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Seasonal Changes in Densities, Distribution and Movements of Sparrow Hawks

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SEASONAL CHANGES IN DENSITIES, DISTRIBUTION AND MOVEMENTS OF SPARROW HAWKS

(TITLE)

BY

Martin D. Jakle

THESIS

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INTRODUCTION

The sparrow hawk (Falco sparverius) is one of the most widespread and abundant raptors in North America. Only two studies of sparrow hawk ecology have been made, however. The Craigheads (1956) investigated the role of sparrow hawks in the ecology of predators and prey in Michigan and Wyoming. Enderson (1960) studied winter, spring and early summer populations of sparrow hawks in an intensively cultivated area in east-central Illinois. The aim of the present study was to determine seasonal differences in population densities, distribution and movements of a wild population of sparrow hawks on a thirty square mile study area composed both of wooded and cultivated areas in east-central Illinois. The study was carried out from February through December, 1968.

LITERATURE REVIEW

The diverse types of habitat found in Illinois support many different species of hawks. Graber and Golden (1960), in a study of population trends of raptors, reported the most common species of hawks in the state to be the sharp-shinned hawk (Accipiter striatus), Cooper's Hawk (Accipiter cooperii), red-tailed hawk (Buteo jamaicensis), red-shouldered hawk (Buteo lineatus), broad-winged hawk (Buteo platypterus), rough-legged hawk (Buteo lagopus), marsh hawk (Circus cyaneus) and sparrow hawk or kestrel (Falco sparverius). The red-tailed hawk was the most common species of the state and the sparrow hawk and marsh hawk ranked second and third in abundance, respectively. Graber and Golden (1960) also listed several species of raptors that have been reported in Illinois, but are not considered common residents. These species included the goshawk (Accipiter gentilis), golden eagle (Aquila chrysaetos), bald eagle (Haliaeetus leucocephalus), osprey (Pandion haliaetus), gyrfalcon (Falco rusticolus), peregrine falcon (Falco peregrinus), and pigeon hawk (Falco columbarius).

Trapping and Marking Hawks

Ecological studies of raptors, in which individual birds must be identified, make it necessary to live-trap and mark the birds. Raptors have been live-trapped since early times for use in the sport of falconry (Meredith, 1943). Ancient falconers had many methods of trapping wild hawks including the Dho-gaza trap (Meredith, 1943). This trap consisted of a neutral-colored net fastened vertically between two poles with the corners connected loosely to the poles. A live decoy, such as a pigeon or small owl, was used to lure the raptor into the net. A similar, but more elaborate trapping procedure, was the Dutch method of trapping where the trapper concealed himself in a sod hut and used shrikes

as sentinels to signal the approach of a hawk; the approaching hawk was then lured into one of three hand-operated bow-nets using a live pigeon as bait.

Modern methods of raptor trapping are usually merely improvements on ancient methods. Some workers use steel traps with padded jaws to capture raptors alive (Enderson, 1960), but most trapping procedures are more refined. Burger and Mueller (1959) report having tremendous success with a modification of the bal-charti trap. This trap consisted of a small circular or quonset shaped cage with nooses made of monofilament fishing line attached to the top. A live animal, usually a house mouse (Mus musculus) was placed in the cage as bait. The legs of hawks attempting to take the mouse were entangled in the nooses. These workers trapped 376 sparrow hawks with the bal-charti trap and rated their success of trapping 45.8% in one season and 57.8% in another. Cade (1955) also reported having good success trapping sparrow hawks with this trap, and Enderson (1960) captured 40 sparrow hawks, with as many as eight captures in a single day.

An automatic bow-net type of trap has also been used by a number of workers. This trap consists of a spring-loaded bow-net with a live mouse to lure a hawk to the trap (Tordoff, 1954). Enderson (1960) caught 16 sparrow hawks with this type of trap, but later abandoned it in preference for the bal-charti trap. Cade (1955) also captured sparrow hawks with the bow-net trap and considered it about equally as successful as the bal-charti and Dho-gaza traps.

In ecological studies of raptors there is a difference of opinion as to the necessity of identifying individual birds in order to plot daily and seasonal ranges or territories. A number of workers have considered it essential to mark the birds so that individuals could be rec-

ognized (Enderson, 1960; Cade, 1955). However, Craighead and Craighead (1956), in an extensive study of raptors, felt that marking was "neither feasible nor necessary" since "a few individual hawks could be identified by unusual markings or color, missing feathers, by being the only known representative of a species of the area, or by being isolated from other birds of the same species." The Craigheads considered that a raptor seen in the same area at the same time of day on consecutive days represented the same individual of each observation. These assumptions, although valid in many cases, obviously make it impossible to accurately determine the ranges of fledglings or adults nesting in close proximity.

Many methods of marking raptors for individual recognition have been used. Sherman (1913) tied a red string around the leg of a female sparrow hawk. This type of marking had definite limitations since it was not visible at any great distance. Enderson (1960) marked sparrow hawks by cutting a notch or window in the primaries, secondaries and rectrices. Windows in primaries and secondaries were successful, but windows cut in the rectrices were often impossible to see because the rectrices were not usually spread. Enderson also fitted the birds with a leather strap on one foot to identify perching birds.

Cade (1955), in a behavioral study, color-marked sparrow hawks by using acetone-base lacquer on the dorsal surface of the central rectrices. Another method this worker found successful was to attach colored straps, jesses, to the tarsi of the sparrow hawk. Cade later abandoned all marking because he felt it interfered with the behavior of the wild birds.

A method recently introduced for the study of movements of birds is radio telemetry (Nicholls and Warner, 1968). Radios have been used successfully to determine the movements of owls (Cochran, 1965) and

could probably be applied to studies of the more secretive bird hawks (goshawk, Cooper's hawk and sharp-shinned hawk) or used to locate the nests of the marsh hawk or sparrow hawk.

Life History of The Sparrow Hawk

Numerous studies have been made of the sparrow hawk (Sherman, 1913; Pearson, 1936; Bent, 1938; Heintzetman and Nagy, 1968) although intense ecological and behavioral studies have been limited (Cade, 1955; Craighead and Craighead, 1956; Roest, 1957; Enderson, 1960).

The sparrow hawk, Falco sparverius, is a member of the family Falconidae and the subfamily Falconinae. The genus Falco also contains the peregrine falcon (F. peregrinus), prairie falcon (F. mexicanus), hobby (F. subbuteo), merlin (F. columbarius), gyrfalcon (F. rusticolus) and many others (Grossman and Hamlet, 1964).

The sparrow hawk has a wide distribution in the Western Hemisphere; its range extends from northern Canada in North America to Argentina in South America and to the West Indies (Bent, 1938). There are three subspecies of the sparrow hawk within this range; F. sparverius sparverius, F. sparverius deserticolus and F. sparverius peninsularis. The subspecies F.s. sparverius is found in Illinois (Bent, 1938).

The sparrow hawk is the smallest of the North American hawks (Pearson, 1936), its size in total length has been reported at 9-11 inches (Grossman and Hamlet, 1964), 9-12 inches (Peterson, 1947), and 11 inches (Pearson, 1937). The Craigheads (1956), conducting an examination of raptor weights, found an average weight of 109 grams in 50 male sparrow hawks and 119 grams in 67 females. Another study reports the average weight of 88 adult male sparrow hawks as 102.5 grams and the average weight of 72 female sparrow hawks as 119 grams (Roest, 1957).

Sex can be determined easily in this small falcon as there is a marked difference in coloration (Grossman and Hamlet, 1964). The males have slate-blue wing coverts spotted with black, slate-blue secondaries, and dark brown primaries. The tail is ferruginous with a black subterminal band and a white tip. The back and nape is ferruginous with black horizontal bands; the breast is white to cinnamon and spotted on the sides and flank with black. The back, wing coverts and tail are broadly banded with ferruginous and dark brown in the female sparrow hawk; the underparts are white, streaked in cinnamon.

Differences between immature and adult male sparrow hawks are marked. Immatures show barring of the anterior one-third of the scapular-interscapular region, while adults show no barring in this region. The breast in the immature has black spotting or streaks while the adults show barring in this area, and immatures have rectrices tipped in white instead of ferruginous as in the adults (Grossman and Hamlet, 1964; Parkes, 1955).

Adult and immature female sparrow hawks are more difficult to distinguish (Parkes, 1955). Parkes examined 126 sparrow hawks and found the best criterion for aging immature females was the subterminal black band across the rectrices which was wider than the anterior black bands on the central pair of rectrices only. The subterminal black bands on the tail of the adult female were "decidedly wider than the remaining bands on the tail except on the outer most pair of rectrices."

Habitat requirements of the sparrow hawk are variable since the species ranges from northern Canada to southern South America. In Kansas habitat requirements have been defined by Fitch (1958) as "open ground, with sparse or short vegetation, and high perches from which the hawk may examine the surrounding terrain." Graber and Graber (1963), in Illinois,

reported the sparrow hawk as having a "broad ecological distribution, but ungrazed grasslands and fallow fields were by far the most favored foraging habitats in summer", other important habitats were pastures, fields of mixed hay, and cornfields.

The Grabers (1963), in a comparative study of bird populations of Illinois in 1906-1909 and 1956-1958, state that there has been a population shift in the sparrow hawk. In 1907-1909 the bulk of the population was located in the southern part of the state and in 1957-1958 "most of the population was in the central and northern zones of the state". These workers considered that there had been a 13 per cent reduction in the sparrow hawk population from the 1907-1909 period to the 1957-1958 period; the possible cause of this reduction may have been accountable to the introduction of the starling, a nest site competitor.

Unlike most hawks, which either make true nests in trees or lay their eggs on open ledges of bare cliffs, the sparrow hawk, in a great majority of instances, hides its eggs away in deep hollows, either in a natural cavity in a tree or in a hole excavated by a flicker or other woodpecker of similar size (Bent, 1938). Roest (1955) lists a number of nest sites: 19 nests were located in trees, 38 in flicker holes, 6 in woodpecker holes, 2 in magpie nests, 3 were found in buildings and 1 in a hole in a cliff. Sherman (1913) and Lamore (1963) reported sparrow hawks nesting in nesting boxes. Sparrow hawks, like other raptors, have a tendency to reoccupy previous nesting territories in consecutive years (Craighead and Craighead, 1956). These workers found that several pairs of sparrow hawks had occupied the same nest site for three consecutive years and that one pair had occupied the same nest site for six consecutive years.

The size of the nesting territory of the sparrow hawk varies. Craighead and Craighead (1956) reported an average area of 0.5 square mile

with an average maximum diameter of one mile per territory in Michigan, while Enderson (1960) reported an average maximum diameter of 1.4 miles per nesting territory.

The nest is occupied by April or May (Cade, 1955). Sherman (1913) reported the first of six eggs being deposited in the nest on April 28 and the last on May 8. Enderson (1960), in a sparrow hawk population study in central Illinois, estimated the first egg was laid on April 16, and the clutch was completed on April 22. The earliest laying date in Michigan was April 12 in 1942 and May 1 in 1948 (Craighead and Craighead, 1956).

Clutch size is variable. Cade (1955) examined 60 nests and found 3 nests with 3 eggs, 13 with 4, 41 with 5, and 3 with 6. The Craigheads (1956) found an average clutch size of 4.5 in 1942 and 4.3 in 1948 in Superior township, Michigan, and an average clutch size of 4.4 in Wyoming. From the data gathered by various workers it appears that the usual number of eggs laid by the sparrow hawk is about five per clutch. The incubation period in the sparrow hawk has been reported as being 29-30 days (Sherman, 1913; Cade, 1955) and 30-31 days (Roest, 1957).

After hatching, the young remain in the nest 30-31 days and are nearly always fed by the female (Roest, 1957). Roest also stated that the young remain with the adults as a family group for a short period of time after leaving the nest. After a few days the young begin to drift away, "and by the middle of July all young birds hatched in the spring are living independently". Cade (1955) gives a more accurate description of the activity of the young after leaving the nest. The young leave the nest five weeks after hatching and "remain with their parents as a family unit in the vicinity of the nest for a variable time ranging from two weeks to a month or more", and are fed by the parents to some extent throughout this period.

The migration of the sparrow hawk is irregular. Some birds are winter residents in the same general area they occupied in the spring and summer (Cade, 1955), while others migrate as much as 2600 miles (Roest, 1957). Roest (1957) states that migration begins in September, the exact date depending on food supply and weather conditions. Banding returns from 210 individuals revealed certain trends in the migration of these birds. "Sparrow hawks in northern areas appear to migrate farther south than those in the more temperate areas" (Roest, 1957). Juveniles, in addition, may move northward during late summer after they have left the nest (Roest, 1957). The winter population of a given area is likely to be composed of birds that have nested in the area as well as birds that have migrated to the area from a northern habitat (Roest, 1957).

Sparrow hawks tend to maintain a hunting range in the winter (Craighead and Craighead, 1956). The maximum observed diameter of these winter ranges in Michigan averaged 2.1 miles. The maximum observed diameter of winter sparrow hawk ranges in Illinois averaged 1.5 miles (Enderson, 1960).

Craighead and Craighead (1956) define the winter range of sparrow hawks as "a rather limited area of land over which a hawk moves and hunts during a given period; it is an undefended area, thus differing from a territory". Cade (1955), however, reported that these birds did not defend their winter ranges. When a tethered sparrow hawk, either male or female, was placed in the winter range of a wild sparrow hawk, the wild bird, in a majority of cases, showed aggressive behavior that was manifested in striking and grappling with the intruder or stooping at the intruder without actually making contact with it. Cade concluded in saying that "winter territoriality is a prominent feature in the behavioral cycle of the sparrow hawk", and "functions to maintain an adequate hunting ground for the individual".

The sparrow hawk is classed as a general feeder and is capable of taking a wide variety of prey (Craighead and Craighead, 1956). Much has been written on the general food habits of the sparrow hawk (Bent, 1938; Pearson, 1936; Lamore, 1963). The Craigheads (1956) found the meadow mouse (Microtus pennsylvanicus) the most common food item, the white footed mouse (Peromyscus sp.) was second and small birds third in winter diets. These workers found the summer food of the sparrow hawk to be comprised mainly of meadow mice and small birds, but grasshoppers and other insects also play a major role in its diet during this period.

METHODS AND MATERIALS

Study Area

A 30 square mile study area was selected in east central Illinois where a number of sparrow hawks had been observed previously. The study area was located in the southwest corner of Cumberland County (Sec. 4, 5, 6, 7, 8, 9, 16, 17, 18, 19, 20, 21 T10N, R7E and Sec. 28, 29, 30, 31, 32, 33, T11N, R7E) and the southeast corner of Shelby County (Sec. 23, 24, 13, 14, 11, 12, 1, 2, T10N, R6E and Sec. 35, 36, 25, 26, T11N, R6E).

The terrain of the study area was nearly level except for hilly to gently rolling regions along the Little Wabash River and its tributaries. An impoundment of the Little Wabash River, Lake Mattoon, formed a 1200 acre lake in the north central part of the study area. Elevation ranged from 600 feet above sea level in the river flood plains to 665 feet, with a mean elevation of about 650 feet.

Dominant soil types over most of the area were prairie derived soils, Putnam silt loam, Ebbert silt loam and Cisne silt loam (Wascher, et al., 1939). On these soils the main crops grown were corn and soybeans. Huntsville loam was found in the bottom areas along the Little Wabash River (Wascher, et al., 1939). Along the Little Wabash River and its tributaries, where the land was unsuitable for cultivation, the land is wooded. There were also a few small wood lots scattered through the area. The mature forests in this region were primarily oak while cut-over woods were in the oak-hickory stage of succession. Large cottonwoods and sycamores were commonly found growing along the rivers and in low, wet areas.

The climate is temperate and characterized by a wide range in temperatures between the extremes of summer and winter. The mean temperature is 75° F. in summer and 33° F. in winter. The yearly average rainfall is 41 inches (Wascher, et al., 1939).

A cover map was prepared of the study area based on aerial photographs supplied by the United States Department of Agriculture offices in Shelby and Cumberland Counties. The study area was surveyed from a car or on foot and the vegetation types were recorded on the map: beans and corn, cultivated grasses (wheat, oats, timothy, alfalfa and clover), uncultivated vegetation (grasses, weeds and pasture), woods and water.

Nest Location

The determination of the location of sparrow hawk nest sites was considered essential to movement patterns of the adults during this phase of their life history. Two basic methods were used to locate sparrow hawk nests. One method was to arrive before sunrise at the area a breeding pair was known to hunt and, after one of the parents made a kill, try to follow the bird back to its nest site. The second method was to make frequent observations in the area a breeding pair was using to locate the young birds just after fledging at or near the nest site.

Trapping and Marking

In order to identify individual birds it was necessary to live-trap birds so they could be marked. A quonset shaped bal-charti trap (Berger and Mueller, 1961) 12 inches long, 5 inches wide and 4½ inches tall was made of ½ inch mesh hardware cloth. About 40 nooses made of 30 pound test monofilament fishing line were attached to the top of the trap. Bait used to lure the sparrow hawks to the trap was either white footed mice (Peromyscus leucopus), English sparrows (Passer domesticus), or house mice (Mus musculus).

The usual method for trapping sparrow hawks was to locate a bird sitting on a telephone wire or tree near the road and to drive toward the bird at a constant speed of 35-40 miles per hour, passing the bird at this

speed, then to slow down quickly about 40 yards away from the bird, open car door, set trap out and drive on. The trap was observed by using binoculars from a distance of one-fourth mile. If the hawk had not come to the trap within 30 minutes, the trap was picked up. When there were no roads in the area a sparrow hawk was using, the baited trap was placed near a nesting or feeding site and either watched continuously from a distance or checked at frequent intervals. After a sparrow hawk was caught, it was immediately taken out of the trap and carefully placed headfirst into a sock to keep it quiet and to prevent damage to its feathers.

Several methods were tried as a means of marking birds so individuals could be identified. The first marking method employed was imping (Wood and Fyfe, 1943) a white feather into either one or two rectrices. Imping, however, was discontinued as it proved to be a poor method of marking birds for field identification.

The next method used in the study was paint marking. A pattern was sprayed on the birds with paint using a stencil cut from a sheet of newspaper. Two light coats of international orange paint were applied to the feathers and allowed to dry. Hawks of the same family group were given identical paint marks on the breast, either "_", "|", "+", or "⊥". Another mark from the same series of patterns was placed on the wing, tail, back or between the legs in either white or international orange to identify individual members of a family group. After marking, all hawks were released at the site of capture.

When paint marking proved unsatisfactory for making field identifications, individual birds were marked by cutting windows in the wings or tail (Enderson, 1957). A quarter was placed on the underneath side of an outstretched wing or spread tail and sprayed lightly with paint. The quarter was then removed and the vanes were cut from the shaft in the unpainted

area leaving a circular window easily seen when the bird was in flight. Circular windows were cut in the primary flight feathers and the rectrices. Semicircular notches were cut in the margin of the secondary wing feathers. A third marking method employed was fitting the sparrow hawks with a leather strap on the left leg, right leg, or on both.

Activity

Ranges and movements of sparrow hawks on the study area were determined by recording the locations of all marked and unmarked birds. A Bausch and Lomb Balscope Zoom 60 spotting scope and 7 x 35 binoculars were used in making field identifications. Observations were made by driving a route over the entire thirty square mile study area at irregular intervals. Daily observations were made in those parts of the study area where nesting sites, recently fledged birds, or feeding areas were located. After the fledging occurred, the activities of the family group were divided into four phases. The brancher phase of the young defined by Wood and Fyfe (1943) was divided into the early and late brancher phases. The family group hunting phase described by Roest (1957) was the third phase recorded after fledging. The term dispersal phase was used to describe the fourth activity phase of the young birds. This phase was characterized by the drifting of the young from the family group to areas of their own.

Observations were recorded in a field notebook and all sparrow hawks were given a bird number. The data recorded were: date, time, species of hawk seen, age, sex, mark of individual if possible to determine, weather conditions, place on the study area where the hawk was seen, habitat at that site, hawk's activity, trapping information, and marking information. Notes were frequently removed from the field notebook and stored in a safe place in case the notebook would happen to be lost while in the field.

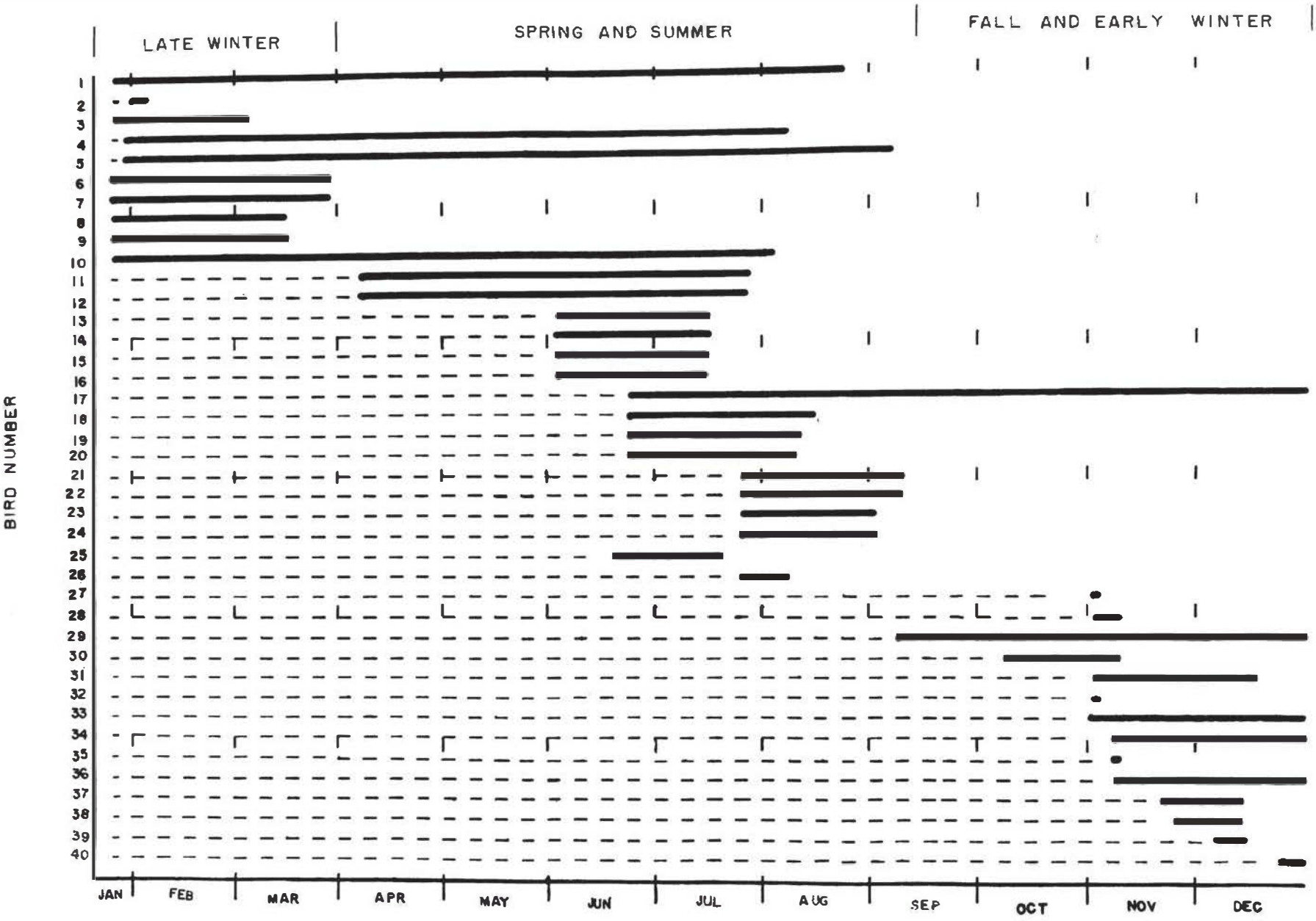
RESULTS

The dynamics of a population of sparrow hawks in east-central Illinois was studied from January 27, 1968, to December 31, 1968. A total of twenty-two sparrow hawks were captured and marked during this study, and four birds were recaptured. Observations were made of 18 additional sparrow hawks which were never trapped and marked; they were considered to be 18 different hawks due to the ranges in which they were observed. The temporal distribution of these birds (Figure 1) shows a marked turnover of residents during the year. The findings, therefore, are divided into three categories based on the activity and temporal distribution of the birds. The late winter period, January 27 to March 30, was characterized by a stable population which began to break up with the advent of warmer weather. The spring and summer period, April 1 to September 15, was essentially that of the pre-nesting, nesting and post-nesting phases of the life history. The fall and early winter period, September 16 to December 31, was one of drift and migration with sparrow hawks moving into and off the study area.

Late Winter Sparrow Hawk Population

Observations of the late winter sparrow hawk population began on January 27, 1968 and ended on March 30, prior to the nesting season. During this period ten sparrow hawks were observed on the study area, and four of the birds were trapped and marked (Table 1). Unmarked birds seen on consecutive days in the same area were considered to be the same individual. The population was relatively stable in that only one of the ten birds did not remain until the first of March (Figure 1). Observations of these birds indicated that the ten sparrow hawks seen on the study area represented four pairs and two single or unmated birds.

Figure 1. The duration of time and season each individual sparrow hawk remained on the study area is indicated by the heavy black lines. Bird numbers indicate the individual sparrow hawks.


LATE WINTER
SPRING AND SUMMER
FALL AND EARLY WINTER
BIRD NUMBER
1
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10
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39
40
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Table 1. Sparrow hawk population on the Neoga study area during the late winter period (January 27, to March 30, 1968).

Bird Number[1]	Sex	Age[2]	Capture Date[3]	Number of Observations	Ranges	
					Area(acres)	Max. Dia. (yards)
1	F	Adult	Feb. 29	6	210	1950
10	M	Adult	---	4	70	900
2	M	Juv.	Feb. 29	1	---	---
3	F	---	Feb. 29	4	70	1300
4	F	Adult	March 17	6	140	2000
5	M	Adult	---	6		
6	M	---	---	7	70	900
7	F	---	---	7		
8	F	---	---	2	155	2000
9	M	---	---	2		

1 Paired bird numbers indicate paired individuals.

2 Hyphens indicate age not determined.

3 Hyphens indicate bird not trapped or marked.

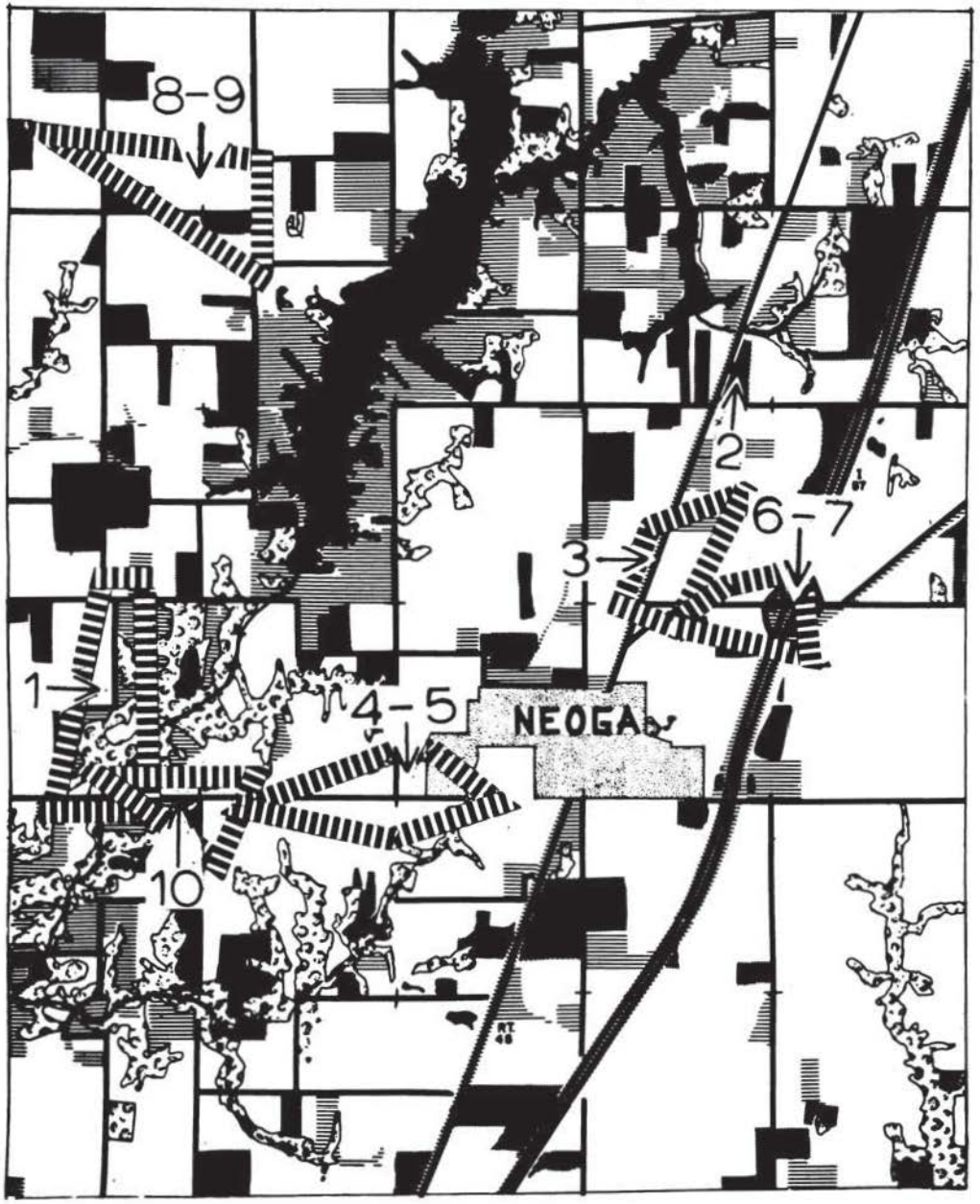
The first pair, female 1 and male 10 (Table 1) ranged over the western part of the study area (Figure 2). The female was observed three times before capture and three times after capture. The area encompassed by the six periods of observation was 210 acres with a maximum diameter of 1950 yards. The range of this female was composed of 21% heavy timber. The range of the male based on four periods of observation was 70 acres with a maximum diameter of 900 yards. The range of the male consisted of only 10% timbered area with a major portion consisting of grassy roadside ditches and picked cornfields. This pair remained on the study area to nest.

The pair of sparrow hawks comprised of female 4 and male 5 ranged over the south central part of the study area (Figure 2). The female was trapped and marked on March 17; she was observed four times unmarked, and two observations were made after marking. All of the observations of both birds were within a 140 acre area with a maximum diameter of 2000 yards (Table 1). Habitat of the area occupied by this pair consisted of grassy roadside ditches, picked corn and bean fields and the west part of the town of Neoga. This pair remained on the study area during most of spring and summer (Figure 1).

The third pair of sparrow hawks, male 6 and female 7, was seen seven times on the east central part of the study area (Figure 2). Although neither bird was marked, all observations were within an area of 70 acres, with a maximum diameter of 900 yards (Table 1). The area occupied by this pair was composed almost exclusively of roadside grasses. Neither bird was seen on the study area after March 30 (Figure 1).

A fourth pair of sparrow hawks, female 8 and male 9, was observed twice in the northwestern part of the study area (Figure 2). The range of this pair (Table 1) covered an area of 155 acres, with a maximum

Figure 2. Ranges of paired and single sparrow hawks as indicated by dashed lines during the late winter phase. Birds 4-5, 6-7, 8-9, and 1-10 are considered pairs while birds 2 and 3 are unmated. Insufficient data were recorded to compute the range of bird 2.



LEGEND

- ROADS
- PERMANENT STREAMS
- INTERMITTENT STREAMS
- WATER
- CORN BEANS
- WOODS
- GRASS WEEDS PASTURE
- OATS TIMOTHY CLOVER WHEAT ALFALFA

SCALE

N

Shelby Co. | Cumberland Co.

26	25	30	29	28	
35	36	31	32	33	T11N
2	1	6	5	4	T10N
11	12	7	8	9	
14	13	18	17	16	
23	24	19	20	21	

R 6E R 7E

diameter of 2000 yards. The dominant types of habitat on this part of the study area were picked corn and bean fields and grassy roadside ditches. This pair was last observed on the study area March 16 (Figure 1).

Two unmated sparrow hawks were on the study area during the late winter. A lone male, 2, was captured and marked on February 29 (Figure 1), but was not observed again. A single female, 3, was observed four times on the central portion of the study area (Figure 2). This bird was not observed after March 3 (Figure 1). The four observations enclosed an area of 70 acres with a maximum diameter of 1300 yards (Table 1). The habitat of this area was composed of grassy roadside ditches and a stubble field.

Spring and Summer Sparrow Hawk Populations

Activities of sparrow hawks during spring and summer (April 1 to September 15) were essentially those of the pre-nesting, nesting and post-nesting phases of the life history. The sparrow hawk populations on the study area during this period consisted of three pairs and two unmated males (Table 2). Two of the four pairs on the study area during the late winter period (pairs 6-7 and 8-9) had left the study area prior to the nesting period (Figure 1). The other two pair present in the late winter period (pairs 1-10 and 4-5) remained to nest. The third nesting pair was not seen on the study area prior to June 8. The distribution of the hawks on the area at this time is shown in Figure 3.

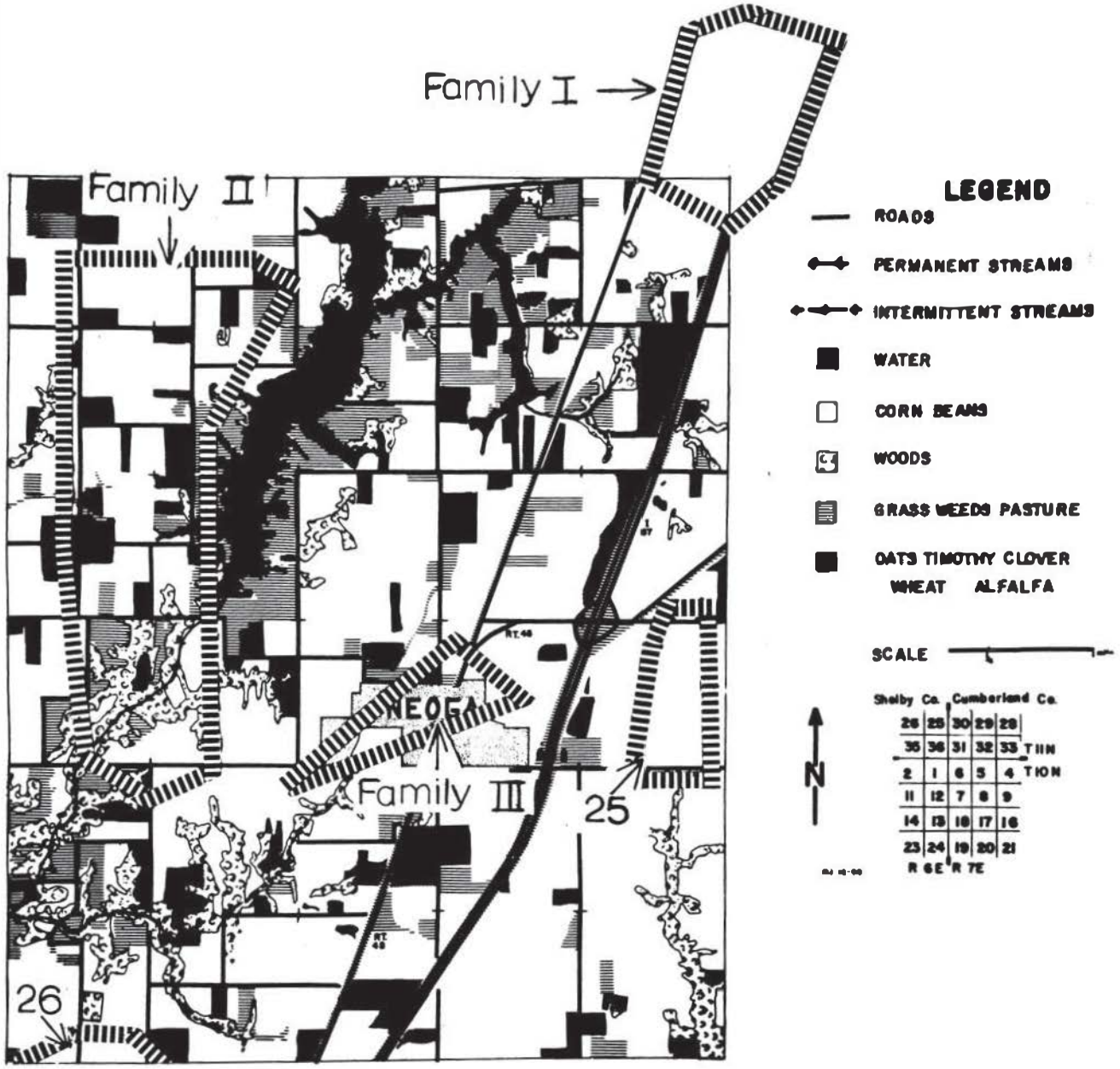
The two unmated males, 25 and 26, were observed on the study area for only a short period of time during the spring and summer period (Figure 1). Male 25 was first observed on the study area June 21 and was trapped and marked the same day. The range determined from four observations over a period of 30 days was 245 acres with a maximum diameter of 1968 yards. The major portion of the area occupied by this bird was composed of cultivated fields, but the main areas of usage were the roadside ditches at the

Table 2. The sparrow hawk population on the Neoga study area during the spring and summer period (April 1, to September 15, 1968).

Bird Number		Sex	Date	Marking Method	
Adult	Young		Captured	Paint	Window
			Family Group I		
11		M	June 14	X	
12		F	---*		
	13	M	June 14	X	
	14	F	June 11	X	
	15	F	June 29	X	X
	16	M	---*		
			Family Group II		
1		F	July 6**	X	X
10		M	---*		
	17	F	July 13	X	X
	18	M	July 13	X	X
	19	F	July 18	X	X
	20	F	July 19	X	X
			Family Group III		
4		F	August 8**	X	X
5		M	---*		
	21	F	July 20	X	X
	21	F	August 7 **	X	X
	22	F	August 7	X	X
	23	M	---*		
	24	M	---*		
			Unmated Males		
25		M	June 21	X	X
26		M	---*		

* Not trapped or marked.
** Recapture

Figure 3. Indicated are the ranges of the adult birds of family groups I, II and III and the two unmated males 25 and 26 on the study area during the summer period.


Family I
Family II
Family III
NEOGA
25
26
LEGEND
ROADS
PERMANENT STREAMS
INTERMITTENT STREAMS
WATER
CORN BEANS
WOODS
GRASS WEEDS PASTURE
OATS TIMOTHY CLOVER
WHEAT ALFALFA
SCALE
Shelby Co.
Cumberland Co.
26 25 30 29 28
35 36 31 32 33 T11N
2 1 6 5 4 T10N
11 12 7 8 9
14 13 18 17 16
23 24 19 20 21
R 6E R 7E
N

north and south extremes of the falcon's territory. Adult male 26 (Table 2) was observed over a period of 14 days on the south edge of the study area (Figure 3). This bird was never trapped and marked. No definite data are available on the movement of this bird since its range undoubtedly extended beyond the Neoga study area.

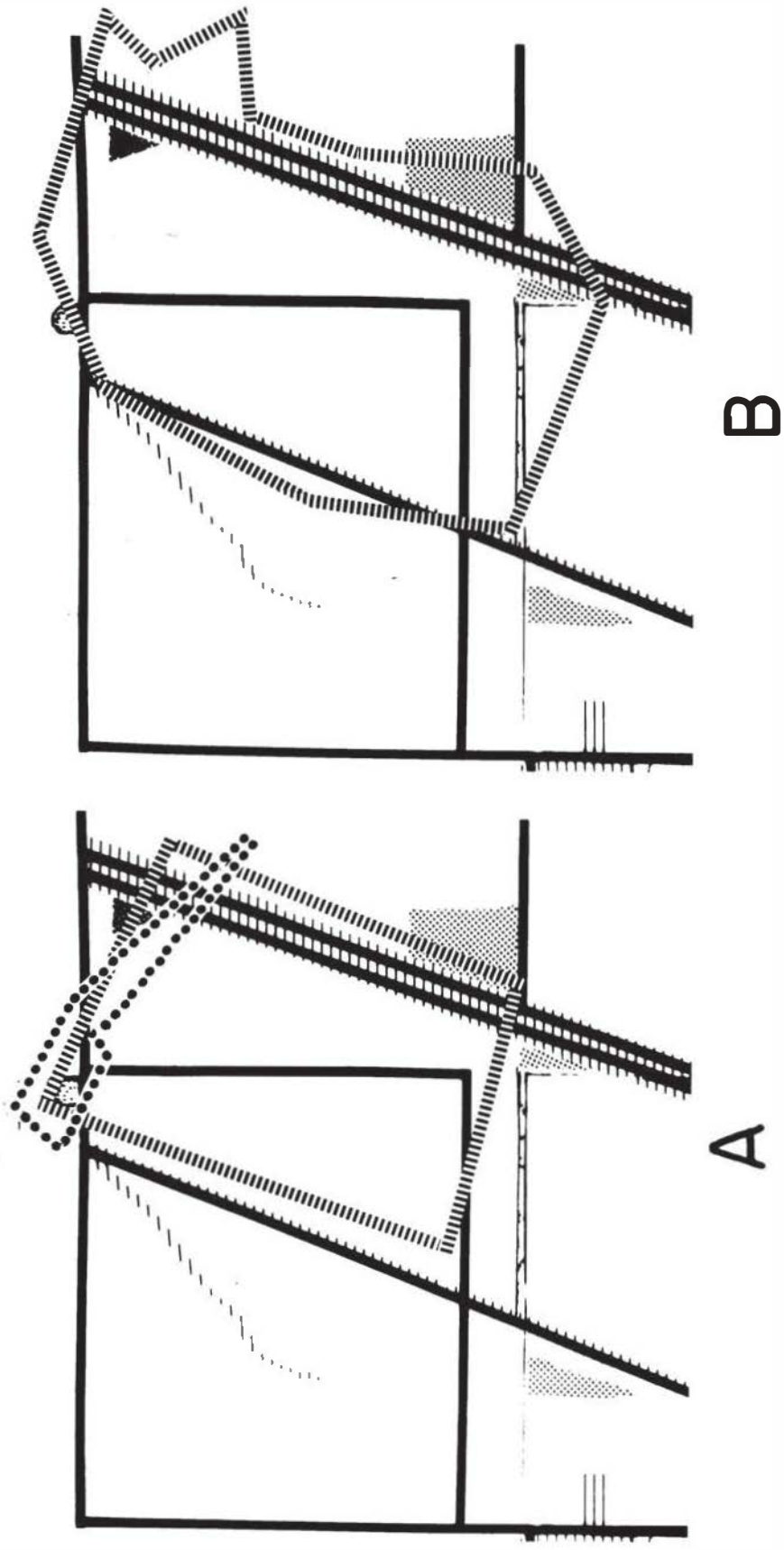
Family Group I

The first sparrow hawk nest site located was that of pair 11 and 12 (Table 2). An adult male sparrow hawk had been seen in the northeast corner of the study area on June 8. The nest site was located on June 10 by observing the male before sunrise, and following him to the nest site after he had made a kill. The family group at the nest site consisted of parent male 11 and parent female 12 and four young: two females, 14 and 15, and two males, 13 and 16. As shown in Table 2, four members of this family group were trapped and marked. Most of the activity of this group was outside the study area (Figure 3).

At the time Family Group I was located, the young were in the late stage of branching and were considered to have fledged approximately seven days before they were discovered. In late brancher stage the young birds were still in the vicinity of the nest and were being fed by the parent birds. At this stage they were capable of catching their own prey since one female, 14, was trapped. The area occupied by the young birds during this phase was about 35 acres (Figure 4A) and ranged as far as 1200 yards from the nest site.

The range of the adult female was not determined while the young were in the late brancher stage, but that of the male was 321 acres with a maximum diameter of 1844 yards (Figure 4A). Habitat was composed almost entirely of cultivated fields while the hunting activities were concentrated in grassy roadside ditches in the area.

Figure 4. Ranges of Family Group I. Part A: Range of parent birds (dashed lines) and young birds (dotted lines) during the late brancher stage. Part B: Range of the entire family group during the family group hunting phase. The nest was presumed to be in the small wooded area at the north end of the area.


B
A

The young began to leave the nest area on June 14 and occupy essentially the same area that the adult male had used while feeding the young. This movement initiated the family group hunting stage as shown in figure 4B. No feeding of the young by the adult birds was observed during this period; instead, the adults and the young ranged at random over the area, sometimes hunting from the same tree or telephone wire. The family group hunting phase lasted approximately 32 days. The area used during this phase was 517 acres with a maximum diameter of 2380 yards. Data on the individual ranges of the young were not available because of unsatisfactory marking techniques. Individual range data on the parent female likewise are not available as she was never marked.

The young began to drift from the family group hunting area around July 16 and were thought to have moved northeast of the study area.

Family Group II

The parent sparrow hawks of Family Group II, male 10 and female 1, were birds that had been late winter residents of the study area (Figure 2) and remained to nest on the western part of the study area (Figure 3). Until the young were located on July 6, the adult female had not been observed since March 25. The male had been seen on five different days during June in the same area he had occupied during the late winter (Figure 5A). At each observation the bird flew north; but attempts to follow him back to the nest were unsuccessful because of the large tract of timber between the hunting area and the nest site. The family group was finally located on July 6 by observing the young sparrow hawks after they had left the nesting cavity. The young, three females and one male (Table 2), were located about twelve days after fledging. The nest site of this family group was never located, but was thought to have been in

Figure 5. Ranges of Family Group II. Part A: Range of the parent male before fledging occurred. The probable nest site is represented by "O". Part B: Ranges of the young birds (dotted lines) and the adult birds (dashed lines) during the morning and afternoon while in the family group hunting stage. Part C: Range of both the young and parent birds forty minutes before sunset while in the family group hunting stage. Part D: Ranges established by the young birds during the dispersal phase; birds 18 and 20 occupied essentially the same area (upper dashed lines), bird 19 (dotted lines) and 17 (lower dashed lines) occupied separate areas.


1 MILE
A
B
C
D

one of a group of four soft maples (Acer saccharinum), at the north end of the territory (Figure 5A).

The young were in the family group hunting phase at the time they were located. The parent birds showed no preference to a particular location, but could be found with equal probability in any part of the hunting area during and after this phase (Figure 5B). The young could usually be seen in the morning and afternoon sitting on telephone lines at the north end of the territory (Figure 5B). The routine of the sparrow hawk family changed radically in the evening starting about forty minutes before sundown. Usually all members of the family group would congregate in one clover field at the northeast end of the family group hunting area (Figure 5C). The birds hunted by hovering in the air over one location for as long as twenty seconds, moving to a new area if no prey was spotted, occasionally making a dive to the ground to capture an insect. They spent equal amounts of time perching and hunting in the air, and on two occasions, five of the six falcons were observed hovering over the field at once.

The family group began to disperse around July 19. By this time all of the family group, except the parent male had been well marked by painting and cutting windows in the secondaries and rectrices (Table 2). During the dispersal phase the family group no longer congregated in the evening at the clover field. Observations of marked individuals showed that the young had established independent hunting areas (Figure 5D). One young female occupied essentially the same area she had during the family group hunting phase. Another young female and a young male occupied an area northeast of the original nest site. The other young birds occupied an area north of the original nest site. The parents continued to occupy the same area they had prior to the dispersal phase.

The total area used by Family Group II during the summer was 2240

acres, an area with a maximum diameter of 2287 yards. The smallest range of the family group existed during the family group hunting phase at which time 205 square miles were used. The hunting areas of the young during the dispersal phase averaged 150 square miles.

Family Group III

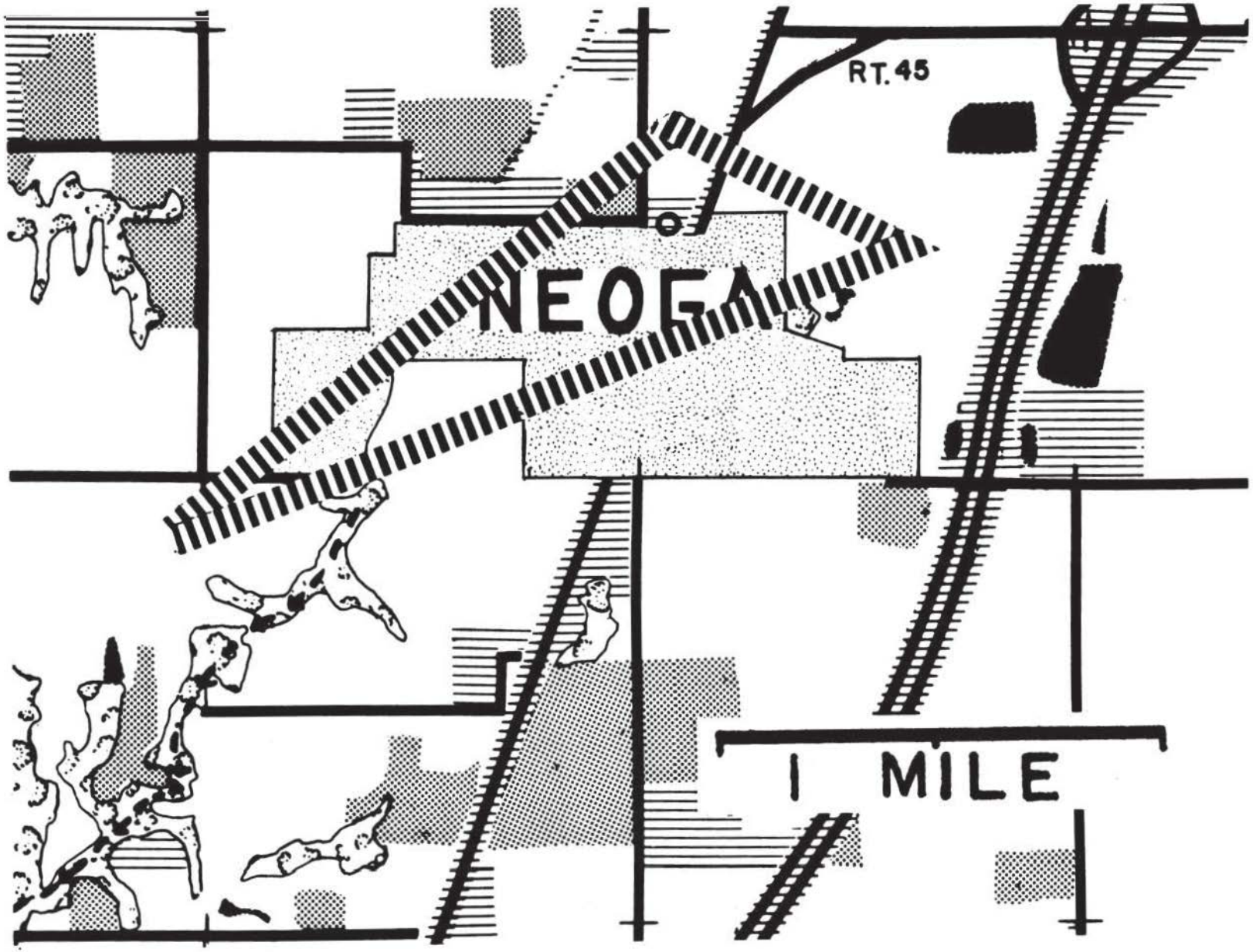
The parent birds of the third family, female 4 and male 5, were present on the study area as a pair during the late winter period (Figure 2). Their range during the summer (Figure 3) was nearly the same as that occupied during the late winter. The nest site was located on July 20 at the north edge of Neoga. The nest was about 35-40 feet above the ground in a hallow cavity in a dead limb of a large soft maple (Acer saccharinum). A well traveled street ran within ten feet of the nesting tree, and it was surrounded by homes.

The nest was located after hearing the adult female call either to a young trained female sparrow hawk kept by the investigator or to a young hawk which had left the nest before it could fly. This young sparrow hawk, female 21, was captured on the ground and kept in captivity for five days, after which she was marked and returned to the nest. The young fledged five days after the nest was located. The brood consisted of two females and two males (Table 2).

The range of the Group III parent male before fledging occurred was found to be 221 acres with a maximum diameter of 2770 yards (Figure 6). This area included the main part of Neoga, but hunting activities centered on grassy roadside ditches just outside of the town. No hunting movement of the female was observed during this period, but she was observed in the area of the nest site.

The first phase recorded after the fledging of the young was the early brancher stage. This phase existed for about four days. The young re-

Figure 6. Range of Family Group III (dashed lines). Indicated is the range of parents while feeding nestlings and the range of the family group during the post-fledging phases.


RT. 45
NEOGA
1 MILE

mained in the nest tree and spent most of their time sitting in the uppermost branches where they were fed by their parents. The young at this period were quite distinct as their tails were shorter than that of an adult bird. The second phase recorded was the late brancher phase which lasted for about seven days. During this phase the activities of the young birds were no longer confined to the single nest tree, but they were capable of making short flights to nearby trees whithin about 50 yards of the nest tree. During this phase the young were still fed by the parents and often gave feeding cries to the parents.

The third phase exhibited by the young was the family group hunting phase. The parent female had died in a bal-charti trap 16 days after the young had fledged; the young and parent male all hunted in the same field 120 yards north of the nest site. This was a one-half acre short grass field with a row of seven pear trees (Pyrus sp.) at the north edge. The family hunted this field from a perch in one of the seven pear trees, and usually spent the entire day in this area. The young gradually enlarged their hunting area, but did not establish individual ranges as had the young of Family Group II. This group apparently left the study area on approximately September 10 as they were not observed after that date (Figure 1).

The total area used by this family group, starting from the late winter until they left the study area was 221 acres. The smallest area used by both the adults and young was one acre during the family group hunting phase.

Fall and Early Winter Sparrow Hawk Population

The fall and early winter phase (September 16 to December 31) of the sparrow hawk life history on the study area was characterized by drift and migration. A total of 15 sparrow hawks were known to be on the study area

during this period (Table 3). At no time, however, was the population greater than eight birds since individual birds apparently moved randomly into and out of the study area. Undoubtedly many other transients moved through the area, but were not observed. By November 1, only one of the birds, number 17, which had been marked in the previous periods remained on the study area (Figure 1).

The length of time an individual remained on the area ranged from one day to the entire period (Figure 1). The first observed immigrant arrived in the area about September 8 before Family Group III had left. Other birds were first observed as late as December 28. In one instance, three hawks (31, 32, 33) were first observed on the study area November 2 as a group. All three birds were trapped and marked; the male, 32, and female 33, left the study area the following day. Female 31 remained on the study area until December 19 and moved into the territory occupied by female 29 (Figure 7). On December 15, 16, and 17, this female was observed with a male, possibly 39 (Figure 7). This was the only observation of pairing during this period. The female was not seen after this date but was known to have remained on the study area since she was found dead on January 2, 1969. A necroscopy showed the sparrow hawk had a broken left wing.

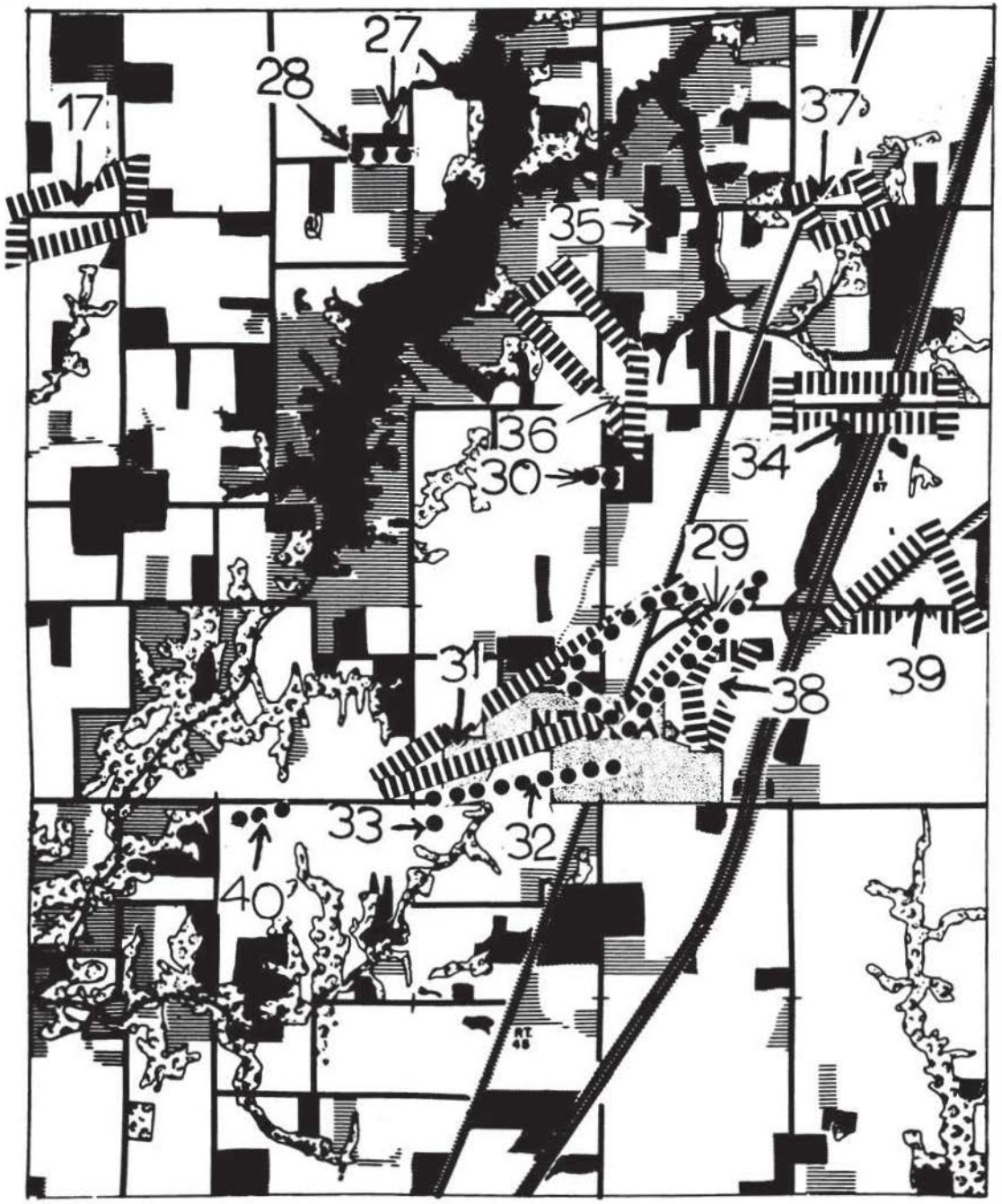
Sufficient observations were made of seven sparrow hawks, 17, 29, 31, 34, 36, 37 and 38 to determine their territories (Figure 7). The territories of birds 17, 29, 31, 34, 37, and 38 centered around the roadside and railroad grassy areas giving the territory the shape of the road or railroad within their territory. Bird 36 was observed hunting mainly in stubble fields. These early winter ranges varied in size from 18 to 207 acres (Table 3). The largest winter territory was found to be that of female 31 and the smallest territory was that of male 37. The average territory

Table 3. Fall and early winter sparrow hawk population on the Neoga study area (September 16 to December 31, 1968).

Bird Number	Sex	Age	Capture Date	Number of Observations	Range	
					Area (Acres)	Max. Dia. (Yards)
17	F	Juv.	December 6*	3	54	1040
27	M	---	---	1	--	----
28	F	Adult	November 9	2	--	----
29	F	Adult	November 9	14	153	1730
30	F	---	---	2	--	----
31	F	Juv.	November 2	10	207	2900
32	M	Juv.	November 2	1	--	----
33	F	Juv.	November 2	2	--	----
34	F	Adult	November 9	8	54	1240
35	M	---	---	1	--	----
36	M	---	---	5	81	1240
37	M	---	---	4	13	520
38	M	Juv.	December 6	6	22	620
39	M	---	---	4	54	930
40	F	---	---	2	--	----

* Recapture

Figure 7. Ranges of sparrow hawks during the fall and early winter period. Enough observations were made of eight birds to compute their ranges (dashed lines except the range of bird 29 which is indicated by dotted lines). The location of sparrow hawks with insufficient observations to determine range are indicated by dots. Numbers correspond to individual sparrow hawks.



LEGEND

- ROADS
- PERMANENT STREAMS
- INTERMITTENT STREAMS
- WATER
- CORN BEANS
- WOODS
- GRASS WEEDS PASTURE
- OATS TIMOTHY CLOVER WHEAT ALFALFA

SCALE

N

Shelby Co. Cumberland Co.

26	25	30	29	28	
35	36	31	32	33	T11N
2	1	6	5	4	T10N
11	12	7	8	9	
14	13	18	17	16	
23	24	19	20	21	

R 6E R 7E

was 74 acres with a maximum diameter of 1090 yards.

Observations of Aggressive Behavior by Sparrow Hawks

During the course of this study, numerous observations of aggressive behavior by sparrow hawks were recorded. The nest of Family Group III was discovered when the parent female was heard calling to or scolding the trained sparrow hawk kept by the investigator on an outside perch seventy yards from the nest site. When the nest site was found, the female showed aggressive behavior toward the investigator by flying low and calling. Three days before the young birds fledged the trained sparrow hawk was flown in the area of the nest site. Both the adult male and female showed aggressive behavior by diving and calling at the trained bird, but no contact was observed. After the young had been out of the nest seven days, in the late brancher stage, the trained sparrow hawk was again released in the area of the nest site. The adult female flew low over the trained female and called to it showing aggressive behavior. At the same time, a fledgling from the family group called incessantly to the trained bird and flew down to within fifteen feet of her, calling and hovering. This act was identical to the feeding behavior of the young to their parents; the young bird wanted to be fed by the trained female.

Eleven days after the young of Family Group III had fledged and were in the family group hunting phase, a juvenile female red-tailed hawk, Buteo jamaicensis, was acquired by the author; when the red-tail was placed on her outside perch in the sparrow hawk's territory all members of the family group flew low over the red-tail calling. Six instances of this type of aggressive behavior were noted during the family group hunting phase.

On October 29, during the fall and early winter period, a trap was placed near a male sparrow hawk, 28, in the northwest part of the study

area. A red-tailed hawk that had not been observed hit the trap and flew away with it. The male sparrow hawk persued the handicapped red-tail, driving it to the ground where the light trap caught in weed stubble. The sparrow hawk continued to dive at the red-tail until the investigator was approximately 25 yards from the birds.

An example of intraspecific aggression was recorded on November 11, well into the early winter phase of the life history. Two female sparrow hawks, 29 and 31, had overlapping territories in the part of the town of Neoga that contained the nest site of Family Group III. Both birds were observed at dusk at the nest tree, calling loudly, flying in circles around the tree and repeatedly landing in it. The old nest site had been observed to be a roosting cavity for female 29 and it appeared that the two females were competing for the nesting cavity as a roost site. No contact was observed during this encounter.

DISCUSSION

Trapping and Marking

Past workers on raptor ecology have not agreed as to the importance of trapping and marking individual birds. Enderson (1960) and Cade (1955) felt it was necessary to mark individual sparrow hawks for recognition. The Craigheads (1956), in a very intensive study of raptor ecology, banded only nestlings. These workers felt that banding and marking was "neither feasible nor necessary" since individuals could often be identified by color, unusual markings, missing feathers, or by occupying an area isolated from other birds of the same species. Trapping and marking must be considered only as tools for use in ecological studies and not goals in themselves.

In this investigation an attempt was made to trap and mark as many sparrow hawks as possible since absolute identification of individual birds would eliminate a major source of bias in determination of ranges. Twenty-two of the forty sparrow hawks known to be on the Neoga study area were trapped and four were recaptured. Adult birds were more difficult to trap; 50% of the adults were captured while 75% of the young raised on the area were captured.

Numerous methods are available for capturing raptors. All captures in this study were made with a bal-charti trap (Burger and Mueller, 1959), with the exception of one young, 21, which was captured on the ground before she could fly.

Other workers have also found this trap highly effective for trapping the sparrow hawk (Enderson, 1960; Cade, 1955). Burger and Mueller (1959), for example, captured a total of 376 sparrow hawks in two years with trapping success rates of 45.8% and 57.8%. The trapping success rate in this investigation was 55%. Although the bal-charti is highly efficient in

capturing sparrow hawks, it was impossible to trap all individuals on the area during any season. Some hawks although repeatedly exposed to the trap could not be captured.

The necessity of marking birds for recognition of individuals was demonstrated in a number of cases. Young birds in a family group were especially difficult to identify. If the young of Family Group II had not been marked the hunting areas established by the young during the dispersal phase would not have been recorded (Figure 5). It was likewise impossible to identify individuals of the same sex with overlapping territories, for example, data concerning the aggressive behavior of females 29 and 31 (Figure 7) would not have been obtained unless both birds had been marked.

Sparrow hawks on the Neoga study area showed a marked tendency to reoccupy areas other sparrow hawks previously had occupied; therefore, seasonal movement of sparrow hawks cannot be accurately determined if the individuals are not marked. An example of reoccupation was observed of females 29 and 31 and a male, possibly 39; these birds occupied the same area in the fall and winter period which had been the nest site of Family Group III.

If females 1 and 4 had not been marked it would have been impossible to know that they were the parents of Family Group II and III, because they were unobserved on the study area for a period of more than two months during the nesting season. It would likewise have been impossible to determine that female 17 had remained on the study area in the fall and early winter period while all the other marked birds had left the study area (Figure 7).

There are many different methods of marking sparrow hawks. To be effective a marking technique must be easily discernible, permanent and

capable of being used to distinguish a number of individuals, several methods were tried during this study. Imping was found to be an unsuccessful marking method since the imped feather was not often visible and was difficult to observe at times of low light intensity. Five birds were marked by this method during the early winter period, but the white, imped feathers were not visible when the tail was closed, and visible at only short distances when the tail was spread.

Paint marking was likewise unsuccessful because the paint was not permanent and was not visible at times of low light intensity. Thirteen sparrow hawks were marked by spray painting the breast, wings and rectrices. Spray paint on the breast was found to be only a temporary mark. Bird 21, for example, was recaptured twelve days after being paint marked on the breast and wings. Almost no paint was still visible on the breast, while the paint on the wings showed no deterioration. Female 17 was recaptured 149 days after marking; no paint remained on the breast and a mere trace could be seen on three primaries near the shafts. It was thought the structure of the breast feathers was not conducive to retaining paint.

A third method of marking was that described by Enderson (1960) in which windows were cut in the primaries, secondaries and rectrices. This worker reported that the window mark was visible for at least a quarter of a mile. Windows were cut in the secondaries, primaries and rectrices of thirteen different sparrow hawks in different sequences. The window cut in the rectrices proved to be a poor mark as the tail was not often observed spread, making the window impossible to see. The windows cut in the secondaries proved to be an ideal mark, observable through a spotting scope for a distance greater than a quarter of a mile. Windows cut in the primaries were more difficult to observe than those cut in the secondaries. These marks were permanent and easy to observe even at times of low light

intensity because of the silhouetting effect of the windows. The obvious drawback of this method was that the bird had to be in flight before an identification could be made and it was often impossible to observe the window if the bird was flying at a low level. Because no two birds were marked alike it was necessary to use many different types of windows to mark individuals. The notch method was also used, it consisted of cutting a semi-circular notch into the margin of the secondaries. This method was likewise quite effective as it increased the number of marks available and was easily discernible.

The best marking method was to attach a 3½ inch leather jess around either or both feet of a sparrow hawk. Identification could be made on either perching or flying birds at about 200 yards with a spotting scope. This method, however, was limited since only three different combinations of marking were possible.

Population Density

The late winter sparrow hawk population on the Neoga study area (Table 1) was thought to be nine birds or 0.3 birds per square mile. Enderson (1960) reported a density of 0.09 birds per square mile on a 43 square mile area in central Illinois and the Craigheads (1956) reported a winter population density of 0.1 sparrow hawks per square mile on a thirty-seven square mile study area in Michigan.

The early winter population of sparrow hawks on the study area consisted of six birds (Figure 1) at the close of the investigation. The population of sparrow hawks during this period was also greater than the winter populations reported by Enderson and the Craigheads.

The early winter sparrow hawk population was a constantly changing one; with birds moving into and out of the study area at random. At no time did the population during this period exceed eight birds and the

lowest number on the study area was three observed on October 11. Data, however, are limited as it was very difficult to determine exactly the date a particular individual moved into or out of the study area. Although 53% of the birds observed on the study area during the early winter period were marked, additional markings would have made the understanding of movements more complete. For example, if male 39 had been marked it would have been known if he was the male that had been observed paired with female 31.

During the spring and summer periods the breeding population consisted of three pairs, or 0.20 breeding birds per square mile, and two males that were thought to be unmated as they were never observed with a female or young on the study area. This breeding population is lower than the 0.58 birds per square mile breeding population reported by Enderson (1960). The Craigheads (1956) reported an average of .22 breeding birds per square mile in Michigan in 1948.

Differences in the number of breeding birds found in this study and those reported by Enderson and the Craigheads in all probability reflect habitat differences. Enderson's study area had little wooded or brushy area while Craighead's study area was composed of 11% brushy and wooded areas. The Neoga study was composed of 10% wooded areas. Ideal habitat, as defined by Fitch (1958), indicates that sparrow hawks prefer short, sparse vegetation such as that found along mown roadsides or ditches.

Distribution and Habitat Utilization

The Craigheads (1956), in reporting data for two different years in the fall, winter and spring seasons, made over 90% of their observations of sparrow hawks in a grassland, or abandoned and cultivated field habitat. The Grabers (1963) state "the sparrow hawk has a broad ecological distribution, but ungrazed grasslands and fallow fields were by far the most favored foraging habitats in the summer." Other important habitats in-

cluded pastures, fields of mixed hay and cornfields. Fitch (1958) reports the habitat requirements as "open ground, with sparse or short vegetation, and high perches from which the hawk may examine the surrounding terrain."

Data obtained from this study revealed essentially the same conclusions; the main habitat used by the sparrow hawk consisted of short grasses and abandoned or cultivated fields. The most important part of the hunting range of most hawks was roadside ditches composed of short grasses. The hunting range of sparrow hawk 25 (Figure 3) is a good example to support this statement as his prime hunting areas were two widely separated roadside ditches. With exception of one individual, 38, no sparrow hawks were observed hunting in a tall grass habitat, such as that found along an unmown railroad. No observations of sparrow hawks hunting in heavily wooded areas were recorded.

Range and Territory

An ecologic study of sparrow hawks must be concerned with the area occupied by the birds. Past reports have disagreed as to whether this area is properly termed a range or a territory. The Craigheads (1956), in a study of raptor ecology, state "a winter range is a rather limited area of land over which a hawk moves and hunts during a given period. It is an undefended area, thus differing from a territory as defined by Noble (1939), and supported by Nice (1943) that is, a territory is any defended area."

The Craigheads, however, did concede that under certain conditions a hawk may defend a favorite perching site. Cade (1955), in contrast, concluded that "winter territoriality is a prominent feature in the behavioral cycle of the American kestrel." This conclusion was based on a study in which a live sparrow hawk, male or female, tethered to a perch or a stuffed sparrow hawk, was placed in a territory occupied by a wild paired or single sparrow hawk. The type of aggressive behavior elicited by the wild birds

ranged from striking the tethered sparrow hawk to no response.

These differences of opinion are justified. During 11 months of intensive field investigation only limited observations of intraspecific aggression were observed. Sparrow hawks tended to remain in their territories making field observations of intraspecific aggressive behavior rare in a population of wild birds.

Seasonal Difference in Range and Territoriality

Winter Territoriality: Data obtained in this investigation, in general, indicate that sparrow hawks are territorial in the winter. This conclusion was based on the direct evidence observed of females 29 and 31 as they showed aggressive behavior in competing for the same roosting site. Indirect evidence of territoriality was the distribution of sparrow hawks during the late and early winter periods (Figure 7) which showed an isolation of both paired and single falcons, but it is possible this isolation could be the result of the distribution of suitable habitat on the study area.

Summer Territoriality: Field observations of wild sparrow hawks during this period did not reveal any examples of intraspecific aggressive behavior which would indicate territoriality. Sparrow hawks are more secretive during this period, limiting observations; therefore, it is difficult to determine the extent of their territories. Territoriality does exist at least experimentally as both parent birds of Family Group III called to and dove at the trained female sparrow hawk when she was released near the wild birds' nest site.

Cade (1955) stated that the only defended area during the nesting season is the area of the nest site. No defense is made of the hunting area. Cade's findings concur with those found in this investigation. The nest site was defended against the intrusion of the investigator and young

trained female sparrow hawk by both the parent male and female. No defense of the hunting area was observed.

During this investigation there was not observed any aggressive behavior between the young and parent birds. No observation of intraspecific aggression was noted among the young of Family Group II; the young had established hunting areas of their own, but made no effort to defend these areas. It is possible that the young of Family Group II were driven out of their parent's hunting range, as Cade (1955) states is sometimes the case, but this was not observed on the study area.

Fall Territoriality: There was no evidence of territoriality during the fall. This was a period of rapid turnover of migrants. The first observed immigrant, 29, arrived on the study area September 10 and the population on the study remained in a state of change until the end of the investigation. The last observation of a bird moving into the area was on December 28 (Figure 1).

Range-Territory Size: The size of a range will vary depending on the length of time an investigator observes an individual, for example, the range of female 1 would have covered an area of 820 acres if observations of the late winter period and spring and summer period were combined, but in reality she was using two different areas at different times. Range size may also be contingent on the numbers of observations. A large number of observations might serve to expand the boundaries of a sparrow hawk's range, but of greater concern should be areas that are the most heavily used and the type of habitat the prime usage area is composed of.

The Craigheads (1956) state that "large hawk ranges were associated with a low density and scattered meadow mouse population, small ranges with high or vulnerable meadow mouse populations. Within certain bounds, the size of a hawk's winter range was inversely proportional to the food

supply." Although no attempt was made to determine the density of prey in this study, observations on habitat usage by sparrow hawks support the Craigheads' thesis. Birds using what appeared to be relatively poor habitat had larger ranges than those using prime rodent habitat. An example to support this statement was the limited range of female 34, which was centered along a roadside ditch (Figure 7) considered to be prime rodent habitat. Female 31 had a large range which included a large portion of the residential section of Neoga (Figure 7) which was thought to be a poor rodent habitat.

Range size was considered to vary not only in relation to the abundance of prey in a given habitat, but also dependent on the total composition of the habitat such as the dispersal of roosting and perching sites.

The largest territory used during the late winter period was that of bird 1 which had an area of 210 acres and the smallest territory used during this period belonged to birds 3, 6 and 7 which had an area of 70 acres. The largest territory used during the early winter period belonged to bird 31 which had an area of 207 acres. The smallest territory used during this period belonged to bird 37 which had an area of 16 acres.

The average size of the late winter territory was 119 acres with a maximum diameter of 1508 yards. The average size of the early winter territory was 74 acres with an average maximum diameter of 1090 yards. These data of winter range size were found to be smaller than those observed by Enderson (1960) who reported an average maximum diameter of 2660 yards per sparrow hawk range.

The Craigheads (1956) reported an average maximum diameter of 3,872 yards per winter range which is considerably larger than diameter observed in this study. These differences in range size might possibly reflect a habitat difference between the three study areas.

Reproduction

Many workers have reported information concerning the general aspects of reproduction of the sparrow hawk such as nest site preference, clutch size and incubation period (Bent, 1938). Little is known about the pair formation of these birds or the activities of the young after fledging.

Pair Formation: The nature of reproduction behavior, pair formation, varies from region to region. Roest (1957) in a study in Bend, Oregon stated that the males arrived about the last week of March, and the females arrived a day or two later. Cade (1955) stated that in "southern California most resident kestrel maintain a permanent pair bond, occupying the same area throughout the year. Some local pairs break up in the fall, and the mates occupy separately defended areas during the winter." Cade also stated that some breeding pairs leave their nesting area in the fall and are not again observed until late December or January. Enderson (1960) in a study in the central United States did not attempt to determine when pair formation took place, but populations on his study areas built up steadily, beginning with one bird on January 11, until a peak of twenty-two birds was reached on April 11 and April 22. The Craigheads (1956) in a study conducted in Michigan stated a number of sparrow hawks nested and wintered on the study area and other sparrow hawks arrived in early March and began to defend nest sites.

The only observations of pair formation on the Neoga study were on December 15, 17 and 18 when female 31 and a male, possibly 39, were observed at dusk roosting in the nest site which had been used by Family Group III, all other sparrow hawks on the study were unmated. At the beginning of this study on January 27 during the late winter phase, eight of the nine birds on the area were members of a pair. These data imply that pair formation of the sparrow hawks in the Neoga area took place sometime between December 31 and January 27.

Nest Site Location: In this study it was considered necessary to discover the location of sparrow hawk nest sites as soon as possible in order to gather data on the activities and ranges of the parents during incubation and feeding of the young. The sparrow hawk nest sites, however, were difficult to find because this rather small species nests in holes or cavities and is secretive during incubation. The Craigheads (1956) also found sparrow hawk nests difficult to locate and state that careful observation of the birds was the best and sometimes only way to locate the nest.

Nest sites of three family groups were located on the Neoga study area. All three were very secretive and found only by intensive field observation. The most productive method for locating nest sites was to follow a parent bird from the hunting area to the nest site.

No correlation can be drawn from this investigation between habitat and nesting site as all three nests were situated in unsimilar habitats.

Family Group Activity: The activity of the young after fledging consisted of four phases based on observations made during this investigation. The first phase, the early brancher phase, is the normal activity of all young sparrow hawks (Frederick II of Hohenstaufen, 1943). The young remained in their nest tree and could be observed hopping from branch to branch where they were fed by the parent birds. The early brancher phase lasted about four days.

The second phase or the late brancher phase, was that period in which the young were fed by the parents, but were capable of making short flights to nearby trees. One female, 14, was caught with a bal-charti trap baited with an English sparrow near the end of this phase, so it is probable that the young were just beginning to develop hunting skills of their own. This phase lasted seven days.

Both Roest (1957) and Cade (1955) report that after fledging the young

remain with their parents within the vicinity of the nest for a short period of time. Roest (1957) states that at this time the adults and four or five immature birds may be seen hunting or perching together as a family group. This family group hunting phase was observed in all three family groups, but varied between the three family groups. The young of Family Group I did not congregate in any particular area; instead they hunted randomly throughout the total area as shown in Figure 4. It was thought that this group did not hunt together in a small area because the habitat of this range was of equal quality with no large concentration of prey. The family group hunting phase of Family Groups II and III was identical in that both family groups concentrated their hunting activities in a small part of the range occupied by the adults during the early and late brancher phases (Figures 5 and 6). This phase lasted about 15 days in Family Group II, but Family Group III remained in the family group hunting phase until they left the study area around September 10, a period of thirty-five days.

Concerning the dispersal of young, Cade (1955) and likewise Roest (1957) found variations in the amount of time the family group remained together. Cade (1955) states during the late summer the young are driven off by their parents if they have not strayed away on their own. Roest (1957) reports the young begin to drift from the parent birds a few days after fledging and are living independently by the middle of July. On the Neoga study area the dispersal phase was observed in Family Group I, but little data are available as the young moved off the study area and were thought to have relocated in an area three miles north of the original nest site. The dispersal phase of Family Group II was quite distinct in that the young left the family group after about fifteen days and established individual ranges. Three of the young moved about one half mile

north of the original family group hunting area (Figure 5). A female established a hunting area of 190 acres and a male and female shared an adjacent and partly overlapping area of 110 acres. The fourth young, a female, stayed essentially in the same area she had during the family group hunting phase. The hunting areas occupied by the young probably were not territories since two birds occupied the same area and this range overlapped with that of another sibling. The parent birds continued to occupy the same area they had during the family group hunting stage.

A dispersal phase apparently did not take place in Family Group III. Adults and young remained together in the area occupied during the family group hunting phase for about thirty-five days. All birds, adult and young, left the study area at the same time.

SUMMARY

A thirty square mile study area was selected in east-central Illinois to study a wild population of sparrow hawks. Observations were made of these sparrow hawks during February through December, 1968 to determine seasonal differences in population densities, distribution and movements.

Sparrow hawks were trapped with a bal-charti trap which was considered highly efficient as 50% of the adults and 75% of the young observed on the study area were captured. All captured birds were marked, the best marking method was found to be cutting windows in the primaries and secondaries or attaching a leather jess to either or both legs. Observations of marked and unmarked birds were recorded throughout the study. It was found necessary to mark birds so individuals could be identified over an expanded period of time.

The late winter population consisted of eight paired and two unmated birds for an average of 0.3 birds per square mile. The average range of each bird during this period was 119 acres. The spring and summer population consisted of eight adults and twelve immatures making an average of 0.7 sparrow hawks per square mile. The range used by each family group varied considerably, the largest being 2,240 acres while the smallest area used consisted of 221 acres.

The early winter period was one of drift and migration to and out of the study area. A total of fifteen birds were observed on the study area during this period, but at no time did the population density exceed eight birds or 0.3 birds per square mile. The average range used by the birds during this period was 74 acres. Only one individual which had been present during the spring and summer period remained on the study area.

There were four phases of activity of the young after fledging; early brancher phase, late brancher phase, family group hunting phase, and the

dispersal phase. The first two phases were essentially the same in the three family groups studied. The family group hunting phase of Family Groups II and III were alike in that the family concentrated their hunting activities in a small part of their range. In Family Group I the young hunted throughout the area the male had previously used. The dispersal phase differed in all three family groups. Family Group I remained in the family group hunting phase thirty-two days, then left the study area. Family Group II remained in the family group hunting phase for fifteen days then the young established hunting ranges of their own near the parents' range. Family Group III remained in the family group hunting phase forty days then left the study area.

During eleven months of investigation only one incident of intraspecific aggression was observed between wild birds. The isolated distribution of sparrow hawks on the study area was considered indirect evidence of territoriality. All but one of the sparrow hawks observed throughout this investigation had a roadside ditch type habitat within its range. This type of habitat was considered to be a primary factor in the selection of hunting ranges.

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