ECOLOGICAL STUDIES ON THE VERTEBRATE FAUNA OF A 500-ACRE FARM IN KALAMAZOO COUNTY, MICHIGAN

By

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A THESIS

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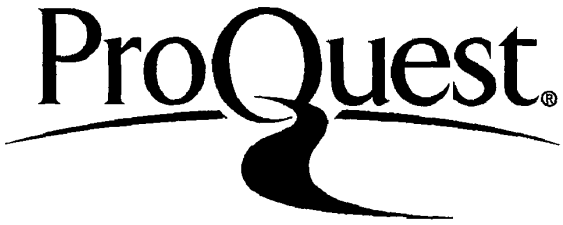

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INTRODUCTION

Quantitative research on animal populations has to a considerable extent been restricted to small areas and small animals. Among the best known works of this nature are those of McAtee (1907), Beebe (1916), Wolcott (1918, 1937), Sanders and Shelford (1922), Weese (1924), Blake (1925), Townsend (1935), Smith (1928), and Shackleford (1929). Small controllable populations of invertebrates have served to reveal fundamental principles of population dynamics (Chapman 1928) that may, perhaps, be applicable to all forms; but specific information as to the actual numbers and relationships of vertebrate animals on representative areas is almost wanting.

It is not difficult to account for the small number of investigations that have been made in this field. There are numerous significant obstacles to area studies involving the handling of large populations of birds and mammals. Continuous year-round field work is very desirable if the annual population cycles are to be interpreted, and this is seldom possible . Territory suitable for such work should, for maximum significance, be fairly representative of widespread conditions. It must also be under control as to policies regarding the trapping, shooting, and management of its animal populations. Such areas are not plentiful. In addition to these considerations, the equipment and help necessary for continuous work on a large number of species have not often been available to the student.

The present study results from a cooperative effort on the part of

Michigan State College and the Michigan Department of Conservation. Preliminary work was done during the fall, spring, and summer of 1934-35 under a graduate assistantship in zoology at the W. K. Kellogg Bird Sanctuary. From September 1935 to August 1937 the study was supported by a half-time research fellowship provided by the Game Division, Department of Conservation. Equipment and expenses also were furnished. Although the interests of the Department of Conservation in these animal populations have principally to do with their value for sport and fur, I have not been limited to a study of game birds and mammals . It has been fully realized that the community of animals associated here must be demonstrated in its entirety before the position of individual species can be appreciated.

The area upon which the work was done is owned and operated by Michigan State College. Under these circumstances policies have been under reasonable control. Residence at the Kellogg Bird Sanctuary from April 1935 until August 1937 has permitted a continuous study. All of my own time was devoted to the work after September 1935, and a full-time assistant was on the project from October to April during both years.

In scope this study is limited principally to upland forms. Thus no particular investigation has been made of the muskrat, and waterfowl are treated only incidentally. The work has been featured mainly by two activities: The intensive use of box traps during the winter months, and daily field work throughout the year. Both of these methods have been of great value in obtaining the data presented.

The object of this paper is three-fold: (1) The area will be

analyzed in terms of its physical characteristics and plant habitats. This is necessary to a proper evaluation of the data on animal populations. (2) There is presented a quantitative study of the resident birds and mammals with special reference to the larger species of greater abundance. Where actual population figures are not available the relative numbers of different animals are indicated. (3) The last portion of the work is devoted to a discussion of the interrelationships of these animals with reference to the use of habitats, seasonal and daily time of activity, and to the position of each in the food cycle.

This is an area study. A unit of the earth's surface, occupied and modified by man, is being described in terms of its plant covering and the animal forms that have found it possible to live here.

PART I THE AREA

The area included in this study is 500 acres in extent and is located in Section 8, Ross Township, Kalamazoo County, Michigan. It includes Wintergreen Lake, which is about 20 acres in extent. The southwest corner of Section 8 lies in Gull Lake , the largest body of water in this portion of the state. Along the shore of the lake and separated from this farm by a road is Midland Park. This resort is a collection of cottages, all of which are occupied in summer and where a few people remain in winter. It lies on the flats next to the lake amid a grove of second-growth oaks. On the west the farm is adjacent to two private Gull Lake estates. On the north, east, and south it is bounded by similar farm land.

PHYSIOGRAPHY AND SOILS

The locality treated lies on an extensive outwash plain which was formed in the angle of the Lake Michigan and Saginaw lobes when the ice border was only a few miles from the present site of Gull Lake (Scott 1921). The region is characterized by pit lakes and kettle holes which, presumably, were formed by the burying of ice blocks which melted and left basins sunk below the surface of the plain. Wintergreen and Gull Lakes were probably so formed, as were the five small kettle holes found on the area.

Wintergreen Lake lies at the 891-foot contour. The highest point on the farm is southeast of the sanctuary and is 935 feet above sea level. The sanctuary and that portion of the farm to the west and east are too hilly for cultivation. The level parts of the farm are on the east and north

borders. It is in these fields that the cultivated crops are raised.

The soil of the farm is a Bellefontaine sandy loam (Perkins and Tyson 1926). It is variable as to humus content and in spots is quite sandy. According to the classification of Veatch (1933) it varies locally from first- to third-class farmland. Where the fields are level excellent crops of grain and hay are raised in good seasons. Leverett (1917) gives the principal crops of Kalamazoo County as hay, corn, wheat, oats, potatoes, and rye, and the average value per acre (1917) as $41.72. Perkins and Tyson give the value of Bellefontaine sandy loam as from $30 to $150 per acre, according to location and improvements.

CLIMATE

Kalamazoo County has an average growing season of from 150 to 160 days (Schneider 1917). The average date of the last killing frost is May 1 to 5. The first killing frost occurs after October 10. Annual precipitation in this portion of the county is usually between 30 and 34 inches (Hill, Riddle, and Elliott 1930). The mean annual temperature at Kalamazoo is 47.9° F. (Perkins and Tyson 1926). The summer and winter means are 69.9° F. and 24.9° F., respectively. This project benefited greatly from the presence of a United States Weather Bureau Station (the Gull Lake Station) at the Kellogg Farm. Thus complete weather data were kept on the exact location of the study.

The two seasons of the work were extremely dissimilar. The 1935

growing season was very favorable to all plant life. As a consequence, herbaceous cover was high in the fall and an excellent crop of wild fruits and seeds was produced. The ensuing winter was one of low temperatures and heavy snows which, late in February, reached a depth of 26 inches. Due to the protecting snow very little ice formed on the swales, and soil on the uplands was frozen to a depth of only a few inches.

The summer of 1936 was one of extreme drouth. A new high temperature (108° F.) was recorded for the Gull Lake Station.[1] Crops were much curtailed throughout the region, and fall cover was not so heavy as in the preceding season. The winter that followed was as mild as the winter of 1935-36 had been severe. The ground was bare much of the time, and although temperatures were comparatively high during most of the season, the soil froze to an average depth of nearly a foot.

As the two growing seasons and their effects are important for the purposes of this work, the compiled weather data are for the 2-year period from April 1, 1935 to April 1, 1937. Figure 1 is a climograph comparing mean monthly temperatures and precipitation for the two years beginning April 1935 and April 1936. The extent to which the two years differed is readily apparent. Other weather data will be adduced as they are necessary to particular phases of the work.

[1]Established April 1929.

Figure 1. Climograph showing mean monthly temperatures and precipitation for the two years beginning April 1935 (dotted line) and April 1936 (solid line).

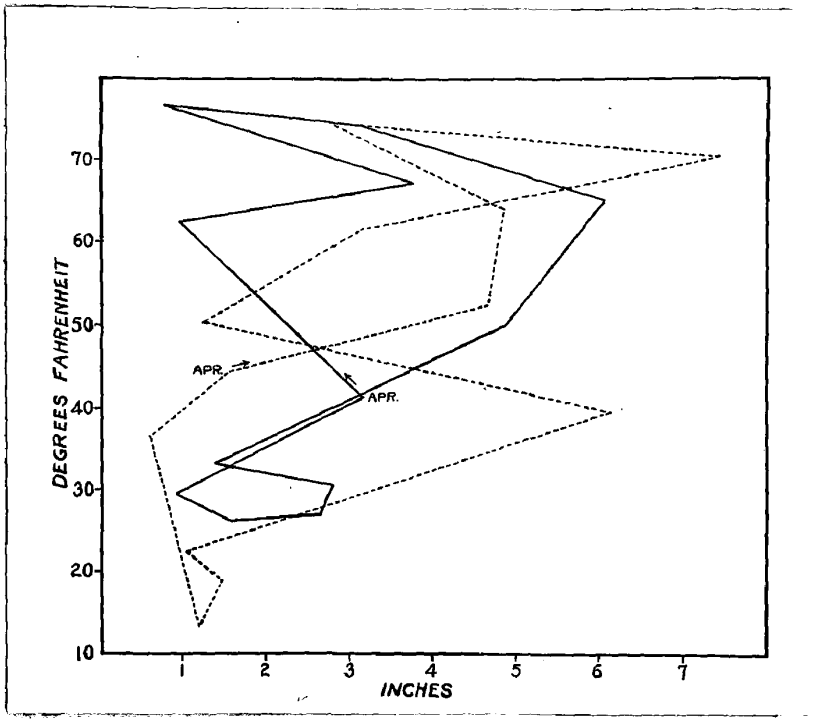

DEGREES FAHRENHEIT
70
60
50
40
30
20
10
APR.
APR.
1
2
3
4
5
6
7
INCHES

Figure 1

RECENT HISTORY

Several farms which then composed this area were purchased by Mr. W. K. Kellogg in 1927, and a year later the entire tract was given to Michigan State College. Eighty acres around Wintergreen Lake were fenced off as the W. K. Kellogg Bird Sanctuary, while the surrounding land became the W. K. Kellogg Farm. The Bird Sanctuary is primarily a waterfowl refuge. In November, at the height of the migration, 3000 ducks of from 10 to 15 species and 500 Canada geese may at one time be found using the lake. From 100 to 300 geese usually remain in the vicinity and feed on the fields in early winter. In the spring it is common for 20 or 30 pairs of mallards and from 10 to 15 pairs of geese to nest around the lake and swales. In summer and winter only a few hundred waterfowl (some captive) occupy the lake and apparently do not greatly affect the resident upland species of the area. The Farm is operated by the College for experimental and demonstration purposes. Corn, wheat, oats, and alfalfa hay are raised; a dairy herd and sheep are kept; and a large poultry plant is operated. In this study no distinction has been made between the territory of the sanctuary and of the farm. Except where the sanctuary is specifically designated, the entire 500 acres is referred to as the Kellogg Farm.

During 1927 extensive plantations of conifers, aggregating about 5000 trees, were set out on the sanctuary and the portions of the farm adjoining to the east and west (fig. 2). Since that time also the natural deciduous brush around the swale and lake margins, which was formerly held back by grazing, has been allowed to increase into dense coverts (fig. 3).

Washes that had started on steep slopes have been filled with stumps. The area apparently supports much more cover now than it did before the sanctuary was established. Otherwise it does not greatly differ from other farm land in the region. Figure 4 shows the distribution of the principal winter cover types during this study.

At the sanctuary the regular winter feeding of small grains has supplemented the natural foods of pheasants and quail. In the winters of 1933 and 1934 standing corn was left in a field at the approximate center of the farm. Chicken house litter containing cracked corn was spread on some fields at two-week intervals through most of every winter. This also has added to the food supply of ground-feeding birds. During this study a few feeding stations were operated for experimental purposes during the winter of 1935-36, and several rye patches also provided food that was available until spring. During the following winter no feeding was done.

The farm area has not been open to general hunting since 1927. The land around Gull Lake for a quarter of a mile back from the shore was closed by an act of the legislature in 1927 and became a sanctuary for all species except rabbits. From 1927 until 1930 intensive "predator control" was practiced at the sanctuary. Steel traps and box traps were constantly set, and all carnivorous mammals and birds were killed as fast as they could be caught. From 1931 to 1935 a small number of skunks, weasels, opossums, hawks, and great horned owls were taken; but the program was not carried on with anything like its former intensity. During this investigation rabbits have been the only species killed on the area until the population studies were completed in the winter of 1937.

Figure 2. Coniferous plantations on the Kellogg Bird Sanctuary in winter of 1935-36.

Figure 3. The west shoreline of Wintergreen Lake showing the dense deciduous brush that has sprung up here since 1927.

Figure 2

Figure 3

Figure 4. Distribution of winter cover types on the Kellogg Farm during the period from 1935 to 1937.

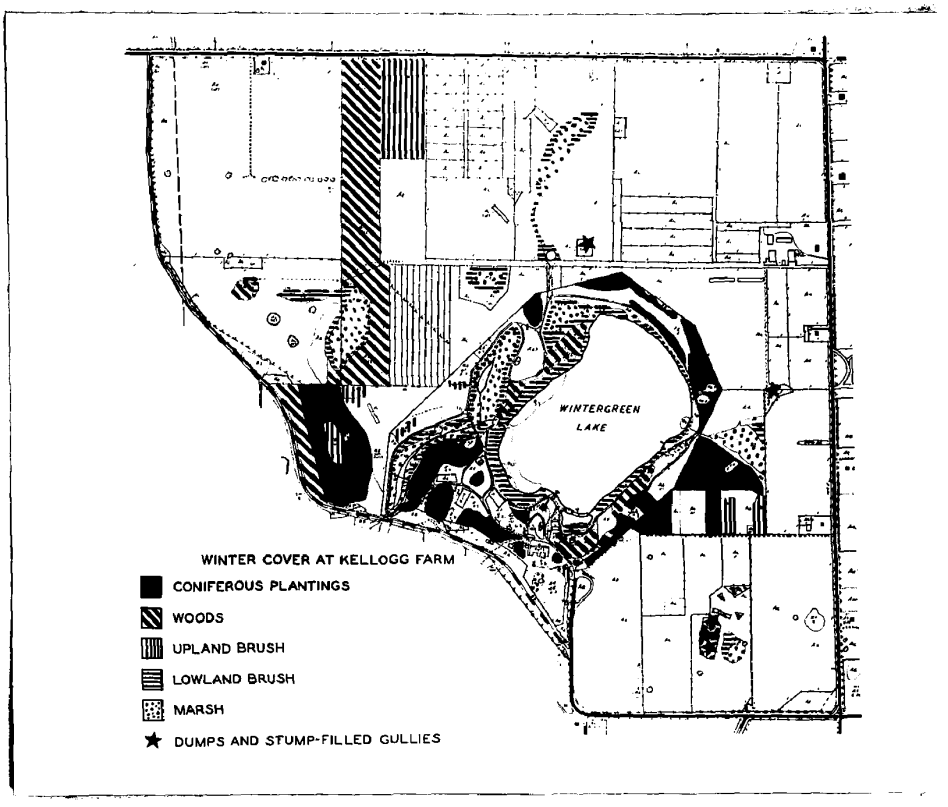

WINTERGREEN
LAKE
WINTER COVER AT KELLOGG FARM
CONIFEROUS PLANTINGS
WOODS
UPLAND BRUSH
LOWLAND BRUSH
MARSH
DUMPS AND STUMP-FILLED GULLIES

Figure 4

VEGETATION

This portion of Michigan was originally covered by a subclimax forest of oak and hickory. That this is a seral stage dependent upon edaphic conditions is shown by the occupation of the richer and more mesophytic soils by beech and maple, which may be considered the true climax for this region and which may be expected gradually to replace the more xerophytic oak-hickory stage. As the region has been recently glaciated, the topography is still young. A great variety of conditions exists between the hydrophytic lakes on the one hand and the xerophytic hills on the other. As the hills are eroded and the lakes are filled the mesophytic areas increase (Cowles 1901) and may, under natural conditions, be expected eventually to characterize the region.

The nature of the original forest was described by Durant (1880) and by Thomas who, writing in 1869 says, "--the surface is rolling--and is composed principally of oak openings with some beech and maple skirting the river and some of the creeks."[2] As the Kellogg Farm supports no beech-maple the entire area may be considered developmental from the standpoint of succession. The hydrosere[3] is represented in the kettle holes and

[2]Kalamazoo River.

[3]The parts of this area that are now covered by oak woods have, since the advent of man, never supported any other type of cover. Hence these areas may be said to have developed by natural stages with no artificial interference. This type of natural sere is designated a primary succession or prisere. The lowest stage of this natural succession is open water; hence it is a hydrosere. The alternative condition is succession starting from bare soil or rock. In such a case the unit succession is termed a xerosere. All the stages of a natural xerosere do not occur on this area.

Wintergreen Lake, while the stages of the xerosere may be found on the upland. As the latter are artificial in origin (due to the activities of man) they are classed here as belong to a secondary succession in contradistinction to the natural, or primary, hydrosere (Weaver and Clements 1929). The sere is used as a convenient vehicle for the presentation of habitat data. The natural, or prisere, is given first, with later a discussion of the main type of secondary succession found here (succession from plowed ground). The artificial plantings are treated under the heading "Artificial cover types".

Habitat Types on Kellogg Farm

In this work the term "predominant" has been used to indicate animals active throughout the year. From the same standpoint all others are "seasonals" (Smith 1928). In designating an animal species as "characteristic" of a given habitat it is implied that the species has shown a marked predilection for that type of environment. Species may not be listed as characteristic of any habitat on the area either because observations are too few to justify it, or because the animal has made intensive use of several habitats. Thus such important animals as the cottontail rabbit, skunk, and pheasant cannot be said to belong to any particular habitat, considering their behavior during the entire year.

The primary succession (a hydrosere)

Open water habitat

This habitat is present only in Wintergreen Lake. It is not treated in this study and is mentioned only as the initial stage in the hydrosere. A list of the fish and amphibia found in the lake is given in the appendix (see check-list of vertebrates for the area, p. 165).

Marsh habitat

The total area of this habitat is approximately ten acres. It is divided into six principal units, the largest of which is the long swale along the outlet of Wintergreen Lake on the sanctuary. Although the water level here is variable, it does not normally fluctuate to the extent that it does in undrained marshes. The level of the lake itself must drop several feet before these swales become dry. The undrained kettle holes on the area (four in number) are, typically, small units of marsh surrounded by a narrow belt of swale brush. These two habitats are clearly defined and hence are discussed separately. Swales are much influenced by the amount of rainfall in any particular season. During an exceptionally dry year the buttonbush of the brushy margins actively invades the marsh. A correspondingly wet year retards this invasion.

The marsh habitat varies considerably with the season and with the extent to which the deposition of humus in any particular swale has tended to fill it in and to render the area more xeric.

In the deepest parts of the swales the water is several feet in depth and the bottom is soft undecayed humus. Here the most characteristic

hydrophyte is Nymphozanthus advenus (yellow pond lily). Polygonum coccineum (water smartweed) is often found in pure growths, particularly along edges where the rhizomes extend beneath the soil and connect with sprouts on the bank. In May of 1935 the water of the swales was in many places completely covered with the small thalli of the floating liverwort Ricciocarpos natans. In this season duckweeds were very scarce. In the 1936 season little Ricciocarpos was present, but the duckweeds Spirodela polyrhiza and Lemna minor occurred in small quantities. Waterfowl fed upon all these natant plants.

In shallow parts of the water a solid stand of Typha latifolia (cat-tail) sometimes occurs to the exclusion of all other species. This plant is found more sparingly in the swales that become dry in late summer. Here Carex sp. (sedge), Phalaris arundinacea (reed canary grass), Calamagrostis canadensis (blue-joint grass), and Polygonum sagittatum (arrow-leaved tear-thumb) are more common. In one swale Eleocharis palustris (spike rush) occurs. Other common plants of this habitat are Asclepias incarnata (swamp milkweed), Rumex verticillatus (swamp dock), and in shaded places Impatiens biflora (jewel weed).

A small swale on the east side of the farm has been drained by a ditch leading into the lake. There is no standing water here at any season and conditions are dryer than in the other marsh areas. A very few square feet of moist ground at the center are occupied by Polygonum Hydropiper (water pepper) and around it an extensive solid growth of Polygonum sagittatum extends out to the edges of the former marsh. We find a similar

condition in the dryer portions of other kettle holes. The above plants, as well as Polygonum Persicaria (lady's thumb), Polygonum acre (smartweed), and Polygonum orientale (prince's feather), are to be found around the lake and the various swales where moisture conditions are favorable. Many of these species produce winter foods of value to seed-eating birds.

The following animals may be considered characteristic of the marsh habitat on this area:

Amphibians

Pseudacris triseriata (Swamp tree frog)

Hyla crucifer (Spring peeper)

Rana pipiens (Leopard frog)

Reptiles

Emys blandingii (Blanding turtle)

Birds

Agelius p. phoenicus (Redwing blackbird)

Botaurus lentiginosus (American bittern)

Porzana carolina (Sora rail)

Anas p. platyrhynchos (Mallard duck)

Mammals

Ondatra z. zibethica (Muskrat)

All of the above Amphibia are inactive in winter. The birds also are absent at this season. The muskrat alone is active throughout the year and thus is the only predominant animal of this habitat.

Figure 5. An undrained kettle hole on the Kellogg Farm showing willow brush in the foreground, an extensive growth of reed canary grass in the marsh, and the Farm woods in the background.

Figure 6. The appearance in winter of the same kettle hole shown in figure 5.

Figure 5

Figure 6

Lowland brush habitat

The irregularity of this habitat and the fact that it occurs in small units render its total area difficult to compute. It is probably near eight acres. Its spotty distribution and the fact that it often is present in long narrow strips make it of more importance to animal species than would be inferred from its actual area. This habitat borders most of the shore line of the lake and forms a brushy margin around the greater portion of the swales.

The lowland brush habitat may be divided into three principal types. Cephalanthus occidentalis is a well-defined type which exists in comparatively pure stands in the wetter portions of the habitat. Exceptionally wet weather retards its invasion of the water but does not kill it out. In dry years it makes rapid progress.

A second type of swale brush, usually found outside (away from the water) and on dryer soil than the buttonbush, is characterized by a mixture of Cornus candidissima (gray dogwood), Cornus Amomum (silky dogwood), Cornus stolonifera (red-osier dogwood), Sambucus canadensis (black elder), and various less plentiful shrubs such as Rosa sp. (bush rose), Viburnum Lentago (nannyberry), Amelanchier canadensis (service berry), and others. The mixed shrubs constitute the most extensive swale brush type. It is variable, often with one of the constituents, such as gray dogwood, red-osier dogwood, or elder, forming a pure stand locally.

A third distinct type of lowland brush is willow. In spots of low sandy soil that are not too wet Salix longifolia (sandbar willow) flourishes.

The stems are typically from eight to ten feet in height and grow in close, pure stands. The best example of this growth is in the large kettle hole on the west side of the farm. In much the same type of situation an active growth of Populus tremuloides (quaking aspen) is sometimes found. The young shoots are often mixed with the shrubs, and in dryer places the larger trees may assume dominance.

There are numerous other plants that are typically associated with the above brushy types. Salix Bebbiana (Bebb willow), Salix petiolaris, and Salix discolor (pussy willow) are common as shrubs, while Salix nigra (black willow) and Salix amygdaloides (peach-leaved willow) become large trees and occur as individuals here and there along the swale and lake margins. In openings among the larger shrubs Spiraea alba (meadow sweet), Rubus idaeus strigosus (red raspberry) and such herbaceous forms as Urtica gracilis (nettle), Thelypteris palustris (swamp fern), and Phytolacca americana (pokeberry) are common. Cuscuta pentagona (dodder) and Polygonum scandens (climbing false buckwheat) are often found vining through the marsh plants or over the buttonbush respectively.

This habitat forms the most important natural winter cover on the area. Although many animal forms use it, few are restricted to it. The greatest discrimination in favor of the swale brush is shown by certain species of nesting birds.

Birds

Dendroica a. aestiva (Yellow warbler)

Empidonax t. trailli (Alder flycatcher)

Dumtella carolinensis (Catbird)

Melospiza m. melodia (Eastern song sparrow)

Mammals

Zapus h. hudsonius (Meadow jumping mouse)

Peromyscus leucopus noveboracensis (Northern white-footed mouse)

Blarina b. brevicauda (Short-tailed shrew)

Of the above animals the white-footed mouse and the short-tailed shrew are predominants.

Lowland woods habitat

Lowland woods is the least extensive of the major habitats found on the Kellogg Farm. It is present only as a trace that tends to mix with the upland woods on low ground. Around the large kettle hole at the south end of the farm woods is the best-defined unit. It is probably less than an acre in extent, although mixture with the upland type makes difficult the setting of limits. North of the outlet of Wintergreen Lake, between the lake and the swale, the presence of considerable red maple gives the growth a low woods character, although the upland oaks are numerous here also.

The most definitive species of this habitat are Acer rubrum (red maple), Ulmus americana (American elm), and Fraxinus americana (white ash). Associated with these trees Laportea canadensis (wood nettle), Impatiens biflora (jewel weed), and Parthenocissus quinquefolia (Virginia creeper) are common. Due to its limited extent no vertebrate animals in particular can be said to characterize the habitat on this area.

Upland woods habitat

On the farm and sanctuary there are approximately 30 acres of oak woodland, which is divided into four principal areas. The largest of these is in the northwest quarter of the farm and is a little under 20 acres in extent. Another plot of woodland lies on the southwest boundary. The latter is all second growth, having been completely cut off within recent times. Only about two acres of this is within the area studied. The trees are from six to ten inches in diameter, and there is a considerable admixture of Populus grandidentata (large-tooth aspen). This species, as would be expected, is fast giving way to the oaks. The oldest oak areas are on the sanctuary. To the southeast of Wintergreen Lake the growth lies in a divided strip of less than three acres. On the northwest side of the lake the "sanctuary woods" forms a unit of about two acres. Cutting has not been extensive in these areas and many of the trees (18 to 24 inches in diameter) may be considered a part of the original forest.

As before stated the upland oak woods represents the most advanced seral stage present on this area. The largest woodlot of twenty acres functions most characteristically, due to its size, and is referred to in this description.

The trees most typical of the habitat are oak and hickory. Of the three species of oak present Quercus velutina (black oak) is the most abundant, with Quercus borealis maxima (red oak) second in importance. Quercus alba (white oak) is the least common of the three. Among the oaks is to be found a fairly constant mixture of Carya glabra (pignut hickory), Prunus

serotina (wild black cherry), Acer rubrum (red maple) and, in spots, Fraxinus americana (white ash). The red maple and ash are more characteristic of the low woodland habitat but often occur as secondary species in the upland oak woods of this region, becoming more numerous in locations of greater moisture.

A few of the oaks are from 18 to 24 inches in diameter. These probably were young trees when the first cutting was done in this locality. Stumps in varying stages of decay show that selective cutting has very probably been going on for fifty years or more. Around the larger and older stumps will sometimes be found a stand of young oaks nearly uniform in size. All the dead, hollow, and misshapen trees have been removed recently for firewood. Few ground logs are present and these are small.

The woods is naturally open in character and in spots a few individuals of Cornus florida (flowering dogwood) or Malus coronaria (wild crab) occur, with here and there a fairly dense growth of Sassafras officinale (sassafras). In areas of increased insolation a sparse tangle of Rubus allegheniensis (blackberry) and Rubus idaeus strigosus (red raspberry) is produced. Individuals of Ribes floridum (wild black currant), Ribes cynosbati (wild gooseberry) and a bush rose, Rosa sp. are to be found at intervals in the stand.

Throughout most of this habitat there occurs a sparse growth of Poa pratensis (Kentucky bluegrass), Poa compressa (Canada bluegrass), or a find grass-like sedge, Carex sp. The moss Polytrichum sp. is common in the more shaded portions.

Among the characteristic herbs of the woods floor are Claytonia virginica (spring beauty), Hepatica americana (hepatica), Viola cucullata (blue violet), Erythronium albidum (white dog's-tooth violet), Geranium maculatum (wild geranium), Polygonatum pubescens (Solomon's seal), Podophyllum peltatum (May apple), Smilacina racemosa (False Solomon's seal), and, in the more sunlit grassy portions, Antennaria canadensis (everlasting) and Galium sp. (bedstraw). Claytonia, Erythronium, and Podophyllum, in particular, tend to form noticeable vernal socies.[4]

On the whole, most of the woodland gives evidence of being well-drained and in spots rather dry, as evidenced by the presence of such plants as Poa compressa, Antennaria, and Sassafras. Ecotones between the woodland and other types of habitat are in most places well defined.

The following vertebrates occur typically in the oak upland habitat:

Amphibians

Hyla v. versicolor (Tree frog)

Birds

Buteo b. borealis (Red-tailed hawk)

Corvus b. brachyrhynchos (Eastern crow)

Myiarchus crinitis boreus (Northern crested flycatcher)

Vireo olivaceus (Red-eyed vireo)

[4]The developmental equivalent of the society (Weaver and Clements 1929). In this case a seasonal socies.

Mammals

Sciurus niger rufiventer (Fox squirrel)

Glaucomys v. volans (Flying squirrel)

Tamias striatus lysteri (Eastern chipmunk)

Peromyscus leucopus noveboracensis (Northern white-footed mouse)

Of the above vertebrates the fox squirrel, white-footed mouse, and crow may be designated as predominants. All others of the indicated species are seasonals. The tree frog and chipmunk are inactive in winter, while the red-tailed hawk, crested flycatcher, and red-eyed vireo are absent due to migration.

The secondary succession (a xerosere)

Plowed ground

As this is the initial stage in an important man-made succession, it is here ranked as a habitat in the sere. No discussion is needed.

Annual weed and cropland habitat

The acreage planted to annual crops varies somewhat from year to year, but averages about 60. Slightly more than one-half the farm (277 acres) has been cultivated, but much of this is usually kept in pasture or hayfields. As before mentioned, the cultivated fields lie on the east and north borders of the farm.

A cornfield most typically represents the annual weed stage in the succession from plowed ground and may be taken as a good example for description. The plants that first appear on newly broken ground are such annuals as Ambrosia elatior (ragweed), Amaranthus graecizans (tumbling pigweed), Chenopodium album (lamb's quarters), and Amaranthus retroflexus (redroot). Grasses characteristic of the first season's growth are Panicum capillare (panic grass), Setaria lutescens (yellow foxtail), Setaria viridis (green foxtail), and Eragrostis cilianensis (stink grass). Digitaria sanguinalis and Digitaria Ischaemum (crab grass) are often found on cultivated ground and in low fields Echinochloa crusgalli (barnyard grass) is apt to be common. Practically all of these ruderals produce fruits that are used as food by winter birds, thus making weed and croplands the most productive habitat from this standpoint.

It is commonly observed that the annual weed stage follows the

breaking of the ground regardless of what the existing plant cover may be. It has been demonstrated that the seeds of these annuals are present in practically all soils, only awaiting favorable conditions to germinate. An experiment initiated by Dr. W. J. Beal in 1879 indicates that the seeds of some species may remain buried and viable for more than 50 years (Darlington 1931). In Woburn barley soil Brenchley and Warington (1930) found more than 150 seeds of Chenopodium album per eight and two-thirds square feet. Chippindale and Milton (1934) demonstrated the seeds of annuals in the soil of permanent pastures that had not been cultivated for many years. That this phenomenon has an important influence upon animal life, particularly in winter, cannot be doubted.

Only one vertebrate species appears to make cultivated fields its permanent habitat. It is active during the entire year.

Peromyscus maniculatus bairdii (Prairie deer mouse)

Grassland habitat

The extent of this habitat can not be accurately stated. It increases as cultivated fields are allowed to revert temporarily to grassland pastures and diminishes as these are plowed for cultivated crops. Grassland is extensive and interdigitates with all the other habitats on the area. Probably one-fifth of the farm usually supports such cover.

The grassland habitat is very reflective of edaphic conditions. The better soils in this vicinity support a rank growth of Poa pratensis (Kentucky bluegrass). The dry, less fertile uplands are extensively

occupied by Poa compressa (Canada bluegrass). Other grasses occurring commonly are Dactylis glomerata (orchard grass), Cenchrus pauciflorus (field sandbur), Phleum pratense (timothy), Bromus tectorum (downy brome grass), and several cultivated grasses that have been used for experimental purposes at the Kellogg Farm.

Some of the more common weeds found growing in grasslands are Verbascum Thapsus (mullein), Cirsium lanceolatum (bull thistle), Erigeron canadensis (horse-weed), Erigeron annuus (daisy fleabane), Plantago lanceolata (buckhorn), and Rumex Acetosella (sheep sorrel).

On the sanctuary ten years of constant pasturing by geese has practically eliminated the grass that formerly grew on the open slopes. As a consequence, these areas are almost entirely occupied by Plantago lanceolata, Potentilla canadensis (cinquefoil), Hypericum perforatum (Saint John's wort), Erigeron annuus, Erigeron canadensis, and a few other species of similar habit. The more dry and sterile soils where erosion has begun are in spots covered principally by the moss Ceratodon purpureus. Of the above species of plants Erigeron annuus, Hypericum, and Erigeron canadensis form well-defined seasonal socies in the order named from June until August.

The following birds and mammals characterize the vertebrate life of the habitat:

Birds

Otocoris alpestris praticola (Prairie horned lark)

Ammodramus savannarum australis (Eastern grasshopper sparrow)

Pooecetes g. gramineus (Eastern vesper sparrow)

Spizella p. pusilla (Field sparrow)

Mammals

Peromyscus maniculatus bairdii (Prairie deer mouse)

Microtus p. pennsylvanicus (Eastern meadow mouse)

Citellus t. tridecemlineatus (Thirteen-lined spermophile)

Of the above-named species all of the birds are absent part of the year due to migration. The spermophile hibernates. Thus the two species of mice are the only predominants.

Upland brush habitat

The largest area of upland brush is a cut-over woodlot of seven acres which lies next to the woods on the north side of the farm. Other small or very sparse units are scattered here and there over the farm and sanctuary aggregating, perhaps, three acres. The habitat is one of the least extensive on the area.

Several species of woody plants characterize the upland brush habitat as it occurs on this area. In the well-drained sandy soil of the vicinity Sassafras officinale is almost sure to be present. Rubus allegheniensis (blackberry), Rubus occidentalis (black raspberry), Rubus idaeus strigosus (red raspberry), and Rosa sp. (rose) commonly form a thick tangle. One of the most typical trees of this type of cover is Crataegus sp. (hawthorn), and oak brush is likely to be an early invader. Over these trees, brush heaps, and through the briars a heavy growth of Vitis vulpina (wild grape) is frequently found. Rhus copallina (dwarf sumach) is often

very common in such habitats.

In the seven-acre brush area on the farm the most common herbaceous species are Poa pratensis, Pteridium latiusculum (bracken fern), Monarda fistulosa (wild bergamot), and Solidago sp. (goldenrod). Asclepias syriaca (common milkweed) also occurs here.

A distinct type of upland brush in this region is Rhus typhina (staghorn sumach) which grows on grassy hillsides where insolation is high and conditions tend to be xeric. This species grows in pure close stands. It is seldom found mixed with other woody plants and is a poor type of cover for animal life.

The northern white-footed mouse (Peromyscus leucopus noveboracensis) is perhaps the most characteristic animal of this habitat. It is active throughout the year.

Upland woods habitat

Invasion of the upland brush by oak and hickory eventually results in its displacement by the upland oak woods. This habitat has already been discussed.

Figure 7. The annual weed and cropland habitat as illustrated by a cornfield in the fall of 1936.

Figure 8. Chenopodium album (lamb's quarters) growing on cultivated ground. This plant produces quantities of food for seed-eating animals in winter.

Figure 7

Figure 8

Artificial cover types

Coniferous plantations

In 1927, when the area was purchased, large plantings of conifers were made on the 80 acres of the sanctuary and the hilly parts of the farm adjoining to the east and to the west. The stands vary in extent from a few scattered trees to five acres of massed pines. The species most commonly used were Pinus sylvestris (Scotch pine), Pinus resinosa (red pine), Pinus Strobus (white pine), and Picea canadensis (white spruce). Smaller numbers of Pinus nigra austriaca (Austrian pine), Pinus ponderosa (western yellow pine), and Picea Abies (Norway spruce) have also been used. On the sanctuary small clumps of Thuja occidentalis (white cedar) and Juniperus communis depressa were planted. Approximately 20 acres have been planted to conifers and the plantings are scattered over an area of about 100 acres, extending from west to east across the farm and including the sanctuary.

The coniferous plantations were made, for the most part, in grassland, and this cover type is present wherever the pines are spaced far enough apart for any other plants to grow. The most characteristic animal of the smaller spruces and junipers is, perhaps, the chipping sparrow (Spizella p. passerina). The large trees are a favorite nesting site of the eastern mourning dove (Zenaidura macroura carolinensis) and the eastern robin (Turdus m. migratorius). The white-footed mouse (Peromyscus leucopus noveboracensis) is also commonly found here.

Deciduous plantations

In the summer of 1935 a study was made of cover distribution on the Kellogg Farm by the Michigan Department of Conservation. Banks, gullies, edges, and corners of fields over the farm were fenced off and planted to oversized nursery stock. Most of the species used were food-bearing shrubs. Some of the genera most commonly represented were Cornus, Viburnum, Berberis, Amorpha, Lonicera, Symphoricarpos, Ligustrum, Rosa, Ptelea, Morus, and Eleagnus.

During the severe drouth of the 1936 growing season these plantings made poor progress and many of the shrubs died. For the period of this study the planted areas have not been an important habitat type and hence can be passed over with little comment. These shrubs are ideally situated to improve the cover distribution of the farm, but their growth to date has not been sufficient for them to serve an important function in this respect.

SEASONAL CHANGES

In order to impart a clearer picture of the changes which this animal environment undergoes it will be well to review briefly the main differences in its seasonal aspects.

In summer the area is characterized by very dense cover everywhere. The vigorous plant growth of this season provides a plentiful basic food supply for herbivores and through them, all other species. Insects, frogs, and other forms are abundant, and the young of all species are present as food and as the consumers of food. The capacity of the area for supporting life reaches its height in summer. Although the numbers of animals present and their activity are at a maximum, the observation of terrestrial forms is extremely difficult due to the sheltering greenery that is everywhere.

In the autumnal aspect the green of summer is gone. Killing frosts have reduced herbaceous vegetation, though it is still important as cover. In wooded areas the ground is thickly layered with leaves. The chief characteristic of autumn, however, is the tremendous abundance of mast, fruits, and seeds. All this does not remain to support resident winter populations, since large flocks of migrant birds demand a large food supply. The foods that are present in fall depend to some extent upon the nature of the growing season that went before. However, abundance is the rule despite the fact that insects are rapidly disappearing and many other forms are becoming inactive.

In winter a variety of conditions may exist; but there is usually considerable snow on the ground in this region, which effects material changes in ground cover. Under deep snow herbaceous vegetation becomes of very minor importance. Thick brush, conifers, or holes in the ground become the retreat of species that need such protection. Large open areas that supported abundant life in summer appear to be deserted in winter. Animal populations and food supplies diminish to their lowest point late in the season, although the early melting of snows may increase the availability of foods to some extent. Winter is the season of the progressive destruction of what the summer has produced.

In early spring vegetation has reached its lowest point, although the disappearance of the snow renders available as cover the more enduring herbaceous plants of the summer before. This absence of snow also makes possible the gleaning of the last remnants of the fall abundance of fruits and seeds. As new plants begin to grow, insect life awakens and many species start to breed. Gradually with the advent of migrant birds and the increasing vegetation the activity of summer is resumed.

PART II THE ANIMAL LIFE OF THE AREA

The widely varying habitats of this portion of Michigan harbor correspondingly different animal populations. The biota of a creek bottom will be found to differ materially from that of an upland farm in an adjacent section of land. Although the region as a whole presents a heterogeneous pattern of distinct communities, nearly any 10-mile square will be found to contain a large portion of the vertebrate species occurring anywhere in southern Michigan.

In the appendix is given a list of all the vertebrates recorded on the Kellogg Farm during three years. Alone, this check-list would give a very poor picture of the associated species living here. Numerous forms listed have been recorded only once on this area, although they may be common within a few miles. In neighboring creek bottoms, in particular, the fauna contains many species not found on the farm. In a glance at the Amphibia a conspicuous lack of salamanders is noticed. Only one salamander has been recorded here in three years, although a particular effort was made to find them. There is only one record of the pickerel frog, which is common around near-by spring-fed streams. The green frog and wood frog are present only in small numbers, while the leopard frog is very plentiful. The Fowler toad and the American toad are both common. Snakes are not numerous on the farm, the ribbon snake probably being most frequently seen. Turtles are abundant both in the lake and in the swales. The list of birds for the area is very complete in the case of waterfowl and sparrows, but is limited for warblers. The sparrow hawk is not often seen here, though it is common a few miles away. The swamp sparrow, Henslow sparrow, indigo bunting, and short-billed

marsh wren are seldom observed on the area, although they may easily be found in certain habitats not far distant. A red squirrel has been found on the farm only once; yet two miles to the east it is common in the tamaracks around Augusta Creek. The only record for a fox[5] was in February 1937, when one animal left tracks on the area for several nights. No star-nosed mole has been captured during this work, but one was taken here in 1933. Bats have been seen here but none collected. Only two pine mice and one least shrew have been taken in three years. The animals of infrequent occurrence are probably of little significance in the bionomics of the area, and they need be little more than mentioned here.

[5]The red fox recorded in the check list was identified on the basis of these tracks. There was little doubt that the animal was this species as the grey fox is very rare in this region.

POPULATION STUDIES ON CERTAIN ANIMALS

In the following pages will be given the results of an attempt to ascertain the numbers present of the species of resident upland birds and mammals. The work has been most intensive on the cottontail, fox squirrel, skunk, opossum, pheasant, and quail. Data on hawks and owls are restricted to field observations.

Methods

The census methods used on the larger mammals varied somewhat and are discussed under the several species. In general, trapping and marking have constituted a basis for the work. A line of from 20 to 70 box traps (fig. 9) was run from October to April during both winters of the study. Figures 10 and 11 give the distribution of traps during the two winter seasons. Traps were placed, for the most part, in brush cover, as this was particularly desirable from the standpoint of the rabbit study. The baits used were an ear of corn and one-half of a chicken. The corn attracted rabbits, squirrels, pheasants, and quail. The chicken was an efficient bait for skunks, opossums, and house cats. Both baits usually were used in the same trap.

Pheasants and quail were censused by traversing the area with as many men and dogs as were available. The numbers of men used varied from 5 to 12, and there were usually from 1 to 4 dogs. Every part of the farm was included, the more dense cover being worked most intensively. Birds flushed

were marked down and duplicates avoided as much as possible. This method was by no means perfect; but a repetition of such censuses, together with regular field work and the results of trapping and banding, appear to have given a fairly accurate indication of the number of birds on the area.

The habitat preferences and relative abundance of mice and shrews were ascertained by operating a line of 200 ordinary mouse traps during fall, winter, and spring, as time allowed. The traps were set three feet apart and baited with peanut butter. The work of Townsend (1935) indicated that this bait would be acceptable to all of the species present here. Field observations on tracks, burrows, and nests also were usedful indices of the abundance of small mammals. The population numbers of these animals are indicated only relatively.

In giving a numerical value to an animal population it is necessary to state the time of year for which the census is calculated. Populations are being continually augmented in the spring and summer breeding season and steadily reduced in winter. Nearly all of the figures for this area represent the winter season. For most species it has not been possible to be more specific than this, but for the rabbit a definite date is given. Population figures are, of course, only approximate.

Figure 9. Box traps covered with quarter-inch-mesh hardware cloth were used in taking the larger mammals.

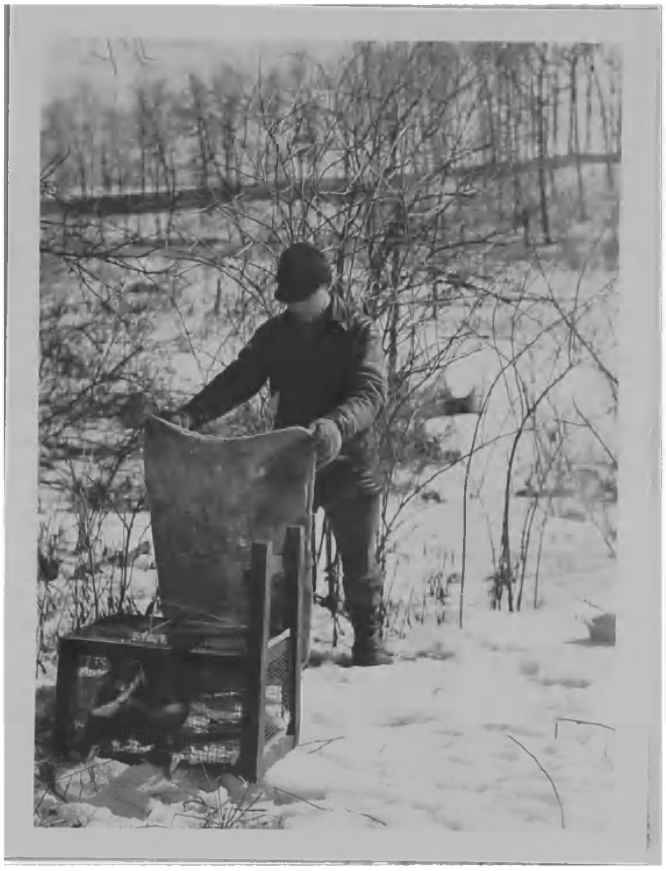


Figure 9

Figure 10. Distribution of box traps during the winter of 1935-36.

Figure 11. Distribution of box traps during the winter of 1936-37.

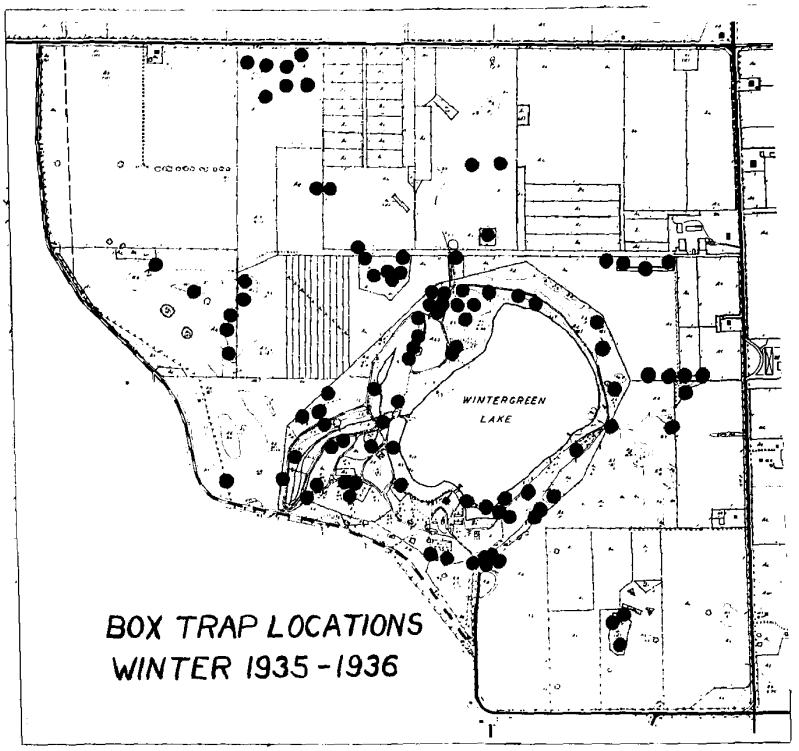


Figure 10

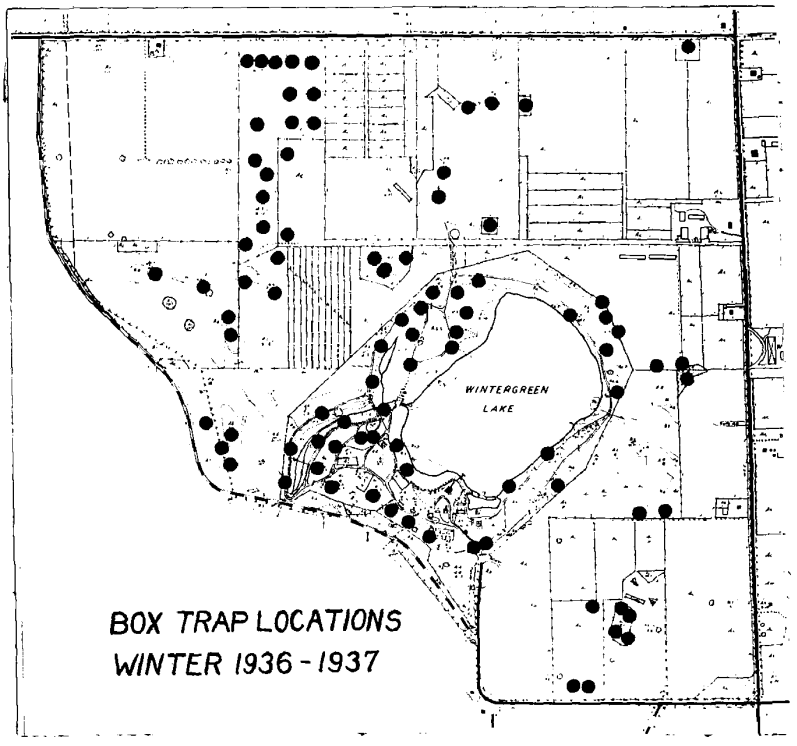


Figure 11

Cottontail Rabbit

The section of land here treated has been known for many years as good hunting territory for cottontails. The increase in the natural coverts since 1927 and the planted conifers appear to have made the area even more favorable to this species.

Technique

After preliminary experiments with apples, oatmeal, wheat, and scratch feed, it was found that the best bait for rabbits was an ear of corn. The chief advantage of this bait was that it was not carried away by mice nor easily covered up by snow. Intensive rabbit trapping was started on January 1, 1936. At this time it was apparent that rabbits had gathered into cover patches all over the farm. Hence traps were confined, for the most part, to these locations (fig. 10). As tracks were nearly absent from open fields and less than 30 traps were available at this time, it was necessary to use the latter as effectively as possible. Throughout this study traps have been placed where signs showed rabbits to be most plentiful. As the trapping was confined chiefly to late fall and winter, the greater part of it was done in deciduous brush, coniferous plantations, planted washes, and dumps, where rabbits were most numerous at this season. Table 1 gives the summarized rabbit trapping data for the entire study.

TABLE 1

SUMMARIZED RABBIT TRAPPING

Period	Trap nights	Individuals handled	Repeats	Total catch
Dec., Jan., Feb., Mar. 1935-36	3,342	70	366	436
Oct. 31 - Dec. 17, 1936	2,045	102*	96	187
Jan., Feb., Mar. 1937	5,289	24	94	106
Totals	10,676	182**	556	729

*Including repeats on some rabbits marked in former trapping periods.

**The rabbits marked formed a numerical series from 1 to 181. There was one uncorrected duplication that makes the total number of individuals 182. Several rabbits were taken by methods other than trapping and so are not included in the total catch by trapping; they are, however, represented here in the total of marked rabbits.

In this study rabbits were marked by tattooing a number on the inside surface of the right ear. The rabbit was placed in a small cloth bag and the ear slipped out through a hole. A sharp pen was dipped in black carbon ink and the number stippled in by puncturing the skin. Such numbers were permanent and easily read.

Census of December 1935

In 1935 rabbit shooting began at the sanctuary and farm on December 3. During the month of December a total of 154 rabbits were killed on the 500 acres. In the trapping period from January 1 to March 31 individual rabbits taken and marked numbered 63. In addition to these, 11 more unmarked rabbits were recorded as mortalities.[6] Hence 228 individual rabbits were handled. If there was no general movement of rabbits onto or from the area during the period of the shooting and the period of trapping, the above number of animals represents a minimum population figure. For those who consider "hunting pressure" as a force tending to drive rabbits off the farm, it is to be pointed out that most of the surrounding land was also being hunted. On the other hand, for those who would consider the hunting on the farm as tending to evacuate favorable habitats which would tend to be filled by an influx from outside, it must be remembered that an apparently similar reduction of the population density was taking place outside the area. Range records show that there is a marked tendency for individuals to remain in a given locality when the ground is covered by snow in the winter. There is no indication of a trend of movement onto or from the farm. There is, however, no actual proof that such a movement did not take place, and this is a possible source of error that may be evaluated in a number of different ways.

[6]Three additional mortalities in which the ears were eaten by predators were probably marked animals (from circumstances). They are not added here as it is likely that they are already included in the total of 63. There is a possible error of three in the total of handled rabbits.

TABLE 2

RABBIT TRAPPING BY MONTHS

WINTER 1935-36

	Dec.*	Jan.	Feb.	Mar.
New rabbits caught	3	37	15	8
Total individuals handled (old and new)	3	39	44	27
Total repeats	0	85	197	84
Trap nights	12	608	1,064	1,658

Individuals caught on Farm	63
" " " Kellogg Estate	7
Total rabbits marked to April	70

*Only three days' trapping included.

If it is postulated that rabbits were not driven off the farm by the shooting and did not gravitate to the area to occupy desirable habitats in which the population was reduced, the main question regarding this type of census is whether or not a large percentage of the rabbit population was handled. Table 2 shows that during January, plus three days in December, 40 rabbits were marked. In February the number of new rabbits caught declined to 15. In March the number of new rabbits dropped to eight. A progressive decline in the number of new unmarked rabbits caught is to be expected as more and more of the population are marked. The fact that only eight new animals were taken during March would tend to show that the

trapping job had accounted for a large portion of the rabbits on the farm. As shown by figure 12, however, the efficiency of traps dropped significantly during March, and this fact must be considered in evaluating the results. It is not possible to say how many unmarked rabbits remained after April 1. It seems probable, however, in the light of subsequent work, that if this number were known, our minimum population figure of 228 would not be increased enough to alter greatly conclusions as to the status of the species on this area. Probably a more reliable basis for judging the census is obtained from the results of an entirely different type of population count taken during the following winter season.

Census of December 1936

In the fall of 1936 facilities were at hand for a census employing the "banding returns" principle which Lincoln (1930) suggested could be used in calculating the abundance of American waterfowl. The plan was to mark as many rabbits as possible over as short a period as possible. Immediately, then, a large number would be shot. From the percentage of marked rabbits in the kill the total population might be calculated. The relationships of the quantities may be expressed by the formula, $A/B = C/X$, in which X equals the total rabbit population and C equals the number of rabbits marked. A and B equal the marked rabbits shot and the total rabbits shot, respectively.

Figure 12. Correlation of rabbit trap efficiency, as calculated by 10-day periods, with snow depth in January, February, and March 1936.

Figure 13. Correlation of rabbit trap efficiency, as calculated by 10-day periods, with snow depth in January, February, and March 1937.

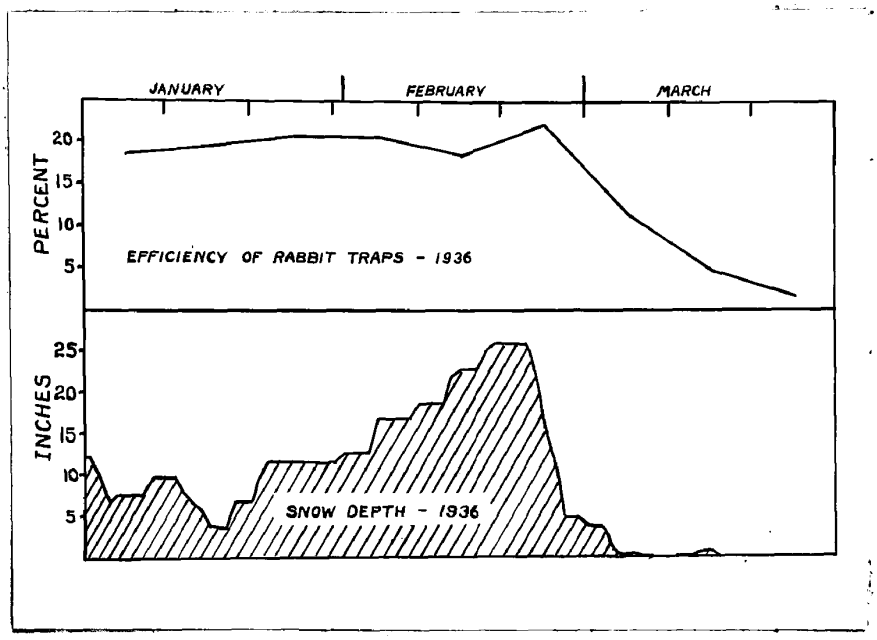


Figure 12

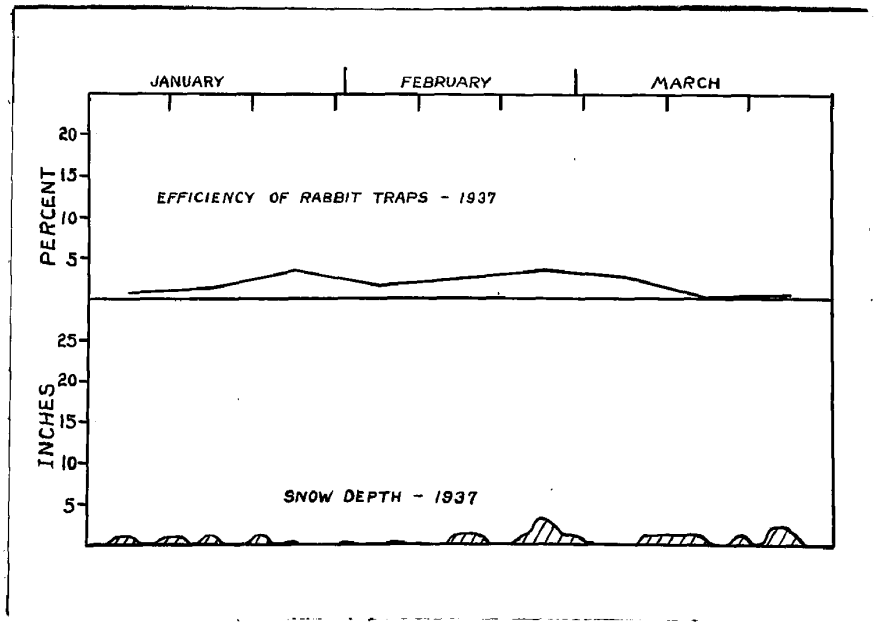


Figure 13

Accordingly on October 31 trapping was begun in the winter coverts (fig. 11, p. 47). During the following six weeks 92 rabbits were trapped and marked. In addition, eight rabbits were taken which had been marked during the preceding winter, and two of which had been taken in a box trap set for cats on the sanctuary a few weeks previously.[7] Thus a total of 102 marked rabbits were known to be alive during the period of six weeks and six days.

TABLE 3

RABBIT TRAPPING BY MONTHS

FALL AND WINTER 1936-37

	Nov.	Dec.	Jan.	Feb.	Mar.
New rabbits caught	70	22	9	2	1
Total individuals handled (old and new)	73	61	21	19	7
Total repeats	25	71	27	47	20
Trap nights	979	1,066	2,021	1,820	1,448

Individuals caught on Farm (in this period) 114

Total rabbits marked to April 1 181

On December 18, 19, and 20, in a systematic hunt covering the entire area, 126 rabbits were shot. As rabbits were killed the locations were marked on a map in the field (fig. 14). In the total kill 57 rabbits

[7]Several such traps were operated at various times and the few animals caught were turned over to me for marking.

were found to be marked. The total population, then, was calculated as follows:

$$\frac{A}{B} = \frac{C}{X} \qquad \frac{57}{126} = \frac{102}{X} \qquad X = 225.4 \text{ rabbits}$$

Probably the most uncontrollable variable in a census of this type is the unrecorded mortality (and possible movement) that occurs among the marked animals during the trapping and shooting period. The shorter the period can be made the smaller will be this error. In the present census this figure amounts to what mortality occurred among a number of rabbits that progressively increased from 1 to 102 in seven weeks. This is probably the greatest unknown in the census.

There are, however, other possible sources of error in this type of census. If any part of the farm had been intensively trapped and not intensively hunted, the indicated relationship of the members of the proportion would not be true. Also if any important rabbit habitat had not been trapped, but had been hunted, a similar error would be introduced. These possible inaccuracies were anticipated and every effort was made to include all of the rabbit habitats in both the trapping and shooting. It is believed that this was very efficiently carried out. On the map in figure 14 are given the locations where every marked and unmarked rabbit was taken.[8] A comparison of this map with that giving trap locations (p. 47) will show that there was little disparity between the areas trapped and those shot

[8]These locations indicate, in all possible cases, where the rabbit was flushed. Where this was not definitely ascertained, the location at which the animal was first seen was used.

Figure 14. Locations at which marked and unmarked rabbits were shot in the census of December 18, 19, and 20, 1936. If this map is compared with that in figure 2, it will be seen that these animals were largely concentrated in deciduous brush and coniferous plantings.

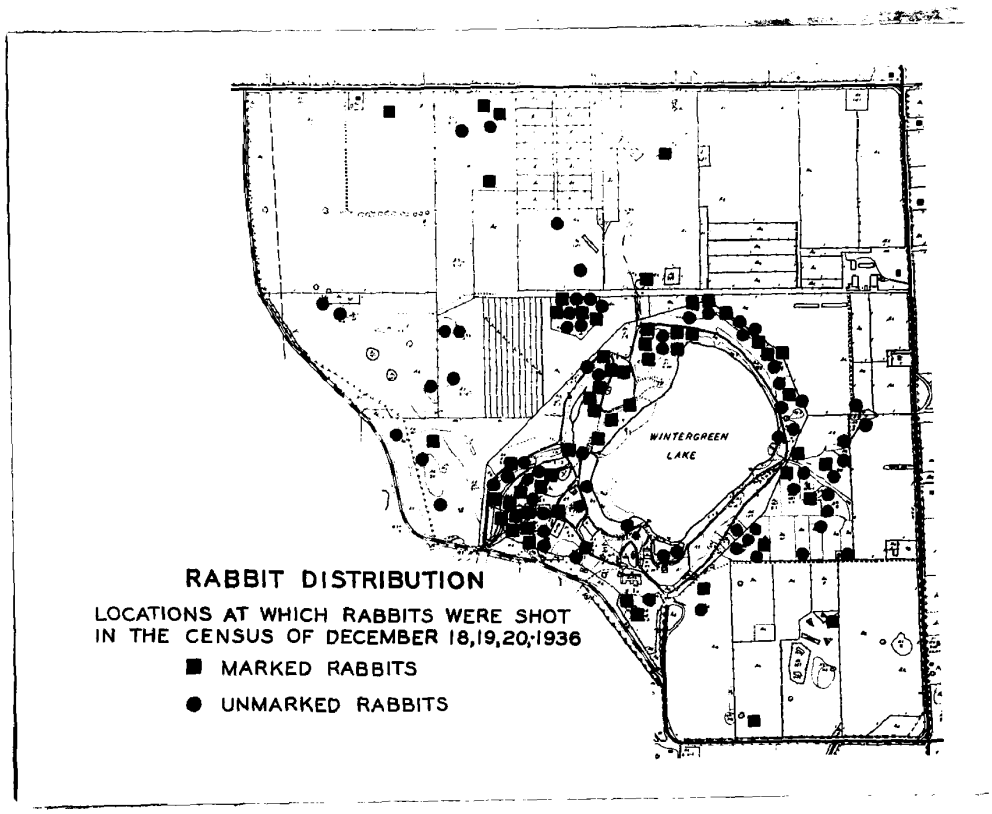

WINTERGREEN
LAKE
RABBIT DISTRIBUTION
LOCATIONS AT WHICH RABBITS WERE SHOT
IN THE CENSUS OF DECEMBER 18,19,20,1936
MARKED RABBITS
UNMARKED RABBITS

Figure 14

over. If there was no great inequality one way or the other, it is quite probable that the minor errors of judgment would tend to cancel out. As for the mathematical errors of the count, these are dependent upon the size of the population and the percentages of the rabbits that were marked and shot. The population appears to have been about 226 animals; and of these 45 percent were marked, and 55 percent were shot. It is improbable that sufficiently large mathematical errors occurred to distort seriously the result.

Evaluation of winter inventories

In considering the two census methods used it is evident that the one employed in the fall of 1936 is the most reliable. During the first winter of the work, trap efficiency was high (fig. 12). This is correlated directly with deep snow, which concentrated rabbits in cover patches and probably rendered the bait more attractive. Thus we were enabled to handle a large part of the population, and what appears to be a good approximation of the number of animals present resulted. Our census of the following fall showed the population to be much the same, but the winter that ensued was a season of little snow and comparatively high temperatures. Trap efficiency was low. Since, of the 226 rabbits indicated to be on the area, 126 had been killed in the census and 10 more had been shot in December hunting after the census, there were probably about 85 rabbits (allowing a few for animals shot but not retrieved in the hunting) on the area. Yet of this number only 27 individuals were handled in the next three months (as compared with 63 the winter before). Obviously the efficiency of the method first used depended upon weather conditions and would have been entirely

inaccurate during the second season. The marking ratio method, however, was dependent upon traps only during seven weeks in November and December. During this period, despite a lack of snow, the bait in the traps was attractive to rabbits. The fact that the population was considerably more than 50 percent higher than it was late in the winter also probably contributed much to the efficiency of the traps and the success of the method. From the results of this study the marking ratios method appears to be a reliable one for censusing rabbits on areas such as this.

In comparing the results of the two censuses for these two years a close approximation is obtained. In 1935-36 the census (calculated as of December 3) indicated 228+ rabbits. In 1936-37 an entirely different type of census (calculated for December 18) gave a result of 226 rabbits.

The fact that there was only two rabbits difference between the two counts does not, of course, indicate a proportionate accuracy in the censuses. Probably any one of the errors involved in either method is large enough to produce a greater discrepancy than this, even if the populations had been the same. The fact that the two census figures would fall within nearly any estimation of the values of the errors involved in each is the point of real significance. Since the second census was not subject to the most important unknown of the first (i. e. an unknown unhandled surplus of rabbits and the possibility of movement during the long trapping period) it may be considered, in a limited degree, a check on the first method. There is no guarantee that the populations were nearly the same, but there was no apparent difference in the numbers of rabbits present in the two years as

judged by field observations during the hunting period.

As to the possibility of using other census methods, no other system proved feasible in this study. Attempted censuses with dogs proved to be hopelessly inadequate. Springer spaniels were used on bird censuses and the highest number of rabbits seen in a day of field work covering the entire area was 21. If enough men are used to drive over patches, the possibility of counting individual rabbits several times is high. In addition, rabbits that are holed up will not be counted. Droppings and tracks have been useful indices of abundance in comparing habitats, but for estimating actual population numbers over a large territory, they have in the present case been found to be entirely unreliable. These results are in keeping with those of Trippensee (1934). He tried similar methods, which are described as (a) the sample area pellet count, (b) dog-census, (c) man count, and (d) track-feeding method. None of these was found to be satisfactory.

Spring population 1936

The best clue to the size of the spring population on the Kellogg Farm comes from the trapping of February and March 1936. An index may be obtained from the number of individual rabbits handled (and thus known to be alive) during this period of 60 days. Some rabbits doubtless escaped handling and some mortality (in rabbits counted) probably occurred. The difference between these two opposing errors is the real error.

In the trapping of February and March, 45 individual rabbits were handled (including both rabbits newly marked and old repeats). During most

of February, trap efficiency was high, averaging near 20 percent. Rabbits were concentrated in cover patches where the box traps were located. When, however, the snow melted late in that month, rabbits apparently spread out and more green foods became available. Trap efficiency dropped to around 2 percent and continued low throughout March (fig. 12). Thus the chances of a rabbit's being handled after late February were considerably diminished, although during most of that month they were good. Considering these facts, and allowing a few for mortality, it seems likely that the April population of cottontails was near 50, or 25 pairs of potential breeders.

Productivity of land

If the above figures are used, a December (1935) population of near 228 cottontails furnished a hunting season kill of 154 and left a population which on April 1 was about 50. This spring breeding stock produced a December population of near 226. Of these, 136 animals were shot and approximately 85 were left, out of which another spring breeding stock would survive. In terms of land units the Kellogg Farm during these two seasons has in December supported one rabbit per 2.1 acres.[9] It appears to be possible for this area to produce consistently a hunting season crop of about 150 rabbits, or one rabbit per 3.2 acres of land.

Seton (1929) states, "It is established that no wild animal can stand a heavier drain than 20 per cent. per annum of its total numbers." Based upon this and using the estimated annual kill (100,000,000) he

[9]On a basis of 480 acres of land (i. e. allowing for Wintergreen Lake).

calculates the total population of the United States to be not less than 500,000,000 cottontail rabbits. Although the above conditions may hold for the country at large, it appears to be possible for a local population to support a considerably larger annual kill than that indicated. Unless the figures presented for the Kellogg Farm are subject to a much larger error than they appear to be, the population here has endured an annual toll of more than 50 percent. However, there may be conditions here, such as the large amount of coniferous cover, that render the area somewhat exceptional. This can be judged only when similar work is done on different territory.

Summary

Box traps baited with an ear of corn were used in capturing rabbits. Under conditions of deep snow, trap efficiency was about 20 percent. Certain individual animals were inclined to develop trap habit. In one case a rabbit was taken 30 times in slightly more than two months. Rabbits were marked by tattooing a number in the right ear. By adding the total December kill to the total number of rabbits handled in the traps during January, February, and March, a minimum population figure of 228 rabbits was obtained for the winter of 1935-36. In December 1937 a census by the "marking ratios" method indicated a population of 226 rabbits. The second census method was found to be the more reliable as it is not so much dependent upon weather and indicated a true population figure rather than a minimum one. The spring rabbit population (1936) of the Kellogg Farm was probably near 50. The December population density was apparently one rabbit per 2.1 acres. It is indicated that this area can consistently produce a hunting season crop of 150 rabbits, or one animal per 3.2 acres of land.

Fox Squirrel

Oak openings in the primitive forest evidently were a most congenial habitat for the fox squirrel. It is not surprising to find the species common in this region where even yet, for an agricultural district, a comparatively large portion of the land is in oak woodland. The grazing of woodlots probably harms the fox squirrel less than any other game species.

Technique

In this investigation it was not possible to employ optimum trapping methods on every species. A much better study could have been made on the fox squirrel had this been the only consideration. These animals were taken in the box traps baited with ear corn. Although comparatively few traps were placed directly in oak woods, the extent to which squirrels travel on the ground rendered them comparatively efficient. The open wire trap is not well adapted to the handling of this species. These animals often fight furiously to break through the hardware cloth and sometimes succeed at the expense of torn claws, worn teeth, and a badly scratched head. Squirrels are very susceptible to shock and exposure to severe weather. As a result, many mortalities occur. In a total of 161 times that squirrels were handled in traps on the Kellogg Farm, 21 individuals were found dead.

During the first winter of the study these animals were marked by cutting a large V in the right ear. This did not designate individuals but merely indicated that the animal had been taken previously. During the second year individuals were marked by clipping a toe or a combination of two

toes. Neither method is to be recommended. Ear notches in some marked squirrels appeared to heal over in a year until it was not possible to make sure the animals had been handled. Although there was no observed incapacity in toe-clipped animals, it would seem advisable to find a different method for an arboreal species.

Numbers present in 1935-36

During this winter fox squirrels were very abundant in the oak woods of the farm and sanctuary. In the winter trapping period 52 individuals were marked and 9 unmarked animals were recorded as mortalities. Thus 61 squirrels were handled, and we have a minimum figure for the early winter population. It is unlikely that all of the squirrels were caught, although it seems probable that a fairly high percentage of them were. There is no good criterion by which the actual size of the unmarked surplus can be estimated.

Numbers present in 1936-37

Due, evidently, to the action of a serious epizootic[10] in the spring and summer of 1936, the squirrel population in the fall of that year

[10] A mange-like disease probably identical with that described by Errington (1933) appears to be endemic among the squirrels of this vicinity. In the spring of 1936 it appeared to spread widely among this species on the Kellogg Farm and in Midland Park. Numerous animals were seen with patches or nearly all of the hair missing, and several sick and dying squirrels were observed and others reported. An examination by Dr. Don R. Coburn, then pathologist of the Game Division, Department of Conservation, revealed no cause for the condition, which took the form of a severe dermatitis accompanied by extensive exfoliation of the skin.

was considerably lower than in 1935. On the farm, squirrels were seen much less often, and in Midland Park the comparative scarcity of the species was even more manifest. The cottages in Midland Park are built among a uniform growth of oak trees. Protection from shooting has been nearly complete, and squirrels have become very common. Any difference in numbers is readily noticed by the residents here, and reports in the fall of 1936 were unanimous in the opinion that the number of squirrels had taken a marked drop. Although from 20 to 40 box traps were operated from November 1 to December 18 on the farm, squirrels were caught only 8 times. However, this may be partly due to the abundance of fall food (notably acorns) which made the corn in the traps less attractive. For the entire trapping period 24 individuals were marked and liberated and 15 unmarked squirrels were recorded as mortalities. The minimum population figure, then, is 39.

Evaluation of data

Considering everything, the figures 61 and 39 can be taken as fairly good indices of the numbers of animals present in the two seasons. The fact that more traps were used and more set in the woods during the second season would tend to neutralize any reduction in efficiency of operation resulting from the open winter. The fact that there was six weeks' trapping in the fall of the second season also tends to swell the total for that year. Any discrepancy in technique appears to be in favor of the 1937 period. However the variables involved are too many and too little understood in the light of squirrel behavior to justify a more specific attempt to correct these figures.

Few population figures have been found in the literature. One is cited by Seton (1929). Near Austin, Texas in a "squirrel bush" of oaks, pecans, and red elms, an area of about 100 acres was alleged by a game warden to have a population of probably 500 fox squirrels. If this estimate and the figures given above for the present area are at all reliable, it would seem that even what appeared to be an abundance of squirrels at the Kellogg Farm in 1935 is not necessarily the maximum population density that the species may reach under some conditions. In the Texas area the population was about five squirrels per acre, while at the Kellogg Farm in the fall of 1935 the population was (on the basis of 30 acres of woodland) 2 squirrels per acre. As fluctuations appear to be an invariable characteristic of rodent populations under natural conditions, each of these figures can be taken to represent a temporary condition only. The true productivity of a habitat must be calculated by averaging the population numbers for a large number of years. For some sample areas in Missouri Bennitt and Nagel (1937) found that the maximum population density was one squirrel per 2 acres of woodland. They add that "—such a heavy concentration seldom occurs." For the southern half of that state they found that one squirrel per 8 acres was a fair average. Presumably these sample areas were open to hunting, and the numbers given may be applicable to similar conditions in Michigan. Appearances would indicate that the 1935 concentration at the Kellogg Farm seldom occurs under ordinary conditions where the animals are hunted.

Eastern Skunk

Of the type of habitat favored by the skunk, Seton (1929) says, "--he loves variety--dry, rolling land, well watered, and alternated with sun and shade. In open fields, mixed with dense cover, he finds his ideal home." This might indeed be a description of the area around the Kellogg Farm, which certainly is very favorable to this species. Mr. William Parks, fur buyer in Augusta, reports that this area produced an excellent yield of skunk furs each season for many years before the establishment of the sanctuary. From 1927 to 1931 intensive predator control was practiced at the sanctuary and many skunks were killed. After that time smaller numbers were taken until the fall of 1935. During this investigation none was killed on the farm between the spring of 1935 and when animals were taken for breeding studies in 1937.

Technique

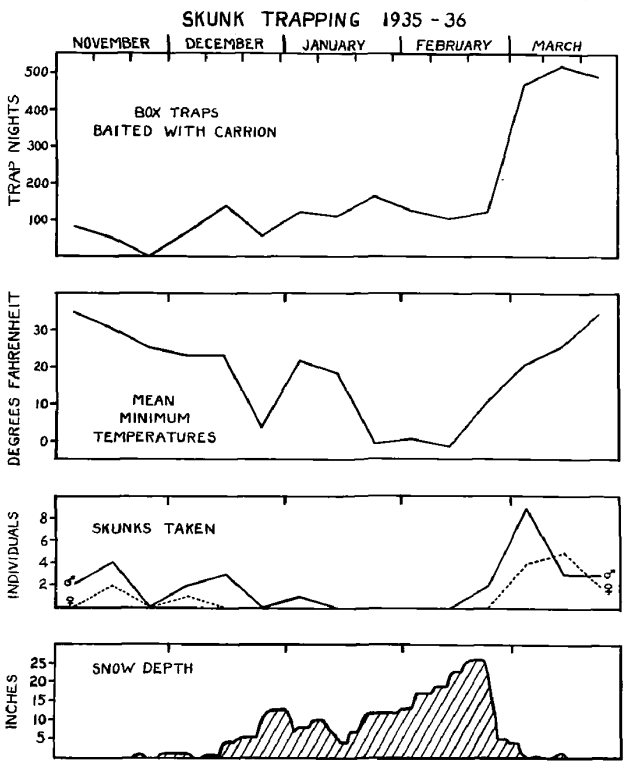
Preliminary experiments during 1934 and 1935 showed that in fall and winter fresh carrion was an efficient bait for skunks. At the large poultry plant of the Kellogg Farm dead chickens were nearly always available. Hence the bait for box traps was standardized at one-half of a chicken. The box traps used were, in general, well adapted to the taking of skunks. Their chief disadvantage lay in the fact that skunks would, at times, tear a hole in the hardware cloth and escape. For skunks alone heavy guage, inch-mesh poultry wire would be preferable as a trap covering.

During the 20-month period from October 1935 to June 1937 a total

of 143 individual skunks have been handled on Section 8 or near-by. Of these 83 were taken for the first time in box traps, 22 were dug from burrows, 31 were caught in steel traps, and 7 were found dead on the highway or elsewhere. Live skunks were handled 191 times and were taken in box traps a total of 165 times. The largest number of repeats for any individual was 6, and the average was 1.7.

Skunks were handled by covering the trap with burlap and dumping the animals into a bag. They were removed from the bag and manipulated by a hold on the base of the tail and the back of the neck. Marking as individuals was done by toe clipping and was satisfactory except for the tendency of skunks to lose toes in traps. There were a few cases of uncertain identity due to this factor.

Figure 15. Male and female skunks taken in box traps as correlated with temperature and snow depth in the winters of 1935-36 and 1936-37. Trap-nights, temperature, and skunks trapped are calculated for 10-day periods.


SKUNK TRAPPING 1935 - 36
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TRAP NIGHTS
500
400
300
200
100
BOX TRAPS
BAITED WITH CARRION
DEGREES FAHRENHEIT
30
20
10
0
MEAN
MINIMUM
TEMPERATURES
INDIVIDUALS
8
6
4
2
SKUNKS TAKEN
♂
♀
INCHES
25
20
15
10
5
SNOW DEPTH

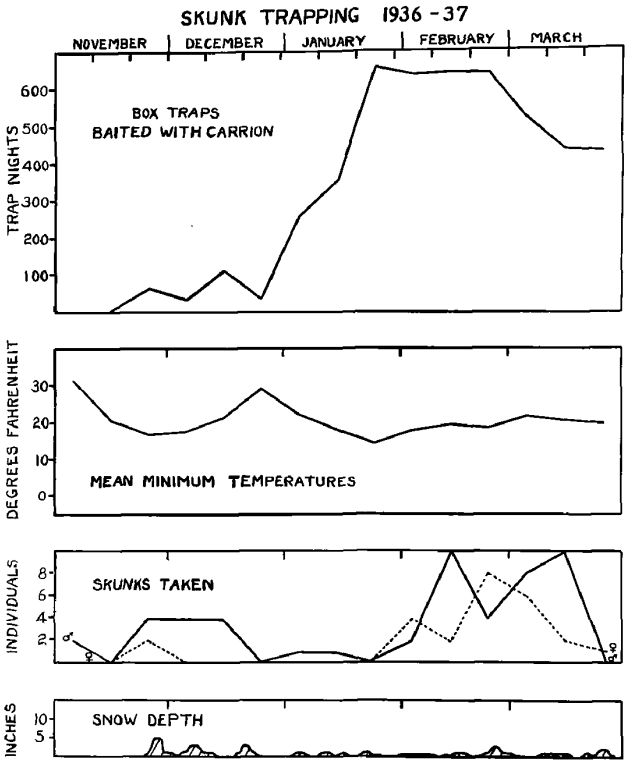

SKUNK TRAPPING 1936 - 37
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TRAP NIGHTS
600
500
400
300
200
100
BOX TRAPS
BAITED WITH CARRION
DEGREES FAHRENHEIT
30
20
10
0
MEAN MINIMUM TEMPERATURES
INDIVIDUALS
8
6
4
2
SKUNKS TAKEN
♂
♀
INCHES
10
5
SNOW DEPTH

Figure 15

Numbers present in 1935-36

The first skunk was captured on October 21, 1935. On January 2, 1936 the fourteenth skunk was taken. During the very cold winter weather no skunks were caught in the traps, and the next animal appeared on February 26. From then on skunks were taken regularly, and by April 12 a total of 30 different animals had been trapped and marked. All of these were caught on the Kellogg Farm. Thus at least 30 different skunks were known to have been on the area during this period of 5 1/2 months.

Upon examination of the sex ratio in this group of skunks, however, it was found that only ten were females. Subsequent work showed that a preponderance of males are handled in winter, due to a differential inclination between the sexes to remain holed up during cold weather. A similar condition was found by Cuyler (1924) in Texas and by Hamilton (1937a) in New York. In the 143 skunks handled in this study there were 79 males and 64 females, or a ratio of .447 females of the total population. It appears that there are fewer females because most of the animals were taken in winter when females were relatively inactive. Of 16 skunks handled from July to October (1936) 8 were males and 8 were females. In the light of these indications and subsequent results, it appears that the actual sex ratio here is 0.5.

Since 20 male skunks were captured over the winter, an equal number of females (presumably holed up much of the time) may, perhaps, be assumed; therefore a total of at least 40 skunks is indicated. This figure is not so well substantiated as would be desirable, but it is the best

indication available of the number of animals which to a greater or lesser extent occupied the area during this period.

Numbers present in 1936-37

From September 17, 1936 until March 22, 1937 traps took 29 individual male skunks and 15 females on the Kellogg Farm (sex ratio .34). During this season, however, 19 burrows (selected for appearances of occupation) were excavated, and these accounted for 2 males and 16 females that had not been handled previously in this trapping period. Thus the total catch was 31 males and 31 females (sex ratio 0.5). Just what constitutes a "resident" skunk is difficult strictly to define, but as used here the word refers to animals that were using burrows on this area. Doubtless some of the skunks caught ranged in part over this area, although their customary burrows were elsewhere. This is supported by the fact that of 8 of the animals marked here 5 were retaken in the "turkey marsh"[11], 2 in Midland Park, and one was followed to a burrow at near-by Duck Lake.

Since an intensive job of trapping was done during the early part of 1937, it appears probable that a large part of the male animals ranging over the farm were caught. The best indication of resident skunks, however, (not animals using the area, as was calculated for the previous season) comes from the females taken from burrows.

[11]A 60-acre area in an adjacent section of land to the northwest. It is owned by Mr. Kellogg, and the sanctuary turkey flock has been kept here--hence the name.

TABLE 4

RESULTS OF SKUNK DEN EXCAVATION 1937

No.	Date (1937)	Locality	Situation	Skunks found ♂	♀	Total	Remarks
1	1/12	Kellogg Farm	Hillside in field	1	10	11	Burrow at least a year old
2	1/22	"	Bank of wash	0	0	0	Old burrow
3	1/22	"	Edge of wash	1	0	1	Male from burrow no. 1, 1/12/37
4	1/28	"	Side of ditch bank	1	10	11	Two skunks previously handled in traps
5	1/28	"	Open grass-land	0	0	0	Old burrow
6	2/ 3	"	Sweet clover field	0	0	0	"
7	1/29	"	Under brush heap	0	0	0	"
8	2/10	"	Island in swale	0	0	0	Fresh tracks leading in and out
9	2/10	"	Grassy hill-side	0	6	6	All from burrow no. 4
10	2/11	"	Sweet clover field	0	0	0	Tracks and fresh nesting material
11	2/12	"	Ditch bank	0	0	0	Tracks leading in and out
12	2/15	"	Lowland brush	1	0	1	Tracks leading in and out
13	2/12	"	Lowland brush	0	0	0	Tracks plentiful

No.	Date (1937)	Locality	Situation	Skunks found ♂	♀	Total	Remarks
14	2/12	Kellogg Farm	Lowland brush	0	4	4	All from burrow no. 4
15	2/15	"	Base of tree	2	0	2	A male opossum also in burrow. 1 ♂ skunk from burrow no. 4
16	2/16	Turkey Marsh	Upland woods	0	0	0	Old burrow
17	2/16	"	"	1	0	1	Male from burrows no. 4 and 15
18	2/17	Kellogg Farm	"	0	0	0	Very large nest of leaves; rabbit remains
19	2/18	"	Base of willow tree	0	0	0	Old burrow
20	2/18	"	Lowland brush	0	0	0	Old burrow; tracks
21	2/19	Duck Lake	Upland woods	0	0	0	Tracks numerous
22	2/19	"	Lowland brush	0	0	0	Skunk had been followed into this burrow two days previously
23	2/25	"	"	1	7	8	None handled before
24	3/ 3	Kellogg Farm	Upland woods	0	1	1	Not previously handled
25	3/ 3	Turkey Marsh	"	1	1	2	Female skunk had been marked on K. F. 1/28/37 and retaken there 2/22/37
26	3/ 4	Augusta Creek	"	0	0	0	Skunk and opossum tracks

More than fifty burrows were watched during the winter, and it is fairly certain that those were excavated about which the most skunk signs occurred. As a number of females were in some cases concentrated in a single burrow (table 4) it appears that a few dens on the area contained most of the resident animals of this sex. In all, 22 females were accounted for by digging. Of the 15 females taken in the traps over the winter period nine were not found in any of the burrows. Of these nine, however, one (skunk no. 1) had repeated five times (in 1 1/2 years) and is almost certain to have been a resident. Of the other eight, three were later caught either in the turkey marsh or in Midland Park and were probably non-residents. The remaining five skunks were taken only once, and there is a good chance that these also were non-residents.

Thus of a total of 62 skunks handled we have 23 females that good evidence indicates were residents (22 from burrows and 1 from traps). Since the work indicates an actual sex ratio of 0.5, we may probably assume an equal number of the males as residents. Thus on a basis of available evidence, the winter population of this 500 acres was about 46 skunks.

Evaluation of data

The work during the season of 1936-37 appears to be a much better population study than that of the winter before. In 1935-36 the severe weather rendered more skunks inactive, and as calculations were based on trap returns, the figures are probably low. Neither is it known what proportion of the calculated minimum of 40 skunks that used the area were actually resident skunks. It appears probable that, at least in this region,

an intensive job of digging is the best method of censusing resident animals.

In terms of the winter census of 1936-37 the Kellogg Farm supported a resident population of one skunk per 10.4 acres of land. What the actual annual yield of fur would be, if the optimum number of animals were harvested, is not indicated. However, as the species is probably polygamous and as ordinary trapping in the winter when most females are holed up takes many more males than females (Cuyler 1924)[12], the annual fur crop probably does not inhibit the reproductive potentialities of the population so much as might be expected.

In the literature I have found relatively few estimates of population numbers. Seton (1909) states, "In the dry part of the pond and poplar belt of Manitoba, it would be safe to estimate the skunk at 1 to every square mile. In the prairie region, it is probably a fifth as numerous, and in the pine forest the number may be again divided by five." It is evident that the status of the Hudsonian skunk in Manitoba is much different from that of the Eastern skunk in Michigan. Of the latter species Norman A. Wood (1922) relates that at his home in Lodi Township, Washtenaw County, about 1870, more than 30 skunks were taken in one trap under an old barn. This sounds much more like the conditions found at the Kellogg Farm.

Bennitt and Nagel (1937) have calculated the skunk population of the state of Missouri for the winter season 1934-35. They considered the

[12]I am told by Mr. William Parks, fur buyer at Augusta, that not more than one-fifth of the skunks that he receives in late fall and winter are females.

average litter to number six; thus the breeding potential is 1:6. However, the most common number of young seen with an adult in the fall is four, giving an actual survival ratio of 1:4. The total kill by man for the year in question was 202,747. The mortality from natural causes was considered as one-third of the harvest by man. Hence the total mortality was near 270,000. On a basis of the above ratio of four young to one female, and considering the sex ratio in the "breeding reserve" to be 0.5, the spring population would be about 135,000 skunks. Since a decline in population was noticed, the authors believe that the actual size of this population was nearer 130,000 animals.

The above authors also draw attention to the fact that, in making such calculations, a pressing need is felt for more accurate information on the lives of animals. The values given to the necessary assumptions in such a census are no better than the facts at hand, and in our present state of enlightenment a fairly large error is in some cases to be expected.

If the disproportionately large number of males taken in the trapping season in Texas as shown by Cuyler (1924), in New York as shown by Hamilton (1932, 1937a), and in Michigan as shown by the present work, holds good for Missouri, the sex ratio in the spring would not be 0.5. Hence if fewer males were present, and the animals are polygamous, the spring breeding population would be lower than that computed above.

Ringneck Pheasant

According to local reports the region around the Kellogg Farm has never supported a large population of pheasants. In Michigan in general the pheasant appears to be most common on land that is more level and fertile than this farm. The species has not been hunted here since 1927, and in the summer of 1933 the Department of Conservation liberated 150 birds as a test planting.

Technique

Leopold (1931) has said, "It is more difficult to make a census of pheasants than of any other American species." From experiences here this view is entirely concurred in. The regular routine field work over the entire area gave a fairly consistent indication of the number of birds present. However, at intervals when men and dogs were available, the entire farm was covered in an effort to check all parts as simultaneously as possible.

During this study it was not found feasible to census pheasants before October due to the height of herbaceous cover during summer and early fall. Even in October this difficulty was important, efficiency being higher in November and December. In this work an effort was made to cover the entire farm in one day. In several cases, however, a small portion had to be finished on the following morning.

In these censuses men were lined up and spaced according to the density of the cover. Dogs were worked at intervals in front of the line of

men. In open fields with snow on the ground the sphere of efficiency of a man and a dog was large. However, where even low cover was present a man was of little use, and the dependence was almost entirely on the dog. (See also Wight 1931.) On several occasions it has been possible to stand quietly outside an area of brush and to see a pheasant double back and escape a dog without flushing. Even these animals do not put up every bird. A repetition of censuses was found to be necessary if accurate information on the number of pheasants present was to be obtained. There has been frequent interchange of birds with surrounding areas that very materially altered population numbers.

Daily field work on the farm has also revealed movements from or to the area and served to show population trends. In addition, box traps took pheasants fairly regularly, and the number of individuals trapped in the winter season was a significant index.

From the standpoint of a pheasant study the wire box traps used are not to be recommended. Birds in traps easily become frightened and almost invariably skin the top of the head while the traps are being approached. In this work pheasants have been taken in box traps 73 times and 7 mortalities have resulted from injuries so received. Wire funnel traps were experimented with but were found to be relatively inefficient as used here. A cat and a Cooper hawk caused the death of three birds in such traps. All but three mortalities due to technique were replaced by liberating birds of similar sex reared at the state game farm.

Pheasants were marked with leg bands and, during the second winter,

tails were bobbed to a length of about 6 inches. This did not appear to impair the flying ability of the birds. Such bob-tailed pheasants were easily recognized in the field, although individuals were not indicated.

Population in fall 1935

In 1935 the area was censused on October 14, October 30, and December 20. The first two censuses were taken under conditions of high ground cover and only 400 acres were worked. Dogs could not at this time be used on the sanctuary. In the first census 29 pheasants were flushed, of which 14 were cocks and 15 were hens. In the second, which was relatively inefficient due to a lack of help, 20 pheasants were flushed of which 10 were cocks and 10 were hens. The census of December 20 was taken under more favorable conditions, the whole area was covered, and 28 pheasants were found. In the latter tally 14 were cocks, 13 were hens, and 1 was unknown. In this census it was felt that a fairly accurate approximation of the number of birds on the area was made. All indications point to an October population of between 30 and 35 pheasants on this 500 acres. Evidently the sex ratio was perfect. By December 20 the number was probably very close to the figure of 28 obtained in the census.

Field work showed that pheasants were well distributed over the farm during this period. At least four birds were known to be using both the turkey marsh and the farm. In early fall hayfields and open areas were being much used, but by late December pheasants were most often found in thick brush or conifers. As an index to the late fall population the figure 30 may be taken as a reliable estimate.

Population in spring 1936

A census of the area on March 23 produced 20 pheasants, 6 of which were cocks, 13 were hens, and 1 was unknown. In April the localization of cocks on particular territories, as well as their crowing, made a check on the number of birds comparatively easy. It is fairly certain that there were about 12 hens on the area at this time and from 9 to 12 cocks. Of the latter only 4 or 5, as judged by their regular association with hens, appeared to be mated. During the winter 25 individual pheasants were handled. Five of these were mortalities, leaving 20 birds theoretically alive. Some of the latter may, of course, have left the area and others moved on. Only four broods are known to have been reared on this area and aggregated about 35 young pheasants in June.

Population in fall 1936

A census on October 9, 1936 covering the farm (400 acres) but not the sanctuary showed a total of 22 birds flushed. Eight of these were hens, 13 were cocks, and one was questionable. At least a few pheasants were known to be on the sanctuary, which could not be worked with dogs due to the presence of migrant waterfowl. Evidently the fall population in 1936 was much the same as in 1935.

In December pheasants became fewer in number and by mid-January birds were seldom seen on this area. The pheasants from the farm had, for the most part, moved north and gathered in a large thicket of lowland brush southwest of Duck Lake. This covert lies just across the road from the

northeast corner of the farm. Chicken house litter containing cracked corn was being spread on the corner field of the farm and these pheasants at times fed here in a flock. The largest number counted was 24, but a flock of 15 to 18 was common. A census of the farm was taken on January 22 when this flock was absent. Only five pheasants (four cocks, one hen) were found. Few observations were made during the spring, but breeding birds were again back on the farm.

Summary

The number of pheasants present on the area was indicated by censuses taken with men and bird dogs, by regular field work, and by birds taken in box traps. In late fall of 1935 the population was about 30 pheasants, with the sexes equal in number. The population density was about one pheasant to 16.6 acres. In the following spring the breeding population appeared to be much the same as in the year before. In winter, however, most of the birds of this area moved north into the next section, so that a census in January indicated only about five pheasants on the farm.

Bobwhite Quail

Quail populations in this portion of the state appear to be variable over small areas and short periods of time. The bird is not hunted as game in Michigan and hence its protection on the Kellogg Farm does not render the area exceptional in this respect.

Technique

The quail population of this area was inventoried at the same time as were the pheasants; hence the same methods were used. As quail were in coveys during fall and winter, however, numbers could be fairly well checked merely by locating the coveys present. The principal difficulty was that during the winter quail were often in thick brush and had to be flushed to be counted. Accurate counts could, under these conditions, not always be made. In addition, the regular flushing of the birds disturbed them and evidently served to break up coveys. Catching a portion of a covey in a trap also tended to separate the birds. The interchange of quail between the different groups appeared to be frequent. In this connection Errington and Hamerstrom (1936) point out that they have made it a general policy not to do much banding or collecting on the areas where populations were to be observed under conditions as natural as possible. In some cases coveys could be checked by track counts without molesting the birds, but these occasions were relatively infrequent. In general, it may be said that this work appeared to disturb quail more than any other species that was studied.

Population in fall 1935

In the first fall census (October 14) two coveys of 17 and 7 each were found. In the second of these five of the birds were seen to be juvenals. On October 30 three coveys were on the area and numbered 18, 17, and 5 quail respectively. One covey evidently moved onto the farm late in October. That daily field work was more reliable than infrequent inventories is shown by the results of the December census. At the time of this inventory only 23 quail could be found. Yet during much of early December, field work showed that four coveys aggregating 42 birds were present. A bevy of 14 shifted onto and off the farm several times.

When snows became deep during January and February it was very difficult to follow the movements of the coveys. Birds shifted, ranges overlapped, and groups appeared to split and re-combine. It is doubtful whether by any method an accurate check could have been kept on these quail. A brief summary of observations will indicate the type of activity that occurred.

In January a covey of 14 on the south side of the area (in December) disappeared as residents. They evidently moved south but reappeared from time to time, and 10 of the birds were trapped and banded. Half a mile south a woman began feeding from 15 to 20 quail and it is possible that some of these may have been all or a part of the covey of 14. On the north side of the farm a December covey of 15 also moved off the area, and soon after 18 birds were seen north of the road feeding with a cock pheasant in a patch of corn. As three birds had also been flushed at times, it is

possible that the 18 represented these plus the covey of 15. This is largely supposition, however, as the three may have moved south on the farm and joined other birds. A group of 10 quail near the middle of the area in December remained near a feeding station in January and were local in range but not always constant in numbers. Several times five or six birds flushed instead of the usual number. In February a covey of 15 quail appeared on the southwest side of the sanctuary and were fed there in a swale.

The nearest that I can come to tracing the history of a covey is one that was almost undisturbed in an experimental food patch in the turkey marsh. In February hemp projected above the snow and was fed upon by these quail, which roosted in the open. On February 11 there were 12 birds. Three days later there were still 12, but by the last of February the number had decreased to nine. On March 18 and 20 only six birds were flushed. Evidently the covey was breaking up at this time.

From the above discussion it is evident that any fixation of a population figure for this area in fall or winter would be somewhat arbitrary. The maximum population appears to have been 42, although shifts altered this considerably.

Population in fall 1936

In late summer of 1936 it appeared that two broods that had been reared on the farm joined to form a covey of 25. In September these quail moved north into the turkey marsh and did not return to this area. During the fall and winter only 10 quail were present here and these at times evidently moved into the next section to the north. The maximum population

for the second fall season thus was 10. At times no birds at all were present here, although there were bevies to the south and to the north on other areas.

There is little indication of the actual numbers present in spring. In 1935, 1936, and in 1937 quail were well distributed over the farm, and pairs were seen frequently. During the spring of 1936 as many as five calling males could sometimes be located almost simultaneously.

Summary

The activity of quail has been characterized by frequent movements onto and off the area; thus populations have fluctuated radically. Evidently the maximum number of bobwhites that have been on the farm in two years is 42--the number present in early December 1935. In late fall and winter of 1936-37 the maximum number of quail found here was 10 and at times none at all was on the farm. On such a small area as this it is difficult to assign a numerical value to the quail population, due to the frequent changes resulting from the movements of coveys.

Species of Lesser Abundance

The New York weasel appears to be present in relatively small numbers throughout most of its range (Audubon and Bachman 1849). Seton (1929) estimates its maximum numbers as a pair to the square mile during primitive times in Manitoba. From bounty records, he computes a population of about five to the square mile in Pennsylvania. The largest concentration of weasels that I have found recorded is indicated by Miner (1923), who took 57 of these animals in three traps during one summer. Tracks in winter were the best indication of weasel abundance on this area. On a basis of such evidence the weasel population of the Kellogg Farm was about half a dozen animals in January 1937. Tracks were centered around such areas as a Microtus colony on the south side, the sanctuary woods, a button-bush swale near the center of the farm, and the oak-hickory brush on the north side. Three weasels were taken in box traps during late winter. All of the animals handled were males.

The house cat has been one of the most consistent animals on the area from the standpoint of numbers and activity. In all kinds of weather cats have been found active, and whenever tracking conditions were good, field work indicated that from one to five animals had probably visited the area. During the first year of this work 30 individual cats were caught in the traps. Inasmuch as many of the animals taken were probably pets, they were kept for two days, in case they were called for. Of the 30 taken 23 were not claimed and were killed. During the second winter all that were caught were killed immediately and the stomachs preserved. Twelve cats were

taken from September 1936 to April 1937. Evidently some of the animals found on the farm were abandoned by summer residents in Midland Park, and "drift" from other localities probably replenished the population here, much as on several areas cited by Leopold (1931). Only one case of breeding here is known, a female having borne a litter in one of the sanctuary buildings. The average number of cats on the farm at night was probably four or five.

The opossum has within the past 20 years extended its range northward into Michigan (Seton 1929). At the Kellogg Farm it is not now abundant, opossums having been taken in traps only 30 times during the two winters of the work. Twelve individuals were marked by toe clipping. Three of these animals were juvenals taken in the fall of 1936. In the total of marked animals six were males and six were females. There is little to indicate the number of animals usually present, though from tracks and trap records in winter it probably was not more than three or four.

In summer raccoon tracks have frequently been observed in the swales on the sanctuary. Two of these animals were seen at dusk on an evening in October 1934, and one (a female) was captured in a box trap in April 1936. In accordance with the sanctuary policy it was necessary to deport the latter animal and liberate it elsewhere. There are several more sight records of raccoons and all were obtained in summer. No tracks have been seen after October, and the species was undoubtedly absent during the winter. Probably not more than two or three have been present at any one time in summer.

There is only one record of a fox on this area in two years. In January 1937 one of these animals hunted here for several nights and one was reported seen in the next section to the north. No other signs of the species have been found.

Woodchucks are not common on the area at present, although reports indicate that they were when the farm was established. Old burrows are very numerous, and doubtless many were originally dug by this species, although they are now used by skunks. Woodchucks have been seen only three times in three years. In addition, two specimens were caught in steel traps in the farm woods in the spring of 1937.

On one occasion (January 1936) during the day two great horned owls were located almost simultaneously in the farm woods. Two birds have rarely been heard calling, but more than this are not known to have been present at one time. It may safely be said that ordinarily not more than one horned owl was on the area. Although regularly observed only in winter, the species has occurred intermittently here in summer. In June 1936 one of these owls was caught in a chicken coop a mile south of the farm. In June 1937 young chickens were disappearing from the poultry yard on the Kellogg Farm. Steel traps were set and two horned owls were caught.

During the winter of 1935-36 from one to three Cooper hawks were regularly to be found on the farm. In the following winter the number was larger, appearing to vary from two to five. During the latter season three or four hawks could frequently be seen in the course of a day's field work. The difference in size between the sexes and in color between adults and

juvenals often made it possible to count individuals with little chance for error. Most of the hawks seen on this area, however, have been juvenal females.

Small Mammals

Of the two species of ground squirrels on the area the thirteen-lined spermophile is by far the most abundant. Although their burrows are not found on cultivated ground, these rodents inhabit every grassy fence row and all the meadows and permanent hayfields, as well as the open areas on the sanctuary. No attempt has been made to compute the numbers of the species. It is sufficient to say that it is the most abundant mammal on the area larger than a mouse and that it is very commonly seen wherever there is open grassland.

The chipmunk is most plentiful in the farm woods, although nowhere does it reach the apparent population density of the foregoing species. In the spring of 1936 one pair inhabited the sanctuary woods. There appear to have been never more than two or three pairs on the entire sanctuary during this work. The species probably is not of great ecological importance on the area.

Flying squirrels have been very infrequently seen during this study. Two were taken in steel traps in the turkey marsh and one was found dead in a box trap in the farm woods. Flying squirrels have also been seen in this woods on two occasions. Their strictly nocturnal habit makes observation difficult, although it is safe to say that they are relatively uncommon here.

Two species of mice are the most abundant mammals on the farm. In the fall and winter of 1935-36 both the prairie deer mouse and the meadow vole were very numerous. In long grass, thick alfalfa, or sweet clover,

meadow mice were common, and many of their globular grass nests were found above ground. On the other hand, all of the open grass areas, hayfields, and even cultivated fields were occupied by the prairie deer mouse, so that for the area as a whole the latter species was very probably most abundant. The dry summer of 1936 appeared to affect the field mice adversely. The population quite evidently was smaller in the following fall and winter than in the season previous. Many of the old colonies were entirely deserted. Numerous traps could be set in such places without taking an animal. A few colonies on the area, however, appeared to be as populous as ever. The drop in numbers appeared to be correlated with the drying up and comparative barrenness of localities that had supported a lush growth of grass or clover during 1935. There was no apparent diminution in the numbers of the prairie deer mouse, and in the second winter there is little question that the latter species was the most abundant mammal on the area.

The white-footed mouse is the most common small mammal in brush and woodland. The two species just discussed, with the addition of this mouse, form the bulk of the small mammal key industry[13] on this area. The woodland mouse is, due to its more restricted habitat, not so abundant here as the prairie deer mouse or the meadow vole; although it is sufficiently numerous to be an important quantity in the food cycle.

The short-tailed shrew may, from its abundance, be added to the three species listed above as an important prey animal on this area. During

[13]See page 107.

the dry summer of 1936 it was common in the farm woods, though none could be taken in fields adjoining. In the following winter few were found in the woods, but the species was numerous in lowland brush. It has also been taken in marsh grass on numerous occasions in winter. The fery dry summer of 1936 apparently restricted this animal to low ground and woodland and may have reduced its numbers. Enough data are not at hand, however, to demonstrate this point.

The prairie mole is very plentiful here and is probably of considerable ecological significance. Its tunnels are found on lawns, in pine plantings, and in grassland everywhere.

Only four individuals of the Cooper lemming vole have been trapped here, and the species may be listed as very infrequent. Only two specimens of the pine mouse were taken, both of which were in the basement of the residence at the sanctuary. Jumping mice have been caught on a few occasions in box traps, but less than a dozen individuals have been caught or seen in three years. These three rodents are probably of little significance bionomically.

Masked shrews are not common on the area. Several have been taken in mouse traps or found dead. Only one least shrew has come to hand. The star-nosed mole has not been recorded during this study, but a specimen was captured on the sanctuary in 1933.

In summary, the most abundant small mammals on this area, which form the small mammal key industry, are the thirteen-lined spermophile, prairie mole, prairie deer mouse, meadow mouse, white-footed mouse, and short-tailed shrew.

ANIMAL INTERRELATIONS

The purpose of the following discussion is to picture, insofar as possible with the data at hand, the mosaic of interrelationships that constitute the life pattern of this area. Species are here considered chiefly from a qualitative standpoint, although little space is given to those that are not of sufficient size or present in sufficient numbers materially to affect the other animal populations. The more abundant upland mammals and birds that characterize the area are dealt with most completely in this portion, as in the foregoing duscussion of populations.

In treating the mutual effects of one animal species on another it appears most convenient to separate the subject into three major divisions. Animals are first considered from the standpoint of where they live. Species associated in the same habitats will obviously be most capable of close interaction. Time of activity is taken as another point of emphasis. The Cooper hawk is probably of little importance to the Virginia rail, as the former, although eminently raptorial in habit, is present only in winter; while the latter, definitely a prey species, is here only in summer. As another example, the screech owl probably seldom feeds upon the thirteen-lined spermophile, as the owl is nocturnal and the ground squirrel is exclusively diurnal. The third consideration has to do with the food habits of animals. This is, doubtless, the most vital relationship of all. It may be considered from two standpoints: Animals of similar habit that compete for food, and the relations of carnivores to the species upon which they

prey. Few species have been studied completely enough in this work to indicate many of the food relations occurring here. Hence the work of others is used wherever it is of significance. In general, what has been found true of a species on other areas can, if properly used, apply here. Such a method is considered definitely a part of this type of ecological research.

Habitat relationships

If an attempt were made to describe transition zones and seasons, this discussion could well become unmanageable. Hence clearly defined types are chosen for analysis, with the understanding that a great variety of intergrading conditions exists. Habitats are arbitrarily grouped for discussion wherever on this area a similarity of use by animals appears to justify it.

Animals associated in summer habitats

In most cases of common resident species certain habitat preferences have been manifest. The New York weasel is an exception to this. These animals or their signs were found in several types of habitat in summer, although observations were not numerous. Weasels in general have been observed in various situations (Burroughs 1900, Nelson 1918, Bailey 1926, Leopold 1927) and it is doubtful whether there is much of a summer habitat discrimination in this species. The animal is considered to be a potential inhabitant of any of the following cover types and is not discussed under the separate headings.

Swales and lowland brush: In the summers of 1935 and 1936 raccoon signs were common in the swales and around the margin of Wintergreen Lake. On one occasion two animals were seen together. Muskrats are always present in numbers during the summer season. These two species are the mammals most typical of this habitat, although in brush along swales the meadow jumping mouse has often been found. The bird life is more varied. The great blue

heron, little green heron, and the marsh hawk have been regularly present, the least bittern, American bittern, and Florida gallinule are occasional, the sora and Virginia rails frequent, and the mallard duck common. The most typical inhabitant of swales is the red-winged blackbird. In and around the brushy margins yellow warblers, goldfinches, and song sparrows nest commonly; and the catbird, brown thrasher, alder flycatcher, and kingbird are frequently seen. Pheasants (particularly cocks) have often been found in lowland brush at this season.

Fields and grassland: The common summer mammals of this habitat are the skunk, house cat, cottontail rabbit, thirteen-lined spermophile, prairie mole, and prairie deer mouse. Woodchucks are present though not numerous. Where grass is deep the deer mouse is replaced by the meadow mouse. Both species have been found in alfalfa fields. The spermophile favors dry, open situations. On plowed ground skunks and the prairie deer mouse are the mammals most often found. The marsh hawk and crow are common over open grassland, and the great blue heron not infrequently hunts here. Red-tail hawks often hover low over the fields. Birds more properly belonging to the habitat in summer, however, are the ringneck pheasant, bobwhite quail, field sparrow, vesper sparrow, grasshopper sparrow, meadowlark, and horned lark. The bobolink, dickcissel, and Henslow sparrow occur here sparingly at times.

Upland brush: In this habitat the skunk, house cat, cottontail rabbit, and white-footed mouse are common. Where grass is long the field mouse is nearly always present. Some woodchuck dens are also found in

upland brush. The birds ordinarily found here are the catbird, brown thrasher, cardinal, goldfinch, mourning dove, chipping sparrow, pheasant, and quail.

The upland coniferous plantings have a well-defined fauna apart from the deciduous type. The cottontail rabbit, the common mole, and the white-footed mouse are nearly always present; and where grass is thick the meadow mouse is common. Robins and mourning doves nest abundantly in conifers, and catbird nests are not infrequent. Pheasants, particularly cocks, are often seen here in summer. The small spruces and junipers are especially favored by the chipping sparrow, which nests regularly in this type of cover.

Woods: The summer population of the upland woods is typified by the fox squirrel, flying squirrel, chipmunk, white-footed mouse, and short-tailed shrew. The latter species showed an especial preference for this habitat during the very dry season of 1936. Woodchuck dens are common here, but skunks appear to be only occasional in summer. Rabbits also are relatively infrequent. The avifauna is characterized by the crow, red-tailed hawk, red-headed woodpecker, flicker, great crested flycatcher, wood pewee, red-eyed vireo, warbling vireo, Baltimore oriole, and blue jay. So little lowland woods being present, it is not characterized by a well-defined fauna on this area. It has been noted, however, that several opossum dens were in this type of habitat.

Animals associated in winter habitats

Fields and grassland: One of the most typical inhabitants of this type of territory is the prairie deer mouse. In situations having a dense growth of Kentucky bluegrass, alfalfa, or sweet clover, winter colonies of the meadow mouse have often been present. Under deep snow, however, Microtus colonies have been observed to move into upland brush or coniferous plantations where they were not present in summer nor in winter when snow was absent. Weasels were frequently found around mouse colonies, short-tailed shrews have been taken in the runways, and skunks were at times active here during periods of mild weather. The prairie mole is most typically found in grassland. House cats have hunted this habitat under all conditions. In the winter of deep snow (1935-36) flocks of from 10 to 100 tree sparrows and juncos, with a few song sparrows, were common in the open fields. Horned larks, in flocks of a dozen or so, were also present. In February, when the snow reached a depth of one and one-half feet the flocks began to disappear until, late in that month, few of these birds were to be found on the area. In the mild winter of 1936-37 there was little snow until March. The songbird flocks of the preceding winter were conspicuously absent. At times hardly half a dozen tree sparrows and juncos were to be found, and horned larks did not arrive until mid-February. Quail and pheasants have been found in the open under many conditions, though most often when snow was not deep. When snow was absent, pheasants regularly fed in the fields. Crows were active in this habitat regardless of conditions.

Swales: When swales were frozen, the marsh type of cover was used by cottontail rabbits, meadow mice, prairie deer mice, short-tailed shrews, and masked shrews. The most typical mammalian inhabitant is, of course, the muskrat. The marsh grass and cat-tail have also served as cover for pheasants and quail upon occasion. Nearly all of the songbird species listed for grassland have used the marsh in much the same manner.

Brush: In winter lowland brush functions much the same as upland brush for most species. The muskrat, however, is more common in and around the lowland brush areas, and the short-tailed shrew has been found in greatest numbers in such situations. Both upland and lowland types are extensively used by the cottontail, weasel, skunk, house cat, and white-footed mouse. Pheasants and quail are very dependent upon brush cover in winter, and the Cooper hawk is most usually found in such areas. Among smaller birds the cardinal, bluejay, chickadee, downy woodpecker, song sparrow, junco, and tree sparrow are common.

Conifers are most favored by the rabbit and pheasant as winter cover. The Cooper lemming mouse has been taken several times in conifers and also in upland brush.

Woods: The fox squirrel is most typical of this habitat in winter. Skunks, house cats, weasels, rabbits, and white-footed mice are the other mammals that have been found here. Among birds the crow, great horned owl, and Cooper hawk are winter inhabitants, as are the white-breasted nuthatch, chickadee, and downy woodpecker.

The use of dens

Old woodchuck dens are numerous on this area, although only a few woodchucks are to be found here at present. Skunks use practically any kind of burrow, including woodchuck dens, as well as those dug by themselves (Nelson 1918, Seton 1929, Johnson 1930, Goodwin 1935). Such holes undoubtedly form important winter cover for rabbits (Trippensee 1934, Tubbs 1936). Rabbit tracks have frequently been seen leading into burrows which skunks were known to have used at some previous time. When water was low in winter they also occupied old muskrat burrows. Weasel tracks and tracks of the white-footed mouse have been found which indicated a use of such dens. One skunk den that was excavated contained two skunks and an opossum.

Dens may be considered to affect the interrelations of animals in two principal ways. The construction of burrows by the woodchuck and the skunk may abet the efforts of a rabbit to escape from enemies above ground and contribute to its comfort during severe weather (Leopold 1931, Trippensee 1934). These same burrows, however, may serve the weasel and skunk in enabling them more easily to catch the rabbit (Audubon and Bachman 1849, Kennicott 1858, Stone and Cram 1920). The weasel in particular uses its small size and sinewy body to good advantage in entering the burrows of small animals. Bailey (1926) states that on the plains it regularly enters the burrows of pocket gophers. Audubon and Bachman (1849) and Seton (1929) refer to its pursuit of mice and ground squirrels into their homes. Kennicott (1857) and Cory (1912) speak of weasel nests in "deserted" ground squirrel burrows. In this study weasel tracks have been very frequent around

colonies of Microtus. In the tunnels under deep snow these animals were probably protected from most other enemies. A weasel has been seen dodging in and out of the burrow of a mouse, and its stomach was found to contain the remains of the burrow's probable owner (Peromyscus sp.). A vivid impression remains that this animal is primarily adapted to hunting in small holes. These burrows, coupled with the weasel's capacity for over-indulgence in the matter of killing (De Kay 1842, Coues 1877, Merriam 1886, Lantz 1923), appear to make it possible for a small number of weasels to be a material factor in the lives of a very large number of Microtines and other Rodentia.

Activity relationships

As elsewhere pointed out, animals are brought into most direct contact with one another, first, by being in the same habitat; and secondly, by being active at the same time. This is not, by any means, the only way that species interact; but it is the principal way in which predator-prey food relationships are brought about. As a consequence, it is considered important in this discussion.

Seasonal activity

Certain species which are undeniably important as bionomic factors on this area are of seasonal occurrence only. An animal may be designated a seasonal either because it is present and dormant, or absent through migration. Predominants are present and active through the year.

Predominant animals: The carnivorous mammals which are regularly present and perennially active on this area are the house cat, weasel, opossum[14], prairie mole, short-tailed shrew, and masked shrew. The winter activity of the mole has been questioned, but the animal is now known to be active throughout the year (Scheffer 1927, Gregory 1936). Fresh workings during the winter have often been seen in the course of this study, and on January 10, 1936 a specimen was found above ground burrowing about through an inch of snow.

Among the herbivores the cottontail, fox squirrel, muskrat, prairie

[14]Opossums have, however, been inactive during very cold weather.

deer mouse, white-footed mouse, Cooper lemming-vole, and meadow mouse are predominants. In this work no flying squirrel records have been obtained in winter. The concensus of opinion, however, is that the animal does not hibernate (Kennicott 1856, Anthony 1928, Gregory 1936), although it is believed to be inactive and to remain in the nest during very cold weather (Merriam 1886, Wood 1910, Nelson 1918, Stoner 1918, Stone and Cram 1920). In this case it may be listed as predominant.

Predominant birds on this area are the pheasant, quail, screech owl, crow, mourning dove, flicker, hairy woodpecker, downy woodpecker, blue jay, chickadee, starling, English sparrow, goldfinch, and song sparrow. The great horned owl is a regular winter inhabitant but is, apparently, only occasional here in summer; hence it is not included in the above. The goldfinch and song sparrow have been present in winter in small numbers only. The horned lark was present throughout the winter of 1935-36 but did not arrive until February in 1937. It is ordinarily not predominant, but a late winter and summer resident.

Seasonal animals: The annual migration of most birds and the winter dormancy of certain mammals give the winter and summer vertebrate populations of the Kellogg Farm materially different aspects.

Species that are dormant in the winter are the woodchuck, spermophile, chipmunk, jumping mouse, and the skunk. Skunks do not hibernate, as do the other species, but remain inactive in dens during the coldest part of the winter. A thaw will find some old males abroad, but during January and February the number of active skunks is small.

Of the migratory birds that visit the area a few species are present only in winter. Such residents that leave in spring are the Cooper hawk, great horned owl (with exceptions), tree sparrow, and junco. Snow buntings, redpolls, and siskins are only occasional.

With regard to summer populations, all of the mammals listed as predominant or dormant in winter are, of course, active in summer. One species, the raccoon, has been found on the area only in summer. At this season a few individuals have intermittently fed in the swales. No raccoon signs have been found in winter or spring. Evidently these animals have their dens on some near-by area.

Most bird migrants are found in this locality only in summer. The following species have been regularly present during three seasons: Pied-billed grebe, great blue heron, little green heron, black-crowned night heron, American bittern, least bittern, Canada goose, mallard duck, red-tailed hawk, marsh hawk, Virginia rail, sora rail, coot, killdeer, spotted sandpiper, herring gull, ring-billed gull, black tern, black-billed cuckoo, nighthawk, chimney swift, hummingbird, kingfisher, red-headed woodpecker, kingbird, great crested flycatcher, phoebe, alder flycatcher, least flycatcher, wood pewee, prairie horned lark, tree swallow, bank swallow, rough-winged swallow, barn swallow, purple martin, house wren, catbird, brown thrasher, robin, bluebird, starling, red-eyed vireo, warbling vireo, yellow warbler, meadowlark, redwing, Baltimore oriole, bronzed grackle, cowbird, towhee, grasshopper sparrow, vesper sparrow, chipping sparrow, and field sparrow.

Species in the check-list that are not discussed as to seasonal activity either have occurred here sporadically or have been recorded only during the spring and fall migration seasons.

Daily activity: Among the predominant animals of the area the following are chiefly nocturnal: House cat, opossum, rabbit, muskrat, prairie deer mouse, white-footed mouse, and flying squirrel. The last three named appear to be exclusively nocturnal. All the others have been seen abroad in the daytime. From records secured in this work the weasel appears to be active at any time through the day or night. This is in agreement with the findings of Coues (1877), Herrick (1892), and Nelson (1918). Kennicott (1857) considered it to be principally nocturnal. As for the short-tailed shrew, few records of daytime activity have been obtained here, but Nelson considers it to be active with little regard to the time of day. All other of the perennially active mammals are diurnal.[15] Of the birds listed as predominant the screech owl is the only nocturnal species. All others are diurnal.

Of the species present in summer the skunk is for the most part nocturnal, though individuals have been seen at various hours throughout the day. Raccoons are doubtless nocturnal, although one morning observation was made. The jumping mouse has been seen several times in the daytime, though the species is nocturnal (Kennicott 1856, Seton 1909, Nelson 1918). The woodchuck, spermophile, and chipmunk are diurnal. Other mammals active

[15]Few data have been obtained here regarding the activity of meadow mice, but Hamilton (1937) found them to be chiefly diurnal with activity greatest in early morning and late afternoon.

in summer have already been discussed. Of the summer birds the screech owl has been cited as nocturnal. The night heron is crepuscular and nocturnal. The great blue heron is active both day and night, as is the nighthawk. Intensive study has not been made of the marsh and shore birds, though most are active by day and, except during migration, appear to be relatively inactive at night. Nearly all the smaller birds are diurnal.

Most of the winter birds and mammals have been referred to under predominants. Of the seasonal species the great horned owl is nocturnal and the tree sparrow and junco diurnal.

Food Relationships

Plant and animal populations are most effectively unified into ecological communities through the absolute necessity of each individual in every species for food. Considering the patently fundamental place of plants and invertebrates in the food relationships of animal society, a discussion of birds and mammals alone necessitates a somewhat artificial simplification. No attempt is made here to treat even the latter groups completely. Certain phases of the subject have been investigated which appeared to be important to the status of one or several of the more influential species, and which seemed to be amenable to logical analysis under the existing conditions.

Elton (1927) resolves the food relations of animals into four principles which he designates as follows: (1) Food chains and the food cycle, (2) Size of food, (3) Niches, and (4) The pyramid of numbers. It will be profitable to review the implications of each of these principles.

Herbivores are the fundamental class in animal society, and through them the energy derived by plants from sunlight is transferred to all the carnivores. Food habits among carnivores differ widely, certain species being preyed upon by certain other species, which may in turn be eaten by still larger forms. Thus chains of animals are formed, linked together by food. These may extend from the smallest herbivores up to the largest carnivores which dominate the community. The aggregate of all the food chains in a community is spoken of as a food cycle. As each species in a food chain is usually larger than the species below it, the principle of size of

food is introduced. Animals utilize food within certain size limits because species above these limits are too large to be killed and species below are too small for the numbers that can be eaten. Thus an animal occupies a specific place in a community because it utilizes food of a certain size. The plan of communities everywhere is much the same, and although species of similar habit in widely separated communities may differ in taxonomic position, their functions or "niches" in the ecological structure may be essentially the same. One well-defined niche is that of herbivorous animals that are so numerous as to support a large number of carnivores. These herbivores form what is termed a "key industry", a good illustration of which would be the small mammal key industry that occurs nearly everywhere. It will be observed that, progressing downward in the food chain, one finds that as animals decrease in size they increase in numbers; so that, considered numerically, food relationships can be represented by a pyramid with a multitude of small animals at the base, smaller numbers of animals intermediate in size in the middle, and finally tapering off to a few individuals of large species at the top. Enough data are not available to treat the fauna of the Kellogg Farm completely from all of the angles cited above. These conceptions stated by Elton are considered, however, a fundamental preface to any discussion of food relations, as they create a pictorial structure in which can be placed any apparently disconnected facts which are brought to light.

Food relations of herbivores

Inasmuch as herbivorous species do not habitually utilize one another as food, their most apparent food linkage is through competition for a common supply. In summer this rivalry has not appeared to be intense, as the superabundant vegetation present on this area has evidently been more than enough to supply the needs of all. In winter the problem is vital, as food supplies may be used up or become less available through deep snow. The present study treats the winter season only.

Herbage feeders: Two species of mammals, the rabbit and meadow mouse, are the most influential herbage feeders on this area. The muskrat belongs more properly to the aquatic habitats and was not intensively studied. Animals that feed upon the leaves and stems of plants may not only compete for food but, through the girdling of shrubs and trees, destroy cover that can materially affect future winter populations of both carnivores and herbivores.

Rabbits eat a great variety of herbaceous vegetation (Seton 1909) and apparently prefer this type of food. In the very open winter of 1936-37 very little bark of any kind was taken. A winter staple on this area is buckhorn. Under conditions of less than an inch of snow rabbits have often scratched through and fed upon this plant.[16] Yarrow is another herb that was so taken, and rabbits have been seen eating dandelion and bluegrass.

Under the conditions of very deep snow existing in the winter of

[16]Kennicott (1857) states that rabbits seldom, if ever, dig through the snow, and this has usually been found true where its depth was an inch or more.

1936-37 very little herbaceous vegetation was available and, apparently as a consequence, rabbits fed extensively upon bark. These rodents use woody plants as food by pruning, budding, and gnawing the bark from the stems. Kennicott (1857) found that pruning was the type of work most frequently found in orchards. However on this area few such cases were observed, and nearly all of the rabbit work was upon bark. Feeding upon woody plants by rabbits has been described by Audubon and Bachman (1849), Lantz (1907a, 1929), Todd (1927), Nelson (1918), Stoner (1918), Trippensee (1934), and Siegler (1937).

On this area dwarf sumac and staghorn sumac were the two species that were most often taken. Figure 16 shows the "rabbit line" on staghorn sumacs in a kettle hole near the farm. Twenty-eight species of woody plants were observed to be used, among which were willow, sassafras, wild crab, apple, buckthorn (Rhamnus cathartica), wild black cherry, elder, rose, grape, and several species of dogwood. Even oak and hickory were eaten in some places. Although the work of rabbits was widespread and easily noticed in winter, it was of little actual significance in reducing cover on the area.

Meadow mice are known to live to a great extent upon grass and other green herbaceous food; but in winter, especially when snow is deep, they eat the bark from nursery stock, shrubs, and trees of many kinds (Kennicott 1856, Butler 1892, Herrick 1892, Bailey 1900, 1924, Lantz 1907b, Evermann and Clark 1911, Cory 1912, Nelson 1918). On the Kellogg Farm in the winter of 1935-36 meadow mice extended their ranges under cover of the

deep snow into tree and shrub plantations where they had not been numerous before. After the snow melted twelve species of trees and shrubs were found to have been girdled by these mice. The most extensive girdling was done on Scotch pine. In the turkey marsh to the northwest of the farm, in a planting of 97 pines only 27 trees escaped damage and about 50 were killed (fig. 17). Other conifers that were taken were western yellow pine, Austrian pine, and ground juniper. In a mixed planting of white, western yellow, and Austrian pines on the farm nearly all of the latter two species were girdled, although white pines were found to be untouched. Deciduous shrubs and trees that were preferred by the mice were mulberry (Morus rubra and M. alba), wafer ash (Ptelea trifoliata) (fig. 18), wild black cherry, honeysuckle (several cultivated species), and catalpa (Catalpa speciosa) (fig. 19). In a near-by orchard apple trees had the lower limbs barked where they were covered by snow. In the winter of 1936-37 very little bark was taken by mice. This is probably due in part to the fact that field mice were fewer in numbers, but may be ascribed principally to the lack of snow. As a result herbaceous plants were available, and there was no protection for the above-ground activities of the species.

Figure 16. Staghorn sumacs barked by rabbits during the winter of 1935-36.

Figure 17. Scotch pines girdled by meadow mice in the winter of 1935-36. The tree in the right foreground is about 5 inches in diameter.

Figure 16

Figure 17

Figure 18. Wafer ash (about 1 inch in diameter) girdled by meadow mice during a period of deep snow.

Figure 19. Three-inch catalpa tree girdled by meadow mice. The upper limit of the bare area represents the snow level.

Figure 18

Figure 19

The work of rabbits and meadow mice is not difficult to distinguish. Rabbits leave ragged edges and do not take the bark cleanly, whereas the mice remove it smoothly down to the white wood and completely lay bare the area worked upon. Rabbits eat bark above the level of the snow; and all of the observed mouse girdling has been done in tunnels beneath its surface.

Woody vegetation has been sufficiently abundant on the area studied to obviate the necessity for any intense competition between the rabbit and meadow mouse for this type of food. Meadow mice have done more to reduce cover, due to the species attacked, than rabbits; however, all of such rodent activity together has not been sufficiently intensive to affect materially the amount of cover present. Hence, notwithstanding the potentialities with which the above habits are fraught, they are probably not of great significance to other species on this area.

Seed and fruit feeders: During most growing seasons plants of every description produce large quantities of fruits and seeds. These ripen in the fall and form a progressively diminishing food supply during the winter for certain ground-feeding birds and other animals. In the fall of 1935 on this 500 acres a collection of more than 90 species of such fruits and seeds was made. Only those were taken which appeared to be usable by winter birds as food or were listed by some author as such. Some fruits disappeared during the fall. Of those that were more persistent a record was kept of the length of time during the winter that they remained apparently available as a food supply for birds. Table 5 in the appendix gives the

approximate abundance and duration of availability of 81 species. This represents the winter season of 1935-36 only and can not be taken as indicating the ordinary relative persistence of the various species. Some were buried under two feet of snow and others were almost entirely used up by the birds feeding upon them. In general, fleshy fruits disappeared early, leaving the dry fruits of grasses (Poaceae), buckwheats (Polygonaceae), and other common weeds found on cultivated ground as the most important winter foods of seed-eating birds and mammals. Cultivated grains were present in certain feeding stations and rye patches, but did not greatly interfere with the study of natural foods.

On this area, from point of size, the pheasant is the largest animal dependent upon grain and seeds in winter. That the species utilizes quantities of the common weed seeds as food has been shown by many investigators (Leffingwell 1928, Forbush 1929, Swenk 1930, Beebe 1931, Green and Beed 1936, Dalke 1937, Gigstead 1937). A total of 70 fall and winter stomachs were obtained from hunters and by other means in this and near-by counties. A qualitative examination showed ragweed, green and yellow foxtail, several species of smartweed and bindweed, and other common weeds to be frequently taken. Corn and other cultivated grains were present in quantities. The crop of a hen shot on February 3 contained rye, vetch, and dodder. Burdock, bittersweet, and grape were also often eaten in late winter.

The bobwhite quail utilizes similar foods in winter (Judd 1905, Nice 1910, Errington 1930, 1931, Bird and Bird 1931, Handley 1931, Leopold

1931). Eleven fall stomachs from this vicinity yielded quantities of ragweed, foxtail, panic grass, and buckwheat. Bobwhites are known to be particularly fond of legumes, and two of these stomachs contained the seeds of sweet clover (Melilotus).

In the winter of 1935-36 a large portion of the natural food supply of the area was taken by flocks of songbirds. Tree sparrows and juncos were particularly abundant, and horned larks were common. The food habits of these birds have been studied by Judd (1898), McAtee (1905), Beal and McAtee (1912), and Gabrielson (1924). It has been fully demonstrated that common weed seeds form the bulk of their winter foods. A collection from this area of 124 stomachs (principally of juncos and tree sparrows) was made in December, January, and February. A qualitative analysis showed that 30 species of fruits and seeds had been taken as food. Following is a list of the 10 species most frequently taken and the number of stomachs in which traces or quantities of the food were found:

Ambrosia elatior (ragweed)	73
Chenopodium album (lamb's quarters)	54
Poa spp. (bluegrass)	27
Nepeta Cataria (catnip)	23
Amaranthus retroflexus (redroot)	21
Monarda fistulosa (wild bergamot)	14
Rumex Acetosella (sheep sorrel)	9
Amaranthus graecizans (tumbling pigweed)	8
Sporobolus spp. (dropseed grass)	8
Setaria lutescens (yellow foxtail)	7

Two other species of animals are of undoubted importance as feeders upon weed seeds. Although all mice appear to use this food to some extent, the white-footed mouse and prairie deer mouse are notable for the habit (Audubon and Bachman 1849, Kennicott 1856, Merriam 1886, Seton 1909, Cory 1912, Nelson 1918, Stoner 1918, Bailey 1926, Johnson 1930, Gregory 1936). As has been pointed out by Dice (1922) and Johnson (1926), a well-developed habitat selectivity is shown by these two species. The prairie deer mouse inhabits the open fields, and the white-footed mouse is a woodland form. On this farm one of the two is found everywhere except in very wet marsh. The prairie form is widely distributed in the open fields and grassland, while the woodland form inhabits all of the woods and brushland. The only habitat where both have been found is a grassy area sparsely planted to small conifers.

As a consequence of this habitat preference the food of P. leucopus noveboracensis contains a higher percentage of nuts and tree seeds than that of P. maniculatus bairdii. Osgood (1909) states that the former is very fond of basswood seeds, wild cherry pits, and acorns. Both species lay up winter stores, but both are also active foragers in all kinds of weather. From the standpoint of weed seeds all evidence points to the prairie deer mouse as the most important competitor of ground-feeding birds. A nest of this species that was excavated in January 1937 contained approximately a pint of seeds of bush clover (Lespedeza sp.), ragweed, wheat, black bindweed (Polygonum Convolvulus), yellow foxtail, campion (Silene sp.), and sheep sorrel. Tracks in the snow showed that this mouse regularly fed upon ragweed, tumbling pigweed, and lamb's quarters.

Two winters' observation on this area indicates that the intensity of competition for the above type of food depends principally upon the depth of winter snow. Deep snows quickly reduce the supply of available foods and concentrate the efforts of all species upon what remains. The nature of the growing season or other factors may determine the amounts of some foods that are produced. The drouth in 1936 evidently curtailed the crop of arrow-leaved tear-thumb and certain other species. However, the harvest from common weeds such as ragweed, lamb's quarters, amaranths, and others appears to be a very dependable quantity. These types made an excellent growth during the hottest part of the summer in 1936, when the ground was very dry and dusty four feet beneath the surface.

The very deep snow in the winter of 1935-36 rendered unavailable the low-growing foods such as sheep sorrel. Hence the dependence of nearly all seed-eating animals was upon ragweed, lamb's quarters, redroot (fig. 20), bergamot (fig. 21), and such other species as projected above the snow. Ragweed was the most abundant of these, and by the middle of February plants of this species had been almost completely stripped of their fruits. When such a condition was reached, the flocks of songbirds almost entirely left the area. Where before several hundred tree sparrows and juncos had not been unusual, hardly a bird was to be found. Errington (1930) refers to a season of deep snow when the ragweed supply was exhausted by the middle of January. In speaking of quail the same author (1931) calls attention to the "--terrific food competition furnished by small birds, ringnecked pheasants (in one area) and rodents--".

Figure 20. Redroot upon which snow buntings fed above two feet of snow in February 1936.

Figure 21. Wild bergamot upon which tree sparrows fed, February 1936.

Figure 20

Figure 21

Considering the widespread and intensive activity of mice and songbirds, it appears that these animals took the greater part of the winter's supply of seeds. The fact that the mice store food in quantities, and the ability of the songbirds to abandon the area if necessary leaves the pheasant and quail as the species most likely to suffer in case of food shortage. The shortage in February 1936 did not last, as the deep snows melted late in that month. Pheasants found enough burdock, dodder, vetch, grape, bittersweet, and cultivated grains to satisfy their needs. Quail used such foods as sumac drupes and ash samaras, or moved about until a feeding station, shocked corn (on near-by farms), or other supply was found. No starvation or decline in health was observed among the birds here.

Evidently this is another relationship which, under some conditions, might seriously impinge upon two resident species, the pheasant and the quail. Under the conditions studied, however, the food shortage induced, in part, by mice and songbirds did not result in a loss of life among the game birds. In the following winter (1936-37) the supply of food available was much larger than in 1935-36, due to the small amount of snow on the ground. In that season very few songbirds were present; most of the pheasants and quail moved to adjoining sections of land; and the mice, evidently, were left in control of a food supply much in excess of their needs.

Mast feeders: One source of food on this area which should not be overlooked is the very large harvest of acorns which has been produced each fall. For three seasons this has been one of the most abundant and important fall foods found here. White oaks have produced little, red oaks slightly

more, and black oaks very large quantities. In addition to being the most frequent species the black oak bears an acorn that is small enough to be swallowed by pheasants and ducks; whereas the other two species are too large to be used until they are opened by squirrels, stepped upon, or otherwise broken up.

During October and November much of the mast harvest disappears through the activities of fox squirrels, which store away large numbers of acorns in dividuals holes in the ground. Mallard ducks take most of the supply near the water, and other birds such as bluejays and pheasants are active elsewhere. The chipmunk (Audubon and Bachman 1849, Kennicott 1856, Cory 1912, Howell 1929) and white-footed mouse also use quantities of this food. There is no evidence from this work that competition for the acorn harvest is ever acute, although by analogy a small crop and the exhaustion of the supply in the fall might mean privation to the fox squirrel in late winter.

Food relations of carnivores

The more that is learned of the food habits of animals the more omnivorous most species are found to be. Thus ground squirrels are known to feed extensively upon insects (Gillette 1889, Orcutt and Aldrich 1892, Bailey 1893, McAtee 1925), while such structurally authentic carnivores as the raccoon and skunk consume quantities of fruits, mast, and grain (Dearborn 1932, Hamilton 1936a). In the following discussion several species are treated which, though primarily herbivorous, have certain significant carnivorous habits that make it logical to include them here.

Carrion feeders: As a food carrion appears to be most significant at the time of the melting of winter snows. Then all of the diseased and subnormal animals that succumbed to winter weather are revealed, and the increased activity of skunks and opossums certifies that the supply will not last long. Skunks in particular have been found to be lean and evidently hungry after more or less inactivity and are capable of eating large quantities of carrion. In one case a skunk carcass was found to have been almost entirely eaten (by skunks) in one night. Such remains are usually trimmed by mice, which also eventually destroy the bones that are left. It appears probable that in spring this is the principal source of animal food for such Rodentia as require it; and the calcium furnished by bones may well be important to pregnant females. In the winter of 1936-37 carrion was not covered by snow and was taken at any time animals were active; but in the winter of 1935-36 the sudden melting of deep snow in February rendered very noticeable the intensive use of this food by the species indicated. Crows feed upon

carrion habitually and consume most of the carcasses of animals killed on the highways.

At the poultry plant of the Kellogg Farm several thousand chickens are reared on open range each year. At night after the chickens are housed female skunks and their young are often found in the poultry yard eating the chickens that have died of disease and other causes. It is not to be doubted that this supply of carrion is on this area an important source of food for young skunks. Twelve box traps were set in the chicken range on the night of July 17, 1936. In the morning nine skunks and a barn rat had been caught, and one of the other traps was sprung.

Predators of small mammals: The small mammal key industry of the Kellogg Farm consists principally of six species: The thirteen-lined spermophile, meadow mouse, prairie deer mouse, white-footed mouse, short-tailed shrew, and prairie mole. In addition to these are the chipmunk, Cooper lemming-vole, pine mouse, jumping mouse, least shrew, and cinereous shrew; but the latter species are of such infrequent occurrence that they are probably of little ecological significance. The cottontail rabbit may be included in the small mammal key industry, but it appears more logical to discuss the species with animals of larger size.

The mammalian predators of the above group on this area are the skunk, weasel, house cat, opossum, and short-tailed shrew. The two first mentioned are doubtless of greatest importance. That the skunk is a pertinacious destroyer of mice, particularly Microtines, has been attested to by nearly all of the investigators who have touched upon the subject

(Richardson 1829, Kennicott 1858, Merriam 1886, Seton 1909, Cory 1912, Nelson 1918, Stone and Cram 1920, Cuyler 1924, Dixon 1925, Hatt 1930, Johnson 1930, Dearborn 1932, Goodwin 1935, Hamilton 1935, 1936b). A series of 99 skunk stomachs from fall, winter, and spring was collected during this study.[17] Of these, 38 were empty or contained only trap debris. Of the remaining 61 stomachs, 12 contained the remains of mice, all of which were Microtus. These rodents formed 44.5 percent of the contents of the 12 stomachs and 8.7 percent of the contents of the total series of 61. One stomach was from December, 3 from January, 1 from February, 4 from March, and 3 from April. In a report on 62 skunk stomachs (three species) Lantz (1923) found that small mammals were most commonly taken from January to March. In an examination of 414 fecal samples from May to September Hamilton found 14.1 percent small mammals which were chiefly mice. In field work on this area it was very evident from fecal specimens and signs that feeding upon small mammals began as soon as skunks were active in spring and continued into the summer. In August and September insects (grasshoppers and beetles chiefly) formed the bulk of material in droppings and later fruits became important. The significance of the above facts is manifest when it is considered that rodent populations are at a minimum in late winter and spring, and thus predation at this season is most effective in reducing the yearly population.

[17] I am indebted to Dr. Clarence Cottam, In charge, and Mr. E. L. Nelson of Food Habits, Division of Wildlife Research, Bureau of Biological Survey, for arranging for the analysis of these stomachs in the laboratory at Washington.

Skunk diggings have been very common in tunnels of the prairie mole, and a skunk has been found in the day time eating the remains of a mole (possibly carrion). It appears likely that on this area skunks are an effective check on mole numbers.

As alluded to previously, weasels are most effectively adapted to preying upon small fossorial animals. They are persistent enemies of such mammals as chipmunks, spermopniles, and all species of mice. The latter fact is supported by observations on this area as well as by a large mass of evidence accumulated by many investigators (Richardson 1829, De Kay 1842, Audubon and Bachman 1849, Kennicott 1857, Rhoads 1903, Fisher 1908, Wood 1910, Cory 1912, Dearborn 1932, Hamilton 1933, 1935, Goodwin 1935, Errington 1936). Of 15 weasel stomachs taken on and near this area 9 were empty. In all of the remaining 6 were found the remains of mammals. One contained flesh and fur of Sylvilagus, 2 of Microtus, and 3 of Peromyscus. All appearances indicate that the weasel may be the most effective check on the numbers of the spermophile on this area. These ground squirrels are abundant and strictly diurnal. In the daytime they remain close to the burrow and appear to be very alert and watchful. Thus it is doubtful whether a large number are taken by avian predators, although their habits protect them not at all from weasels (Bailey 1926, Seton 1929). Few mammals are known to eat the short-tailed shrew, though Nichols and Nichols (1935) write of shooting a weasel that was carrying one. There is probably no species of small mammal on this area that is not, at least occasionally, preyed upon by this carnivore.

In the winter of 1935-36 under deep snow small mammals appeared to be well protected from house cats. In the following winter, when very little snow was present, cat tracks were often found in Microtus colonies in the fields. During the latter season 18 cat stomachs were collected on this area, of which 3 were empty. In the 15 which contained food, Microtus remains (and one Synaptomys) occurred in 12 and formed 31.1 percent of the food. Evidently cats hunted such prey regularly during this winter season. These animals are known to kill many species of small mammals (Forbush 1916, Van Hyning 1931), although most authors point out that they take them much less often than birds (Bailey 1923, Couch 1928, Hatt 1930). To date enough food studies have not been made on the cat to warrant conclusions as to the extent to which the animal feeds upon small mammals. However on this area appearances indicate that natural predators such as the skunk, weasel, and some birds are of much more importance in reducing their numbers.

The opossum is very omnivorous and eats many kinds of plant and animal food (Rhoads 1903, Cory 1912, Seton 1929, Dearborn 1932). Although they doubtless destroy some rodents, the extent to which opossums feed upon carrion renders evidence from stomach analysis very questionable. Of this species 30 stomachs have been collected, principally in fall and winter. In this series 3 were empty and 7 contained remains of mice (Microtus). In the 27 stomachs that contained food these mice constituted 6.4 percent. One of the stomachs contained remains of a short-tailed shrew, though this may well be carrion, as these animals are often found dead (Emmons 1840, Evermann and Clark 1911). Evidently opossums prey upon mice to some extent

although, as few are present on this area, they probably are not a very important factor in reducing populations of these rodents.

There is considerable evidence that the short-tailed shrew is an enemy of mice (Merriam 1886, Shull 1907, Hahn 1909, Nelson 1918, Bailey 1923, Anthony 1928). Johnson (1930) states, "The short-tailed shrew, where it is abundant, is more important in the control of mice than all other natural enemies of mice combined." However in 244 stomachs examined by Hamilton (1930) only 4 contained mouse remains. In this study shrews have often been taken in Microtus colonies during the winter and, from the amount of food required by this species, mice may well be a considerable item in the diet at times when insects are relatively unavailable.

The avian predators of small mammals are so well known that no lengthy treatment is needed here. The predaceous birds on the area that are important as enemies of this key industry are the marsh hawk, red-tailed hawk, screech owl, and great horned owl. From its abundance and persistent hunting the marsh hawk is doubtless of greatest importance. Red-tailed hawks have been few in number and not always present. The two owls probably take a large yearly toll. That small mammals form the bulk of the food of these birds has been shown by the extensive work of Fisher (1893) and numerous contributions by other investigators (Bird 1929, Cahn and Kemp 1930, Errington 1932, 1933, Pearson 1933). Useful summaries of other work are given by Baldwin, Kendeigh, and Franks (1932), May (1935), and Bent (1937). During the fall migration season rough-legged hawks are frequently seen hunting on this area, and in 1934 one of these birds was seen by Mr.

F. F. Tubbs to settle onto a pole trap with a mouse (Microtus p. pennsylvanicus) in its talons. In February 1937 a Cooper hawk was observed tearing at a grass nest of the field mouse, and an investigation disclosed three young mice in the debris. On two occasions great blue herons have been seen at close range to catch meadow mice, and have often hunted in grassy meadows where Microtus was plentiful. The hunting technique was the same as that used on frogs and appeared to be effectual.[18] Fisher (1908) has observed a similar relationship between herons and rodents. Crows have also often been seen in and around meadow mouse colonies and have doubtless taken their share. The work of Barrows and Schwarz (1895) and Kalmbach (1918) has shown that small mammals form a considerable portion of the food of crows. That a part of such food is carrion is very probable. Evidence is good, however, that much of it is the result of direct predation. Judd (1902) also refers to the destruction of small mammals by crows.

The enemies of small mammals include practically every carnivorous species on the area. Couch (1928) has observed that, in general, predatory birds are more effective in destroying rodents than predatory mammals. There is no entirely reliable evidence upon which to base a conclusion; however from the numbers of skunks, weasels, and cats present, as compared with the numbers of marsh hawks, screech owls, and great horned owls, it appears that on this area predatory mammals are the most potent controlling force.

[18]In both cases where herons were seen to catch a mouse the animal was taken to water and emersed before being swallowed.

Predators of larger mammals: The larger mammals of this area are here considered to be the cottontail, fox squirrel, weasel, skunk, opossum, and cat. Only one species of predator appears to kill all of these animals--the farm dog. Dogs have not been listed as a part of the fauna of the area as they are present only incidentally. On a few nights in winter dogs evidently hunted the area, and one rabbit is known to have been killed. Doubtless such hunting occurred at other seasons but was seldom observed. The dog has here been considered a part of the human factor, a standpoint that has not seemed justifiable in the case of the house cat, which is habitually feral.

As an animal community the Kellogg Farm is dominated by the great horned owl. Although I am not aware that this bird has been known to kill adult cats, it has been found to include in its diet all of the other species listed above. Its food habits were studied by Fisher (1893), Bird (1929), Errington (1932) and English (1934b). On this area only two pellets were found. One contained the neck vertebrae and feathers of a black duck (the kill was also found) and the other consisted of rabbit fur and bones. Two more pellets from a woods a few miles away contained rabbit remains. One rabbit kill was examined that can probably be ascribed to this species. It appears, from the evidence at hand, that this owl may be one of the principal natural factors that reduce the winter population of the cottontail on this area. Various reports indicate that the great horned owl is one of the few species that prey upon the skunk (Audubon and Bachman 1849, Wilkinson 1913, Seton 1929, Goodwin 1935). On this area only one kill was found that might

have been owl work, and evidence in the case was very unsatisfactory. In view of the continuous field work that was being done and the lack of any further indications, it appears that not many skunks have been taken during this study.

The red-tailed hawk is the largest diurnal bird of prey found here and may be listed as an enemy of the rabbit, squirrel, and weasel (Fisher 1893, Errington 1932, Pearson 1933, English 1934a, 1934b). Other works are cited by May (1935) and Bent (1937). In this study on one occasion a red-tail flushed from the ground was seen to be carrying a fox squirrel in its talons. The marsh hawk is the most numerous hawk on the area in summer and probably accounts for many young and possibly some adult rabbits (see references indicated above). It has also been demonstrated that the crow takes numerous young rabbits (Barrows and Schwarz 1895, Judd 1902, Kalmbach 1918). Several raided rabbit nests have been found in this work that pointed toward the crow as a probable predator.

Of the larger mammals the rabbit is most often preyed upon by other mammals. One of its principal enemies on this area is the house cat. In the winter of 1935-36 two adult rabbits were killed, with very good evidence that the predators were cats. One rabbit was killed and partly eaten by a cat in a funnel trap set for pheasants. In the spring of 1936 one cat in Midland Park is known to have brought in two young rabbits. In his very comprehensive work on the domestic cat Forbush (1916) states that they are very active in the pursuit of young and old rabbits and that they also kill squirrels. Seton (1909) and Linsdale (1928) cite other records of rabbits

having been killed by cats. Being ground foragers, the skunk and opossum doubtless take numerous nests of young rabbits, although many of the rabbit remains found in stomachs may be classed as carrion. Skunk diggings have been found in close approximation to raided rabbit nests on this area, and Cory (1912) and Cuyler (1924) have included young rabbits in the list of the skunk's food. Kennicott (1858) and Brayton (1882) state that skunks capture adult rabbits by catching them in burrows. That the weasel also kills adult rabbits in holes is indicated by statements of Audubon and Bachman (1849) and Kennicott (1857). Fisher (1908), Seton (1929), and Stone and Cram (1920) also list the rabbit as weasel food. Hamilton (1935) found rabbit remains to constitute 13.1 percent of the contents of a series of 360 fall and winter stomachs from New York State. Dearborn (1932) found that rabbits formed 14.29 percent of the mammalian food in 37 Michigan specimens. Flesh and fur of a rabbit were present in one of the 15 weasel stomachs collected in this work and examined in the laboratory of the Biological Survey. That weasels can catch young rabbits in the open is shown by an observation of Leopold (1937). There is little evidence to indicate how great a factor the weasel is in reducing rabbit numbers on this area. It is evident that these carnivores take large numbers of mice, which are plentiful here and easily captured. As a result I suspect that the number of adult rabbits killed is small, although young rabbits may well pay a heavier toll. In summary, it may be said that rabbits form a considerable part of the basic food supply of the larger carnivores found here and as such, in common with the smaller rodents, are an important quantity in the food economy of the area.

Predators of birds: In the present work few data have been obtained on the summer predators of birds. At this season cats are numerous and probably kill birds regularly. The marsh hawk may also take a share in summer; and when the great horned owl is present, avian food is doubtless a part of its diet. Crows are known to kill young birds and are common on the Kellogg Farm at this season. The above are probably the most important summer predators of birds, although there is almost no actual evidence. As elsewhere pointed out, good observations in summer on some phases of field research are comparatively rare.

In winter the great horned owl and Cooper hawk are the only resident avian predators of birds. All evidence indicates that the screech owl is not important in this respect. In two pellets of the horned owl from a perch a few miles from the farm were the remains of a cock pheasant. Numerous feathers scattered about showed that the bird had been carried to a stub to be eaten. In three years at least three of these owls have been taken on or near the farm under conditions indicating that they had been killing young or full-grown chickens. One is known to have killed a black duck. Bird remains were common in the food specimens analyzed by Fisher (1893), Errington (1933), and English (1934b). In spite of this evidence, the black duck above referred to is the only wild bird known to have been taken by a horned owl on the farm. Rabbits and other rodents have been more numerous than pheasants and quail, and appearances indicate that they have been the main sustenance of these owls.

The most important winter predator of birds on this area has been

the Cooper hawk. During the first winter of the work two adult pheasants (one in a funnel trap) were known to have been killed by this bird (fig.22). In the second winter and spring four known pheasant kills by Cooper hawks were recorded and one case was observed that was questionable. On several occasions old remains were found after carrion feeders had performed their offices and it was not possible to judge as to the original predator. In the six cases enumerated above hawks were actually flushed from the kill. In one case a bird returned at least six times to a dead pheasant, Kills of other species that were found where evidence indicated this hawk were a meadowlark, a junco, and a cardinal. When it is considered that by no means all of the kills on such an area as this can be found immediately and some not at all, it is evident that the Cooper hawk has been a real limitation to pheasant numbers. During the second winter no quail were on the area much of the time and no predation at all has been recorded for this species during the study. It has been shown that the Cooper hawk lives primarily upon birds as food and is particularly destructive to pheasants and quail (Fisher 1893, Baldwin, Kendeigh, and Franks 1932, Errington 1933, English 1934b). As from one to five of these birds have been present at all times throughout both winters, from this fact alone it would appear probable that considerable mortality occurred among the winter birds of the farm.

Figure 22. A hen pheasant killed in lowland brush cover by a Cooper hawk.

Figure 22

Among the mammalian predators of birds the cat has, from observations, been the most efficient. It is very doubtful that the weasel takes many birds, and the skunk and opossum are little inclined to prey upon adults; so that in winter the domestic cat appears to be practically the only important enemy on the ground. In the first winter of the work a cat entered a funnel trap and killed and partly devoured a cock pheasant. A hen in the same trap dashed herself to death in fright. In the following winter a cat killed two wing-clipped Mongolian pheasants at the sanctuary and carried them into the pines to be eaten. There are no known cases of cats having killed birds in the wild, although several old remains have been found to which no cause could be ascribed (and which may also have been due to Cooper hawks). I have no doubt, however, that cats take numerous birds and very probably pheasants on this area. The many records of cat predation cited by Forbush (1916) and others (Bailey 1923, Hatt 1930, Stoddard (1931), as well as the consistent hunting by these animals in all kinds of weather, lend weight to this analogy.

Nest predators: The impacts of predators on bird populations through nest losses is one aspect of the predator-prey relations problem that can be studied, to some extent, quantitatively. The difficulty of evaluating an individual predatory species as a limiting variable to bird numbers makes it increasingly important that such a method be used on those parts of the problem that can be so treated.

In the spring and summer a fairly large number of mallard ducks nest around Wintergreen Lake and the swales on the sanctuary. In 1935 the

history of 31 duck nests was followed, and 11 of these were destroyed by predators. The losses could not be ascribed to individual species, as there were no reliable criteria by which to recognize the work of each. In the spring of 1936 a nest predation experiment was performed that was designed to indicate differences in the work of various predators. If the work of these animals could be recognized, the facts obtained could be applied to nests raided under natural conditions in the wild.

As population studies were in progress on the farm and it was not desirable to injure or kill any animals on this area, the study was made in the turkey marsh. Ten false nests of four or five hens' eggs each (incubator infertiles) were placed in a variety of cover situations. Around each nest were set four steel traps. The nest sets were run early every morning and were operated from March 19 to June 12--a total of 850 nest-nights. At first it was felt that, due to artificial conditions such as a scent trail to the nests and other factors which might affect predatory species differentially, the data gained could not be used quantitatively to indicate the relative amounts of nest destruction accomplished by each species. From the results, however, I believe that these factors were relatively unimportant. Stoddard (1931) came to the same conclusion with regard to predation on quail nests that were visited regularly in his studies. Nests that were checked frequently suffered no more from predators than those upon which few observations were made. He states that in areas where human trails are frequent (as in the turkey marsh here referred to) ground predators probably do not habitually follow them.

In the trapping at nest sets the following animals were taken: 14 skunks, 9 crows, 8 fox squirrels, 5 opossums, 3 weasels, 3 bluejays, and 8 miscellaneous animals most of which were probably caught incidentally (a thrush, a turtle, etc.). Of these sets 29 were raided without the predator being identified, and 33 were disturbed with good evidence remaining as to the animal involved (fig. 28). Such evidence was hair in a trap, droppings, or very typical work on eggs. Of the cases which were identified on such a basis 9 were attributed to skunks, 15 to crows, 6 to squirrels, and 3 to opossums. For these four species of animals, then, the total cases of predation were: Crow, 24; skunk, 23; squirrel , 14; and opossum, 8.

After comparing the shells of eggs eaten in certain proved instances of nest destruction, it was evident that in some cases the work of the four most important predatory species could be distinguished. Skunks commonly chewed a large hole in the shell, leaving the edge crushed and the membrane frayed. Well-defined tooth marks in eggs are relatively rare. Skunks usually scatter the egg shells from a nest out on one side for a distance of from 10 to 20 feet (fig. 24). Opossums have been found to munch up eggs, leaving the shells completely crushed. Opossum work cannot, however, always be separated from skunk work. In the eight observed cases of opossum predation the eggs were eaten in or within a few feet of the nest. Crows may split a cap neatly off one end of an egg (fig. 25), leaving no ragged edge or frayed membrane, or they may cut a groove or hole in one side. In the latter case the edges may be punched in, but are not crushed and ragged as in skunk work. Crows usually are unable to remove all the contents of an

unincubated egg. They may also carry eggs away to be eaten elsewhere. Fox squirrel work is most typically represented by a neat cup left with the edges trimmed smooth and the contents licked out clean. The shells are usually left at the base of a tree (fig. 27) or on a stump. Shells left by squirrels and crows are sometimes similar.

It is to be emphasized that little can usually be inferred from a single egg. When an entire nest of eggs is eaten, however, their position noted, and the vicinity examined for other signs, a very good case may result.

In the application of the above information to nests in the wild, 29 duck nests were studied in the spring of 1936. Of these, 10 were raided by predators. Three cases were identified as crow work, 2 as skunk, and 5 were unknown. Of seven pheasant nests checked, only one was raided—probably by an opossum, though possibly by a skunk. In the spring of 1937 records were obtained on 32 duck nests.[19] Of these, 17 were broken up by predators. Evidence was good that at least four were taken by crows and three by skunks. In most other cases evidence was poor. During this season, however, grackles were more numerous than usual, and several duck nests were found with some eggs having small holes punched in them. It is very probable that these birds were responsible for a part of the losses, although there is little direct evidence. They were not known to have eaten eggs

[19]Most of the field work on this group of nests was done by Mr. Homer L. Bradley, who kept records and kindly called my attention to numerous cases of predation.

during the two years previous. Of a total of 99 nests observed in the wild during the three seasons 39, or 39.3 percent were broken up by predators. It is interesting to note that of 602 quail nests recorded by Stoddard (1931) 37 percent were destroyed by natural enemies. Hamerstrom (1936) found that 19.3 percent of 445 pheasant nests were taken by predators. From indications it appears that about one-third of the nests of ground-nesting birds may be expected to be destroyed by egg-eating animals on this area, and that such a rate of mortality is probably not far from the usual loss suffered in the wild.

Figure 23. Nest of mallard duck in lowland brush as it appeared on April 22, 1936.

Figure 24. The same nest as above on April 26 after being raided by a skunk.

Figure 23

Figure 24

Figure 25. A hen's egg after being eaten by a crow.

Figure 26. A crow caught in steel traps at a false nest of hens' eggs.

Figure 25

Figure 26

Figure 27. Egg shells left at base of tree by a fox squirrel.

Figure 28. A false nest raided by a skunk which escaped being caught but which left ample evidence of its identity. Arrow points to feces, which contained egg shells from a previous visit.

Figure 27

Figure 28

SUMMARY AND CONCLUSIONS

PURPOSE

The purpose of this study is to demonstrate the approximate sizes and most vital interrelationships of the mammal and bird populations on 500 acres of farm land.

AREA

The area studied lies on an outwash plain in a recently glaciated region in southern Michigan. It includes Wintergreen Lake and five small kettle holes. The topography is somewhat irregular, varying between the 891- and 935-foot contours. About 277 acres have been cultivated.

In the order of their development in the hydrosere the plant habitats of this area may be listed as marsh, lowland brush, lowland woods, and upland woods. The stages of a secondary succession, starting with plowed ground, are also present here. The annual weed stage is found on cropland and, if undisturbed, will pass into the perennial weed and grassland stage. This, in time, becomes upland brush, which gives way to the upland oak woods.

This area resembles other surrounding farm land except for the ungrazed brush cover that has grown up in the lowlands and the coniferous plantings that have been made on the more hilly portions. An aggregate of about 20 acres of these plantings are present which vary in size from a few scattered trees to four acres of massed pines.

ANIMAL LIFE

The animal species of this area are discussed from the standpoints of abundance, habitat predilection, time of activity, and position in the food cycle. The summer and winter populations vary in a marked degree due to the fluctuation in numbers of resident animals and to the migratory birds that are present during only a part of the year.

Population Studies

Censuses of mammals were taken principally by returns from trapping and marking. Winter burrow excavation was also used in the case of the skunk. Pheasants and quail were inventoried with bird dogs and by the interpretation of daily field work. Mice and shrews were taken in mouse traps baited with peanut butter. Quantitative studies have not been made on all species, and where figures are not available the comparative numbers present, as judged by indications, are given.

Rabbit

Based upon the December kill and the number of individual rabbits trapped in January, February, and March the minimum population figure for December 1935 was found to be 228. As judged by the number of individual rabbits taken in February and March the April population was about 25 pairs. In six weeks and five days, beginning on October 31, 1936, 102 rabbits were marked by trapping. On December 18, 19, and 20 a total of 126 rabbits were shot. Using the proportion of marked rabbits in the kill, the December

population was calculated at 226 rabbits, or one animal per 2.1 acres.

Fox squirrel

In the fall and winter of 1935-36 sixty-one fox squirrels were marked by ear clipping. This constitutes a minimum population figure for about 30 acres of woodland (one squirrel per 0.49 acres). During the following summer the numbers of this species took a marked drop due, evidently to a mange-like disease that became epidemic. In the winter of 1936-37 only 39 individuals were taken.

Skunk

During the first fall and winter 30 skunks were caught in the traps and marked. Of these 20 were males. The sex ratio here is 0.5, and females are relatively inactive in winter. Hence if an equal number of females is presumed, the total known number of skunks that used the area is about 40.

In the second fall and winter 29 male skunks and 15 females were taken in box traps. During the winter period of inactivity 19 burrows were excavated and two males and 16 females were handled that had not been taken in traps. Thus the total skunks handled on this area was 62, or 31 males and 31 females. However, indications are that only 23 females occupied burrows on this area; and if there were an equal number of males, the total known resident winter population for the farm was 46 skunks, or one per 10.4 acres of land.

Ringneck pheasant

On a basis of bird dog censuses and daily field work the late fall population of 1935 was about 30 pheasants, or one bird per 16 acres.[20] In the following April the number was between 20 and 24. During the second winter many pheasants left the farm and gathered in a brushy area in the next section to the north. On January 22, 1937 only five pheasants were flushed in a census of the farm. Evidently numerous birds returned in the spring.

Bobwhite quail

Quail were censused in the same manner as pheasants. Populations were, however, even more variable due to movements. In December 1935 the maximum number of bobwhites was observed when about 42 birds were on the area. Thus at this time the population density was about one quail per 11.4 acres. This species was much disturbed by the field work during the late winter period of deep snow. Evidently much shifting and splitting of coveys resulted from this factor. In the winter of 1936-37 a maximum of 10 quail were present and at times none at all was to be found.

Species of lesser abundance

The winter weasel population, as judged by tracks, appeared to be about half a dozen individuals. On the same basis, from one to five cats were frequently on the area. The opossum population was small, evidently

[20]Population densities are calculated for 480 acres--Wintergreen Lake occupies 20 acres.

numbering three or four. In summer not more than two raccoons are known to have been present at one time, and there is only one fox record during this work. Woodchucks are uncommon here, only three having been seen in three years. The winter Cooper hawk population has evidently varied from one to five during two winters. The number of great horned owls has usually been one and sometimes two.

Small mammals

Of the ground squirrels on the area the spermophile is abundant and the chipmunk comparatively uncommon. The most numerous small mammal here is the prairie deer mouse, with the meadow mouse evidently second in numbers. The white-footed mouse, short-tailed shrew, and prairie mole are also common. Species of lesser importance are the star-nosed mole, masked shrew, least shrew, jumping mouse, Cooper lemming-vole, and pine mouse. The bulk of the small mammal key industry, then, is formed by the spermophile, prairie deer mouse, meadow mouse, white-footed mouse, short-tailed shrew, and prairie mole.

Animal Interrelations

Animal species interact chiefly by being associated in the same habitats and by being active at the same time. The most vital interrelationships arise through the necessity of every individual for food.

Habitat relationships

In summer herbaceous vegetation provides good cover everywhere and species like the cottontail, house cat, weasel, skunk, pheasant, and quail use nearly every part of the area. The fox squirrel and flying squirrel are restricted to woodland. The white-footed mouse is also found here, but it includes brush areas and coniferous plantations in its habitat. In grassland the meadow mouse, spermophile, prairie mole, and prairie deer mouse are common, as are several species of sparrows and other birds. On cultivated ground the prairie deer mouse is the only permanent resident.

In winter the habitats of the squirrels, mice, and other species are the same as in summer except that meadow mice are often found in brush areas; and in the presence of snow, rabbits, pheasants, and quail are largely restricted to deciduous brush and conifers.

Activity relationships

The cottontail, fox squirrel, house cat, weasel, pheasant, and quail are designated predominants as they are active throughout the year. Among the smaller animals the prairie deer mouse, white-footed mouse, meadow mouse, and short-tailed shrew are the most common predominants. A large number of migratory birds are present only in summer and the raccoon has

also been found here only at this season. Resident animals that are active in summer but inactive during at least the coldest part of the winter are the skunk, opossum, woodchuck, spermophile, chipmunk, and jumping mouse. Common winter birds that are absent in summer are the Cooper hawk, junco, and tree sparrow. The great horned owl is regularly present in winter but appears to be only occasional in summer. The latter season is the time of greatest activity as all resident species are active, as well as a large number of migrant birds. In winter the migrants are absent and several species of resident mammals are inactive.

Food relationships

Food relationships have been most easily studied in winter. It is at this season that supplies diminish and competition becomes most severe. Among herbivores field mice and rabbits are the most typical feeders upon herbaceous plants; and when this food is covered with snow they subsist upon bark. Potentially these two animals compete for this food supply and affect other species by reducing cover. On this area, however, the amount of brush present was so large that neither of these relationships was vital in the winter of 1935-36. Another source of winter food for herbivores is the fruits and seeds of common weeds. Conditions of deep snow reduce the supply and bring about intensive competition between winter songbirds, pheasants and quail, and seed-eating mice such as the prairie deer mouse and white-footed mouse. A food shortage occurred in February 1936. Through their habit of storing food mice probably did not suffer; the flocks of songbirds left the area; and pheasants and quail subsisted on other foods. The shortage was of

brief duration, as snows melted in late February and exposed a new supply.

The carnivores on this area that feed on small mammals are the great horned owl, screech owl, marsh hawk, red-tailed hawk, crow, skunk, house cat, weasel, and opossum. The short-tailed shrew may be added as an enemy of mice.

The rabbit is the most important prey species among the larger mammals. It is taken by the horned owl, red-tailed and marsh hawks, crow, cat, skunk, weasel, and opossum. The fox squirrel is preyed upon by the red-tailed hawk, cat, and possibly the great horned owl and other species. The horned owl appears to dominate the community as it preys upon the skunk and thus utilizes larger food than any other predator on the area.

* * *

It is evident from this study that relatively dense populations of three species of large mammals have existed here together. The cottontail rabbit, the skunk, and the fox squirrel are abundant, and there is no apparent reason why they should not continue to thrive. Six species of small mammals are also particularly plentiful. The spermophile, prairie deer mouse, meadow mouse, white-footed mouse, short-tailed shrew, and prairie mole evidently find this farm a very favorable habitat.

Among birds the number of pheasants is low. The species has been conspicuously preyed upon by the Cooper hawk, but perhaps no more here than elsewhere. The drop in numbers from late fall to spring has been less than one-third, but the productivity of the breeding stock has been low.

Evidently about one-third of the nests of pheasants are broken up by natural enemies. It is, however, doubtful whether the status of the bird can be attributed in any large measure to this factor, as such a proportion of nest losses is probably not unusual in the wild. The exact ways in which this environment is unfavorable to the pheasant have not been definitely established.

The large amount of cover makes this environment favorable to pheasants, rabbits, and other species in severe winter weather. The area also has been prolific of natural food supplies which supported large numbers of winter songbirds and other animals. The flora is very favorable to herbivorous species and hence the large, though probably not abnormal, numbers of small mammals found here are to be expected. It follows from this that the carnivorous species dependent upon the latter should also find the farm a favorable habitat. This is notably so in the case of the skunk; and the numbers of the weasel, cat, marsh hawk, redtail, horned owl, crow, and other carnivores are apparently about "normal" for these species.

On this area of farm land we have, in general, copious food supplies and abundant cover. The animal populations are characterized by large numbers of rabbits, squirrels, and skunks, but small numbers of pheasants. A knowledge of the consistency with which these relative numbers do or do not occur on other areas will throw further light upon the extent to which each of these species tends to determine the status of others.

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APPENDIX

CHECK-LIST OF VERTEBRATES

All of the species listed here have been recorded in Section 8, Ross Township, Kalamazoo County, Michigan, and nearly all were taken during the period from September 1935 to June 1937. For completeness the vertebrate fauna of Wintergreen Lake has been included, although the study has not dealt with "cold-blooded" forms. A total of 16 species of fish, 11 amphibians, 12 reptiles, 162 birds, and 25 mammals have been recorded.

Class PISCES

Amia calva Linne	Bowfin
Erimyzon sucetta kennerlii (Lacepede)	Western lake chub-sucker
Notemigonus crysoleucas auratus (Rafinesque)	Western golden shiner
Notropis cornutus frontalis (Agassiz)	Northern common shiner
Notropis heterodon (Cope)	Black-chinned shiner
Notropis h. heterolepis Eigenmann and Eigenmann	Northern black-nosed shiner
Hyborhynchus notatus (Rafinesque)	Blunt-nosed minnow
Ameiurus n. nebulosus (Le Sueur)	Northern brown bullhead
Amieurus n. natalis (Le Sueur)	Northern yellow bullhead
Perca flavescens Mitchill	Yellow perch
Poecilichthys exilis Girard	Iowa darter
Huro salmoides (Lacépède)	Large-mouthed bass
Apomotis cyanellus (Rafinesque)	Green sunfish

Helioperca macrochira (Rafinesque)	Bluegill
Eupomotis gibbosus (Linne)	Pumpkinseed
Helioperca x Eupomotis	Bluegill x Sunfish hybrid

Class AMPHIBIA

Ambystoma maculatum (Shaw)	Spotted salamander
Bufo americanus Holbrook	American toad
Bufo fowleri Garman	Fowler toad
Acris gryllus (LeConte)	Cricket frog
Pseudacris triseriata (Wied)	Swamp tree-frog
Hyla crucifer (Wied)	Spring peeper
Hyla v. versicolor (LeConte)	Common tree-frog
Rana cantabrigensis Baird	Wood frog
Rana catesbeiana Baird	Bullfrog
Rana clamitans Latreille	Green frog
Rana pipiens Schreber	Leopard frog

Class REPTILIA

Coluber constrictor flaviventris (Say)	Blue racer
Lampropeltis t. triangulum (Lacepede)	Milk snake
Natrix s. sipedon (Linne)	Water snake
Thamnophis sauritis (Linne)	Ribbon snake
Thamnophis s. sirtalis (Linne)	Common garter snake

Sternotherus odoratus (Latreille)	Musk turtle
Chelydra serpentina (Linne)	Snapping turtle
Emys blandingii (Holbrook)	Blanding turtle
Terrapene c. carolina (Linne)	Box turtle
Graptemys geographica (Le Sueur)	Map turtle
Chrysemys bellii marginata (Agassiz)	Western painted turtle
Amyda spinifera (Le Sueur)	Soft-shell turtle

Class AVES

Gavia i. immer (Brunnich)	Common loon
Podilymbus p. podiceps (Linne)	Pied-billed grebe
Phalacrocorax a. auritus (Lesson)	Double-crested cormorant
Ardea h. herodias Linne	Great blue heron
Casmerodias albus egretta (Gmelin)	American egret
Butorides v. virescens (Linne)	Eastern green heron
Nycticorax nycticorax hoactli (Gmelin)	Black-crowned night heron
Botaurus lentiginosus (Montagu)	American bittern
Ixobrychus e. exilis (Gmelin)	Eastern least bittern
Cygnus columbianus (Ord)	Whistling swan
Branta c. canadensis (Linne)	Canada goose
Branta bernicla hrota (Muller)	American brant
Chen h. hyperborea (Pallas)	Lesser snow goose
Chen caerulescens (Linne)	Blue goose
Anas p. platyrhynchos Linne	Common mallard

Anas rubripes tristis Brewster	Common black duck
Chaulelasmus streperus (Linne)	Gadwall
Mareca americana (Gmelin)	Baldpate
Dafila acuta tzitzihoa (Viellot)	American pintail
Nettion carolinense (Gmelin)	Green-winged teal
Querquedula discors (Linne)	Blue-winged teal
Spatula clypeata (Linne)	Shoveller
Aix sponsa (Linne)	Wood duck
Nyroca americana (Eyton)	Redhead
Nyroca collaris (Donovan)	Ring-necked duck
Nyroca valisneria (Wilson)	Canvasback
Nyroca marila (Linne)	Greater scaup duck
Nyroca affinis (Eyton)	Lesser scaup duck
Glaucionetta clangula americana (Bonaparte)	American goldeneye
Charitonetta albeola (Linne)	Bufflehead
Erismatura jamaicensis rubida (Wilson)	Ruddy duck
Lophodytes cucullatus (Linne)	Hooded merganser
Mergus merganser americanus Cassin	American merganser
Cathartes aura septentrionalis Wied	Turkey vulture
Accipiter v. velox (Wilson)	Sharp-shinned hawk
Accipiter cooperi (Bonaparte)	Cooper hawk
Buteo b. borealis (Gmelin)	Eastern red-tailed hawk
Buteo l. lineatus (Gmelin)	Northern red-shouldered hawk
Buteo p. platypterus (Vieillot)	Broad-winged hawk

Buteo lagopus s.johannis (Gmelin)	American rough-legged hawk
Aquila crysaetos canadensis (Linne)	Golden eagle
Haliaeetus l. leucocephalus (Linne)	Southern bald eagle
Circus hudsonius (Linne)	Marsh hawk
Falco peregrinus anatum Bonaparte	Duck hawk
Falco s. sparverius Linne	Eastern sparrow hawk
Perdix p. perdix (Linne)	Hungarian partridge
Colinus v. virginianus (Linne)	Eastern bobwhite
Phasianus colchicus torquatus Gmelin	Ringneck pheasant
Rallus l. limicola Vieillot	Virginia rail
Porzana carolina (Linne)	Sora rail
Gallinula chloropus cachinnans Bangs	Florida gallinule
Fulica a. americana Gmelin	American coot
Oxyechus v. vociferus (Linne)	Killdeer
Philohela minor (Gmelin)	American woodcock
Capella delicata (Ord)	Wilson snipe
Actitis macularia (Linne)	Spotted sandpiper
Tringa s. solitaria Wilson	Eastern solitary sandpiper
Totanus melanoleucus (Gmelin)	Greater yellowlegs
Totanus flavipes (Gmelin)	Lesser yellowlegs
Pisobia melanotos (Vieillot)	Pectoral sandpiper
Pisobia minutilla (Vieillot)	Least sandpiper
Micropalama himantopus (Bonaparte)	Stilt sandpiper
Larus argentatus smithsonianus Coues	Herring gull

Larus philadelphia (Ord)	Bonaparte gull
Larus delawarensis Ord	Ring-billed gull
Hydroprogne caspia imperator (Coues)	Caspian tern
Chlidonias nigra surinamensis (Gmelin)	Black tern
Zenaidura macroura carolinensis (Linne)	Eastern mourning dove
Coccyzus a. americanus (Linne)	Yellow-billed cuckoo
Coccyzus erythropthalmus (Wilson)	Black-billed cuckoo
Tyto alba pratincola (Bonaparte)	Barn owl
Otus asio naevius (Gmelin)	Eastern screech owl
Bubo v. virginianus (Gmelin)	Great horned owl
Strix v. varia Barton	Northern barred owl
Chordeiles m. minor (Forster)	Eastern nighthawk
Chaetura pelagica (Linne)	Chimney swift
Archilochus colubris (Linne)	Ruby-throated hummingbird
Megaceryle a. alcyon (Linne)	Eastern belted kingfisher
Colaptes auratus luteus Bangs	Northern flicker
Centurus carolinus (Linne)	Red-bellied woodpecker
Melanerpes erythrocephalus (Linne)	Red-headed woodpecker
Sphyrapicus v. varius (Linne)	Yellow-bellied sapsucker
Dryobates v. villosus (Linne)	Eastern hairy woodpecker
Dryobates pubescens medianus (Swainson)	Northern downy woodpecker
Tyrannus tyrannus (Linne)	Eastern kingbird
Myiarchus crinitus boreus Bangs	Northern crested flycatcher
Sayornis phoebe (Latham)	Eastern phoebe

Empidonax t. trailli (Audubon)	Alder flycatcher
Empidonax minimus (Baird and Baird)	Least flycatcher
Myiochanes virens (Linne)	Eastern wood pewee
Otocoris a. alpestris (Linne)	Northern horned lark
Otocoris alpestris praticola Henshaw	Prairie horned lark
Iridoprocne bicolor (Vieillot)	Tree swallow
Riparia r. riparia (Linne)	Bank swallow
Stelgidopteryx ruficollis serripennis (Audubon)	Rough-winged swallow
Hirundo erythrogaster Boddaert	Barn swallow
Progne s. subis (Linne)	Purple martin
Cyanocitta c. cristata (Linne)	Northern blue jay
Corvus b. brachyrhynchus Brehm	Eastern crow
Penthestes a. atricapillus (Linne)	Black-capped chickadee
Baeolophus bicolor (Linne)	Tufted titmouse
Sitta c. carolinensis Latham	White-breasted nuthatch
Certhia familiaris americana Bonaparte	Brown creeper
Troglodytes a. aedon Vieillot	Eastern house wren
Telmatodytes p. palustris (Wilson)	Long-billed marsh wren
Cistothorus stellaris (Naumann)	Short-billed marsh wren
Dumetella carolinensis (Linne)	Catbird
Toxostoma rufum (Linne)	Brown thrasher
Turdus m. migratorius (Linne)	Eastern robin
Hylocichla mustelina (Gmelin)	Wood thrush
Hylocichla guttata faxoni (Bangs and Penard)	Eastern hermit thrush

Hylocichla ustulata swainsoni (Tschudi)	Olive-backed thrush
Hylocichla f. fuscescens (Stephens)	Veery
Sialia s. sialis (Linne)	Eastern bluebird
Regulus s. satrapa Lichtenstein	Eastern golden-crowned kinglet
Corthylio c. calendula (Linne)	Eastern ruby-crowned kinglet
Anthus spinoletta rubescens (Tunstall)	American pipit
Bombycilla cedrorum Vieillot	Cedar waxwing
Sturnus v. vulgaris (Linne)	Starling
Vireo flavifrons Vieillot	Yellow-throated vireo
Vireo olivaceus (Linne)	Red-eyed vireo
Vireo g. gilvus (Vieillot)	Eastern warbling vireo
Mniotilta varia (Linne)	Black-and-white warbler
Dendroica a. aestiva (Gmelin)	Eastern yellow warbler
Dendroica c. caerulescens (Gmelin)	Black-throated blue warbler
Dendroica coronata (Linne)	Myrtle warbler
Dendroica v. virens (Gmelin)	Black-throated green warbler
Dendroica fusca (Muller)	Blackburnian warbler
Geothlypis trichas brachidactyla (Wainson)	Northern yellowthroat
Setophaga ruticilla (Linne)	American redstart
Passer d. domesticus (Linne)	English sparrow
Dolichonyx oryzivorus (Linne)	Bobolink
Sturnella m. magna (Linne)	Eastern meadowlark
Agelaius p. phoeniceus (Linne)	Eastern redwing
Icterus galbula (Linne)	Baltimore oriole

Euphagus carolinus (Muller)	Rusty blackbird
Quiscalus quiscula aeneus Ridgway	Bronzed grackle
Molothrus a. ater (Boddaert)	Eastern cowbird
Richmondena c. cardinalis (Linne)	Eastern cardinal
Hedymeles ludovicianus (Linne)	Rose-breasted grosbeak
Passerina cyanea (Linne)	Indigo bunting
Spiza americana (Gmelin)	Dickcissel
Acanthis l. linaria (Linne)	Common redpoll
Spinus p. pinus (Wilson)	Northern pine siskin
Spinus t. tristis (Linne)	Eastern goldfinch
Pipilo e. erythrophthalmus (Linne)	Red-eyed towhee
Passerculus sandwichensis savanna (Wilson)	Eastern savannah sparrow
Ammodramus savannarum australis Maynard	Eastern grasshopper sparrow
Passerherbulus henslowi susurrans Brewster	Eastern Henslow sparrow
Pooecetes g. gramineus (Gmelin)	Eastern vesper sparrow
Junco h. hyemalis (Linne)	Slate-colored junco
Spizella a. arborea (Wilson)	Eastern tree sparrow
Spizella p. passerina (Bechstein)	Eastern chipping sparrow
Spizella p. pusilla (Wilson)	Eastern field sparrow
Zonotrichia l. leucophrys (Forster)	White-crowned sparrow
Zonotrichia albicollis (Gmelin)	White-throated sparrow
Passerella i. iliaca (Merrem)	Eastern fox sparrow
Melospiza l. lincolni (Audubon)	Lincoln sparrow
Melospiza georgiana (Latham)	Swamp sparrow

Melospiza m. melodia (Wilson)	Eastern song sparrow
Calcarius l. lapponicus (Linne)	Lapland longspur
Plectrophenax n. nivalis (Linne)	Eastern snow bunting

Class MAMMALIA

Didelphis virginiana Kerr	Virginia opossum
Scalopus aquaticus machrinus (Rafinesque)	Prairie mole
Condylura cristata (Linne)	Star-nosed mole
Sorex c. cinereus Kerr	Masked shrew
Cryptotis parva (Say)	Least shrew
Blarina b. brevicauda (Say)	Short-tailed shrew
Procyon l. lotor (Linne)	Raccoon
Mustela frenata noveboracensis (Emmons)	New York weasel
Mephitis nigra Peale and Beauvois	Eastern skunk
Vulpes f. fulva (Desmarest)	Red fox
Marmota monax rufescens Howell	Rufuscent woodchuck
Citellus tridecemlineatus (Mitchill)	Thirteen lined spermophile
Tamias striatus lysteri (Richardson)	Lyster chipmunk
Sciurus hudsonicus loquax Bangs	Southern red squirrel
Sciurus niger rufiventer (Goeffroy)	Fox squirrel
Glaucomys v. volans (Linne)	Eastern flying squirrel
Peromyscus maniculatus bairdii (Hoy and Kennicott)	Prairie deer mouse
Peromyscus leucopus noveboracensis (Fischer)	Northern white-footed mouse

Synaptomys c. cooperi Baird	Cooper lemming-vole
Microtus p. pennsylvanicus (Ord)	Eastern meadow mouse
Pitymys pinetorum scalopsoides (Audubon and Bachman)	Northern pine mouse
Ondatra z. zibethica (Linne)	Muskrat
Rattus norvegicus (Erxleben)	Norway rat
Zapus h. hudsonius (Zimmerman)	Meadow jumping mouse
Sylvilagus floridanus mearnsii (Allen)	Cottontail rabbit

TABLE 5

ABUNDANCE AND AVAILABILITY AS FOOD FOR BIRDS OF SOME FRUITS AND SEEDS IN THE WINTER 1935-36

Fleshy fruits	Duration of availability				
	Nov.	Dec.	Jan.	Feb.	Mar.
Aronia arbutifolia (Red chokeberry) (3)*	———				
Aronia melanocarpa (Black chokeberry) (3)	———				
Celastrus scandens (Bittersweet) (2)	———	———	———	———	———
Cornus Amomum (Silky dogwood) (1)	———	———			
Cornus candidissima (Gray dogwood) (1)	———	———			
Cornus florida (Flowering dogwood) (3)	———	———			
Cornus stolonifera (Red-osier dogwood) (1)	———	———			
Crataegus (Hawthorn) (2)	———	———	———		
Evonymus atropurpureus (Wahoo) (3)	———	———			
Ilex verticillata (Michigan holly) (3)	———	———	———		
Juniperus communis depressa (Ground juniper) (3)	———	———	———	———	

*Approximate abundance from field observations: (1) -- abundant
(2) -- common
(3) -- less common

	Duration of availability				
	Nov.	Dec.	Jan.	Feb.	Mar.
Lonicera caerulea (Mountain fly honeysuckle) (3)	———	———	———	———	
Lonicera japonica (Japanese honeysuckle) (3)	———	———	———	———	———
Malus coronaria (Wild crab) (3)	———	———	———	———	———
Parthenocissus quinquefolia (Virginia creeper) (2)	———	———	———		
Phytolacca americana (Pokeberry) (2)	———	———	———		
Polygonatum pubescens (Solomon's seal) (3)	———	———	———	———	
Prunus serotina (Wild black cherry) (2)	—				
Rosa sp. (Rose) (1)	———	———	———	———	———
Rhus copallina (Shining sumac) (1)	———	———	———	———	———
Rhus glabra (Smooth sumac) (1)	———	———	———	———	———
Rhus typhina (Staghorn sumac) (1)	———	———	———	———	———
Sambucus canadensis (Elderberry) (1)	———	———			
Smilacina racemosa (False Solomon's seal) (3)	———	———			
Smilax herbacea (Herbaceous smilax) (3)	———	———	———	———	
Smilax hispida (Hispid smilax) (3)	———	———	———	———	

	Duration of availability				
	Nov.	Dec.	Jan.	Feb.	Mar.
Solanum carolinense (Horse nettle) (3)	———	———	———		
Solanum Dulcamara (Bittersweet nightshade) (1)	———	———	———		
Solanum nigrum (Black-berried nightshade) (3)	———				
Sorbus americana (Mountain ash) (3)	———	———			
Symphoricarpos racemosus (Coralberry) (3)	———	———			
Viburnum acerifolium (Maple-leaf viburnum) (3)	———				
Viburnum Lentago (Nannyberry) (3)	———	———			
Viburnum Opulus americanum (High-bush cranberry) (3)	———	———	———	———	———
Vitis vulpina (Wild grape) (1)	———	———	———	———	———
Dry fruits and seeds					
Amaranthus graecizans (Tumbling pigweed) (2)	———	———	———	———	
Amaranthus retroflexus (Redroot) (1)	———	———	———	———	
Ambrosia elatior (Ragweed) (1)	———	———	———	———	
Arctium minus (Burdock) (1)	———	———	———	———	———
Bromus tectorum (Brome grass) (2)	———	———	———		

	Duration of availability				
	Nov.	Dec.	Jan.	Feb.	Mar.
Carex sp. (Sedge) (2)	———	———	———		
Cephalanthus occidentalis (Buttonbush) (1)	———	———	———	———	———
Chenopodium album (Lamb's quarters) (1)	———	———	———		
Cuscuta pentagona (Dodder) (2)	———	———	———	———	
Echinochloa crusgalli (Barnyard grass) (3)	———	———			
Echinocystis lobata (Wild cucumber) (3)	———	———	———		
Fraxinus americana (White ash) (2)	———	———	———	———	———
Lespedeza hirta (Bush clover) (3)	———	———	———		
Lychnis alba (White cockle) (3)	———	———			
Melilotus alba (White sweet clover) (1)	———	———	———	———	
Monarda fistulosa (Wild bergamot) (1)	———	———	———	———	
Monarda punctata (Horse mint) (3)	———	———	———		
Nepeta Cataria (Catnip) (2)	———	———	———	———	
Oenothera biennis (Evening primrose) (2)	———	———	———		
Panicum capillare (Old witch grass) (2)	———	———			

	Duration of availability				
	Nov.	Dec.	Jan.	Feb.	Mar.
Plantago aristata (Bracted plantain) (3)	———	———	———		
Plantago major (Common plantain) (1)	———	———	———		
Poa pratensis (Kentucky bluegrass) (1)	———	———	———		
Polygonum acre (Smartweed) (3)	———	———			
Polygonum coccineum (Water smartweed) (2)	———	———			
Polygonum Convolvulus (Black bindweed) (2)	———	———	———	———	
Polygonum Hydropiper (Water pepper) (2)	———	———			
Polygonum orientale (Prince's feather) (3)	———	———			
Polygonum Persicaria (Lady's thumb) (1)	———	———	———		
Polygonum sagittatum (Arrow-leaved tearthumb) (1)	———	———	———		
Polygonum scandens (Climbing false buckwheat) (2)	———	———	———	———	———
Prunella vulgaris (Self heal) (2)	———	———	———	———	
Quercus alba (White oak) (2)	———	———	———		
Quercus borealis maxima (Red oak) (1)	———	———	———		
Quercus velutina (Black oak) (1)	———	———	———		

	Duration of availability				
	Nov.	Dec.	Jan.	Feb.	Mar.
Robinia Pseudo-Acacia (Black locust) (3)	———	———	———		
Rumex Acetosella (Sheep sorrel) (1)	———	———			
Rumex altissimus (Tall dock) (3)	———	———	———	———	———
Rumex crispus (Curled dock) (2)	———	———	———	———	———
Rumex obtusifolius (Broad-leaved dock) (2)	———	———	———	———	———
Rumex verticillatus (Swamp dock) (3)	———	———	———	———	———
Setaria lutescens (Yellow foxtail) (1)	———	———			
Setaria viridis (Green foxtail) (3)	———	———	———		
Steironema ciliatum (Fringed loosestrife) (3)	———	———	———		
Verbena hastata (Blue vervain) (2)	———	———	———	———	
Verbena urticaefolia (White vervain) (2)	———	———	———	———	