, R. L.  
1956. The forest habitat of the University of Kansas Natural History Reservation. Univ. Kansas Publ., Mus. Nat. Hist. 10:77-127.
- ° FITCH, H. S., and PACKARD, R. L.  
1955. The coyote on a natural area in northeastern Kansas. Trans. Kansas Acad. Sci. 58:211-221.
- ° FITCH, H. S., and RAINEY, D. G.  
1956. Ecological observations on the woodrat, *Neotoma floridana*. Univ. Kansas Publ., Mus. Nat. Hist. 8:499-533.
- ° FITCH, H. S., and SANDIDGE, L. L.  
1953. Ecology of the opossum on a natural area in northeastern Kansas. Univ. Kansas Publ., Mus. Nat. Hist. 7:305-338.
- ° FREDRICKSON, R. W.  
1954. Myriapoda of the University of Kansas Natural History Reservation. Unpublished thesis, University of Kansas Library.
- ° FREIBURG, R. D.  
1951. An ecological study of the narrow-mouthed toad (*Microhyla olivacea*) in northeastern Kansas. Trans. Kansas Acad. Sci. 56:376-386.
- ° GREENBERG, B.  
1952. A review of the New World *Acomatacarus* (Acarina, Trombiculidae). Ann. Ent. Soc. Amer., vol. 45, no. 3, Oct. 25, 1952:473-491.

- HALL, E. R., ANDERSON, S., JONES, J. K., JR., and PACKARD, R. L.  
1957. Vernacular names for North American mammals north of Mexico. Univ. Kansas Mus. Nat. Hist., Misc. Publ. no. 14:1-16.
- HARLAN, J. R., SPEAKE, E. B. and REECE, M. F.  
1956. Iowa fish and fishing. Iowa State Cons. Com., 377 pp., 22 pls.
- ° HARTMANN, E. L.  
1956. The bryophyte flora of the University of Kansas Natural History Reservation. Trans. Kansas Acad. Sci. 59:57-70.
- ° JANES, D. W.  
1959. Home ranges and movements of the eastern cottontail in Kansas. Univ. Kansas Publ., Mus. Nat. Hist. 10:553-572.
- JOHNSTON, R. F.  
1960. Directory to the bird-life of Kansas. Univ. Kansas Mus. Nat. Hist., Misc. Publ. no. 23:1-69.
- ° KARDOS, E. H.  
1954. Biological and systematic studies of the subgenus *Neotrombicula* (Genus *Trombicula*) in the Central United States (Acarina, Trombiculidae). Univ. Kansas Sci. Bull. 36 pt. 1 (4):69-123.
- ° KRAMER, C. L.  
1956. Lichens of the University of Kansas Natural History Reservation. Trans. Kansas Acad. Sci. 58-519-524.
- ° LEGLER, J. H.  
1960. Natural history of the ornate box turtle, *Terrapene ornata ornata* Agassiz. Univ. Kansas Publ., Mus. Nat. Hist. 11:527-669
- ° LEONARD, A. B., and GOBLE, C. R.  
1952. Mollusca of the University of Kansas Natural History Reservation. Univ. Kansas Sci. Bull. 34:1013-1053, 2 pls.
- ° LOOMIS, R. B.  
1956. The chigger mites of Kansas (Acarina, Trombiculidae). Univ. Kansas Sci. Bull. 38:1195-1444.
- MAGGOWAN, K., and HESTER, J. A., JR.  
1962. Early man in the New World. Anchor Books, Doubleday and Co., Inc. N. Y. xxiii + 333 pp.
- ° MARTIN, E. P.  
1956. A population study of the prairie vole (*Microtus ochrogaster*). Univ. Kansas Publ., Mus. Nat. Hist. 8:361-416.
- MARTIN, P. S.  
1958. Pleistocene ecology and biogeography of North America. Amer. Assoc. Adv. Sci., Publ. 51:405.
- ° MCFARLAND, A. N.  
Spring moths (Macrolepidoptera) of the University of Kansas Natural History Reservation. In press.
- ° MICHENER, C. D. and WILLIE, A.  
1961. The bionomics of the primitively social bee, *Lasioglossum inconspicuum*.
- MOORE, R. C., FRYE, J. C., and JEWETT, J. J.  
1944. Tabular description of outcropping rocks in Kansas. State Geol. Surv. of Kansas, Bull. 52, 1944 Reports of studies. Part 4, pp. 137-212, figs. 1-9.
- ° ORDWAY, E.  
1961. The biology of *Augochlorella*, a green sweat bee in Kansas. Proc. North Central Branch Entom. Soc. Amer., 16:17.  
1964. *Sphexcodes pimpenellae* and other enemies of *Augochlorella*. Jour. Kansas Ent. Soc., 37(2):139-152.

- ° PACKARD, R. L.  
1956. The tree squirrels of Kansas: ecology and economic importance. Univ. Kansas Mus. Nat. Hist., Misc. Publ. no. 11:1-57.
- PARKS, G. S.  
1854. 'The Tourist' Column. The Kansas Herald of Freedom, 1 (no. 1) Wakarusa, Kansas Terr., October 21, 1854.
- ° RAINEY, D. G.  
1956. Eastern wood rat, *Neotoma floridana*: life history and ecology. Univ. Kansas Publ. Mus. Nat. Hist., 8:535-646.
- ° RETTENMEYER, C. W.  
1963. Behavioral studies of army ants. Univ. Kansas Sci. Bull., 44:(9): 281-465.
- ROBINSON, [Mrs]. S. T. D.  
1899. Kansas; its interior and exterior life, including a full view of its settlement, political history, social life, climate, soil, productions, scenery, etc. Journal Publ. Co., Lawrence, Kansas (10th ed.) xi + 438 pp.
- ° SANDIDGE, L. L.  
1953. Food and dens of the opossum (*Didelphis virginiana*) in north-eastern Kansas. Trans. Kansas Acad. Sci. 56(1):97-106.
- SCHOEWE, W. W.  
1949. The geography of Kansas. Part II. Trans. Kansas Acad. Sci. 52:261-333.
- SMITH, H. M.  
1956. Handbook of amphibians and reptiles of Kansas. 2nd [revised] edition. Univ. Kansas Mus. Nat. Hist., Misc. Publ. no. 9:1-356.
- ° STEWART, P. L.  
1960. Lung-flukes of snakes, genera *Thamnophis* and *Coluber*, in Kansas. Univ. Kansas Sci. Bull. 41, no. 8:877-890.
- ° STOCKHAMMER, K. A.  
1961. Aspects of the life history of the sweat bee, *Augochlora p. parva* (Say). Proc. North Central Branch Entom. Soc. Amer., 16:17-18.
- TAFT, R.  
1950. The great sandy desert. Trans. Kansas Acad. Sci., 53:441-442.
- ° TOMASELLI, R.  
1958. Plant communities of the western half of the University of Kansas Natural History Reservation (1952-63). Casa Editrice Rengo Cortina, Pavia (Italy), 27 pp., many maps.
- WEDEL, W. R.  
1959. An introduction to Kansas archeology. Smiths. Inst. Bur. Ethnology, Bull. 174:xvii + 723 pp.
- ° WOLFENBARGER, K. A.  
1953. Systematic and biological studies on North American chiggers of the genus *Trombicula*, subgenus *Eutrombicula* (Acarina, Trombiculidae). Ann. Ent. Soc. Amer., vol. 45, no. 4:645-677.
- WORMINGTON, H. M.  
1957. Ancient man in North America. Denver Mus. Nat. Hist., Popular Ser. no. 4:xviii + 322 pp.

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