To the Graduate Council:

I am submitting herewith a dissertation written by Robert Edward Merritt entitled "The Spatial Relations Within a Selected Population of the Cardinal (*Cardinalis cardinalis*)." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Zoology.

J. C. Howell, Major Professor

We have read this dissertation
and recommend its acceptance:

Arthur W. Jones

James M. Giles

James T. Tanner

H. R. DeSalvo

Accepted for the Council:

Sutton A. Smith
Vice Chancellor
Graduate Studies and Research

Thesis
Z5b
M397
cop. 2

THE SPATIAL RELATIONS WITHIN A SELECTED POPULATION OF THE CARDINAL (*Cardinalis cardinalis*)

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee

Robert Edward Merritt

August 1975

1228013

ACKNOWLEDGMENTS

The writer wishes to thank Dr. J. C. Howell for his suggestions and aid throughout the period of research as well as the extended writing period.

Appreciation is extended to Dr. H. R. DeSelm for his advice concerning the planning of the botanical portion of the research and evaluation of the manuscript.

The writer is grateful to Dr. James T. Tanner for his critical reading of the manuscript.

Thanks are also due Dr. A. W. Jones for his consultation and evaluation of the manuscript.

Appreciation is extended to Dr. J. N. Liles for his willingness to become a part of the committee and for his evaluation of the manuscript.

The writer is also indebted to the Department of Zoology of The University of Tennessee for the use of equipment and materials during the study.

ABSTRACT

The Cardinal (*Cardinalis cardinalis*) is found in a variety of habitats over its range. It has adapted well to urban and suburban environments. It is believed that the preferred habitat has been dense vegetation characteristic of riparian undergrowth. Spatial relationships within a population of Cardinals in a wooded area have received little attention in the literature.

One objective of the present study was to determine the size of the territory maintained by a pair of Cardinals in a selected population. A second objective was to record general behavior patterns in relation to the territory.

The study area was selected near the center of the Cardinal range. It consisted of 30.95 acres of mixed forest and wooded pasture near Knoxville, Tennessee. There was a stable population of Cardinals using the study area.

Observations were made on the study area during 1970 and 1971 from February to July. A total of 844 hours was spent within the boundaries recording activities of the Cardinals.

Some pair bonds were established early in the period studied. Courtship activities were also taking place. The pair bond persisted throughout the nesting cycle each year. There was evidence that one male may have changed partners the second year because he did change the territory that he occupied.

Territorialism was present in the Cardinal population. The territories remained constant each year with only a small change

in area. A new territory was created within the study area the second year which altered the size of two adjoining territories. The territories were occupied during February and early March each year. Marked individuals occupied the same territories both years. The areas of the 11 territories occupied in 1970 ranged from 1.2 to 6.0 acres. The average size was 2.4 acres. The areas of the 12 territories on the study area during 1971 ranged from .85 to 6.4 acres. The average size was 2.3 acres in 1971.

Territorial defense was exhibited by both males and females. Males defended against males and females defended against females. The males showed a guarding action over their territory by sitting in a tall tree overlooking the area during the day. The males also patrolled their territory periodically usually singing at each stopping point. The female's defense was noted only when a new female was attempting to invade the territory. Her reactions were very similar to those of the male with the use of song and also actual combat to drive out the intruder.

There were 29 nests found within the boundaries of the study during the two years. The nesting success of 10 nests during 1970 was 37.5 percent, and for 19 nests found in 1971 was 38 percent. The study terminated before the nesting season ended.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	LITERATURE SURVEY	3
	Pair Bond	3
	Behavior	5
	Nesting	9
III.	STUDY AREA	11
	Selection	11
	Location	13
	Physical Characteristics	13
	Vegetation	15
	East-facing slope forest	17
	North-facing slope forest	17
	West-facing slope forest	18
IV.	FIELD TECHNIQUES	19
	Establishing the Grid and Vegetation Sampling	19
	Attracting Cardinals	19
	Trapping Cardinals	21
	Marking and Observing Cardinals	21
V.	OBSERVATIONS	24
	Pair Bond	24
	Pre-Territorial Activity	27
	Territorial Activity	29
	Occupation of Territories	35
	Use of recorded songs and mounted birds	41
	Extra territorial movement	45
	Territorial invasions	46
	Mapping of territories	48
	Activity periods	48
	Nesting	50
VI.	DISCUSSION AND CONCLUSIONS	61
	Pair Bond	61
	Behavior	62
VII.	SUMMARY	71
LITERATURE CITED		73
APPENDIX		76
VITA		81

LIST OF TABLES

TABLE		PAGE
I.	Average Monthly Temperature and Total Monthly Precipitation	14
II.	Number and Percent of Trees	16
III.	Territories of Marked Birds	28
IV.	Sizes of Territories in Acres	49
V.	Nest Observations 1970	57
VI.	Nest Observations 1971	58
VII.	Color Banding Schedule	77
VIII.	Banding Schedule 1970	78
IX.	Banding Schedule 1971	79

LIST OF FIGURES

FIGURE		PAGE
1.	Map of the Study Area Showing Numbered Stations and Contour Lines	12
2.	Patrolling Route of Male Cardinal of Territory VIII on March 6, 1970	31
3.	Patrolling Route of Male Cardinal of Territory VIII on May 1, 1970	32
4.	Breeding Territories During 1970	38
5.	Breeding Territories During 1971	40
6.	Territorial Boundaries and Nest Locations for 1970	52
7.	Territorial Boundaries and Nest Locations for 1971	53

CHAPTER I

INTRODUCTION

The studies of bird behavior have increased in number in the past decade. As information and techniques have been developed to give accurate estimation of bird populations, the need for more detailed studies has become apparent. Long term observations of individual passerine birds and bird populations are needed to determine the activity cycles and behavior patterns within a species about which little information is available. It is during this period of the year that the species' activities change from winter flocking to territorial pairing and nesting takes place. Some investigations of territorial size and related behavior have been completed at the northern edge of the Cardinal range by Dow (1969). He made a comparison of peripheral populations and a population inhabiting hedge rows near Nashville, Tennessee. There have been numerous accounts of urban pairs, also. The preferred habitat of the Cardinal is believed to have been dense vegetation characteristic of riparian undergrowth (Dow, 1969). The use of hedge rows and urban areas resulted from the increase in populations and that distance could be maintained easily between pairs.

This investigation was undertaken to determine the spatial relationships and behavior related to them in a selected population of Cardinals (*Cardinalis cardinalis*). This study was concerned with a population of Cardinals occupying a mixed forest area near Knoxville, Tennessee, which is near the center of the Cardinal's range. A total of two six-month periods of field observation were carried out from

February through July 1970 and February through July 1971. The wooded area used in this study was part of a breeding bird census area. The Cardinal population was known for the last five years. The area has remained relatively undisturbed during this time because it was owned by the University of Tennessee and used only for teaching and research purposes.

The identification of individual members of the population was accomplished by the use of color bands. A United States Fish and Wildlife Service band was also used as long term identification. The bands permitted individual recognition so that the movements of marked birds could be recorded. The establishment of territorial boundaries and movements of individuals could also be determined.

The activities of members of the population were observed during the pre-territorial, territorial and nesting times of the reproductive cycle. A total of over 844 hours of field observation provided the basis for this study. The observations were carried out from one half before sunrise on occasion to sunset on others.

CHAPTER II

LITERATURE SURVEY

In attempting to discover the spatial relations and related behaviors of the Cardinal, a survey of the literature revealed that detailed studies of this bird have not been made. The principle problem is the difficulty of marking individual birds so that they are easily identified at a distance. Hundley (1952) attempted to use colored bands for marking individual birds. However, she stated, "Since the color bands were impractical for field identification due to the bird's habit of perching with feet drawn up under the abdominal contour feathers, and the inability of the observer to see bands covered by grass or leaves on the ground, the only records of value were those few birds that were actually recaptured at another station." Because of the difficulty of observing known individuals, the literature is indefinite concerning individual activities of these birds.

I. PAIR BOND

Welty (1962) comments that "The coming together of two birds for the procreation of young often originates a more or less durable bond between them. . . ." A survey of the literature fails to reveal a consistent pattern of pair formation of Cardinals. There have been limited descriptions which suggest that pairing takes place during the months of March and April. Lack (1940) wrote "Pairs of Cardinals (*Richmondena cardinalis*) and California Thrashers (*Toxostoma redivivum*) will remain at least loosely associated in winter and so may be said

to be pairs for life." Ganier (1941) suggested that in March the flocks break up into pairs. Laskey (1944) stated, "The groups and loose flocks, formed during fall and winter, disband gradually as males choose territory and obtain mates." However, it was also noted that a single pair remained together for three years. Laskey also wrote that "The female of a pair tends to follow her mate after the breeding season and through the winter, but in autumn males become mildly dominant when feeding, keeping the females in the background by running at them." Fitch (1960) stated, "Formation of pairs occurs only after the males are thoroughly enscounced on their territories." Lemon (1966) observed 25 males occupying territories for at least two years and in some instances as long as five or six years. The females were quite faithful but moved more often than the males. Thus there seems to be a lack of studies of marked birds over a long duration of time that would prove that this species will maintain a pair bond for life.

The number of years a bird lives would indicate the limits of a pair bond relationship. The longevity of the Cardinal is indicated by numerous banding records. Ganier (1937) reported a male banded at Nashville, Tennessee during February 1924 that was last seen in November 1936 at his feeding shelf. The bird had raised a brood that year, even though the bird seemed "very old." The banding literature has numerous records of Cardinals attaining the age of three, four, and five years. With this evidence of longevity, it would seem that mating for two to six years may be a possibility.

II. BEHAVIOR

Howard (1920) described the behavior of resident species in Great Britain prior to nesting. The description stated that males leave the winter flock for short periods of the day to spend time by themselves in a prescribed area that he called the territory of the pair. The male defended this area from other males of the same species and accepted a female as its mate.

Nice (1937) stated:

> The theory of territory in bird life is briefly this: that pairs are spaced through the pugnacity of males toward others of their own species and sex; that song and display of plumage and other signals are a warning to other males and an invitation to a female; that males fight primarily for territory and not over mates; and finally that the owner of a territory is nearly invincible in his territory.

Noble (1939) proposed the definition of territory in bird life as any defended area. This definition was criticized by Armstrong (1965) for its vagueness and he suggested that territory be defined as "an area defended primarily or exclusively against competing members of the same species." It was this definition that was accepted by the writer for this study. Nice (1941) listed six different kinds of territories as follows:

A. Mating, nesting, and feeding ground for young
B. Mating and nesting, but not feeding ground
C. Mating station only
D. Restricted to narrow surroundings of nest
    1. Colonial species
    2. Solitary species
E. Winter territories
F. Roosting territories

Cardinal territories generally seem to belong to Type A.

Hinde (1956) concluded: "In fact few statements of universal

validity can be made about territory in birds and it is better to aim at some comprehension of its diversity." He suggested several possible functions of territory and the following seemed pertinent to this study:

1. Familiarity with area from site attachment may assist feeding, escape from predators, and may increase fighting potential.
2. The territory may reduce interference in various reproductive activities by other members of the species.
3. The territory facilitates the formation and maintenance of the pair bond.

Welty (1962) wrote that the isolation of birds can benefit males especially during courtship activities. As the nesting cycle continues, this lack of interference from other mated pairs benefits reproduction during nest building, copulation, and rearing young. This isolation will also reduce fighting and conserve energy. Certainly territorialism will reduce intraspecific competition.

The initiation of territorial activity at Nashville, Tennessee took place on mild, sunny days in February according to Laskey (1944). This was initiated by males singing and chasing females. She also stated " . . . by late March, most of them [Cardinals] are settled on their territories with only occasional intrusions by unmated individuals." The males defended the territory against males, and females defended against females but the Cardinal was considered by Laskey to be " . . . only mildly belligerent and one seldom sees a fight involving them." After this time there were only a few intrusions by other individuals. Both Laskey (1944) and Gould (1961) reported that boundaries were defended by males fighting intruding males and mated females chasing intruding females. Fitch (1958) wrote, "For a period of weeks stress

increases as males defend their newly established territories against the encroachment of neighbors, and against the wintering Cardinals still wandering over home ranges in the general area. However, territoriality develops gradually." Gould (1961) stated that territory was maintained by males through proclamation, combat, and patrolling was irregular.

A survey of the literature does not reveal a clear picture of the size of Cardinal territories. Fitch (1958) did not measure any territories in Kansas but estimated the average size of Cardinal territories by the mean distance between singing males in 169 instances. Using this distance as the diameter of a circular territory, the average size was 3.1 acres. Gould (1961) measured six Cardinal territories in the desert south of Tuscon, Arizona, that averaged 3.7 acres. An estimate of size for Cardinal territories in Canada was reported by Dow (1969). He determined the size of territories varied from 2.91 to 46.48 acres depending on population density and the greatest density was found in non-preferred habitats such as hedge rows where presumably distance could be easily maintained between pairs.

The literature is very consistent regarding the stability of territories. Barry (1925) who studied Cardinals in West Virginia reported: "The feeding ground of a pair of Cardinals is confined to certain definite limits, the size depending upon the amount of available food. Within these limits the pair raise their numerous broods each season. Almost invariably they may be found in these confines at any hour, summer or winter." This suggests that the Cardinal remains on its territory the entire year in this area. Laskey (1944) stated:

"There are numerous records of banded individuals that remained in the same area for several years." However she also reported that during the fall and winter there were groups that occurred at good feeding areas. It was suggested that these flocks were probably made up of largely young of the year birds.

Howell (1965) began a breeding bird census on 60 acres of The University of Tennessee Cherokee woodlot. Part of the census area overlapped the area used in this study. This work has continued to the present and the following pairs of Cardinals were recorded for the census area:

1965 - 34 pairs
1966 - 40 pairs
1967 - 48 pairs
1968 - 56 pairs
1969 - 36 pairs
1970 - 34 pairs
1971 - 34 pairs

In his notes (personal communication 1972.) he stated that in 1970 a determined effort was made to combine territories when it could be shown that the recording of the same singing bird might have occurred twice at two different locations on the same census trip. This could account for the slightly reduced number of pairs during 1970 and 1971 but the reduction of breeding pairs in 1969 was more significant since there had been no change in the method of counting territories at that time. Throughout the entire period of Howell's study, the consistency of singing records on the plotting maps indicated that the territories were relatively stable over the area. No estimate was made as to the size of individual territories.

Lemon (1965), during a study of Cardinal songs in London, Ontario,

observed that the territories of 25 marked males were very stable. It was noted that where territories did not abut, the boundaries were less definite and may have been determined by suitable vegetation.

III. NESTING

The selection of a nesting site is associated with suitable cover. Barry (1925) stated that Cardinals nest along roadsides and at the edge of streams. Small trees covered with vines, blackberry patches, and thickets were frequent sites. In Nashville, Tennessee, and vicinity, Laskey (1944) observed that young evergreens, privet hedges, roses, and vines such as honeysuckle were most often used as nesting sites. Gould (1961) made the general statement that Cardinals nested anywhere in their territory.

After the nest site was selected by the pair, Barry (1925) determined that eight days were necessary to build a nest. Ganier stated that the first nest each year may take 2-3 weeks for construction. Observations made by Laskey (1944) also showed a variation in time required for construction. One nest was begun April 6, 1931, and finished by April 10, while a nest begun April 1, 1934, was completed by April 4. The third observation showed that a nest started on April 7, 1937, was completed by April 16.

The earliest records of the first set of eggs by Cardinals recorded by Barry (1925) were April 15, 1924, and April 9, 1925, at Morgantown, West Virginia. Forbush (1929) gave the nesting dates as April 2-25 in Florida and April 30 for Pennsylvania. The earliest date for Tennessee recorded by Shaver and Roberts (1930) was March 28,

1922. Ganier (1941) stated that the first set of eggs at Nashville, Tennessee was April 3. However, usually the eggs were laid between April 10 and April 20. In 1935 the first set of eggs observed by Laskey (1944) was on April 1. In 1938 the first set was present on March 28.

The common size of the clutch has been established at three eggs by Barry (1925), Ganier (1941) and Laskey (1944). However, Barry (1925) stated that the clutch may vary from two to four eggs with the usual number being three. Ganier (1941) found that one nest in thirty may contain four eggs while later nests may contain only two eggs. Laskey (1944) found that of 35 nests, 8.5 percent contained four eggs.

The success of the nesting season is usually measured by the total number of fledged young. The number of nest failures is not well documented in the literature. Barry (1925) stated that 20 nests out of a total of 32 under observation were unsuccessful. These nests were all early spring nests. In an attempt to find the causes for these failures, it was noted that a group of small boys in the vicinity were known to rob bird nests of the eggs. Also the bad weather and lack of cover at this time of year were given as causes.

CHAPTER III

STUDY AREA

I. SELECTION

The area was selected for this study because it had a known and consistent population of Cardinals. This area included the northern portion of J. C. Howell's Audubon Breeding Bird Census area. J. C. Howell is Professor of Zoology at The University of Tennessee, Knoxville. The boundaries of the forested study area were defined by open pasture on three sides. In order to use these pre-existing boundaries, it was necessary to add additional quadrats to the Breeding Bird Census area. The original stations of that census area were used, and new stations were established for the extended area. The stations were 256 feet apart. Each was marked by white paint and numbered on the tree closest to the corner of the quadrat. Those stations on the census area that had been previously numbered were continued (see Figure 1). This enabled the observer to locate an individual bird on a map of the area.

The breeding bird census was initiated in the spring of 1965. During the following years it was found that the population of Cardinals remained in the area even though it did fluctuate from year to year. Within the portion of the census area that was used for this study, the number of pairs of Cardinals varied from 10 to 22. This indicated that the population was large enough to be conveniently studied.

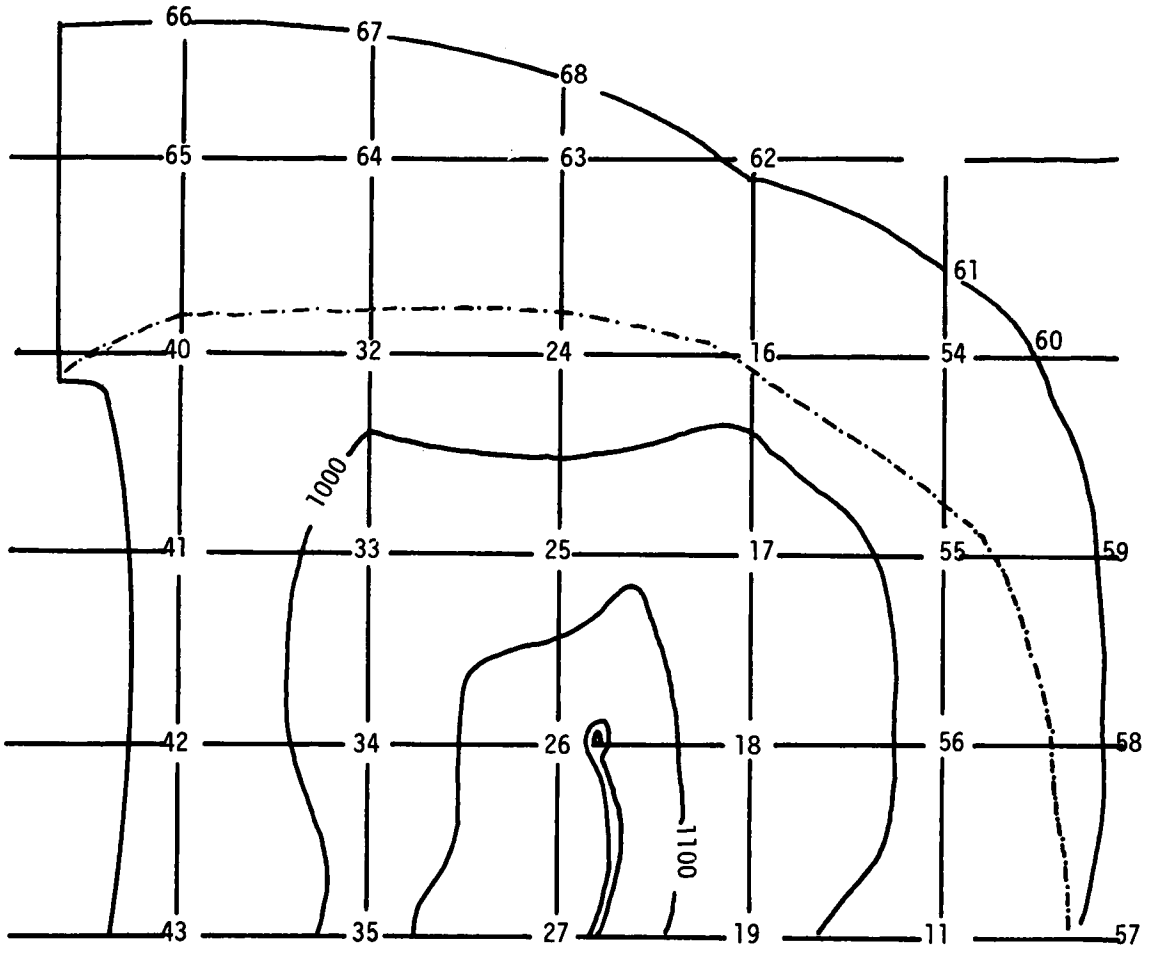


Figure 1. Map of the study area showing numbered stations and contour lines. The fence is represented by -·-·-· and a road is indicated by ═══ .

II. LOCATION

The study area was part of The University of Tennessee Cherokee Farm woodlot which consists of 137 acres of woods and wooded pastures lying two and one-half miles south-southwest of Knoxville City Hall. The study area consisted of 30.95 acres of the woodlot. This area is located on the U. S. G. S. Knoxville Quadrangle map at 83^{o} 56' 30" W and 35^{o} 56' 15" N.

III. PHYSICAL CHARACTERISTICS

The study area consisted of a wooded hill with elevations ranging from 850 to 1200 feet and with east-, west-, and north-facing slopes. There were rock outcrops of Chapman Ridge Sandstone of the Ridge at the 1050' contour line. At the base of the hill there were outcrops of Lenoir Limestone (Milici, 1973).

The red-yellow podzolic soils over the study area belonged to the Tellico series. The soil was shallow and acid in nature in the forest area. At the northern edge of the area, the open pasture, the soil was the Talbott silty clay loam (Roberts, 1955).

There was a shallow pond at the northern edge of the study area which varied in size from one-eighth to one-half acre according to the weather conditions. The depth ranged from 0-6 feet with a marshy area at the east end.

The climate was of the modified continental type. It was a warm and temperate climate with hot summers and long hot or cold periods uncommon (Roberts, 1955). During the time of the study the weather was considered normal (see Table I).

TABLE I

AVERAGE MONTHLY TEMPERATURE AND TOTAL MONTHLY PRECIPITATION

	1970	1971	Record Mean
Monthly Temperature (Degrees Farenheit)			
February	39.3	39.4	41.8
March	48.7	45.6	49.3
April	61.2	58.5	58.8
May	68.6	63.9	67.4
June	73.4	75.9	74.9
July	78.5	75.4	77.7
Monthly Precipitation (Inches)			
February	2.86	4.93	4.65
March	3.18	4.21	5.15
April	7.20	3.87	4.16
May	0.74	3.78	3.69
June	4.26	3.73	4.08
July	3.11	8.76	4.56

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration Environmental Data Service, Local climatological data annual summary with comparative data, 1973, Asheville.

IV. VEGETATION

The vegetation of this area lies within the Oak-Chestnut Forest Region (Braun, 1950). In the study area there was no single dominant plant species (see Table II). The wooded section had been cut over many years before.

The total area was actually made up of three distinct sections defined by land use as woods, wooded pasture and pasture.

The wooded pasture extended from the fence to the edge of the study area on the east-facing slope and to the edge on one-half of the north-facing slope. It included 6.88 acres. The canopy consisted of tulip-tree, black walnut (*Juglans nigra*), black locust (*Robinia pseudo-acacia*), and some tall slippery elm trees. The sub-canopy was not as obvious in most areas. When it was present, it consisted of winged elm (*Ulmus alata*), redbud, and hickories. In isolated areas there were dense mats of honeysuckle and trumpet creeper at the sub-canopy level. There were no shrubs and ground cover was very sparse due to cattle grazing. Of the trees, 67.9 percent were under 8 inches dbh.

The pasture was an area of 4.19 acres on the northwest edge of the study area. There were red cedar (*Juniperus virginiana*), winged elm, and black walnut widely spaced over the area. The soil layer was very shallow and covered with grass.

The wooded area consisted of east-, west-, and north-facing slopes bounded by a fence at the lower elevation which prohibited grazing. The total area was 19.88 acres.

TABLE II

NUMBER AND PERCENT OF TREES*

Species	Numbers of Stem	Percent
Acer negundo	39	2.970
Acer rubrum	42	3.199
Acer saccharum	98	7.464
Ailanthus altissima	21	1.599
Carya spp.	195	14.851
Celtis occidentalis	26	1.980
Cercis canadensis	43	3.275
Cornus florida	62	4.722
Diospyros virginiana	53	4.037
Juglans nigra	30	2.284
Juniperus virginiana	17	1.295
Liriodendron tulipfera	111	8.454
Nyssa sylvatica	22	1.676
Pinus virginiana	20	1.523
Quercus alba	17	1.295
Quercus prinus	115	8.759
Quercus rubra	93	7.083
Robinia pseudo-acacia	52	3.960
Sassafras albidum	90	6.855
Ulmus alata	44	3.351
Ulmus rubra	55	4.189
Other trees	68	5.179
Total	1,313	100.000

*6.01 acres sampled.

a. East-Facing Slope Forest

East-facing slope forest canopy height was approximately 60 feet and it was made up primarily of white oak (*Quercus alba*), red oak (*Quercus rubra*), tulip-tree (*Liriodendron tulipifera*), American hackberry (*Celtis occidentalis*), and (only at the summit) chestnut oak (*Quercus prinus*). There were a number of openings due to fallen trees and a path along the crest.

The sub-canopy level was at 25 feet and composed of flowering dogwood (*Cornus florida*), hickories (*Carya spp.*), sassafras (*Sassafras albidum*), ashleaf maple (*Acer negundo*), and young tulip-trees. This level was made more evident due to the presence of grape (*Vitis sp.*), honeysuckle (*Lonecira japonica*), Virginia creeper (*Parthenocissus quinequefolia*), trumpet creeper (*Campsis radicans*), and poison ivy (*Rhus radicans*). These vines were dense in the tops of the trees of the sub-canopy. Below this layer were numerous shrubs and seedlings making the total cover relatively complete. West of station 56 there was an extensive rock outcrop. Of the trees counted, 22.4 percent were under 8 inches diameter breast high (dbh).

b. North-Facing Slope Forest

The north-facing slope was much steeper and there were more frequent outcroppings. The canopy was approximately the same height consisting of red oak, tulip-tree, chestnut oak, persimmon (*Diospyros virginiana*), American hackberry and hickories. The sub-canopy was made up of slippery elm (*Ulmus rubra*), red oak, ashleaf maple, sugar maple

(*Acer saccharum*), flowering dogwood, redbud (*Ceris canadensis*) and hickories. However, the vine cover was not as extensive at the sub-canopy level. At station 16 there was an area of approximately one-fourth of an acre covered with shrubs which was overgrown with honeysuckle. The trees were denser on this slope than the east-facing slope. Shrub cover on the lower slope position was great. Sixty-two percent of the trees censused were under 8 inches dbh.

c. West-Facing Slope Forest

The west-facing slope was more gradual than the others. There were a few dense areas of young trees less than one inch dbh and in between these areas were widely spaced large trees which gave the vegetation of this slope a very open appearance. There was very little honeysuckle and only one small section contained wild grape. The lower edge was fenced and bordered by an open pasture. Between stations 42 and 43 there was a rather dense honeysuckle thicket along the fence. the canopy was made up of chestnut oak, scarlet oak (*Quercus coccinea*), white oak, red oak, sugar maple, tulip-tree, persimmon, and hickories. The sub-canopy was not as obvious and consisted of red maple (*Acer rubrum*), young sugar maple, flowering dogwood, redbud and sassafras. In this area, 53 percent of the trees were under 8 inches dbh.

CHAPTER IV

FIELD TECHNIQUES

I. ESTABLISHING THE GRID AND VEGETATION SAMPLING

The study area was divided into quadrats with stations 256 feet apart. The lines were laid out north-south and east-west over the 30.95 acres as suggested by Hall (1964). Each quadrat consisted of one and one-half acres.

This system served as a basis for determining the vegetation sample. The quadrat lines were used as routes to sample the vegetation. In an area of four feet on each side of the quadrat line, all trees one inch to eight inches dbh were identified and the height was estimated. All trees over eight inches dbh were identified and their height was estimated in an area twenty feet on each side of the quadrat line. Those trees under one inch dbh were omitted from the count. All identifications were made using Petrides (1958).

II. ATTRACTING CARDINALS

The birds were observed feeding on the ground and seemed to prefer this to feeding at the feeding stations. The Cardinals were hesitant to come to the feeding stations when other species were present. Large numbers of Purple Finches (*Carpodacus purpureus*) were using the feeding station during February and March and this limited the usage of the feeding platform by the Cardinals. Four Potter-type traps were used in conjunction with the nets. They were placed on the feeding

platforms early in the study. Later the traps were placed near the feeders, at the edge of the roosting areas and in open areas in the wooded pasture.

Tape recorded songs were used to attract specific individuals for location and identification checks. Originally recorded male Cardinal songs were copied from tapes at the Laboratory of Ornithology, Cornell University. Recordings were made in the study area during the second year to determine if the local songs were more efficient. The recording of local songs was very difficult due to the local surface noises. The local recordings were not used because of the poor quality. The birds appeared to be very shy during the early trials and would not come close. It was decided that camouflage netting would make the observer less conspicuous while playing the recordings. This proved true as the birds came much closer to the recorder than without the netting. The use of a bird blind proved too cumbersome to move over the area. Mounted male and female Cardinals were used in addition to the recorded songs. The mounted birds were placed about four feet high on the lower branches of small trees. Mounted specimens were placed within two feet of the mist net as an aid to netting the birds. This technique was not successful and was discontinued.

The extensive use of tape recorded songs should be made in the future. The concentrated use of this technique during the period of time that the Cardinals occupy their territory would attract the birds to the recorder, and their location would be determined more easily.

III. TRAPPING CARDINALS

The trapping of the Cardinals began in February of 1970. Five-meter, nine-meter, and twelve-meter 1 1/2 inch mesh Japanese mist nets were used during the initial banding. The nets were placed near established feeding platforms in the hope that feeding birds would be netted. It was soon discovered that this technique was not very productive. After catching a single Cardinal others would avoid the net if it was not moved. It was possible to drive the birds into the net occasionally. The birds would avoid the nets if they were in the same locations after a single Cardinal had been entangled in them. This was confirmed continually by the limited number of birds caught at each site.

The net-shyness of the Cardinal was exhibited in many ways throughout the study. On one occasion a male Cardinal came to the feeding platform from directly above it by fluttering down like a helicopter. There was a mist net between the feeder and the honey-suckle-covered shrubs and one on the opposite side of the feeder. Due to the bushes on the opposing sides this was the only open area. The nets only proved effective if the bird was frightened and the net was across the escape route. In the wooded area the nets would catch one bird and then had to be changed to catch additional birds. Occasionally more than one bird was caught in the same net.

IV. MARKING AND OBSERVING CARDINALS

It was deemed necessary to mark individual birds in order to identify and follow them for the duration of the study. Plastic

color bands were used because of their lightness and permanency. A color marking schedule (see Appendix) was prepared in cooperation with J. C. Howell. This schedule was approved by the Bird Banding Office of the Migratory Bird Population Center of Laurel, Maryland. The multiple band marking plan used a single color to denote the banding year and a United States Government aluminum band on the right leg of the bird. Two other colored plastic bands were placed on the left leg. Multiple bands were used so that the loss of one band would not lead to confusing individuals which had lost a band with others which had been originally marked with only three bands.

Dyed feathers were used during 1971. Various types of dyed fluorescent feathers were attached by Duco Cement to the crest feathers of each bird. These feathers or pieces of a feather were approximately two inches in length and were fixed so that the natural contour of the feather followed the curvature of the head. The duration of the dyed feathers was one month or less in most cases.

There is a need for a better marking system. Due to the perching posture of the Cardinal the color bands were difficult to observe. The marking system should be easily visible from at least 100 feet. This would also permit following of the birds for longer periods of time once they were identified.

During 1971 a portable cassette recorder was used for recording observations in the field and found to be satisfactory. Only twice were observations not recorded due to malfunction of the machine. This method made it possible to observe the bird continually while recording the observations. Field observations were made all day from

one-half hour after sunrise until late in the evening before it was too dim to identify birds. A total of 844 hours was spent in the area. The birds were most active during the morning hours. The weather had a great influence on the activity of the Cardinals. There were many days when it was difficult to locate individual birds.

CHAPTER V

OBSERVATIONS

I. PAIR BOND

The observations were begun by February 1 in 1970 and 1971. Feeding platforms had been placed previously in the study area during January 1970. This was an attempt to concentrate birds for netting and trapping in order to mark them.

There is some evidence that some pair bonds may have already existed at this early date. A male was observed approximately forty feet high in a tree on February 11, 1970. A female was sitting and preening in the same tree. The male was chipping with the characteristic Cardinal call. They both flew off together within five minutes. A male and female were entangled in a mist net about 24 inches apart on February 20, 1970. This would indicate they were flying through the woods together. Two males and a single female were observed feeding on the ground near station 67 on February 22, 1970. The two males flew to the same branch, and one male then flew away. The female showed no reaction during this encounter. The remaining male and female continued feeding in the area.

Activity of the Cardinals was limited to the sunny days during the month of February. On cloudy cold days the birds were at the feeders and spent much of their time in the honeysuckle thickets. This made observation difficult. The males came individually to the feeders only when there were few other species present. Females followed the same pattern and neither sex would remain long. Usually the birds

could not be seen on overcast cool days. The presence of the birds in the area was detected by the call notes and the birds were seen when they came to the feeding stations. Seven hours and forty-five minutes were spent in the study area on Febraury 20, 1970, and only one male was observed but three were trapped. The temperature was 26^{0} F at 0815 hours EST and there was 25 percent cloud cover.

The singing increased, and more observations of males and females together were made, as the weather became warmer in March. On March 7, 1970, a male was observed near station 55 chasing a female. The male would replace the female on the branch as she flew ahead of him. There seemed to be no hurry as the birds moved through the trees. This continued for five minutes in an area of about one-half acre in the wooded pasture. As the two birds moved through the trees at a height of 20 to 30 feet, there were rapid chip notes by both birds. On March 10, 1970, a male was observed singing northwest of station 24. He sang somewhat softly for 20 minutes. A female flew into the tree where the male was singing. The male stopped singing and moved down near the female. She flew to a nearby tree, and the male followed. The two birds flew into the woods together and disappeared from view.

On March 11, 1970, a male and female were observed feeding together on the ground in the wooded pasture southwest of station 63. They flew into a low tree together and remained there three feet above the ground. A second female flew to the ground six feet from the pair. The male ignored the new arrival and very shortly she flew south into the woods. The pair then flew north into the pines.

The first indication of established pair bond was on February 6, 1971. A male and female were entangled in a mist net about twelve inches apart, indicating that the two birds were flying together and were presumably paired. On February 11, 1971, a male and female were caught at the same time in a Potter-type 4-cell trap at station 56. Obviously the birds were feeding together. At 1605 hours EST on February 20, 1971, three pairs of Cardinals were observed flying north through the woods from station 56 at a height of 40 feet. The group flew to the honeysuckle thicket just south of station 16, which was used as a roosting site. During the afternoon of February 22, 1971, a male and female were observed at station 59. The male was singing and the female was in the same tree. They left the tree and flew west into the wooded area. A second pair was observed at station 16 and later a third pair was sighted at station 25. The third pair was moving through the honeysuckle-covered bushes with the male replacing the female at each branch.

The number of observations of a male and female together had increased by March as it did in 1970. At 0845 hours EST on March 1, 1971, a male and female were sighted at station 58. The male was chasing a female. The male then flew southwest, and the female followed. Later, at 1025 hours EST, two males were chasing a female by station 64. One male then left, and the second male continued chasing the female in the area, back and forth, about four feet off the ground. Three pairs of Cardinals were observed at station 16 in a vine-covered tree, and all were very alert, chipping actively. Each pair left separately from the others, flying in a different direction.

Not a single marked pair resulted from the eighteen marked birds of 1970. In the second year, 1971, three pairs resulted from the additional 25 adults banded. However, two of the three males were banded in 1970 indicating their return to the study area (see Table III).

II. PRE-TERRITORIAL ACTIVITY

Observations in the month of February during both years indicated Cardinals used a large area of honeysuckle-covered shrubs south of station 16 and a similar area southwest of station 55 at this time of year. These areas served as protective cover during inclement weather and also on overcast days. The feeder at station 16 had a number of Cardinals using it continually because of the concentration of birds. Mist nets were used around this honeysuckle area. Traps and nets were also placed individually in the vicinity of stations 11, 18, 24, 32, 43, 67, and 68. During February 1970 all birds were captured in the vicinity of station 16. During February 1971 seven birds were captured outside the area of station 16.

Netting and trapping were carried out for 31 days in March, 1970. One female was captured on March 14th and a pair on March 19th. Trapping was resumed on April 15th with no results until a single male was netted near nest I at station 56 on May 15th.

A concentrated effort was made throughout the entire month of March, 1971, to capture birds. A total of 13 birds was captured. Seven were taken near station 16, and six were taken over the study area. Due to the lack of marked birds on the area it was decided to continue netting and trapping during April, 1971. This continued effort realized 11

TABLE III

TERRITORIES OF MARKED BIRDS*

Territory	1970		1971	
	Male	Female	Male	Female
I	Not Banded	Not Banded	Not Banded	Not Banded
II	RAYG	Not Banded	RAYG	Not Banded
III	Not Banded	Not Banded	YAOR	YAYG
IV	Not Banded	Not Banded	Not Banded	Not Banded
V	RARW	Not Banded	RARW	Not Banded
VI	Not Banded	Not Banded	RARG	YAGY
VII	Unknown	RARG	Not Banded	RARG
VIII	RARY	Not Banded	Not Banded	Not Banded
IX	Not Banded	Not Banded	Not Banded	Not Banded
X	Unknown	Not Banded	YABR	Not Banded
XI	Not Banded	Unknown	Not Banded	Not Banded
XII	Not Banded	Unknown	Not Banded	YARY
XIII			RARY	YAOR

*Color codes used in banding:

A Aluminum
B Blue
G Green
O Orange
R Red
W White
Y Yellow

additional marked birds.

The total number of color-banded adult birds in 1970 was 18, and six young were also color-banded. From this number six marked birds were identified with territories within the study area (see Table III). There were 16 unmarked birds occupying territories within the study area. In 1971, with the additional trapping and netting, a total of 25 new birds were color-marked, and eight adult birds were retrapped from 1970, making a total of 33 adult birds marked. Twelve marked birds occupied territories within the study area (Table III). During the second year there was one additional territory recognized. Of the total birds present in 1971, 26 had territories within the study area. As a result of the marking program in 1970, 27 percent of the residents were marked, and in 1971, 46 percent of the residents were marked. Since not all birds were marked only the daily movements of residents that were marked were recorded. The new birds that may have entered the area could only be determined by their behavior patterns.

III. TERRITORIAL ACTIVITY

Observations of singing increased steadily through the month of March. Definite areas gradually came to be used continually. Each location of a singing male was plotted on a map of the study area. A single map was used for each week's observations. From these maps it was possible to see that males sing in very regular locations. These locations were generally at the boundaries between adjacent territories. Where there was no neighbor, there are very few records of singing. The territory edge under this condition was difficult to determine.

Chasing between males increased as the singing increased. Six different observations were made of males chasing males in the first half of March. These were in areas where boundary lines were developed positively at a later date. The singing duels and chasing activities were observed in the afternoons. On March 3, 1971, at 1610 hours EST, a flock of ten Cardinals moved from station 56 northward toward the honeysuckle area at station 16. This indicated that territorial boumdaries, however well established, were not defended in the afternoon.

Observations were made of males patrolling territory boundaries. On March 6, 1970, from 0710 hours until 0817 hours EST, the male occupying territory VIII was observed moving about the area in a very definite manner. He flew from one high position to another, singing at each stop. He did not cover the entire boundary of the territory during the patrol. All of the territory was in view although only approximately half of the boundary was actually patrolled (Figure 2). The same male was observed patrolling the same area as before by a different route on May 1, 1970, at 0715 hours until 0831 hours EDT (Figure 3). The same male sang at each stop. This male was observed flying over the area north of station 40 in a patrol-type action, but there was no singing at each stop during the afternoon. A male Cardinal was observed at 1000 hours EST on April 10, 1971, over the western end of territory VII. This male made five different stops in a circular pattern, but did not sing. On the same day at 1140 hours a male moved from 50 feet north and 75 feet east of station 26 to station 34 and back to the original starting point. He stopped eight times and sang

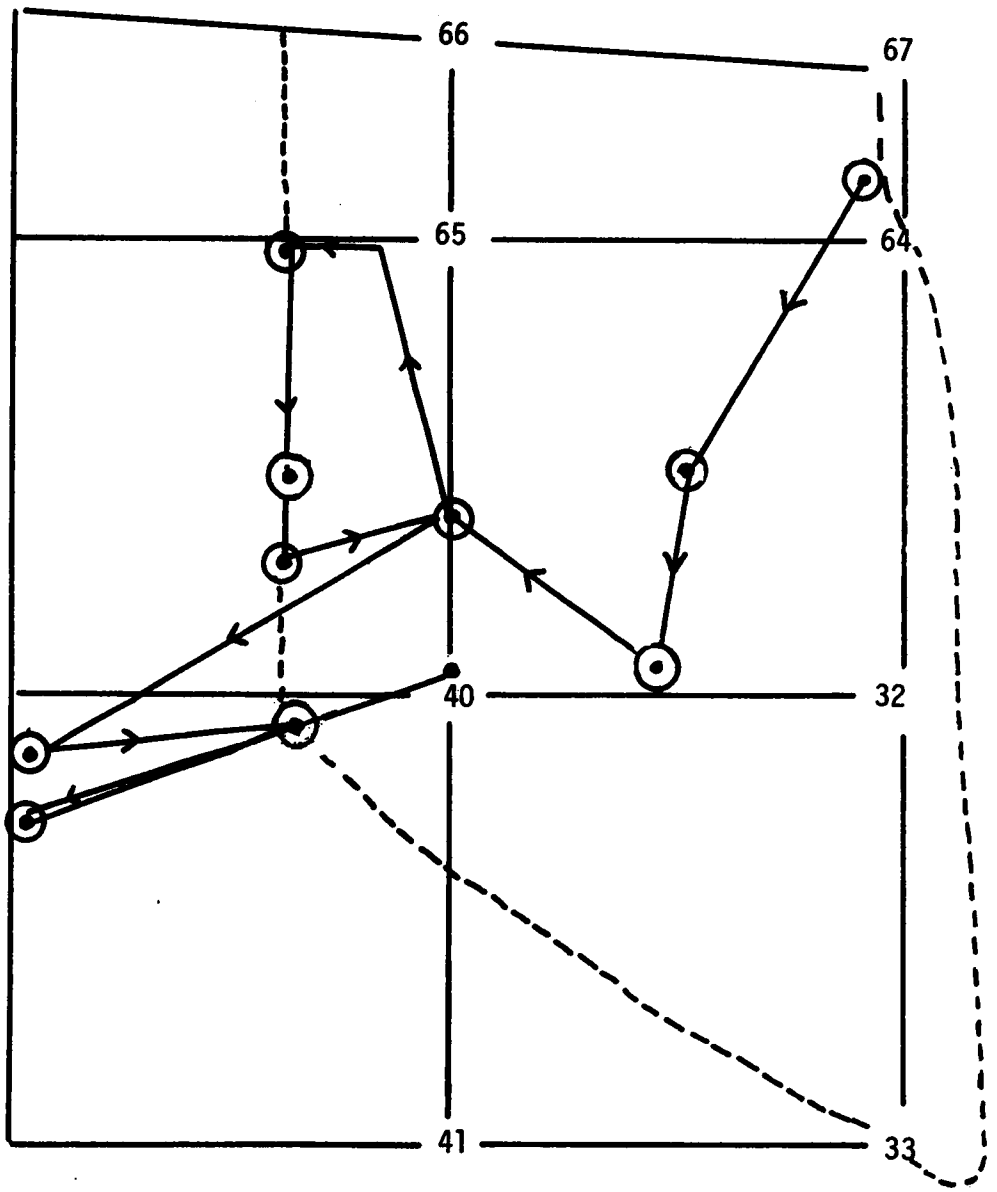


Figure 2. Patrolling route of male Cardinal of territory VIII on March 6, 1970. The quadrat lines are represented by ——— and the territorial boundary by -----. The singing stops are indicated by ● and the direction of flight by arrows.

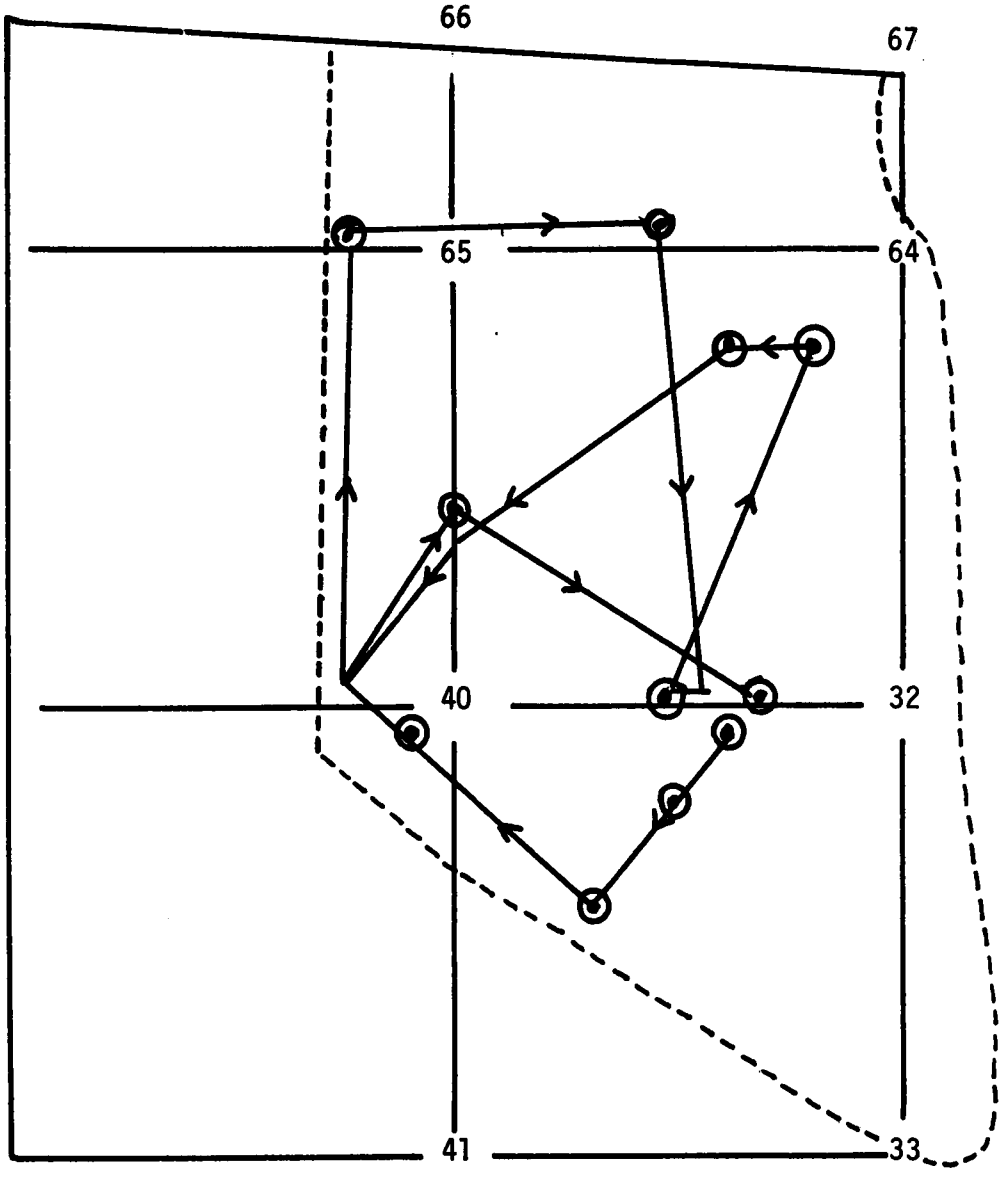


Figure 3. Patrolling route of male Cardinal of territory VIII on May 1, 1970. The quadrat boundaries are represented by ——— and the territorial boundary by ----. The singing stops are indicated by ⊙ and the direction of flight by arrows.

at each stop. This was the western edge of territory X. There were other occasions during April and May when short flights were made along territory boundaries with two or three stops and singing at each. Usually the bird then returned to dense cover. Once the bird entered honeysuckle-covered trees or bushes it was impossible to follow his movements.

It became obvious that the male birds also spent some time sitting in the tops of tall trees which gave them a view of their territories during the same period that patrolling activity took place. This activity gave the impression of the male bird guarding his territory. The male of territory II was observed sitting in the top of a tall tree on March 11, 1971. He was very alert but did not sing. He remained in this position for approximately eight minutes and then flew to a vine-covered tree and sang. Another male at station 24 was observed in the top of a tree looking over the area that same morning. He did not sing. Four days later this male was observed in the same tree. He seemed very alert and kept looking over the territory. At 0948 hours EST on April 17, 1971, the male at station 16 moved into the open at the end of a limb, becoming very conspicuous. He was very alert and remained out in the open for about six minutes before singing and flying to the ground to feed. Before the leaves were fully developed, other male birds were observed in similar positions. Sometimes this behavior included singing if the bird was stimulated by a neighbor singing or by a male Cardinal entering his territory.

Most of the singing was confined to early morning in early spring, but as the season progressed there also developed singing in the late

afternoon. Usually during the early afternoon there was a distinct lack of singing. The exception occurred when the male bird was disturbed by some activity in his territory or at near-by areas. Singing was used as a means of locating birds and a record was kept of the locations. This was not an attempt to locate every singing bird or to tabulate the number of songs per hour over the study area. Of those songs recorded on the study area, singing showed a steady increase from February, 1971 to a peak in April. There was a decline for the remainder of the observation period. The average songs per observation hour were as follows: .69 songs in February, 2.17 songs in March, 3.95 in April, 3.23 in May and 2.50 in June. The weather had a definite effect on singing. The birds remained in the honeysuckle-covered shrubs with little or no singing on overcast days or on those in which precipitation occurred.

The males spent more time in their territories with the increase in the singing. Many birds were observed roosting in the large honeysuckle area by station 16 during the month of February. On March 17, 1971, the last observation of a group of birds roosting at the honeysuckle area was made. Later there were other observations of groups of Cardinals in this area during the daylight hours on overcast days but they no longer roosted in groups. It was believed that the pairs roosted in their respective territories from this time on.

It became apparent, as the gradual occupation of territories was taking place, that definite areas in the wooded pasture and the edges of the open pasture areas at the boundaries of the study area were being used by many pairs of Cardinals at the same time. These

buffer areas were generally used for feeding. Three pairs of Cardinals were observed feeding at the open pasture edge by station 60 on March 18, 1971. The three pairs left the area in separate directions. In the open area between station 54 and 55, numerous observations were made of individuals and pairs feeding. This was in the grazed woodland area. This area was incorporated in territory III and the partial territory IV. The male from territory II was also observed feeding in this area. The other open area northwest of station 16 was used for feeding purposes by the pairs which had territories adjacent to it. No territorial tensions were observed in this area.

IV. OCCUPATION OF TERRITORIES

It was very difficult to determine when the Cardinals actively began occupying their individual territories because this was a progressive procedure. Evidence that they were occupying territories consisted of the following: patrolling, chasing, physical combat,and singing. One indication that boundaries were established, and thereby indicating that the territory was occupied, was the activity of patrolling the boundaries by the male. The first observation of this was made March 6, 1970, at 0730 hours EST in the area of station 40 (Figure 2, p. 31). This area was quite open, and it was possible to keep the male in sight for long periods of time. The route of patrol varied from following the boundary line to flying from a central perch to the boundary and back.

A pair of Cardinals was observed near station 54 on the morning of March 7, 1970. The male was chasing the female from branch to branch

northwest of the station, moving in an S-shaped path. When the male reached a point about 50 feet northwest of station 54 he stopped and returned to the tree at station 54 giving a low whistle. The female returned to the tree where the male was perched. Then he started to chase her again, and as he reached the same point as before, he stopped and returned to the original tree. Again he called, and the female returned. Finally they flew southwest together. This was interpreted as the male's reluctance to leave his territory. By this date the boundaries were established in some territories.

Territorial tension increased through the month of March and continued into April. While pairs were remaining in their respective territories, there were many birds moving over the study area that did not have territories. This was evidenced by the trapping of a male and two females during March, 1970, that did not remain in the area. No birds were captured during the month of April, 1970.

Thirteen individuals were caught during March, 1971, and only three were recorded as having territories within the study area. One of the remaining 10 was later found occupying a territory outside the boundaries of the study area.

Continued trapping was carried out in the month of April, 1971, and an additional 11 individuals were marked with only four of them having territories within the study area.

Territorial chases between males of adjoining territories continued through April and May of 1970. Generally the females followed their mates as the chases took place but did not actually enter into the activity. However, on March 23, 1971, two marked females

were chasing north of station 16. Periodically they stopped and sang. There were two males in the area singing, but they did not concern themselves with the females. This lasted about 25 minutes, and then the birds dispersed. A more violent encounter was witnessed in the same area on March 27, 1971, with the same marked female and an unmarked female. The marked female was the aggressor and chased the unmarked bird for about one hour through the sub-canopy. Many direct attacks were attempted, but the marked bird never actually made contact with the other bird. During this time the two males were singing at one another and did some chasing nearby. The unmarked pair were from outside the study area and were apparently trying to acquire some territory along the edge. At the end of the chase the marked female went to the top of the tree and sang very loudly. The other pair left the area. During this time the male remained near the female in the territory. This was the only fight actually witnessed between two females during the study. The whole character of the fight was just the same as if two males were fighting.

The first observed boundary dispute by two male birds was witnessed May 21, 1970. This occurred 150 feet northwest of station 56 where there was an open area caused by a rock outcrop. At this point three territories adjoined. The marked male from territory II, the male from territory XI, and the male from territory III were involved (Figure 4). However, during the chasing only two of the three male birds were involved. The third bird was always near, but never entered the chase until one bird stopped. The chasing took place along the boundary between territory III and territory X south to

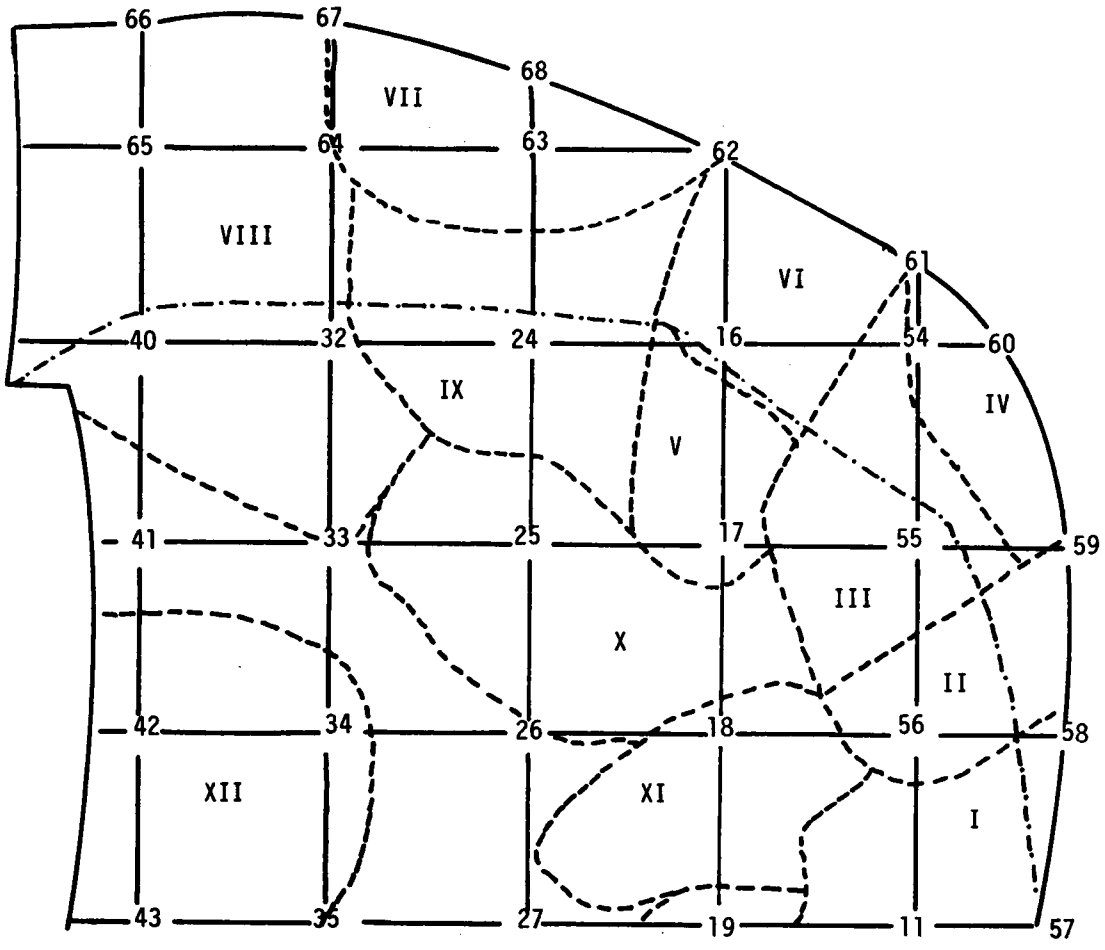


Figure 4. Breeding territories during 1970. The territorial boundary is represented by -----, the fence is represented by -·-·-· and the quadrat line by ———.

territory II (Figure 4). Occasionally the birds would stop, return to their respective territory, and sing very loudly. This lasted 14 minutes. Then a singing bout continued between the three birds for about 20 minutes with each bird in its respective territory. The male from territory II flew into territory XI and was immediately chased back (Figure 4). Again each sang very loudly and clearly. There seemed to be an area about 10 feet wide in which the birds moved back and forth and sang only when they were in their own territory. Finally, only singing continued, but the male from territory III flew back to area III after the other two males stopped singing (Figure 4). This encounter lasted two hours. However, during the entire time there was no actual contact between any two birds.

The first physical combat was witnessed on March 3, 1971, at 0938 hours EST. The male from territory III began by chasing the white-barred feathered male from territory V (Figure 5). The chase took place from two feet to six feet above the ground, through the bushes along the northwest border of territory III. The two birds flew at each other and struck bills. There were periods of singing during the chase by both birds. As the two birds chased along the western boundary of territory III, the male of the adjoining territory X joined the chase. The white-barred male left, and the other two continued to chase with periodic singing. The chasing continued to the boundary of territory II, and the male of territory II returned to his territory from the buffer area in the wooded pasture east of station 55 (Figure 5). He flew in, took over the chase, and the male from the west withdrew. The chase now centered about 75 feet north of station 56. At

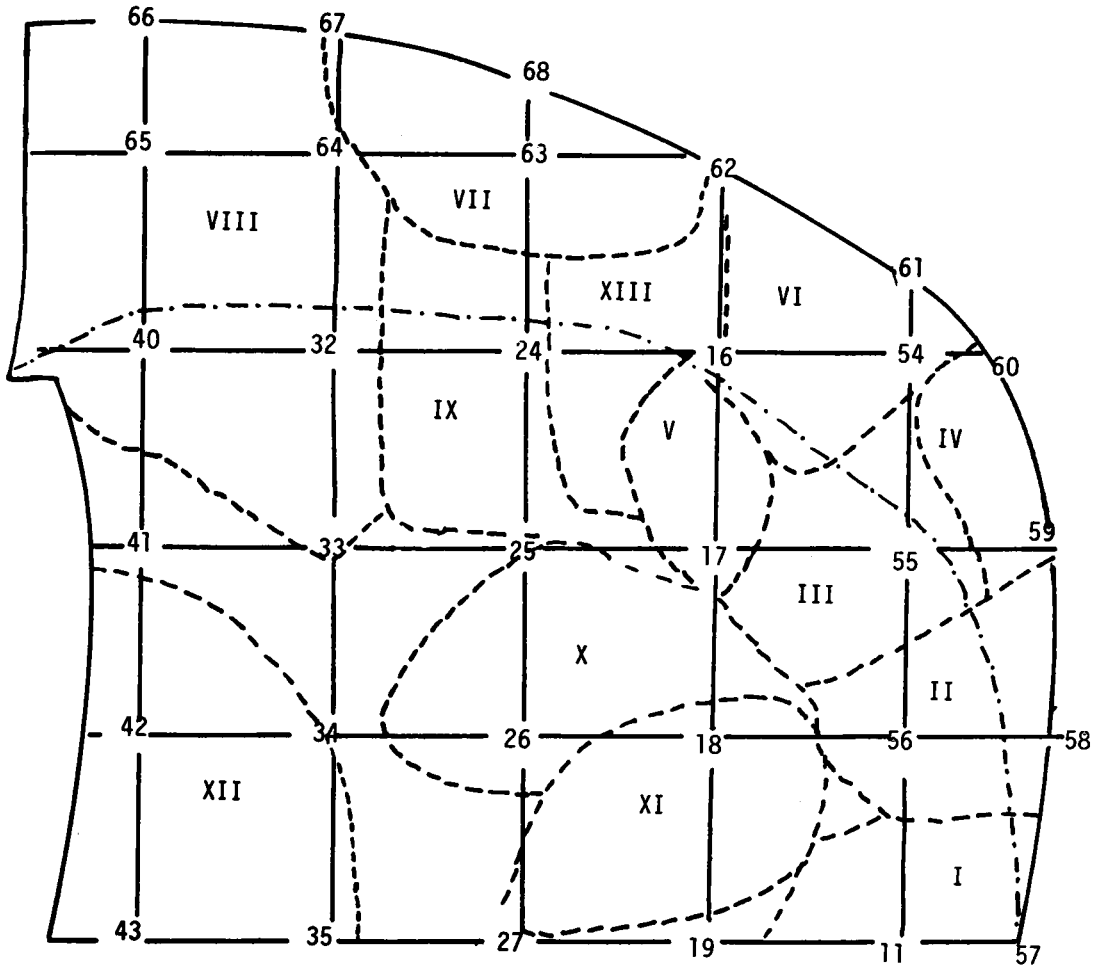


Figure 5. Breeding territories during 1971. The territorial boundary is represented by ---, the fence by -·····, and the quadrat line by ——.

this time the two females and the two males continued chasing. Female chased female, and male chased male back and forth across an imaginary line dividing the two territories. The two males flew at each other and hit bills with feet extended toward each other. This ended with a scuffle on the ground. Then each male flew up into a tree about 20 feet high and 20 feet apart to sing. The two females continued to chase and sing also. This dispute lasted approximately one hour, and the writer's presence seemed to have no effect on the action. At one point in the action the two males were only three feet above the writer's head. The action from the beginning of the chase took place along the boundaries of territory III as they were defined in 1970 (Figure 5). The male of territory II had occupied that territory in 1970 and had been marked during 1970. He had returned to the same territory in 1971. The male of territory III was not marked in 1970, so no identification was possible in 1971.

a. Use of Recorded Songs and Mounted Birds

It was decided to use a recorded Cardinal song in an attempt to determine the reaction of the territorial pair during this period of high territorial tensions. The recorded song was obtained from the Library of Natural Sounds, Laboratory of Ornithology, Cornell University, Ithaca, New York. The original recording was made at Park Headquarters, Great Smoky Mountain National Park, Tennessee, by R. C. Stein on May 3, 1963.

The first attempt using the recording was carried out on April

20, 1970, in territory VIII. A mounted male Cardinal was placed on a feeding platform 100 feet east of station 40 and the recording was played in short bursts. Both the male and female came to the location and stopped about 15 feet from the mounted bird. They remained in the tree looking at the bird, then flew off. Each time the recording was played the pair returned. This continued for 10 minutes during which time the male chased another bird from the area and then the pair left.

A second attempt was made using a blind made of camouflage cloth and an umbrella frame on April 21, 1970. This was set up in the center of the adjoining territory near station 24. The blind was about 25 feet from the mounted bird which was placed on a log in the open. When the recording was played, the male bird arrived in about one minute and flew by the mounted bird to land on the ground 15 feet to the east. Then he quickly flew into a low tree, chipping very loudly. Shortly he flew south 50 feet to the fence. As the recording was played, the male flew back to the mounted bird and hit it with his bill in a glancing blow which knocked it over. He stopped in a tree 10 feet high and 15 feet from the mounted bird and sang the same song as the recording. This singing lasted about two minutes. After the mounted bird was set up again, the bird made numerous flights to the ground by the mounted bird and seemed to be eating. During this time he sang in low shrubs near the log and when on the ground would flutter his wings. Each time the bird left the area he would return when the recorded song was played. After the first five minutes the female came to the area and remained for

about one half hour in the general vicinity. This activity lasted two hours with the male returning and flying by the mounted bird and then moving about on the ground near the bird. However, only once did it actually knock the bird off the log. Finally, the male left the area and went to the woods and did not return.

The following day, April 22, 1970, the same setup was moved to the north edge of territory III. After playing the recording the male came to the mounted bird but left immediately. With continued playing of the recording the male did not return. It was then decided to move closer to the center of the territory to see if the response was any different. The mounted bird was placed on the branch of a tree seven feet from the ground. The blind was 10 feet from the bird at station 55. Just 10 minutes after playing the recorder, the male bird flew at the mounted bird, attacking it from the back. The attacker hit the left wing of the mounted bird with his feet and at the same time hit the back of the head of the mounted bird with his bill. The left wing was torn off and the bird carried the head of the mounted bird to the ground, continuing to peck at it for about five seconds on the ground. After flying to a branch 10 feet from the body of the mounted bird, the male gave a low gurgle sound. A new attack could not be instigated by playing the recorder. Then the mounted bird was reassembled and the recorder played, but no additional combat took place. The male remained in the area but would not attack the mounted bird. This episode lasted approximately one hour.

An attempt was made on April 30, 1970, to use the mounted bird as a decoy to net additional Cardinals. A five-meter mist net was put

up four feet from the mounted bird in the same area as before. The male Cardinal came to the mounted bird but flew parallel to the net. This indicated again the net-shyness. This occurred only once, and the bird would not return but did remain in the area for about one hour.

A mounted female was used on May 7, 1970, to see if there was any difference in attracting birds to the net. No reaction was achieved in this trial at all, but it was quite windy, and this could have been the reason.

The first time the mounted bird and recorder were used in conjunction with the mist net during 1971 was on April 9. The mounted bird was placed directly north of the mist net 80 feet north of station 24. Within one minute a male flew just above the net over the mounted bird. The female was also in the area. After 45 minutes of playing the recorder periodically with no results, the trial was stopped. At 1750 hours EST the same day a second try with the same location of the mounted bird and net was made. The male returned but did not fly at the mounted bird. He merely circled around the bird remaining from 20 to 60 feet away. This trial was terminated after 30 minutes. The following day at 1800 hours EST the mounted bird was placed in the center of territory VIII with the mist net three feet north of the mount. After playing the recording the male arrived 20 feet above the mount and sang. However, no attack was made and the male left shortly. It was necessary to check the traps so the mounted bird and mist net were left in position. Within an hour the observer returned to the net and again played the recording. The male flew through the area well

above the net but did not return. No more trials were made with the mounted bird and net.

The recorder and song were used during the rest of the day to attract males and define territorial lines. The males would approach the recorder and sing if in their territory. Males would come to and beyond their territorial line but would not sing when out of their own territory. However, the recording did not always attract the male. Many times no male or female would appear, giving the impression that the birds were not in their territory.

b. Extra Territorial Movement

Even though every bird in the study was not marked, there were observations of birds that were not in their territories or more than one male in a single territory. The Cardinals left their territories rather frequently. At 1740 hours on April 23, 1970, a male was observed singing 40 feet east of station 64 and then flew north across the pond where he sang again. The Southern shore of the pond was the territorial boundary of the pair of territory VII. On April 29, 1970, a female was observed flying from the pasture area west of station 42 through the woods east to beyond station 32. She crossed territory XII and went east. She did not sing and flew rapidly. Again, on May 20, 1970, a male was observed flying from station 65 northeast to the pine area of station 63. He was only five feet above the ground and flying very fast.

During 1971 additional observations were also made of individuals definitely outside these territorial boundaries. The most obvious

occurred on March 31, 1971, when the marked male of territory II returned from north of station 55. Then on April 13, 1971, at 0948 hours EST a female was observed 100 feet due north of station 16. She flew back to station 55 and then dropped to the ground where the male was feeding. At 1627 hours EST on April 15, 1971, a pair was observed feeding in the tops of the trees 150 feet west of station 55. They had moved from near station 16. The female was marked with a red-barred feather. This pair was observed using the area defined as territory III surrounding station 55 and had been at least 100 feet northwest of their boundary. This pair continued to use territory III. There were other observations of Cardinals in known territories of other males but it was not known if these individuals had territories of their own.

c. Territorial Invasions

Attempted invasion of territories already established occurred during 1970. The first observation was on May 5, 1970. Some pairs were already nesting, and the pair of territory VII was in the nest-building stage of the reproductive cycle. The first observation involved the male owner chasing the invading male from the pasture edge, half-way between station 68 and station 62, out into a single tree in the pasture and then flying back to the pines. The second attempt took place on May 11, 1970, in the same area. The invading male flew to a branch beside the resident female. Immediately the resident male flew at the invader and chased him out into the pasture area. The resident male returned and broke into song. The female was building a nest on

the pasture side of the pines.

At 1040 hours EST on June 25, 1970, two females were observed chasing 30 feet north of station 54. Two males were having a singing bout with one at the edge at station 60 and the other at station 54. The males sang as the females chased below them. The chase took place in an area of about 20 feet in diameter, and the two birds were never more than five feet above the ground and sometimes on the ground hopping along. During the chase one male flew above the chasing females but never entered into the chase. There were no long flights and no actual combat. The crests of the two females were always lowered. After eight minutes of chasing one female left the wooded area, and the male and remaining female then flew west to the honeysuckle patch south of station 16.

During 1971 only one observation of an attempted invasion was made. At 1029 hours EST on April 13, 1971, a pair was sighted at the edge of the area 75 feet northwest of station 60. The male flew east into the pasture area and sang in a tree 150 feet east of station 61. The female flew north to a brush pile 300 feet north of station 61. This pair returned to station 60 and the pair from territory VI was there to meet them. A mild chase took place for about five minutes, and then the pair from territory VI moved south into the wooded pasture, and the invading pair flew out into the pasture area and did not return. After nesting began there were only the normal chases and tensions in the study area that would be expected. No successful invasions were observed during the study.

d. Mapping of Territories

The mapping of the territorial boundaries was a continuous operation during the spring of each year. The location of the singing males gave a clue to the boundaries as did the chases and actual combat. There was no single period of time prior to nesting that resulted in all of the boundaries having been discovered. During 1970, it was apparent that by the first week in March the various pairs had established their territories. In Figure 4 (p. 38) the boundaries are shown. There were nine complete territories and three partial ones within the prescribed boundaries of the study area. Early in March 1970, territory III was considered larger than later that month. The corridor to station 54 and to the edge along the northern boundary was maintained until nesting began but was not used very often. Occasionally the male of territory III wandered into this area where no other males were present. Later this section became an area used by many individuals for feeding. This was the only obvious change that took place during 1970 (see Table IV).

In 1971 an additional territory was added between station 16 and station 24 (Figure 5, p. 40), however a portion of this area consisted of the open area and was of little value because of the lack of cover.

e. Activity Periods

During the month of February the males sang only occasionally in the morning. Due to the low temperatures and cloudy mornings most time was spent on or near the ground feeding. As the weather improved

TABLE IV

SIZES OF TERRITORIES IN ACRES

Territory	Size in Acres	
	1970	1971
I	1.6	1.2
II	1.2	1.7
III	1.9	1.9
IV	1.6 (partial)	1.2 (partial)
V	1.3	.85
VI	1.6	1.7
VII	1.8	2.2
VIII	6.0	6.4
IX	2.8	2.3
X	2.9	2.4
XI	1.9	2.2
XII	3.0 plus pasture	2.8 plus pasture

with more sunlight and warmer temperatures toward the end of the month, both the males and females became more conspicuous. By March observation of courtship activities had begun to increase. Males chasing females were recorded during mid-mornings. Numerous sightings of females following males were made. In the afternoon activity seemed less, and the males were observed sitting very alert in the tops of the trees but not moving about the area. Often it was difficult to find the birds at all. In late afternoon feeding again seemed to be the major activity, and this time the food was found on the ground primarily. Due to the movement of birds over the area, the territorial birds were constantly alert. It was at this time that singing bouts between males occurred quite regularly.

Early morning from before sunrise until approximately 0900 hours EST was a period of singing. This was followed by periodic feeding. The birds remained within the boundaries of their territories. From 0900 hours until 1130 hours EST more movement took place. This was the period in which patrolling of boundaries and territorial chases occurred. This was also the period when investigation of nest locations and sites took place as the nesting cycle approached. During the afternoon hours there seemed to be less activity over the area generally. Then by 1500 hours feeding and other activities began again. More than 50 percent of the captures of birds over the study area took place during this time period.

V. NESTING

The female became very inconspicuous as nest construction began. Throughout both observation periods only the female was

observed building the nest. The female was observed carrying nesting material in the morning only. No observations of nest building were made after 1130 hours.

The male took no part in nest building or incubation. However, he was always very close by and came if there was any disturbance. He seemed to be on guard. It was during this time that boundary disputes took place and territorial tension was at its highest level. However, during the incubation period he was observed feeding the female, but always after she left the nest. Immediately after the eggs hatched the male arrived at the nest either with food or without food. The males at this time seemed very alert and quite active around the nest. From this point both parents spent most of the morning and late afternoon feeding the young. No observations were made of either parent leaving the territory to get food for the young. They were observed obtaining insect larvae from the surfaces of leaves to feed the young.

The nesting period began about the first of April of each year and continued beyond the end of the study period. No single pair was followed for the entire nesting period. A total of 10 nests was found during the 1970 period and a total of 19 was found during the 1971 period. See Figures 6 and 7 for nest locations.

It was difficult to find any single factor that had a bearing on the location of the nest in a given territory. However, all nests found but one were associated to some degree with honeysuckle. In the majority of cases the nest was constructed in a shrub or tree that had a covering of the vine above the nest. There were nests constructed in cedar trees that had only a single vine in the tree and not a

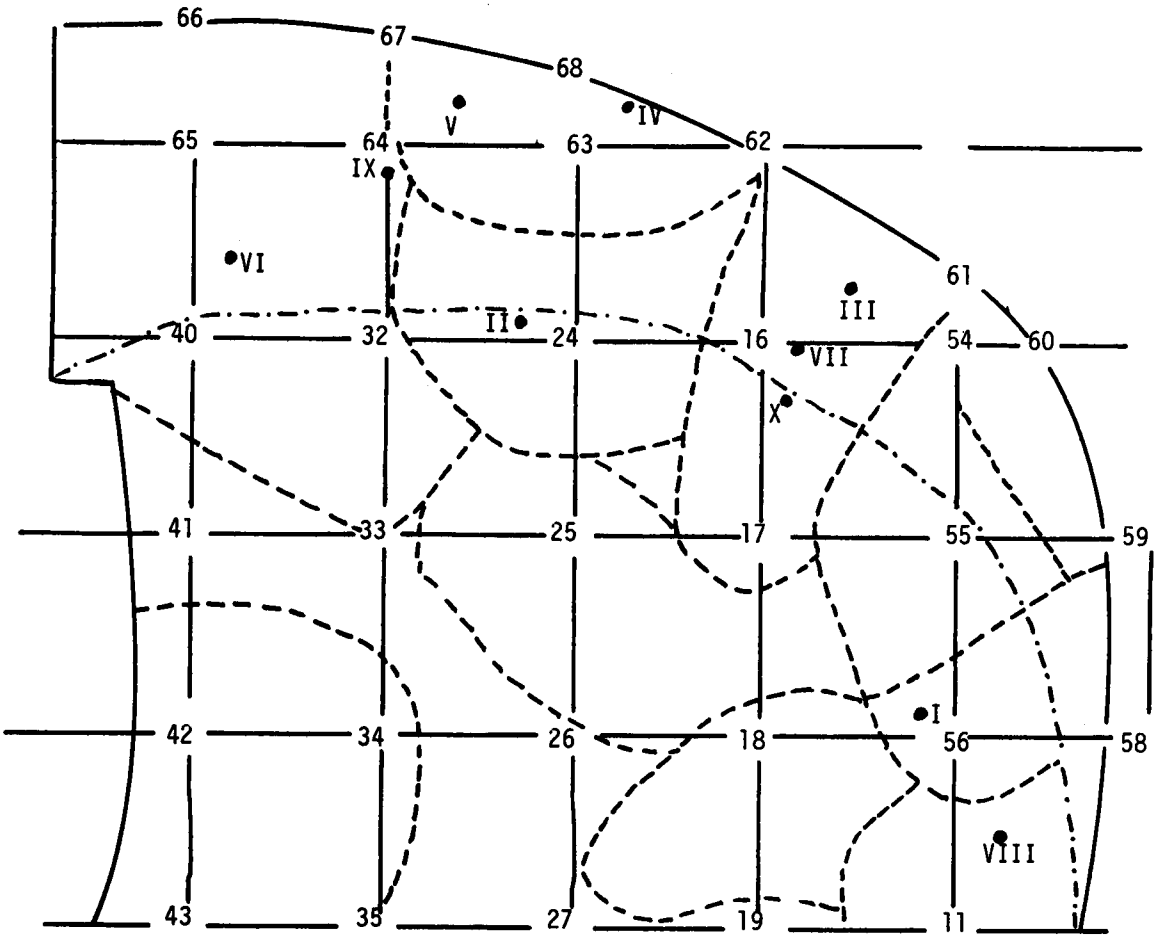


Figure 6. Territorial boundaries and nest locations for 1970. The fence is represented by -·-·-·-, the nest location by ● and the territorial boundary by ------.

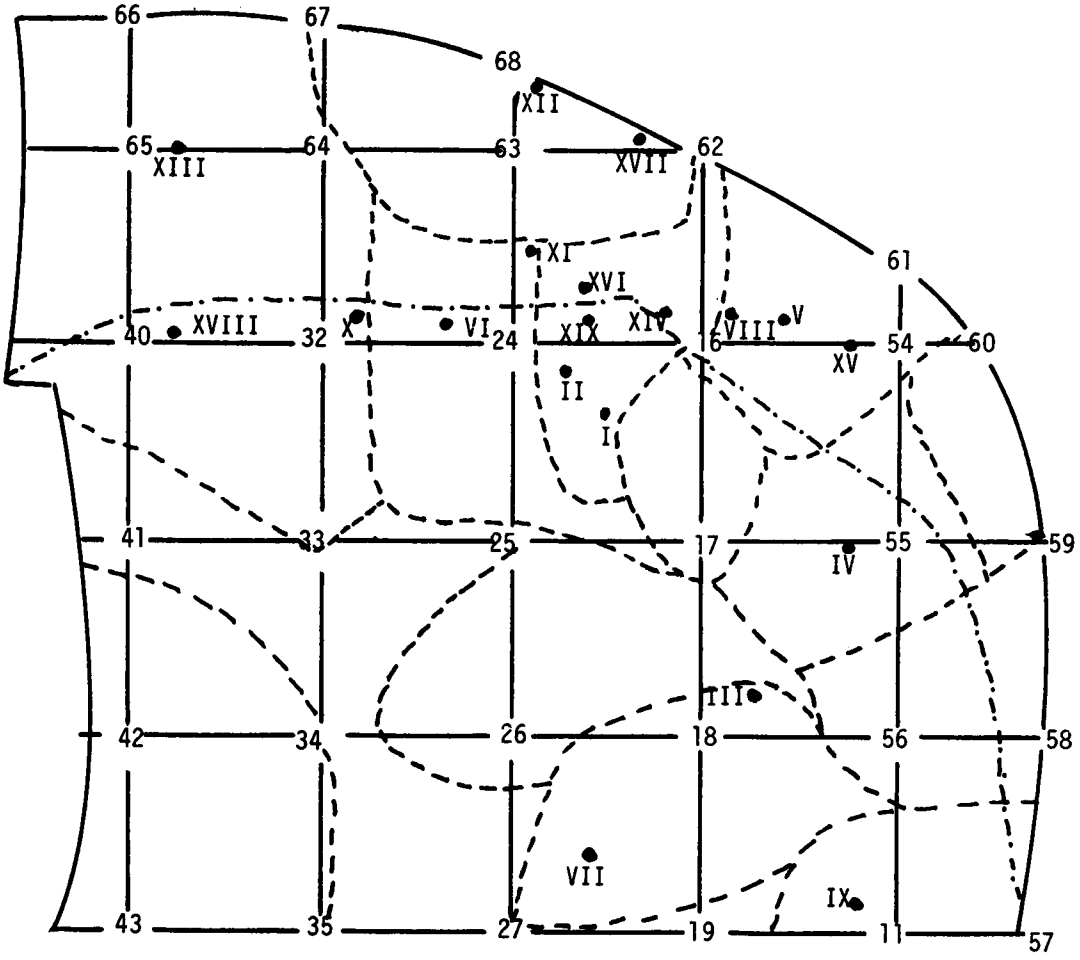


Figure 7. Territorial boundaries and nest locations for 1971. The fence is represented by -·-·-·-, the nest location by ● and the territorial boundary by -----.

total covering. Only one nest that was found had been constructed in a deciduous tree. This was late in the season when the foliage was complete. The nest was in territory VII, and there were very few sites available that had a vine covering.

The height of the nests above the ground varied from 4 to 13 feet during 1970, with an average height for 10 nests of 7 feet 10 inches. In 1971, the nest height varied from 3 feet 6 inches to 13 feet 6 inches with an average height for the 17 nests of 7 feet 5 inches.

Most nests when located were in an advanced stage containing either eggs or young. There were no observations on the actual beginning of the first nest of any pair. However, the pair occupying territory VI was observed raising a brood that fledged May 27, 1970, and on June 9, 1970, the second nest was found and the female was incubating for the second time. It was not known if the young fledged from this second nest.

The pair occupying territory VII was found to have a nest with two eggs on May 15, 1970. On May 25, 1970, the nest was found empty, and the pair had deserted it. On May 27, 1970, just two days later, the female was observed constructing a new nest. The first egg appeared in the nest on May 30, 1970. The clutch of three eggs was completed June 1st. Hatching took place on June 12, 1970, and the nest was destroyed on June 18, 1970, by a severe electric and wind storm. During 1971, although 19 nests were found, there were no consecutive nestings observed as in 1970.

In order to determine when nest building actually began the earliest sighting of a nest was used as evidence. The date when

the initial egg was laid was calculated. Then an approximation could thus be made as to when nesting building began. In 1970 nest I was found on May 4 with three eggs which hatched on May 8. Since the incubation period is 12 days, the first egg would have been laid on April 24, 1970. Assuming that at least one week was used for nest building, the calculated beginning of nesting was about April 17, 1970. In addition to the above calculation an observation was made on May 12, 1970, of a young Cardinal in territory VIII that was able to fly short distances and had a very short tail as well as a black bill. The young are fledged 9 to 10 days after hatching (Brent, 1968). It was assumed that this bird fledged the day before the sighting. Using 10 days until fledging, the hatching date would be May 2, 1970. Incubation took 12 days, which would indicate April 20 as the start of incubation. One egg is laid each day so that three days were required to complete the clutch and seven days were required to build the nest. Thus, nest building began near April 10.

The first observation of nesting was made on April 12, 1971, in territory XIII. The female was observed carrying nesting material. This nest was never used. However, on April 13, 1971, a female was observed carrying nesting material in territory V and this nest was used. The first egg in this nest was laid on April 16, 1971.

The percent of nesting success was determined by using only those nests that had actually had eggs deposited in them. There were nests found that had been abandoned before egg-laying took place or were found after the young had fledged. Only one nest in 1970 was found that was not used during the observation period. A total of six

nests were found that had three eggs or three young in them. Only two nests had two eggs or young and no nests were found that had four eggs. The nesting success was 37.5 percent (see Table V) in 1970 and there was a total of eight young fledged successfully of which six were color marked.

There were six nests found in 1971 that never had eggs in them. Only two nests had two eggs or young and none with four eggs. The calculated nesting success of the 12 nests was 38 percent, and there were 12 young fledged successfully, of which 8 were color marked (see Table VI).

The high percentage of nest failure was unexpected in 1970. There was only one desertion that was probably caused by the investigator. Nest II in territory IX was found May 4, 1970, with three young that appeared to be about two days old. On May 5, 1970, an umbrella type blind of camouflage cloth was placed 6 feet from the nest in order to observe the feeding. This nest was deserted on May 7, 1970, and it is believed that the blind was placed too close to the nest.

The only actual observation of a predator destroying a nest was on June 18, 1971. At 1530 hours EDT the observer returned to nest XIII to band the nestlings. Two young were removed from the nest in order to band them. Upon returning the two young which had been banded to the nest, the third nestling was removed. The nestling was banded and when it was about to be returned to the nest a snake was observed coiled around the nest with one of the young in its mouth. The snake was removed and collected for identification. It was identified as a Black Rat Snake (*Elaphe obsoleta obsoleta*)

TABLE V

NEST OBSERVATIONS 1970

Nest No.	Date of First Obsv.	Condition of Nest	Number of Eggs	Date Hatching	Date Fledged	Date Destroyed
I	5/4	Finished	3	5/8	5/18	
II	5/4	Finished	3 yg			5/7 Deserted
III	5/7	Finished	3	5/19	5/27	
IV	5/5	Building	2 5/15			5/25 Nest empty
V	5/27	Building	3	6/13		6/19 Nest empty
VI	6/8	Finished	3			6/11 No eggs
VII	6/9	Finished				6/27 Nest empty
VIII	6/22	Finished	2	6/23 (cal)	7/1	
IX	7/19	Finished	3			
X	7/8	Carrying material				

TABLE VI

NEST OBSERVATIONS 1971

Nest No.	Date of First Obsv.	Condition of Nest	Number of Eggs	Date Hatching	Date Fledged	Date Destroyed
I	4/13	Building	3	5/3		5/4 Empty Not used
II	4/12	Building	0			
III	4/15	Building	2	5/10		5/17 Nest empty
IV	4/25	Finished	3			5/14 Nest empty
V	4/25	Finished				Not used
VI	4/29	Finished	3			5/4 Nest empty
VII	5/3	Finished	3	5/17		5/22 Nest empty
VIII	5/10	Finished	3	5/12	5/22	
IX	5/11	Finished	3	5/14	5/21	
X	5/17	Finished				Not used
XI	5/26	Finished				Not used
XII	5/13	Finished	3			6/7 Nest empty
XIII	6/1	Finished	3	6/13	6/9	One young killed
XIV	6/1	Finished	3	6/8 (cal)	6/15	
XV	6/3	Unfinished				Never used (Tipped)
XVI	6/29	Finished	3			7/7 Nest empty

TABLE VI (continued)

Nest No.	Date of First Obsv.	Condition of Nest	Number of Eggs	Date Hatching	Date Fledged	Date Destroyed
XVII	6/29	Finished	2	*		
XVIII						Not used
XIX	7/3	First day	1			7/17 Destroyed

*There was no hatching date established for this nest and the last observation was made July 12, 1971 at which time there were two young in the nest.

(Cf. Conant, 1958). The snake was 46 inches long and was the second individual seen in the area. No damage was done to the nest so the young were left in the nest. This experience gave the indication that other nests that had missing eggs or young could have been a result of such activity.

There was no evidence of any change in pairs during the observations of the nests. Those pairs that were marked remained in the same territories and with the same partner.

CHAPTER VI

DISCUSSION AND CONCLUSIONS

The activity of the Cardinals was greatly affected by the weather. The presence of the birds was easily determined when the weather was sunny and warm. It was difficult to find the birds when the weather was overcast and rainy because the birds frequented the honeysuckle-covered areas during these periods. The males were not in their territories all the time. When the males sang, they sang in areas that later became Cardinal territories. In only one instance, on March 7, 1970, were two males observed singing 50 feet apart in two adjacent trees in the open pasture which was was considered outside the study area. Numerous observations of singing males with a silent male nearby were recorded. As the weather began to warm up by the middle of February, it was common to observe two males sitting together or chasing one another. This activity was most common in the morning. Also at this time there were observations of groups of birds moving over the area. The size of the group varied from two pairs to as many as four pairs.

I. PAIR BOND

Some pair bonds were established early in the period studied. The observations of males and females together moving over the study area exhibited behavior patterns which would indicate pairing had taken place. On March 11, 1970, a male and female were together when a second female flew into the area. The fact that she was completely

ignored by the male would support this conclusion. However, not all birds were paired at this time.

Courtship activities were taking place during February as indicated by the males chasing females. This behavior occurred prior to nesting and would reinforce the pair bond each year. The observations of males and females together increased during March.

It was not possible to make any definite statement of the duration of a pair bond beyond one nesting season. No single pair was marked during 1970. However, each marked bird returned to the study area the second year. The male of territory VIII did not return to the same territory in 1971 but to a new territory that was partially taken from territory VI. Every other marked male or female returned to the same territory the following year. Because of this consistency it seems that the pair bond may be extended for more than one nesting cycle as Lack (1940) has suggested. If Cardinals return to nest in the same territories, it is possible that this would continue until one member of the pair is lost by death. The pair bond was maintained for the entire nesting season. The observation of marked pairs during 1971 recorded no changes in partners.

II. BEHAVIOR

Territorialism was present in the Cardinal population. The observations verified the concept that Cardinal pairs maintain a definite territory. The pair made use of the territory for the majority of their activities during the reproductive cycle. However, both members of the pair wandered outside the boundaries. This was

most noticeable when they were feeding. Generally this wandering occurred prior to nesting or by the males when the female was incubating. The territory was used for courtship, feeding, and nesting as determined by Nice (1941).

Territories were occupied during February and early March. The occupation during February was not continuous. During periods of cold and stormy weather the birds used the dense honeysuckle patches for protection and roosting. The time spent in the territories increased as the weather improved. The territories were occupied continually by the first week in March. The increased frequency of singing developed along with territorial occupation. The location of singing birds remained constant with only additional observations of the same birds being recorded in the same areas. The singing posts were established in convenient tall trees. These posts were not always close to the boundary of the territory. The taller trees within the territory appeared to determine the singing posts. When a tall tree did occur on the boundary, it was used by both males of the adjoining territories at different times.

Individual males or females occupied the same territories each of the two years. The male of territory II was marked the first year and returned to the same territory the second year. The female of territory VII also occupied the same territory each year. However, the male of territory VIII in 1970 moved to territory XIII in 1971. Territory XIII was an additional territory which was added in 1971. There were six additional Cardinals retrapped in 1971 that had been trapped in the study area during 1970 but did not have

a territory within the study area during the study.

Territorial tension increased as the nesting time approached. This was indicated by the increased number of observations of singing that reached a peak during the month of April. The guarding and patrolling activities were evident during this period. This was also the period when non-resident Cardinals were observed in the study area. The males were conspicuous in their territories and were very alert to these intruders. They did not appear to react as vigorously to the adjoining neighbor.

Territorial boundaries were precise between two adjacent pairs. No territorial disputes were observed until May. All pairs were nesting then and there were no Cardinals present that did not have territories. During this period, the aggressive actions were directed at pairs in adjacent territories. If there was no adjacent pair the boundary was difficult to determine. The boundary appeared to be an area about 10 feet wide and occurred in areas with little or no canopy cover. During the territorial disputes, the birds moved across this area and turned back at the opposite edge from their territory.

The return of a member of a pair to the same territory the second year would reinforce the same boundary each year. In the two years there was only one boundary that changed any sizeable amount. The territorial boundaries remained in the same general locations with the exception of territory XIII which was added in 1971. Only when a new male replaced an absent member of the population was there a necessity for reaffirming the boundary line. This

would then result in physical combat between the resident and the newcomer. Only one combat bout was necessary to establish the boundary, and it was in the same position as the year before. This bout would include the female fighting female and male fighting male. No observations were made of a male fighting a female. The only variation to this pattern occurred when the female constructed her nest near the boundary of a territory. This caused intrusions into the adjoining territory during the feeding of the nestlings. The adjoining pair was nesting at the time so there were only occasional chases when the males were in the same vicinity and the intruder returned to his territory with no confrontation. This limited encroachment was accepted by the neighboring pair.

A new territory was added the second year. The marked male of territory VIII occupied territory XIII in 1971. The area was included in territory VI and also part of territory IX during 1970. The area used by the pair was what could be called optimum nesting territory. There was an overstory of honeysuckle and wild grape vines providing very dense vegetation. However, it also included an open area that was considered a buffer zone the previous year. It may have been that because of the dense cover not as much land area was necessary as in other territories. Both territories that lost area still were of a size to accommodate a pair. The male from territory VIII was familiar with this side of the hill and apparently lost territory VIII. He remained in the same general area by creating a new territory. This territory did not become obvious until the nesting season was in progress, although the exact date that the pair moved into this area was not determined.

The areas of the territories in 1970 were determined by observation of male singing posts and territorial chases. Territory IV was only a partial section of the pair's total territory. The remaining portion was located east of this section across the pasture and road from the study area. The pair traveled across the open area to use the portion in the study area but no nests were discovered on the study area. A similar situation occurred on the western boundary of the study area. Territory XII also included a portion of the pasture and isolated trees outside the boundary of the study area. No nests were recorded in territory XII. However, the area was used continually by the pair. It was felt that the pair did nest within the study area even though no nest was found. The average size of 11 territories, including that portion of territory XII on the study area, was 2.4 acres during 1970.

The area of the territories in 1971 was determined by the same method as during 1970. The use of a tape recorded song was also employed which gave more precise observation of boundaries. If the male sang in response to the recorded it was accepted as evidence that he was within the territory. The males were not observed to sing outside their territorial boundaries. This permitted a more precise method of determining the boundary lines. The average size of the 12 territories observed in 1971 was 2.3 acres. The consistency of territory size between the two years indicated a readjustment of size to accommodate the additional pair but did not affect the average size significantly. The smallest territory was recorded in 1971 as .85 acres. This territory decreased from 1.3

acres in 1970. It was influenced by the additional territory in 1971 and was the territory with the densest honeysuckle and wild grape cover in the study area. This is the smallest territorial size recorded for a Cardinal. The literature cites Cardinal territories ranging in size from 2.91 to 46.48 acres depending on the density of the population.

Two areas within the grazed wooded section of the study area were determined as buffer zones. It was here that more than a single pair of Cardinals were observed feeding at the same time. There was no dense cover on the ground but they were surrounded by dense cover. The birds used the area for ground feeding. Occasionally there was some chasing that occurred but only when the males were close together. There was limited use of these areas due to the lack of cover.

The defense of the occupied territory occurred in two distinct phases. Early in the occupation attention of the resident male was directed toward wandering pairs that were passing through the area. There were very few observations of chases between neighbors. Then as nesting began there were no intruders, and the attention was directed toward the neighbor. The confrontations between adjoining pairs were observed in May and June. The guarding or lookout behavior was more obvious early in the occupation of the territories, while patrolling behavior continued through the nesting season. The intruding pairs during the early period were easily chased out of the territory if they stopped within the boundaries. There was no fighting observed at this time. The physical combat took place between adjacent pairs over a definite bounary line.

The trials of using a mounted male and recorded song were used

when the female was incubating. The territorial tension was highest at this time. There were no trials of just a mounted bird without the recorded song because it would be left to chance that the owner would discover the mounted bird. The two attacks that were stimulated by these trials were indicative of the tension that was evoked. Lorenz (1972) has stated that Corvids attack from the rear of the bird in fighting situations. This was the situation that occurred in these trials. In both instances the first attack was made from behind the mounted bird. It is possible that this behavior pattern is more widespread than just among the Corvidae.

The destruction of the nest or loss of eggs caused increased territorial encounters. At this time the male and female were actively looking for nest sites. This activity caused more contact or near contact as the birds moved over their territory. The male and female were more active, and as a result, there were chases that occurred with neighboring males. When the nest site was selected, territorial activity diminished. The male was always near the female and remained so during the incubation period. It appeared that the nesting activities had priority over any territorial activities unless for some reason there was direct interference.

The songs of the female Cardinal were indistinguishable from the male during the study. During 1970 two positive identifications of a female singing were made. One occurred when the female was frightened from the nest. The second occurred when the female was near station 64 singing in the open. This may have been the result of a foreign pair attempting to invade the territory of the resident

pair. At the time of the observation this conclusion was not evident.

The observations of female singing increased during 1971 and the function of the singing became more evident. Two females were observed in a singing bout similar to the behavior of two males. This bout was followed by active chasing by the resident female. This chasing continued until the invading female actually left the area. The male took no active part in the chase but was aware of the activity. The male's attention was directed against another male in the area. There were no aggressive acts of males against females during the study.

The song of the female was used just as the male song. The female sang and the male came to her. The song was used during the chasing of another female and also for independent notification of territorial occupation. The frequency of usage was much lower than that of the male.

The location of the 29 nests found in the study area showed no pattern within each territory. The only single common factor found among the nests was that all but one nest were associated with honeysuckle vines. The single nest was found in a deciduous tree after the leaves were complete developed. Even those nests in Red Cedar had at least one honeysuckle vine on the outside of the tree. The nests usually had a covering of the vine above the nest. On the west-facing slope there was no vine covering of shrubs or trees and no nests were found. There was very little usage by the Cardinals of this area.

The nesting success for 10 nests found during 1970 was 37.5

and for the 19 nests found in 1971 the success was 38 percent. Barry (1925) found that 12 of 32 nests were successful (37.5 percent). She considered the number of nest failures abnormally high.

The nesting success is affected by the longevity of the species and by available habitat. The banding records show many Cardinals live to be five to seven years old, so the species can maintain its population with a low rate of reproductive success. The observations show that Cardinals return to the same territories so there is no problem with nesting pairs if the habitat is not destroyed. The territories are relatively static so a low nesting success would not affect the population as there would be approximately one-third increase available each year to replace those that do not return to their territories. The movement of the flocks during the winter months and early spring would permit newcomers to find the open territories.

There were no indications of a third successful nesting during the time of study. However, the study was stopped during the last week of July. The high rate of nest failure would limit the time available for raising a third brood successfully. One pair did leave their territory after raising one brood successfully. The actual cause of leaving was never determined. Certainly a third brood would be possible and an occasional fourth brood could occur.

CHAPTER VII

SUMMARY

1. The data used in this study were collected from February through July 1970 and in the same period in 1971.

2. The study area was located on The University of Tennessee Cherokee Farm woodlot located two and one-half miles southwest of Knoxville City Hall.

3. The area contained 30.95 acres of the woodlot and consisted of a wooded hill with wooded pasture at the base. Grid lines were established at 256-foot intervals. Recording stations were established at the intersections of the grid lines.

4. The vegetation of the area was mixed forest but included some grazed forest and open pasture.

5. Japanese fowling nests and Potter-type traps were used in order to mark a total of 43 Cardinals during the study. United States Fish and Wildlife Service bands, color bands and dyed feathers were used to identify individuals.

6. A total of 844 hours of observation was carried out on the study area. Binoculars and a spotting scope were used throughout the study.

7. A recording of a male Cardinal song and mounted Cardinals were used to instigate territorial defense.

8. Some pair bonds were established early in the study. Courtship activities were taking place in February.

9. No single pair bond was dissolved during either nesting season.

10. Territorialism was present in the Cardinal population. Pairs did wander outside the territory on numerous occasions.

11. The occupation of the territory occurred gradually with longer periods of time spent in the territory as the reproductive season progressed.

12. The average size of 11 territories in 1970 was 2.4 acres. The range was from 1.2 acres to 6.0 acres.

13. The average size of 12 territories in 1971 was 2.3 acres. The range was from .85 acres to 6.4 acres.

14. Individual males and females, with one exception, returned to the same territory occupied in 1970 during 1971.

15. One male left the territory occupied in 1970 and established a new territory in 1971.

16. There were additional Cardinals in the area each year that did not remain after the territories were occupied.

17. The Cardinal pairs occupied the same territories throughout the nesting season.

18. Ten nests were found in 1970 with 37.5 percent successful. Nineteen nests were found in 1971 with 38.0 percent successful.

19. A Black Rat Snake was observed taking seven-day-old young from the nest.

20. Both sexes were observed to sing only within their territory (or in areas not included within an established territory).

LITERATURE CITED

LITERATURE CITED

Armstrong, E. A. 1965. Bird display and behavior. Dover, New York.

Barry, Mary. 1925. The life history of the Cardinal. Unpublished Master's thesis, George Peabody College for Teachers, Nashville, Tennessee.

Bent, A. C. 1968. Life histories of North American Cardinals, Grosbeaks, Buntings, Towhees, Finches, Sparrows, and Allies. Part one. Dover, New York.

Braun, E. Lucy. 1950. Deciduous forests of eastern North America. Blakiston Co., Philadelphia.

Conant, R. 1958. A field guide to reptiles and amphibians of the United States and Canada east of the 100th meridian. Houghton Mifflin, Boston.

Dow, D. D. 1969. Home range and habitat of the Cardinal in peripheral and central populations. Can. J. Zool. 47:103-114.

Fitch, Henry S. 1960. Home ranges, territories, and seasonal movements of vertebrates of the Natural History Reservation. Univ. of Kansas Publications, Museum of Natural History. 11: 290-293.

Forbush, E. H. 1929. Birds of Massachusetts and other New England states. Vol. 3. Norwood Press, Norwood, Mass.

Ganier, Albert F. 1937. Further notes on a very old Cardinal. Wils. Bull. 49:15-16.

_____. 1941. Through the seasons with the Cardinal. Migrant. 12:1-4.

Gould, P. J. 1961. Territorial relationships between Cardinals and Pyrrhuloxia. Condor. 63:246-256.

Hall, G. A. 1964. Breeding-bird censuses--why and how. Audubon Field Notes. 18:413-416.

Hinde, R. A. 1956. Biological significance of territories of birds. Ibis. 98:340-369.

Howard, H. E. 1920. Territory in bird life. Murray, London.

Howell, J. C. 1965. Breeding bird census report. Audubon Field Notes. 19:593-594.

Hundley, Marion L. 1952. Winter distribution of the eastern Cardinal in the vicinity of Morgantown, West Virginia. J. of Sci. Labs. 43:66-111.

Lack, D. 1940. Pair formation in birds. Condor. 42:269-286.

Laskey, Amelia R. 1944. A study of the Cardinal in Tennessee. Wils. Bull. 56:27-44.

Lemon, R. E. 1965. The song repertoires of Cardinals (*R. cardinalis*) at London, Ontario. Can. J. Zool. 43:559-569.

_____. 1966. Geographic variation in the song of Cardinals. Can. J. Zool. 44:413-428.

Lorenz, Konrad. 1971. Studies in animal and human behavior. Vol. 1. Harvard University Press, Cambridge, Mass.

Milici, Robert C. 1973. The stratigraphy of Knox County, Tennessee. Geology of Knox County, Tennessee. Bull. 70:18.

Nice, M. M. 1937. Studies in the life history of the song Sparrow. Vol. II. Dover reprint, 1964. Dover Pub., N.Y.

_____. 1941. The role of territory in bird life. Amer. Midl. Nat. 26:441-487.

Noble, G. K. 1937. The role of dominance in the social life of birds. Auk. 53:263-273.

Petrides, G. A. 1958. A field guide to trees and shrubs. Houghton Mifflin Company, Boston.

Roberts, Wallace, B. C. Nichols, J. M. Odom, M. H. Gallatin, L. E. Odom, and T. E. Beesley. 1955. Soil survey of Knox County, Tennessee. Series 1942, No. 10. U.S. Government Printing Office, Washington.

Shaver, J. M. and Mary Roberts. 1930. Some nesting habits of the Cardinal. J. Tenn. Acad. of Sci. 5:157-170.

Thirty-second Supplement to the American Ornithologists' Union Check-List of North American Birds. Auk. 90:411-419.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration Environmental Data Service, Local climatological data annual summary with comparative data, 1973, Asheville.

Welty, J. C. 1962. The life of birds. W. B. Saunders Company, Philadelphia.

APPENDIX

TABLE VII

COLOR BANDING SCHEDULE*

Adult 1970		Nestling		Adult 1971	
Rt. Leg, Top Band 1st	Lf. Leg, Top Band 1st	Rt. Leg, Top Band 1st	Lf. Leg, Top Band 1st	Rt. Leg, Top Band 1st	Lf. Leg, Top Band 1st
1. ra	rb	1. ga	rb	1. ya	rb
2. ra	rg	2. ga	rg	2. ya	rg
3. ra	ry	3. ga	ry	3. ya	ry
4. ra	ro	4. ga	ro	4. ya	ro
5. ra	rw	5. ga	rw	5. ya	rw
6. ra	br	6. ga	br	6. ya	br
7. ra	bg	7. ga	bg	7. ya	bg
8. ra	by	8. ga	by	8. ya	by
9. ra	bo	9. ga	bo	9. ya	bo
10. ra	bw	10. ga	bw	10. ya	bw
11. ra	gr	11. ga	gr	11. ya	gr
12. ra	gb	12. ga	gb	12. ya	gb
13. ra	gy	13. ga	gy	13. ya	gy
14. ra	go	14. ga	go	14. ya	go
15. ra	gw	15. ga	gw	15. ya	gw
16. ra	yr	16. ga	yr	16. ya	yr
17. ra	yb	17. ga	yb	17. ya	yb
18. ra	yg	18. ga	yg	18. ya	yg
19. ra	yo	19. ga	yo	19. ya	yo
20. ra	yw	20. ga	yw	20. ya	yw
21. ra	or	21. ga	or	21. ya	or
22. ra	ob	22. ga	ob	22. ya	ob
23. ra	og	23. ga	og	23. ya	og
24. ra	oy	24. ga	oy	24. ya	oy

*Color codes used in banding:

a aluminum
r red
b light blue
g light green
y yellow
w white
o orange

TABLE VIII

BANDING SCHEDULE 1970

Band No.	Sex	Color Rings*	Date	Remarks
59-125901	F	RARB	2/7/70	
59-125902	F	RARG	2/7/70	
59-125903	M	RARY	2/7/70	
59-125904	F	RARO	2/7/70	
59-125905	M	RARW	2/11/70	
59-125906	F	RABR	2/11/70	
59-125907	M	RABG	2/13/70	
53-145000	F	RABY	2/19/70	Banded 8/5/64
59-125908	M	RABO	2/20/70	
59-125901	F	RARB	2/20/70	Retrap
59-125900	M	RABW	2/26/70	
59-125904	F	RARO	2/26/70	Retrap
59-125910	M	RAGR	2/27/70	
59-125911	M	RAGB	2/27/70	
59-125912	M	RAGY	2/27/70	
59-125913	F	FAGO	2/28/70	
59-125903	M	RARY	2/28/70	Retrap
59-125914	F	RAGW	3/14/70	
59-125915	M	RAYR	3/19/70	
59-125916	F	RAYB	3/19/70	
59-125917	U	GARB	5/15/70	Nestling
59-125918	U	GARG	5/15/70	Nestling
59-125919	U	GARY	5/15/70	Nestling
59-125920	M	RAYG	5/15/70	
59-125921	U	GARO	5/27/70	Nestling
59-125922	U	GARW	7/1/70	Nestling
59-125923	U	GABR	7/1/70	Nestling

*Color codes used in banding:

A Aluminum
R Red
B Light blue
G Light green
Y Yellow
W White
O Orange

TABLE IX

BANDING SCHEDULE 1971

Band No.	Sex	Color Ring*	Feather Color	Date	Remarks
59-125924	F	YARG	white	2/6/71	
59-125925	M	YARB	white	2/6/71	
59-125926	F	RARY	red	2/7/71	
59-125927	M	RARO	yellow	2/11/71	
59-125904	F	RAR	yellow barred	2/9/71	replaced band with O
59-125904	F	RARO	lost feather	2/11/71	replaced with yellow
59-125928	M	YARW	red	2/11/71	
59-125929	M	YABR	brown	2/11/71	
59-125930	M	YABG	black	2/15/71	
59-125931	F	YABY	black	2/15/71	
59-125932	M	YABO	blue	2/20/71	
59-125914	F	RAGW	blue	2/23/71	last year retrap
59-125904	F	RARO	no feather	3/5/71	dead in net
59-125933	M	YABW	green barred	3/5/71	
59-125929	M	YABR	no feather	3/5/71	replaced with O
59-125912	M	RAGY	green barred	3/9/71	last year retrap
59-125934	F	YAGR	red barred	3/9/71	
59-125935	F	YAGB	yellow barred	3/9/71	
59-125936	F	YAGY	brown barred	3/11/71	
59-125937	F	YAGO	pink	3/11/71	
59-125911	M	RAG	pink	3/11/71	replaced band with R
59-125928	M	YARW	red	3/11/71	retrap, feather good
59-125938	F	YAGW	white barred	3/16/71	
59-125939	F	YAYR	yellow	3/24/71	
59-125905	M	RARW	white barred	3/31/71	last year retrap
59-125940	replaced 59-125905 band damaged			3/31/71	
59-125941	F	YAYB	white	4/8/71	
59-125942	F	YAYG	red barred	4/14/71	
59-125943	F	YAYO	yellow barred	4/15/71	
59-125944	M	YAYW	yellow barred	4/19/71	
59-125945	M	YAOR	yellow	4/22/71	
59-125910	M	RAGR	white	4/22/71	
59-125946	replaced 59-125910 band damaged			4/22/71	
53-145000	F	RABY	brown	4/22/71	last year retrap
59-125947	F	YAOB	red	4/24/71	
59-125948	M	YAOG	brown barred	4/26/71	
59-125949	F	YAOY	brown barred	4/29/71	
59-125902	F	RARG	grey and white	4/29/71	last year retrap
59-125950	U	GARB		5/19/71	nestling
59-125951	U	GARG		5/19/71	nestling
59-125952	U	GARY		6/14/71	nestling
59-125953	U	GARO		6/14/71	nestling

TABLE IX (continued)

Band No.	Sex	Color Ring*	Feather Color	Date	Remarks
59-125954	U	GARW		6/14/71	nestling
59-125955	U	GABR		6/18/71	nestling
59-125956	U	GABG		6/18/71	nestling
59-125957	U	GABY		6/18/71	nestling

*Color codes used in banding:

A Aluminum
R Red
B Light blue
G Light green
Y Yellow
W White
O Orange

VITA

Robert Edward Merritt was born in Watertown, New York, on March 22, 1925. He attended elementary school in that city and was graduated from Watertown High School in 1942. The following September he entered New York State College for Teachers at Albany, New York. On April 1, 1944 he entered the United States Navy and was discharged April 30, 1946. The following September he returned to New York State College for Teachers at Albany and graduated June 1949.

He began study toward a Master's Degree the following September at Cornell University. He received this degree June 1950 and was employed by the City of Watertown, New York to teach seventh, eighth, and ninth grade science. July 1, 1951 he was employed by the Commission of Game and Inland Fisheries at Richmond, Virginia as an Educational Specialist. Two years later he was employed by Longwood College, Farmville, Virginia as an Assistant Professor of Biology. In September 1962 he was appointed Associate Professor of Biology at Indiana University of Pennsylyania.

He entered the Graduate School at The University of Tennessee in June, 1958 and received the Doctor of Philosophy Degree with a major in Zoology in August 1975. He is a member of Eastern Birdbanding Association, The Brooks Bird Club, American Ornithologist's Union, and the Inland Birdbanding Association.

He married the former Dorothy Ann Diffin and has two children.