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To the Graduate Council:

I am submitting herewith a thesis written by Noel Stewart Yoho entitled "Aspects of the Winter Behavior of Bobwhite Quail (Colinus virginianus) in Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

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ASPECTS OF THE WINTER BEHAVIOR OF BOBWHITE QUAIL (COLINUS  
VIRGINIANUS) IN TENNESSEE

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A Thesis  
Presented to  
the Graduate Council of  
The University of Tennessee

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In Partial Fulfillment  
of the Requirements for the Degree  
Master of Science

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by  
Noel Stewart Yoho  
August 1970

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## ABSTRACT

This study was conducted on a 214 acre area of the Ames Plantation, Fayette County, Tennessee. Information on winter behavior of bobwhite quail (Colinus virginianus) was obtained through flushing, trapping, color-marking, and telemetering quail during January-March, 1970.

Coveys were most active during the two hours after daybreak. Increased activity after mid-afternoon followed six hours of limited movement. Weather conditions weakly affected covey movements. Movements increased on warmer days. During rainy or windy weather, coveys remained sheltered under vegetation much of the time.

Coveys usually aggregated as an intruder approached. This defense mechanism allows the covey to flush as a unit, startling the intruder. Flush behavior was greatly influenced by vegetation within 200 yards of the covey. Coveys tended not to move much during the day after being flushed.

Most covey ranges located along a field trial course were abandoned within a few days after the start of the trials. Since unaffected coveys remained within their range, the shuffle produced an exodus of quail from the field trial course.

Covey ranges averaged 16.3 acres. Most ranges were overlapping. Coveys spent little time in cultivated fields although 90 percent of winter foods of the birds consists of soybeans and corn (Eubanks, unpublished data). Cedar woods, hardwood stands, and old fields were used randomly by the quail population. Understory composition greatly influenced woodland utilization. Baiting or trapping within covey

ranges did not noticeably influence daily movements of quail. Additions of food or cover to areas of one-quarter acre or more within covey ranges resulted in frequent use of these areas. Coveys did not usually cross range boundaries.

Interchange of quail between covey ranges was common throughout winter. An average covey lost and gained a member every three days. Replacement of birds lost from covey ranges was rapid. Rapid replacement was attributed to communication between coveys.

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## CHAPTER I

### INTRODUCTION

This study examines several aspects of behavior of bobwhite quail (Colinus virginianus). Field work was conducted during January-March, 1970 on a quail management area on the Ames Plantation in southwestern Tennessee.

The bobwhite quail has been the object of intensive study throughout its range. Several researchers have investigated the behavior and ecology of this game bird during fall and winter. Gooden (1952), Buss and Mattison (1954), Hawkins (1958), and Roseberry (1964) linked daily movements of coveys to weather factors such as snow, rain, and low temperature.

The strength of bonds existing between individuals within coveys has been disputed. Several workers have recaptured banded birds and commented on changes in covey composition. Stoddard (1931, p. 169) noted that changes in covey composition occurred in southeastern coveys, but believed that quail attempted to remain with a given covey. Harvey (1953) concluded that exchange of individuals between coveys in Virginia may be common throughout winter. The extent to which quail change covey affiliation may be related to population density. Gooden (1952) and Boehnke (1954) studied an Iowa population with a density sufficiently low that covey ranges did not overlap. In this population individuals did not change coveys. The fact that covey ranges overlap does not necessarily indicate that interchange will occur. Murphy and Baskett

(1952) investigated coveys in Missouri with overlapping ranges and concluded that coveys did not exchange members.

Little information of the reaction of quail to disturbance exists. Rosene (1969, p. 94) noted that too much disturbance on an area caused coveys to leave. The fate of quail following range abandonment has not been reported.

The present study establishes the effect of several winter weather factors on quail behavior. The behavioral responses of quail subjected to flushing and to a field trial are evaluated. The extent of interchange of quail between coveys in southwestern Tennessee is estimated and several possible selective advantages of interchange of quail between covey ranges are offered. A final objective of the study was determining the extent to which quail utilize different habitat types. Characteristics of covey ranges and reactions of quail to alterations within covey ranges are examined.

## CHAPTER II

### DESCRIPTION OF THE STUDY AREA

#### A. LOCATION AND REGIONAL PHYSIOGRAPHY

The study area was located on the Ames Plantation, an 18,600 acre agricultural experiment station administered by The University of Tennessee. This plantation, in Fayette and Hardeman Counties, lies within the Plateau slope of southwestern Tennessee. Quail behavior was studied on a 214 acre plot within a quail management unit.

The southeast corner of the study area is 1.1 mile from Route 18 on the Buford Ellington Road. This road borders the rectangular area on the east (Fig. 1). Gravel surfaced roads form north, west, and south borders.

Soil parent materials consist of a three foot layer of loess overlying coastal plains material, mostly sand. Loring and Calloway series soils characterize the area (University of Tennessee, n.d.). Drainage ranges from moderately good to restricted. The topography is smooth. Elevation is about 600 feet (Flowers, et al., 1964). Several intermittent streams originate around the edge of the study area. These streams cut deeply into the underlying sand and meander away from the study area.

#### B. CLIMATE

The climate is humid and temperate. A long growing season, averaging 209 days, and a high annual rainfall, averaging 51.6 inches,

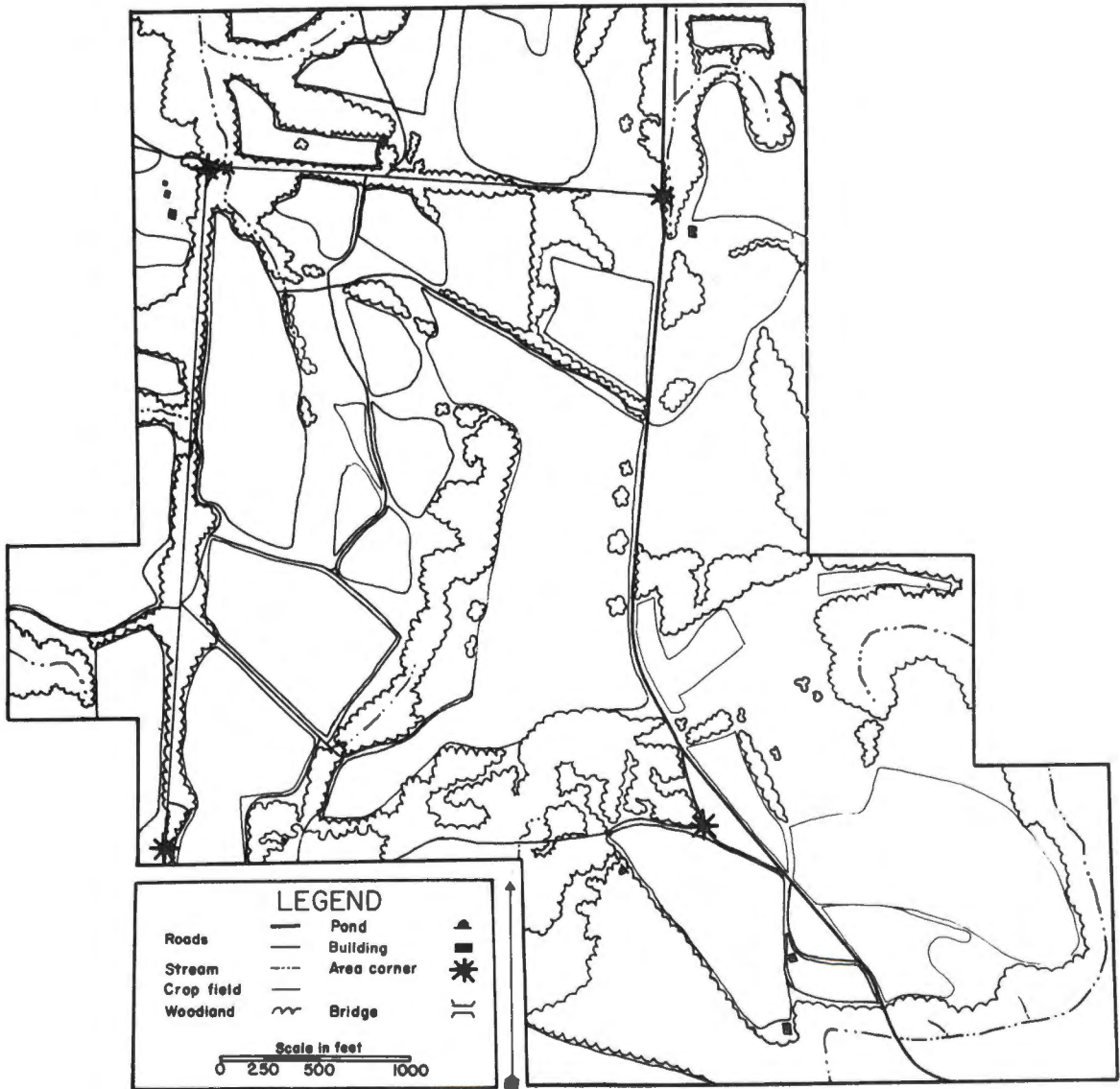


Figure 1. Map of the study area, a 214 acre segment of the Ames Plantation, Fayette County, Tennessee.

enable production of many crops, (University of Tennessee, n.d.). Mean seasonal temperatures range from 42°F. in winter to 78°F. in summer.

Winter of 1969-70 was severe in west Tennessee. Temperatures at nearby Bolivar averaged 4.6°F. below normal during the study (U. S. Dept. Commerce, 1970). Daily maximum temperatures averaged 49.8°F., and the average minimum temperature was 28.8°F. Maximum daily temperature was less than 32°F. eight times during the study.

Precipitation during the study was also below normal. Usually the study area receives about 17 inches of precipitation during winter. Slightly more than 11 inches were recorded during the winter 1969-70.

### C. VEGETATION

Varied habitats exist on the study area. A cedar (Juniperous virginiana) grove with an understory of broomsedge (Andropogon sp.) extends into the southern portion of the study area. This savannah-like cedar grove occupies 33 acres of the study area.

North of these cedars lie a series of soybean (Glycine max) and cotton (Gossypium sp.) fields. These fields range in size from 1.2 to 40 acres. Idle ground and bushy cover patches encircle each field. Two strips of hardwoods run north and south through this central portion of the study area. One strip equally divides the central portion while the other is on the western border. The central portion of the study area occupies 140 acres.

The northern portion of the study area consists of 41 acres of idle land interspersed with hardwood stands. Hardwood stands consist mostly of sapling and pole sized oaks (Quercus spp.),

sweetgum (Liquidambar styraciflua), and hickories (Carya supp.). Hardwood understories range from open to dense. Dense understories are characterized by honeysuckle (Lonicera japonica) and blackberry (Rubus sp.).

A large corn (Zea mays) field and a series of smaller soybean fields, interspersed with woodland, border the study area on the north. To the east, idle land is broken up by a few small crop fields and sapling hardwood stands. The forenamed cedars and a large corn field edge the area to the south. Large corn and soybean fields lie west of the study area.

#### D. QUAIL POPULATION

In addition to agricultural usage, the study area is intensively managed for quail. Winter and spring quail censuses are conducted annually by personnel of the Department of Forestry, The University of Tennessee. The winter census, immediately prior to this study, revealed a density of one quail per two acres on the study area. The spring census, at the termination of the study, indicated the population had declined to one quail per 2.4 acres.

## CHAPTER III

### METHODS

Live-trapping of quail was conducted on the study area to obtain birds for marking. Quail were aged, sexed, banded, and marked with radios or colored streamers. Other information recorded included date of capture and trap site. The heaviest bird captured from each covey, if considered healthy, was harnessed with a transmitter.

The second heaviest quail was retained. This bird provided a second chance to telemeter a covey should the first bird fail to perform satisfactorily.

Remaining quail were color-marked with streamers. All quail were released at their point of capture.

#### A. TRAPPING

Eight funnel traps were used. Traps were made of one-half inch nylon mesh sewn to steel rod frames.

Bait sites selected were at edges of merging cover types near recent covey flushes. Trapping was conducted in activity centers of covey ranges when these became evident. Baits consisted of shelled corn and cracked corn. After most bait was consumed, a trap was supported eight inches above newly added bait. These sites were checked daily. When bait was depleted, traps were lowered to the ground and baited.

Traps were set early each morning, and examined late in the morning and evening. Each evening traps were lifted onto supports to minimize damage to traps by mammals. Trapping continued three out of four

days for a maximum of three weeks at each site.

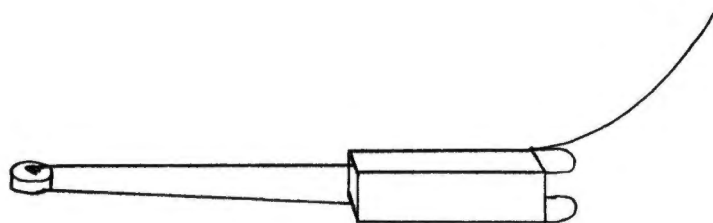
#### B. TELEMETERED QUAIL

The telemetry system was purchased from Sidney Markusen, Esko, Minnesota. The receiver was battery-operated and equipped with directional hand antenna. The portable receiver weighed five pounds. Nine transmitters, each equipped with a ten-inch whip antenna, were used. Each emitted a continuous signal. Transmitter frequencies ranged from 150.830 Mc. to 151.070 Mc. RM-625 Mallory batteries equipped with soldering tabs powered the transmitters. Weight of transmitter and harness was 14 grams.

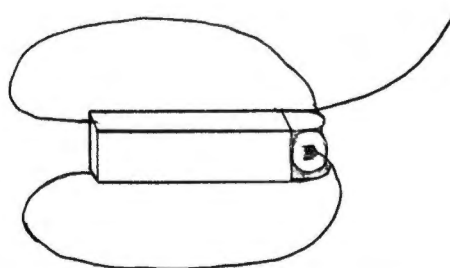
##### Attachment of Transmitter to Quail

Lead wires, arising from the front of the transmitter, were cut to 13 mm. and soldered to a mercury battery (Fig. 2). The battery was sealed to the rear of the transmitter with electric tape and candle wax. Lead wires were positioned against the transmitter and taped to it from rear to front. Wings of the quail were fed through the lead wire loops. Taping lead wires from the front of the transmitter to the rear of it tightened the loops correctly.

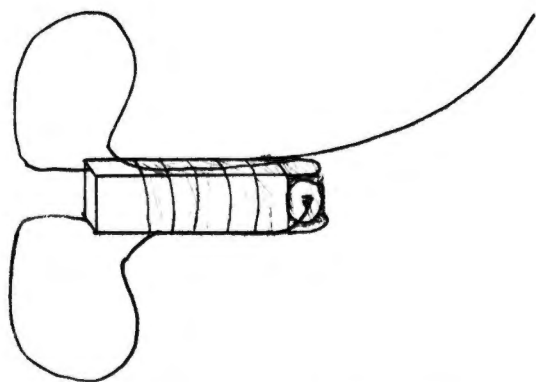
Transmitter weight did not noticeably impair birds, but balance of the transmitter between the wings was crucial to the quail's ability to resume normal behavior. The trailing antenna dragging through vegetation was undoubtedly a constant harassment to quail.



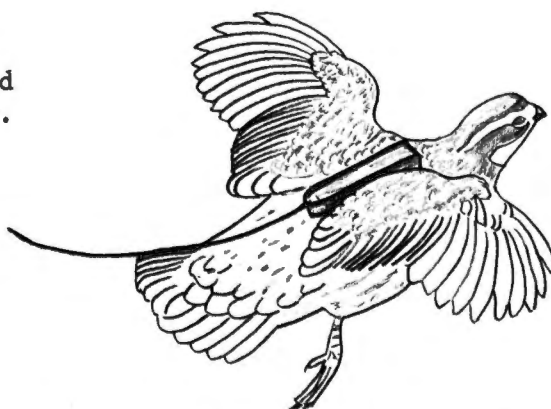
Step 1. Transmitter leads are cut to 13 mm. and soldered to battery.



Step 2. Battery is secured to posterior end of transmitter.



Step 3. Lead wires are taped against the transmitter.



Step 4. Lead wire loops are slipped over wings and taped posteriorly against the transmitter to correctly secure the system.

Figure 2. Attachment of transmitters to bobwhite quail.

### Locating Signals from Transmitters

Coveys containing a telemetered bird were located at two hour intervals diurnally. Transmitter signals were detected by systematically searching covey ranges with the receiver. The bird was approached to within 30 to 70 yards as indicated by signal intensity and then circled. Continuous bearings, taken while circling the transmitter, indicated the covey's position. This position was plotted on a field map.

Signals were normally obtained when the receiver was within 50 to 100 yards of the transmitter. Occasionally signals were audible one-half mile or more distant.

Signal reception was greatly diminished during wind and rain. During this weather quail burrowed under dense vegetation. On occasion the signal was audible only within ten yards.

### C. COLOR-MARKED QUAIL

Each captured covey was assigned an easily-discernible color of streamer. Six colors or combination of colors were used. The 25 x 90 mm. streamers were made of vinyl-coated nylon fabric. Streamers were initially pinned to the wing of captured covey members, but later streamers were pinned to harnesses cut from vinyl-coated nylon.

Systematic searches were conducted to flush coveys on the study area. Data recorded at each flush included the location, time, number of birds flushed, and color of streamers seen, if any. Covey identification was based on color of streamers on flushed birds and the flush location and landing site of coveys. Other data obtained included characteristics of range utilization by coveys. Flush and landing sites of coveys were plotted on a field map.

#### D. WEATHER

Readings of light intensity, wind velocity, and wind direction were taken at two hour intervals. The onset, termination, and relative intensity of diurnal precipitation was also recorded in the field. Barometric pressure was read at sunrise, noon, and sunset. Temperatures, miles of ground level wind per day, and daily precipitation were obtained from an official station of the U. S. Weather Bureau located on the Ames Plantation three miles from the study area. Temperatures were noted at two hour intervals diurnally as well as at the time of all flushes.

#### E. STATISTICS

Data processing was accomplished through computer programming. All tests were conducted at the 0.05 level of probability. In this report the symbol (\*) indicates that a statistical relationship is significant at this level of probability. The symbol (NS) is used when the relationship is not significant.

A Chi-square Test of goodness of fit for single classification frequency distribution was used in examining sex and age ratios of re-captured quail. This same analysis was applied to relative use of habitat types by coveys. Duncan's Unequal Multiple Range Test was used to examine relationships between two hour movement periods during the day. Discrete habitat variables influencing flush behavior were examined with a Model II Analysis of Variance. The influence of weather variables and continuous habitat variables on flush behavior and daily movement was examined with a Correlation Matrix (BMD03D).

## CHAPTER IV

### RESULTS AND DISCUSSION

Seventeen covey ranges were located on or near the primary study area (Fig. 3). Behavioral responses of these coveys to weather, disturbance, and habitat conditions were studied. Of the 17 coveys, 15 ranged on the primary study area. Two coveys, 2 and 17, which did not have ranges overlapping the primary study area were also studied.

Sixteen telemetered quail provided information on nine covey ranges. Telemetry data included 88 days of information extracted from 166 days that quail carried transmitters.

Trapping resulted in the capture of 103 quail. Subsequent recaptures and observations of the 92 quail which were color-marked enhanced identification of coveys and provided data on the interchange of quail between covey ranges.

Data on flush behavior were recorded following each of 119 covey flushes. Measured flush behavior included flush distance (the distance from an intruder at which a covey rises), and flight distance (the distance a flushed covey flies before landing).

#### A. TRAPPING RESULTS

Preliminary trapping during the spring of 1969 resulted in the marking of 38 quail. During the winter of 1969-70, 103 quail from ten coveys were captured and marked. Of these, five were quail marked the previous spring. All five were recaptured within 200 yards of their initial point of capture.

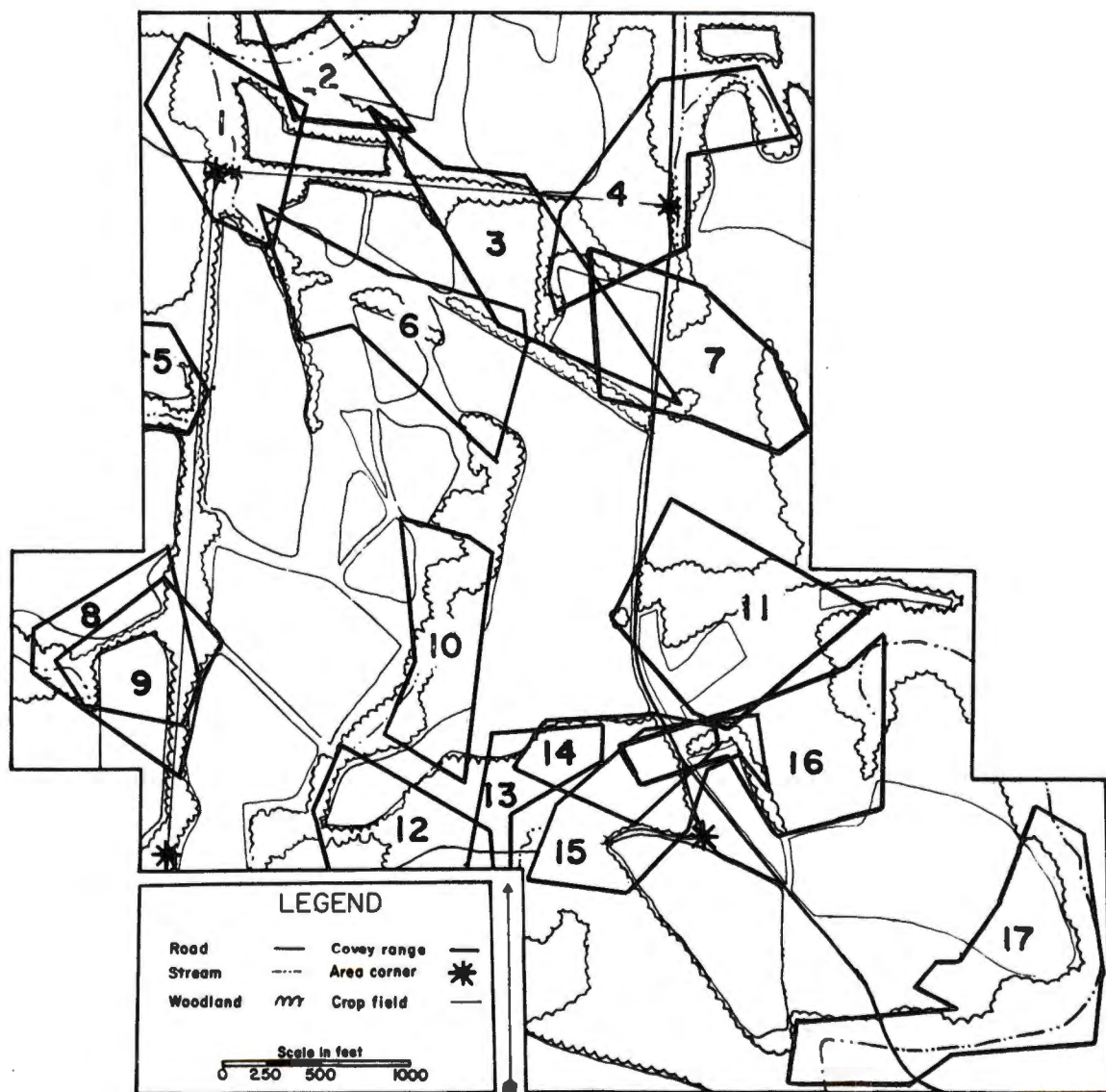


Figure 3. Range boundaries of 17 coveys on or near the study area during winter 1969-70, Ames Plantation, Tennessee.

### Factors Influencing Trapping Success

Trapping success was poor through mid-February. Improved success after this time probably reflected diminishing food and improved trapping techniques. Trapping success was consistently higher during rainy days as Lewis (1954) and Nevels (1956) noted. Trapping was highly effective once centers of activity of covey ranges were located.

### Evaluation of Nylon Traps

Obtaining uninjured quail to carry transmitters was vital to the success of this study. The fact that no animals, including quail, noticeably injured themselves in traps was probably due to the elasticity of nylon webbing.

Cotton rats (Sigmodon hispidus), which were abundant on the study area, decapitated several trapped white throated sparrows (Zonotrichia albicollis). However, other birds in traps, including other sparrow species, were not attacked by cotton rats.

Trap repair was a frequent chore, a major disadvantage of nylon traps. Mammals frequently severed the nylon webbing. Also, the traps were highly visible, and may have been less efficient than wire traps at capturing quail.

### Susceptibility of Sex-age Classes to Capture

During the winter, 32 captured quail were recaptured a total of 70 times. Some individuals were trap-prone, but quail from the four sex-age classes were recaptured as frequently as expected from initial capture ratios ( $\chi^2 = 0.2843$  NS). Marsden and Baskett (1958) also found

that both ages and both sexes of quail were equally susceptible to trapping in Missouri.

#### B. AVERAGE DAILY MOVEMENT

Telemetered quail were located, as nearly as possible, at two hour intervals. The straight line distance between each location was assumed to represent movement during that period. The clock time at which periodic locations were obtained changed during the study as the two-hour intervals were set in relation to sunrise and sunset.

Telemetered quail were often difficult to locate. When more than two and one-half hours elapsed between fixes on telemetered quail, the interval was dropped from analysis of periodic movements. When two or more of these two hour records were missing, that day's data on the covey's movements were not used.

Coveys moved an average of 427 yards (standard deviation = 198 yards) during the day. Frequently, similar movement patterns to the same portion of the range occurred on successive days.

Coveys usually left roost after dawn but prior to sunrise, probably in relation to light intensity as suggested by Klimstra and Ziccardi (1963). Coveys moved in linear fashion to some portion of the range at this time, probably to feed. Movement during the first period, averaging 123 yards, was significantly longer than movement during any other period (Table 1).

After early linear movements, coveys usually wandered randomly much of the day. Seldom did lengthy movements occur during the six

TABLE I

RESULTS OF DUNCAN'S NEW UNEQUAL MULTIPLE RANGE TEST FOR  
DIFFERENCES IN PERIODS OF TWO HOUR MOVEMENT OF  
COVEYS TELEMETERED DURING THE WINTER 1969-70,  
AMES PLANTATION, TENNESSEE\*

| Mean periods of two hour movement in yards, starting with<br>the first two hours after sunrise |             |             |             |             |             |
|------------------------------------------------------------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Period<br>3                                                                                    | Period<br>4 | Period<br>2 | Period<br>5 | Period<br>6 | Period<br>1 |
| 48.0                                                                                           | 51.1        | 54.0        | 77.4        | 94.5        | 122.7       |

\*Underlined values are not significantly different from each other at the 95 percent level of probability.

hours from mid-morning until early afternoon. Similar movements, averaging 54, 48, and 51 yards, occurred during these three periods.

Increased movement toward the end of the day lasted twice as long as early morning activity (Fig. 4). Coveys often shifted range or moved toward roost during the fifth period in mid-afternoon, and movements averaged 77 yards. Movements averaged 95 yards during the sixth period. Directional, often lengthy walks to roosts often occurred as sunset approached.

### C. WEATHER AND QUAIL BEHAVIOR

#### Influence of Weather on Daily Movement

Weather conditions weakly influenced daily movement. Temperature during daylight hours was the only weather variable significantly related to daily movement ( $r = 0.2364^*$ ). Coveys moved greater distances on warm days than on cold days.

The response of coveys to the amount of wind during the day ( $r = -0.1768$  NS) and the amount of rain during the day ( $r = -0.1546$  NS) was nearly significant. Coveys were not inclined to move long distances during rainy or windy weather.

Apparently, weather during the night influenced covey movements the next day. Measurements of wind and rain taken during the 24 hour period from sunset to sunset correlated more closely to daily movement than did sunrise to sunset measurements of wind ( $r = -0.1376$  NS) and rain ( $r = -0.1416$  NS).

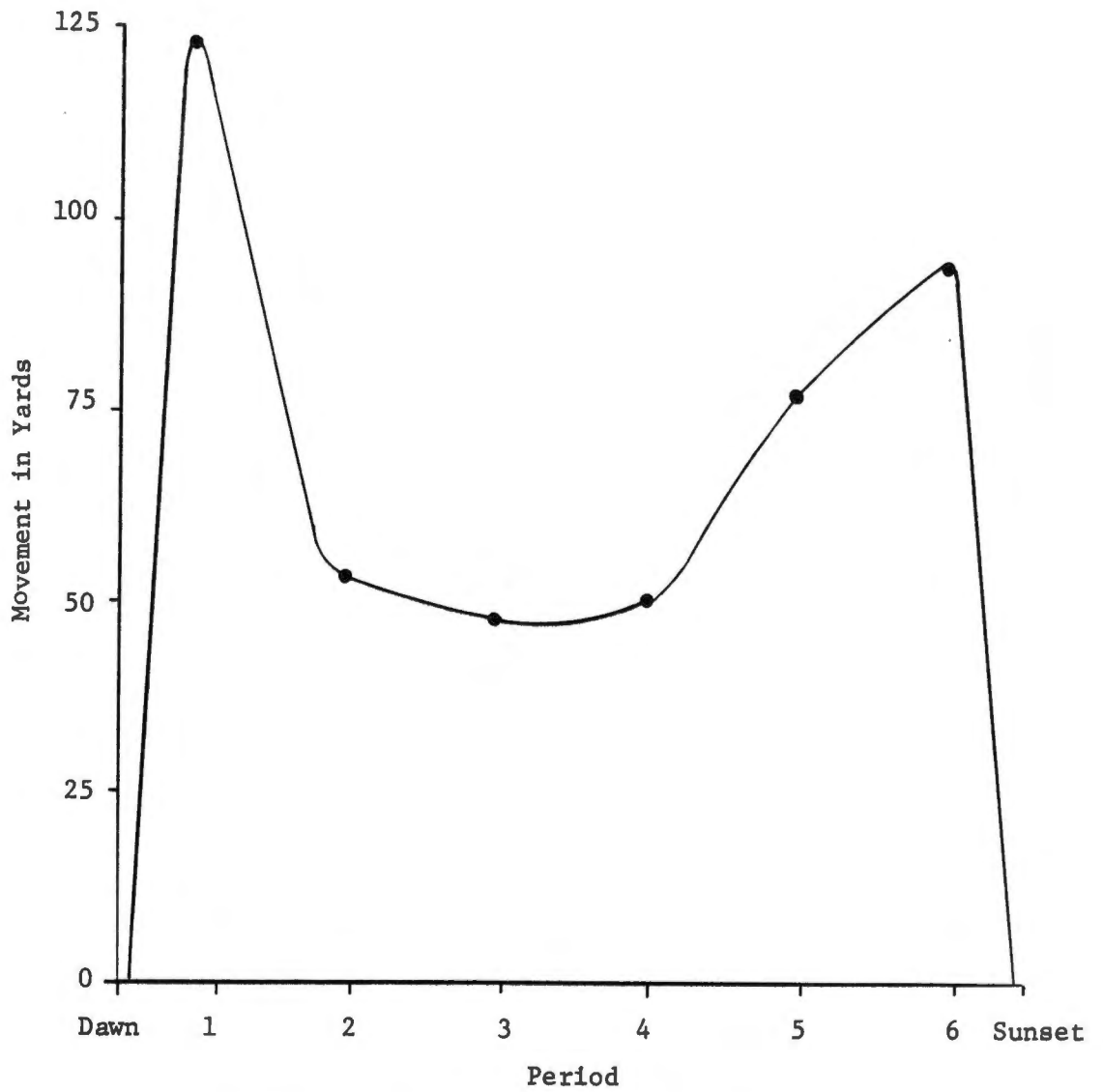


Figure 4. Changes in average movements of telemetered coveys during two hour periods throughout the day during winter 1969-70, Ames Plantation, Tennessee.

Buss and Mattison (1954) and Gooden (1952) also concluded that wind, precipitation, and decreased temperature were important weather factors reducing movement of coveys. Limited data precluded examination of snow cover which these workers deemed a fourth important weather variable reducing covey movements. Hawkins (1958) noted that bobwhite movements decreased at low temperatures, and when snow was on the ground.

During mornings and evenings characterized by high winds, i.e., frequent gusts of more than ten miles per hour, coveys often remained on roost two or more hours after sunrise or established roost two or more hours before sunset. Coveys did not roost during morning or evening rainfall. Otherwise, wind and rain affected quail similarly.

During windy or rainy days, coveys sometimes remained stationary for several hours during the middle of the day. Usually movements occurred during each two hour period, but these were shorter than movements during less severe weather. Coveys burrowed into dense cover after each movement. Possibly movements during inclement weather signified short periods of feeding or reflected attempts of coveys to locate better shelter. Movements during rain and wind involved little time. Coveys were sheltered and inactive most of the time during inclement weather.

#### Influence of Weather on Flush Behavior

Flush and flight distances of disturbed coveys were not predictably related to any measured weather variables. Coveys displayed a significant tendency to flush at greater distances as photoperiod increased ( $r = 0.2312^*$ ). A smaller correlation between ground temperature and

flush distance ( $r = 0.1776$  NS) probably reflected the strong relationship of day length and ground temperature.

On several occasions the flight of quail flushed during rains appeared lethargic. On two occasions birds released immediately from traps during rain could not fly. Although the birds did not appear to be soaked, the quail were retained until their wing feathers dried, at which time they flew well.

#### D. DISTURBANCES AND QUAIL BEHAVIOR

Some factors affecting quail behavior during the study were not evaluated. One such factor was the influence of the investigator's daily activities within covey ranges. However, mere presence of persons within covey ranges was believed to elicit minimal behavioral response.

During the first two months of study, activity of other people on the study area consisted largely of training bird dogs. Horsemen following bird dogs traveled through the study area every two or three days. Trainers fired blanks as pointed coveys flushed. Rarely were quail shot on the study area. Data on these flushes were seldom recorded.

Predators were another unmeasured disturbing factor. One telemetered quail and one color-marked quail were known to be killed by predators. Remains of two unmarked quail were also seen.

Large flocks of Brewer's blackbirds (Euphagus cyanocephalus) and purple grackles (Quiscalus quiscula) remained in the study area throughout winter. Evidence of numerous cases of predation on these birds were seen. This readily available avian prey probably significantly reduced predation pressure on quail and may have minimized predation as a source of disturbance.

### Aberrant Behavior Resulting from Marking Quail

Capturing, marking, and releasing constituted a traumatic experience of quail during the study, but no lasting effect of this harassment was evident for color-marked birds. These birds soon rejoined coveys and resumed normal behavior.

Behavior of telemetered quail was altered for a time after release. Only one telemetered quail rejoined his covey within two hours after initial release. Often birds joined coveys during the day of release, but two day lag periods were common. All telemetered quail coveyed within three days after release.

During this lag period telemetered quail could be readily captured. These birds flushed one to five times before burying themselves in honeysuckle. Once buried, the birds were reluctant to move and could be captured by hand.

Movements of these lone birds were inconsistent. Movement of a few single quail resembled that of coveys, but most moved a short distance and remained stationary for several hours. These birds uttered covey calls infrequently during most of the day. Covey calls were always given as sunset approached. Telemetered quail invariably roosted in dense honeysuckle when alone.

After joining a covey, telemetered quail were not noticeably deviant in behavior. With one exception telemetered birds were always with a covey after having rejoined one. Thereafter, these quail could not be recaptured by hand. The single exception was a male found alone after several hours of immobility. The transmitter antenna had been

twisted into a tight loop, and was tangled in vegetation. This bird rejoined his covey within two hours after release.

#### Reactions of Coveys to Intrusion

The point of awareness of the observer by coveys was estimated by positive reaction of the telemetered quail and his covey. Running behavior, which imparted a pulsating tone to the signal, was detected 250 yards distant during some approaches.

Coveys in cultivated fields, or in tall dense herbaceous cover, most frequently ran from a distant intruder. Coveys in cultivated fields ran to cover offering better concealment. Elder (1956) pointed out that quail have a tendency to run when they are in scanty cover.

Coveys in dense herbaceous cover ran toward shorter less dense cover. This movement enhanced a rapid unobstructed flush when an intruder closely pressed the covey, as thick overhead vegetation no longer enveloped the birds.

Coveys in dense cover were hesitant to flush. Even when closely pursued, coveys ran in circles within this vegetation. On two occasions all efforts to flush coveys with a telemetered quail in dense vegetation failed.

Coveys in moderate cover reacted to intruders at distances of 20 to 60 yards. When directly approached, these coveys frequently reacted by running a short distance. Subsequent flushes indicated that separated covey members had aggregated during this run. On three occasions vegetation was sufficiently dry to hear covey members running toward a common point. This defense reaction allows the covey to flush as a unit, startling an antagonist.

Coveys were adept at concealing themselves immediately prior to flushing. Although color-markers were apparent when quail were flying, these were never seen while birds were on the ground. On several occasions marked birds known to be underfoot were not seen prior to their flush.

#### Reactions of Coveys Being Flushed

Coveys were approached to within an average of 22 yards before the birds flushed. These coveys flew an average of 101 yards before landing. The flush distance did not influence the distance that the birds flew ( $r = -0.1352$  NS). Coveys which flushed 5 yards from an observer flew no farther than coveys which flushed 50 yards from an observer.

Flush distance was unrelated to covey size ( $r = 0.1553$  NS). However, flight distance increased as the number of birds in a covey increased ( $r = 0.2990^*$ ). Coveys with 12 or more birds exhibited variable flight distances. Often these larger coveys flew 50 or more yards farther than the farthest flight distance of smaller coveys.

#### Influences of Flushes on Behavior

No changes in flush behavior occurred on successive flushes of coveys during a day. The flush distance of each successive flush of a reorganized covey was no different than the initial flush distance ( $r = 0.0527$  NS). Flight distance also was not affected by repeated flushes ( $r = -0.0719$  NS).

Flushing a covey had a definite effect on its movement during a day ( $r = -0.2717^*$ ). After being flushed, coveys restricted movements for the remainder of the day. The more times a covey was flushed, the

less inclined it was to move around. Flushing of coveys had more effect on their movement than any other factor examined in this study.

#### Flush Characteristics of "Spooked" Coveys

Coveys occasionally flushed when activity was occurring within 50 yards of their position, as when traps were being repaired. These "spooked" coveys flew less than 35 yards. Lengthly runs usually followed this short flight.

#### Interactions of Bird Dogs and Quail

Coveys with telemetered birds were flushed by bird dogs on nine occasions. When harassed by dogs, these coveys ran more rapidly and for longer distances than when they were approached by a man.

During windy or rainy weather, and sometimes when weather was pleasant, coveys buried themselves in dense vegetation. Deep in vegetation coveys are in a still air chamber. The probability that scent would not escape this chamber partly explains why dogs cannot scent coveys well on certain days.

#### Disturbance of Roosting Coveys

Observations made during this study support Bartholomew's (1967) statement that undisturbed coveys do not move at night. Disturbance of roosting coveys results in members either running or flushing. Coveys running from nighttime disturbance flush if pursuit continues.

#### Behavior Following Flush

Much variation exists in behavior of quail following a flush.

Many birds remained motionless after landing. Others ran up to 40 yards before hiding.

The time to covey reformation varied greatly. While a covey regrouped within 15 minutes early one afternoon, other flushed coveys remained scattered most of the day.

Scattered coveys usually regrouped with the use of covey calls. Regrouping covey members frequently employed antiphonal calls.

Covey members often did not respond to covey calls given early in the day. However, birds reacted immediately to calls uttered near sundown. At the onset of evening calls, separated covey members moved rapidly toward their source.

#### Influence of the Field Trial on Quail Behavior

During February 16-27, National Field Trial Championships were held on Ames Plantation. Field trial courses dissected ranges of three coveys monitored with four telemetered birds. Covey 16 inhabited a range crossed by both morning and afternoon field trial courses. During eleven days of field trials, an average of 150 horsemen followed two bird dogs through covey ranges. The impact of field trials on quail behavior was remarkable.

Covey 16 was in a field fifteen yards from the south end of a cover strip on the afternoon of February 16 (Fig. 5). At the approach of six horsemen from the northeast, the covey entered the cover strip and ran 80 yards northward in it. As a score of horsemen rode into this area from the north, the birds reversed direction and ran to the southern portion of the cover strip. Encountering increasing numbers of horsemen,

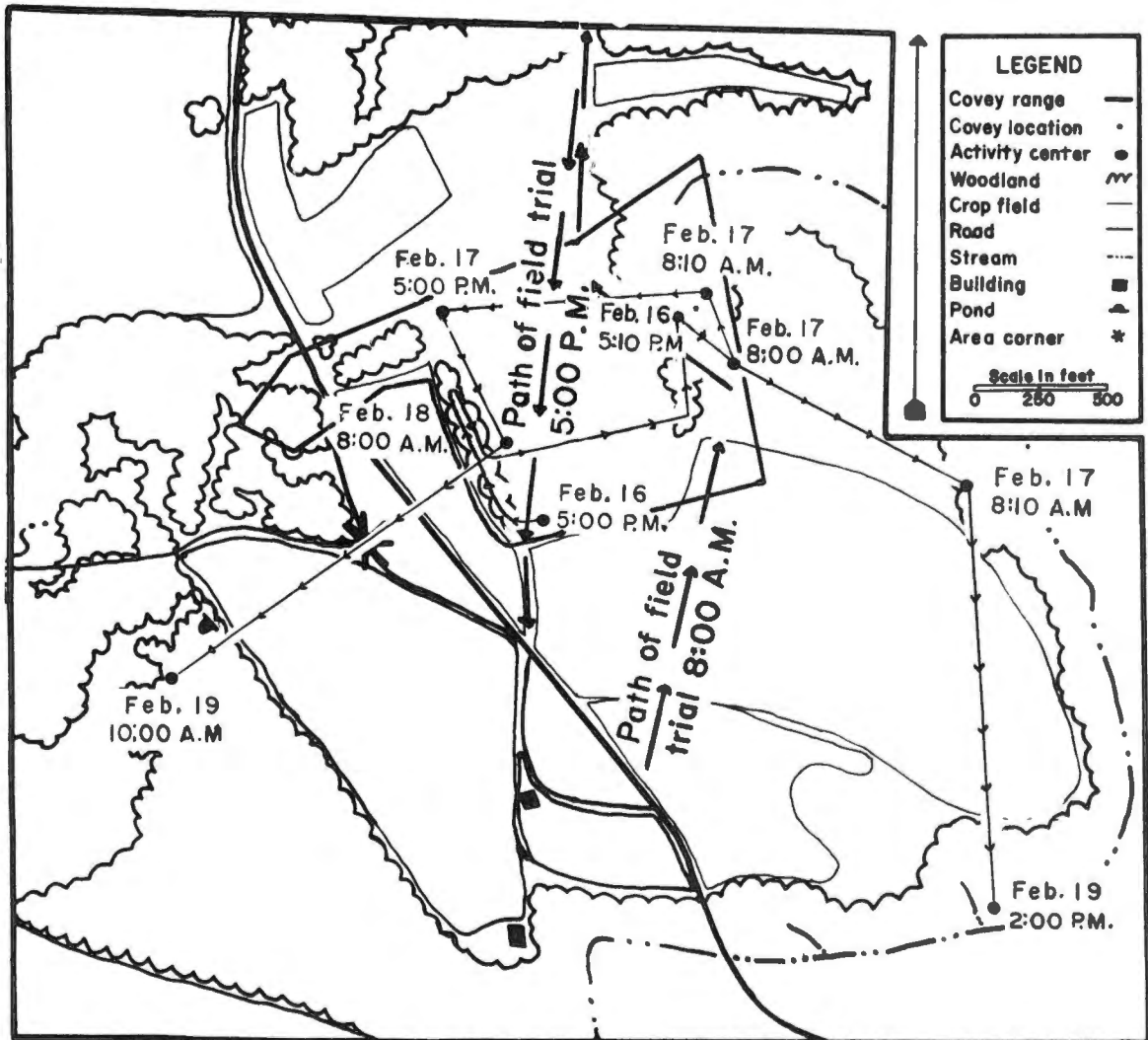


Figure 5. Reactions of covey 16 to the initiation of the National Championship Field Trials within its range, February 16-18, 1970, Ames Plantation, Tennessee.

the quail abandoned the narrow cover strip and ran 175 yards across an idle field to a neck of woods. During this dash the covey ran unobserved through the midst of at least fifty horsemen. Entering the woods, the quail turned to the north and ran 100 yards into dense honeysuckle. This 450 yard run occurred in less than 10 minutes. The magnitude of this reaction is emphasized by comparison with the 427 yard average daily movement of telemetered coveys.

The following morning the covey was at roost, directly in the path of the advancing field trial. As the two dogs approached, the covey divided. Five quail ran westward into woods. The other birds ran eastward, abandoning the covey range. These birds joined covey 17 which ranged southeast of the field trial course.

The five remaining birds of covey 16 were not closely passed by the field trial during the afternoon. Similarly the following morning, this segment was distant from the course. Not directly affected by field trials since the covey split, this segment nonetheless abandoned the range early in the afternoon. These birds joined covey 15, ranging southwest of the field trial course. The two telemetered birds from this now unused range of covey 16 continued to provide data on the respective covey ranges each used for the remainder of the study.

Covey 8 with a third telemetered bird was exposed to the field trial on the first morning. The field trial crossed the covey range missing the birds by 250 yards. This covey remained stationary until late afternoon. That night the bird became the only telemetered victim of predation.

The fourth telemetered bird was released onto its range with covey 7, February 17. This bird wandered alone for three days. Abandoning this range, the bird joined covey 4 which ranged north of the field trial course. Possibly this bird's covey abandoned its range during his capture.

#### Extent of Range Abandonment

Apparently quail abandoned most covey ranges crossed by field trial courses. The disturbance made these ranges unsuitable for quail. A census was conducted by personnel of the Ames Plantation immediately prior to the field trial. This census revealed 43 coveys on the afternoon field trial course. A census conducted similarly, immediately following the field trial, located two coveys ranging on the field trial course (James Bryan, pers. comm.). Evidence of telemetry data suggests that most disruption of established distribution of quail occurred during the first days of the field trial. Mechanisms of range abandonment may have included a shift of range by integral coveys as well as a dispersal of quail from affected covey ranges. Dispersal of marked quail indicated that disintegration of coveys rather than a change of home range by coveys usually occurred.

Lengthly, erratic movements characterized the two telemetered covey fragments. Aberrant movement ceased within four days as fragments integrated coveys inhabiting undisturbed ranges. A change of covey affiliation by groups of color-marked birds was also seen after this time. Since coveys on undisturbed ranges remained stable, the shuffle produced an exodus of quail from the field trial course.

The extent to which quail reestablished ranges after the field trials was not ascertained. A covey occupied some of the abandoned range of covey 6 within five days of termination of the field trial. The former range of covey 15 was not reestablished during the study, although adjacent coveys invaded segments of this range.

#### E. COVEY RANGES

Winter ranges of coveys 8, 14, 15, 16, and 17 were described accurately by radio telemetry locations (Figs. 6-10). Ranges of coveys were roughly outlined within four days after telemetered quail joined coveys. Data were obtained on these five ranges for several days after the final range extension was recorded. Range sizes of these five coveys varied from 10.0 acres to 28.9 acres, averaging 16.3 acres. Data from four other coveys containing telemetered quail were not adequate to accurately describe range size. Ranges of these four coveys as well as ranges of other coveys on the study area were defined by connecting outer observational points of each covey. Accuracies of these minimum home ranges are questionable, but the ranges are similar in size to the five well described ranges.

#### Range Fidelity

Coveys displayed rigid fidelity to established home ranges during winter. With the exception of coveys which abandoned their range during the field trials, only once did a covey cross a range boundary established by a week or more of telemetry data. In February, covey 17 crossed a road and spent the day within adjacent woodlands. This area

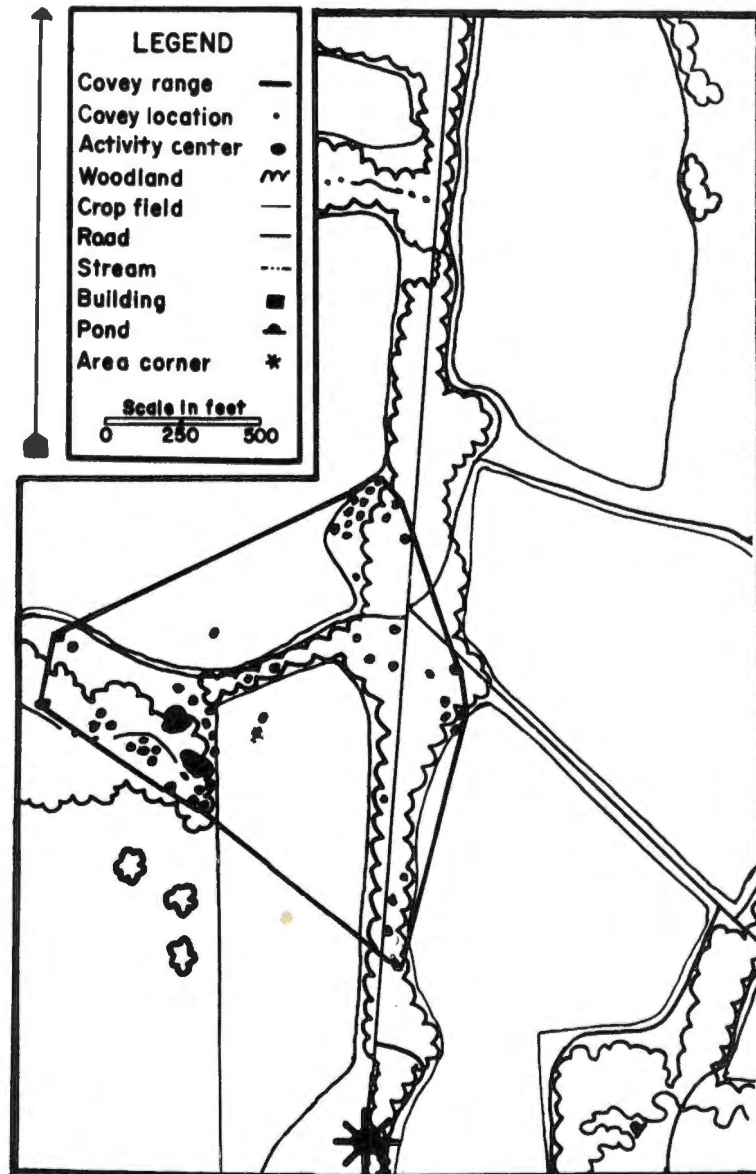


Figure 6. Observed locations and activity centers of covey 8 within its range on the western-most portion of the study area, December 29, 1969 to March 7, 1970, Ames Plantation, Tennessee.

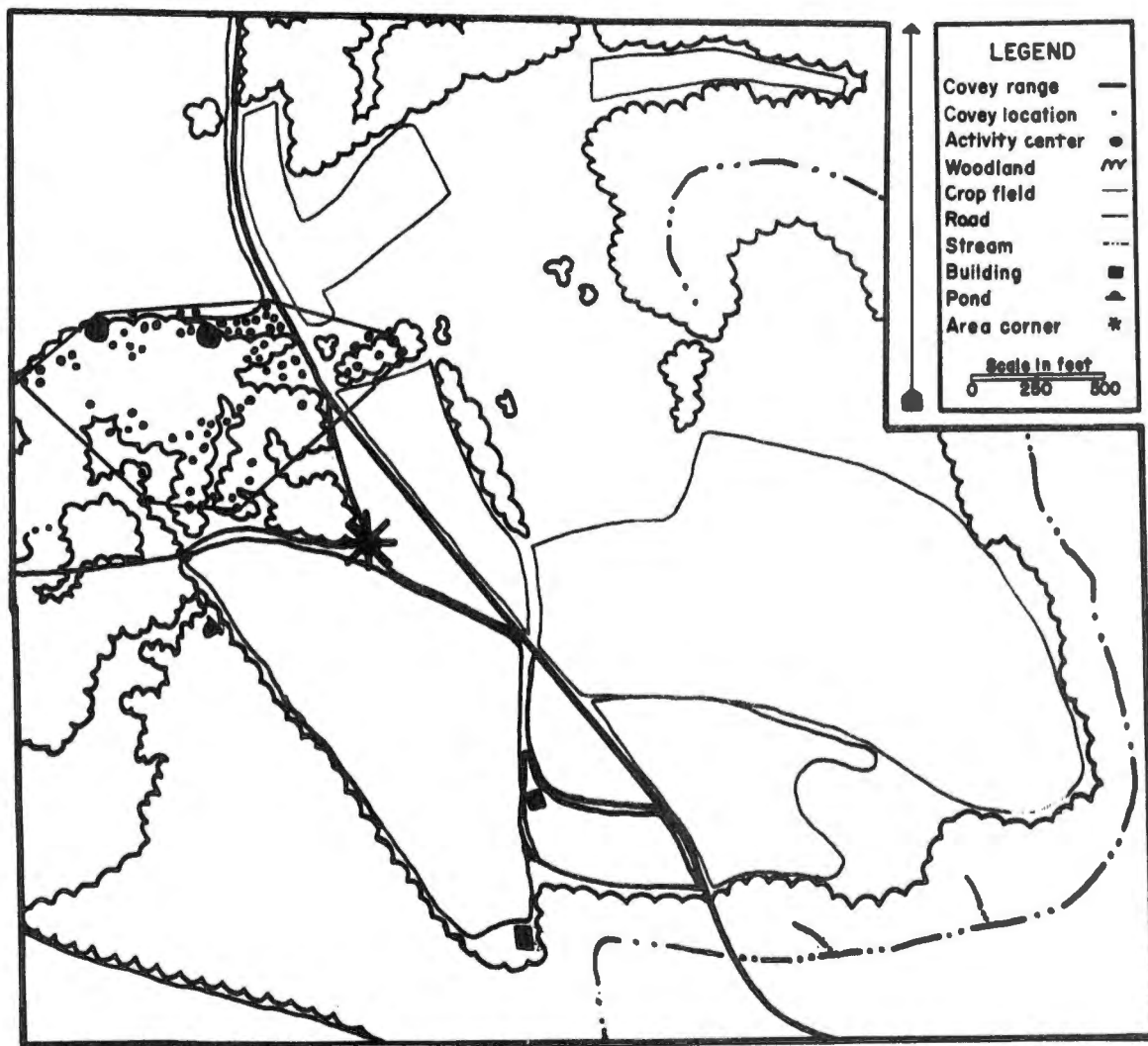


Figure 7. Observed locations and activity centers of covey 14 within its range in the southeastern portion of the study area, December 29, 1969 to March 17, 1970, Ames Plantation, Tennessee.

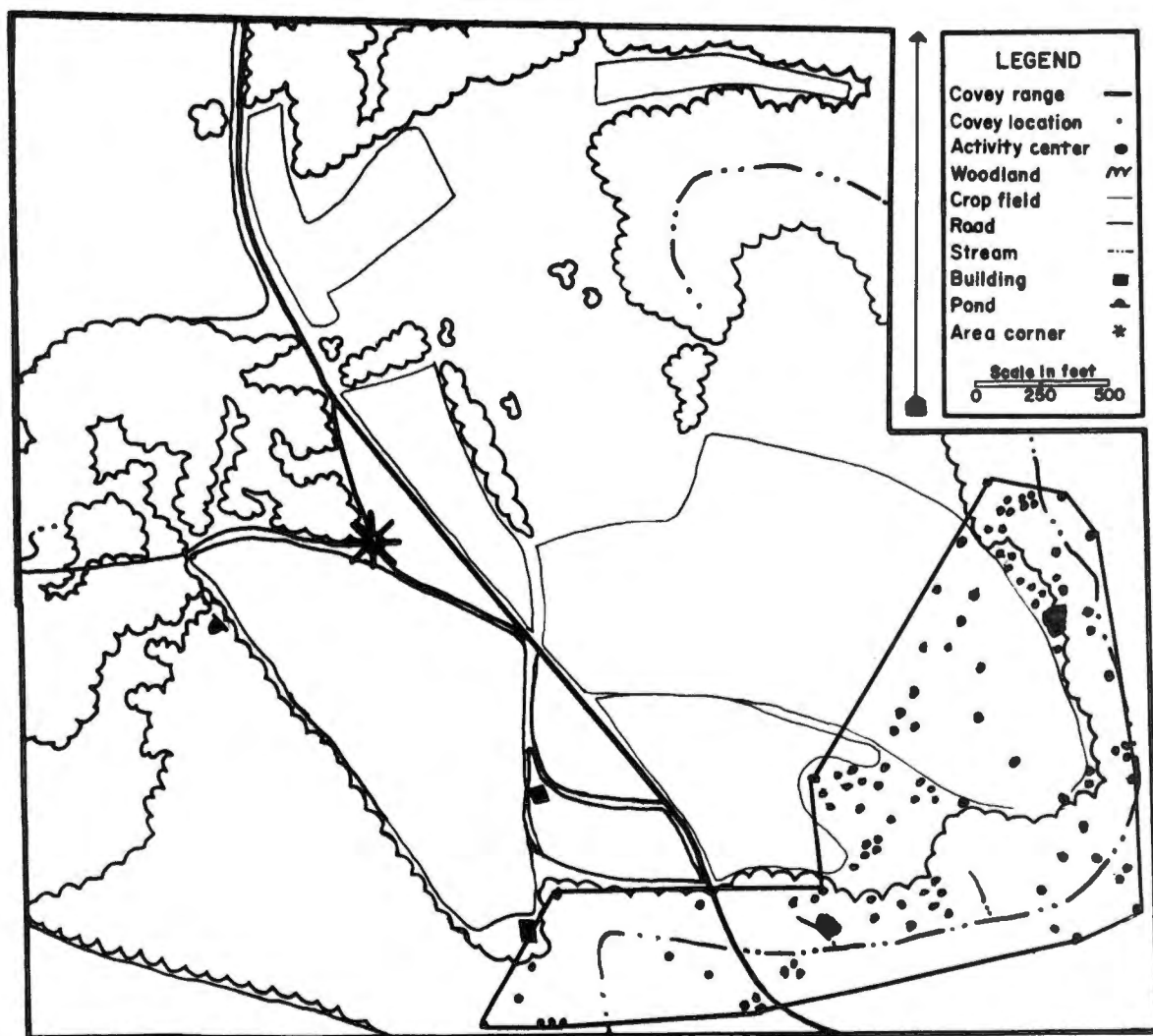


Figure 8. Observed locations and activity centers of covey 15 within its range February 17 to March 14, 1970, Ames Plantation, Tennessee.

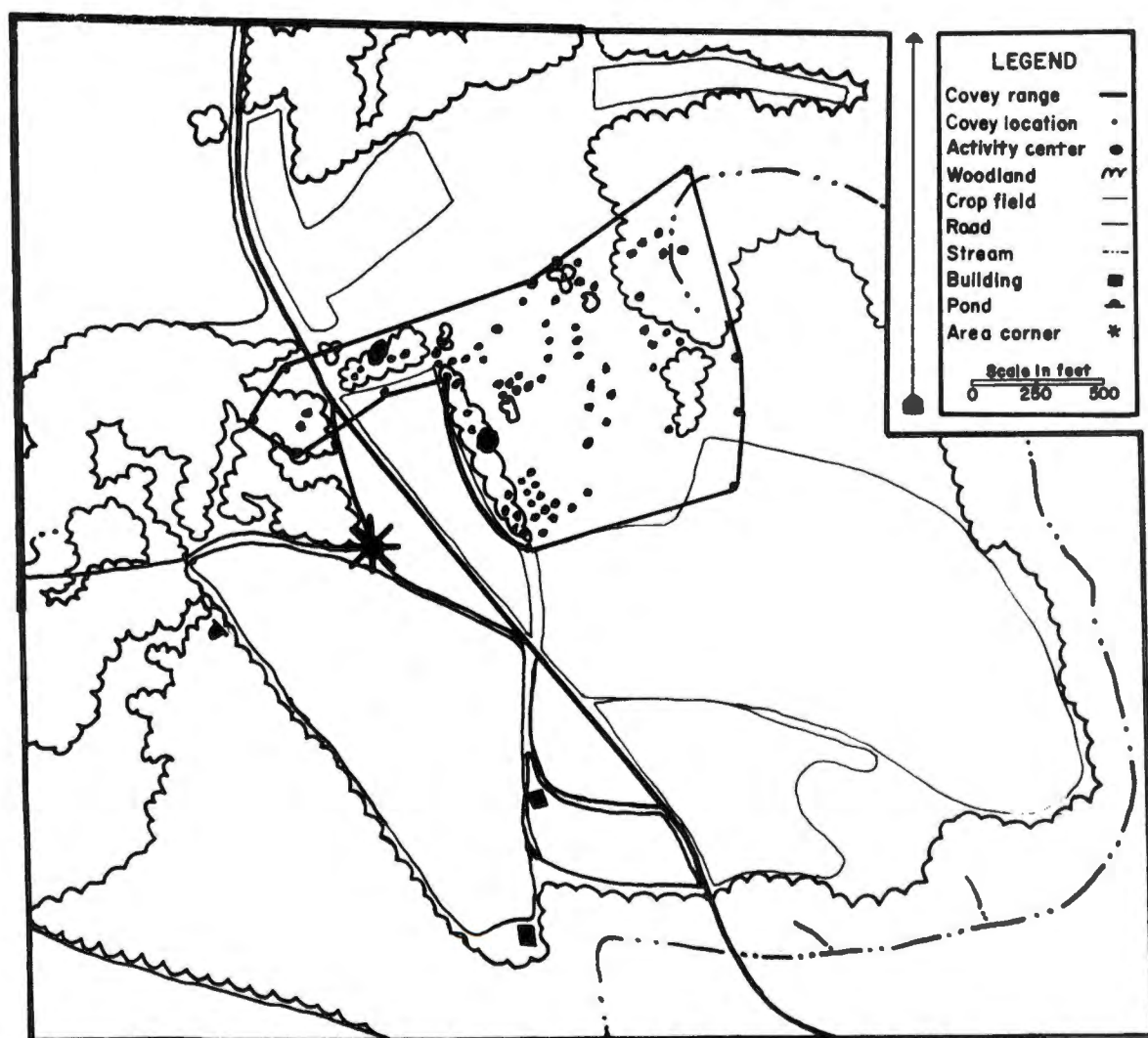


Figure 9. Observed locations and activity centers of covey 16 within its range January 3 to February 19, 1970, Ames Plantation, Tennessee.

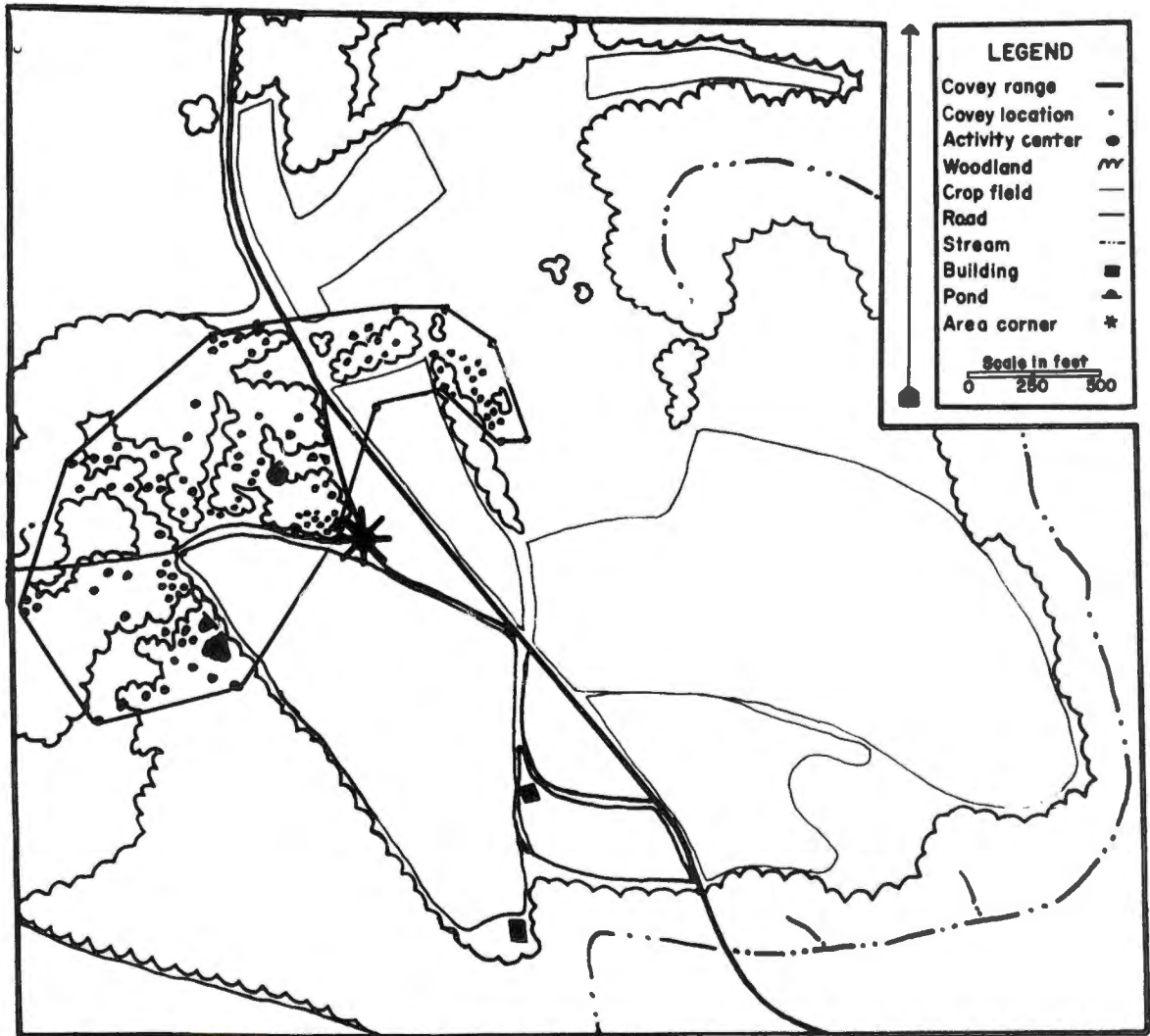


Figure 10. Observed locations and activity centers of covey 17 within its range February 18 to March 16, 1970, Ames Plantation, Tennessee.

was annexed into the covey range and frequently revisited.

Flushed birds were never observed to fly across range boundaries. This finding enhanced definition of ranges of coveys on the study area which were not telemetered.

#### Utilization of Cover Types

The number of telemetry locations of coveys in different cover types were compared to the percent of covey ranges consisting of these types to examine habitat preferences of coveys during winter. The five coveys whose ranges were best described were considered.

Tendencies of coveys to run prior to flushing precluded using flush data to examine use of cover types. The fact that birds run to particular cover would bias results.

Large portions of cultivated fields were part of the ranges of coveys 8, 15, and 17. Coveys were rarely found in cultivated fields. Therefore, it was not surprising that these coveys used habitat types nonrandomly.

The cornfield in the range of covey 17 was the only cultivated field in which the location of a covey was not uncommon. Broken corn-stalks and weeds remained standing in this cornfield providing concealment for quail. Extensive cover was not present on other cultivated fields on the study area.

Despite the limited time coveys spent in cultivated fields, 90 percent of winter food of quail on the quail management area consists of soybeans and corn (Eubanks, unpublished data). All 17 coveys studied had ranges which included portions of a cornfield or soybean field.

Covey 17 deviated from a pattern of random range utilization although its range included little cultivated land ( $\chi^2 = 80.8748^*$ ). Sixty-nine percent of this deviation resulted from intensive use of a one-half acre marsh overgrown by trumpet creeper (Campsis radicans). The covey used this marsh eight times as much as random use would dictate.

Of the five coveys, only covey 16 used its habitat randomly ( $\chi^2 = 2.5743$ , NS). The range of this covey included little cultivated land and no marsh.

The relative use of cedar woods, hardwood stands, and old fields was then examined. To accomplish the analysis cultivated fields and associated telemetry locations were not included as part of covey ranges. Similarly, the area of the marsh in the range of covey 14 and the telemetry locations in that area were dropped from the analysis.

Cedar woods, hardwood stands, and old fields were common to all five ranges and were readily used by each covey. Nonetheless, only covey 15 ( $\chi^2 = 2.2523$  NS) and covey 16 ( $\chi^2 = 0.6781$  NS) used these three habitats randomly. Covey 8 used hardwood stands in its range less than expected and was found in old fields and cedar woods more often than if it had used this range randomly ( $\chi^2 = 15.1081^*$ ). Covey 15 spent twice as much time as expected in hardwood stands and was in idle fields only one-third the expected time ( $\chi^2 = 25.4622^*$ ). Covey 17 was located in cedar woods with twice the expected frequency ( $\chi^2 = 9.7422^*$ ).

Differential use of these three types reflected preferences of individual coveys. Observed and expected telemetry locations of all five coveys in cedar woods, hardwood stands, and old fields were summed to estimate relative use of these cover types by the quail population on

the study area. The resulting test indicated that general use of these three cover types by the quail population was 'random ( $\chi^2 = 0.7922$  NS).

Understory composition greatly influenced use of cedar woods and hardwood stands. Coveys usually remained near honeysuckle or other dense understory cover. Overstory structure of this cover was of secondary importance.

### Activity Centers

Within covey ranges, certain small areas were used intensively. Each of the five well-described ranges had two activity centers. Coveys were found ten or more times in each activity center during the study. These areas were small, including 50 square yards or less. Excepting the one activity center which was a roosting headquarters, each activity center was characterized by honeysuckle in an understory adjacent to grain or weed fields.

### Influence of Habitat Alteration on Range Utilization

Baiting or trapping within covey ranges did not noticeably influence daily movements of quail. Coveys utilized bait sites in passing but did not linger near bait. Also quail seemingly disregarded trapped covey members.

Modification of larger areas in covey ranges precipitated changes in range utilization. Cutting of quarter-acre cedar tracts resulted in thorough use of these areas by coveys 13 and 14. The quail apparently fed on the newly disturbed ground, and frequently occupied brush resulting from the cuts.

Several horses were stabled in a one-acre portion of the range of covey 14 during the field trials. The covey immediately responded to soybean straw used as bedding. A center of activity developed in the covey's range as a result of this habitat alteration.

### Roosting Characteristics

Often coveys scattered during the day did not call together until late afternoon. Scattered coveys always called together before roosting. These coveys occasionally roosted at the point of aggregation. Similarly, integral coveys occasionally roosted where they were located when sunset approached. More often an abrupt, directional, and often lengthy walk to roost was made. Birds separate from the covey when this walk began became excited. These birds ran rapidly, often flying short distances, toward the group. Concurrently, the separated birds uttered the alarm cry described by Stokes (1967).

Most of these evening movements led to roosting headquarters, areas of 300 square yards or less, where coveys roosted two or more times each week. Four of five intensively studied coveys utilized roosting headquarters. The fifth covey did not seek specific areas in its range for roosting. The other four coveys had one to three roosting headquarters. Tendencies to use these roosting areas were stronger in some coveys than in others. Covey 17 used one headquarters an average of five nights each week during the month that the covey was telemetered.

Roosts occurred most frequently in small openings in a mixture of brushy and herbaceous vegetation, often in association with honeysuckle. In contrast to findings of Klimstra and Ziccardi (1963) and Bartholomew

(1967) who examined roosting characteristics of quail in Illinois, roosts in broomsedge during this study were uncommon. Klimstra and Ziccardi (1963) found that disturbance resulted in coveys seeking dense roosting cover. Perhaps roost selection by telemetered coveys in the present study reflected their subjection to harassment. However, Bartholomew (1967) accumulated his data through radio-telemetry as I did. Therefore, the present results may indicate differences in roost selection by bobwhite coveys in various parts of their range.

#### Influence of Vegetation on Flush Behavior

The influence of vegetation on flush behavior was evaluated by comparing characteristics of cover surrounding covey flush sites to the distance that the covey flushed from an intruder and to the distance that the covey flew. Cover types considered included fields, hardwood stands, cedar woods, and pine stands. The distance in yards to cover types surrounding the covey's point of flush was estimated. Cover height was determined by estimating in feet the average height of dominant vegetation within a cover type.

Flush behavior of coveys was altered by characteristics of vegetation within 200 yards of the flush site. Vegetation from which coveys flushed influenced their behavior to a lesser degree than did other nearby cover types.

The height of vegetation into which coveys flew influenced their flight distance. Coveys possibly flew farthest, seeking tall escape cover, when most alarmed. At any rate, birds flew farther when they entered taller cover than when they entered lower vegetation ( $r = 0.2963^*$ ).

Coveys near taller vegetation flew farther when flushed than coveys surrounded by shorter vegetation ( $r = 0.4458^*$ ). Eighteen percent of the difference in distances that flushed coveys flew was attributable to the height of taller vegetation nearest the flush site. No other factor influenced flush behavior nearly so much. Coveys apparently were more alarmed when flushed near woodlands than when old fields surrounded their position.

Significant statistical relationships existed between the cover type of nearby vegetation and the distance from an intruder that coveys flushed (Table 2). Coveys flushed farther from an intruder when the covey was associated with stands of loblolly pine (Pinus taeda) than when this cover type was not nearby. Coveys in hardwood stands flushed closer to an intruder than coveys in cedar woods or old fields. No biological explanations of these statistical relationships of flush distance and dominant vegetation within local cover types were apparent. Similarly, the statistical significance relating flush distance to height and species composition of cover types which flushed coveys entered had no apparent biological basis.

#### F. CHANGES IN COVEY COMPOSITION

Bobwhite quail coveys are a loosely knit social group utilizing a unit of habitat (Stoddard, 1931, p. 169). Quail frequently left the covey in this habitat and exploited other suitable habitat. These newcomers joined quail already using this range, so that interchange of quail between coveys was common throughout winter. Observations of

TABLE II

EFFECT OF COVER TYPES OF NEARBY HABITAT ON THE DISTANCE FROM  
AN OBSERVER AT WHICH COVEYS FLUSHED DURING THE WINTER  
1969-70, AMES PLANTATION, TENNESSEE

| Average distance<br>in yards from an<br>intruder that<br>coveys flushed | Cover type from which coveys flushed                                   |       |          |            | F-Value  |
|-------------------------------------------------------------------------|------------------------------------------------------------------------|-------|----------|------------|----------|
|                                                                         | Cedar                                                                  | Pine  | Hardwood | Herbaceous |          |
|                                                                         | 23.62                                                                  | -     | 8.54     | 22.87      | 3.887*   |
| Average distance<br>in yards from an<br>intruder that<br>coveys flushed | Cover type closest to the cover from which the<br>covey flushed        |       |          |            | F-Value  |
|                                                                         | Cedar                                                                  | Pine  | Hardwood | Herbaceous |          |
|                                                                         | 22.61                                                                  | 25.00 | 30.57    | 20.14      | 0.533 NS |
| Average distance<br>in yards from an<br>intruder that<br>coveys flushed | Taller cover type closest to the cover from which<br>the covey flushed |       |          |            | F-Value  |
|                                                                         | Cedar                                                                  | Pine  | Hardwood | Herbaceous |          |
|                                                                         | 18.00                                                                  | 40.00 | 28.86    | 11.88      | 3.757*   |
| Average distance<br>in yards from an<br>intruder that<br>coveys flushed | Cover type that the flushed covey entered                              |       |          |            | F-Value  |
|                                                                         | Cedar                                                                  | Pine  | Hardwood | Herbaceous |          |
|                                                                         | 10.73                                                                  | 39.17 | 26.58    | 23.96      | 4.827*   |

color-markers, flush counts, recapture of quail, and telemetry records all supplied evidence of interchange of quail between covey ranges.

#### Color-marked Quail

Color-markers were attached to 92 quail in 12 covey ranges. Yellow and blue wing tags pinned to 18 birds in coveys 1, 2, and 3 were never sighted after release of the birds. Piercing the loose skin at the base of the neck with aluminum pins apparently resulted in the death of these quail. Subsequently color-markers were attached to harnesses. These markers were believed to have had little effect on quail survival. Color-markers were seen at each flush of a covey subsequent to the marking of four or more members of that covey.

Light green color-markers were attached to 15 quail in coveys 7 and 8 (Fig. 3, page 13). Initially, five birds from covey 8 were color-marked. Light green markers were seen in both coveys the next day. Late in the study red markers were attached to 12 quail. These quail were all captured at the same trap site but were members of coveys 3, 4, and 7.

Trapping in the southeast portion of the study area resulted in the color-marking of 13 birds in covey 11 with yellow markers, 16 quail in covey 14 with orange markers, 8 quail in covey 15 with light green-orange markers, and 15 quail in covey 16 with blue markers. Of the 52 quail color-marked in these four coveys, 19 were later observed in other coveys (Fig. 11). Of these 19, 12 shifted to coveys with a range overlapping the range of the birds' previous coveys. Seven birds joined coveys whose ranges approached the closest point of the birds' former range from 100 to 250 yards.

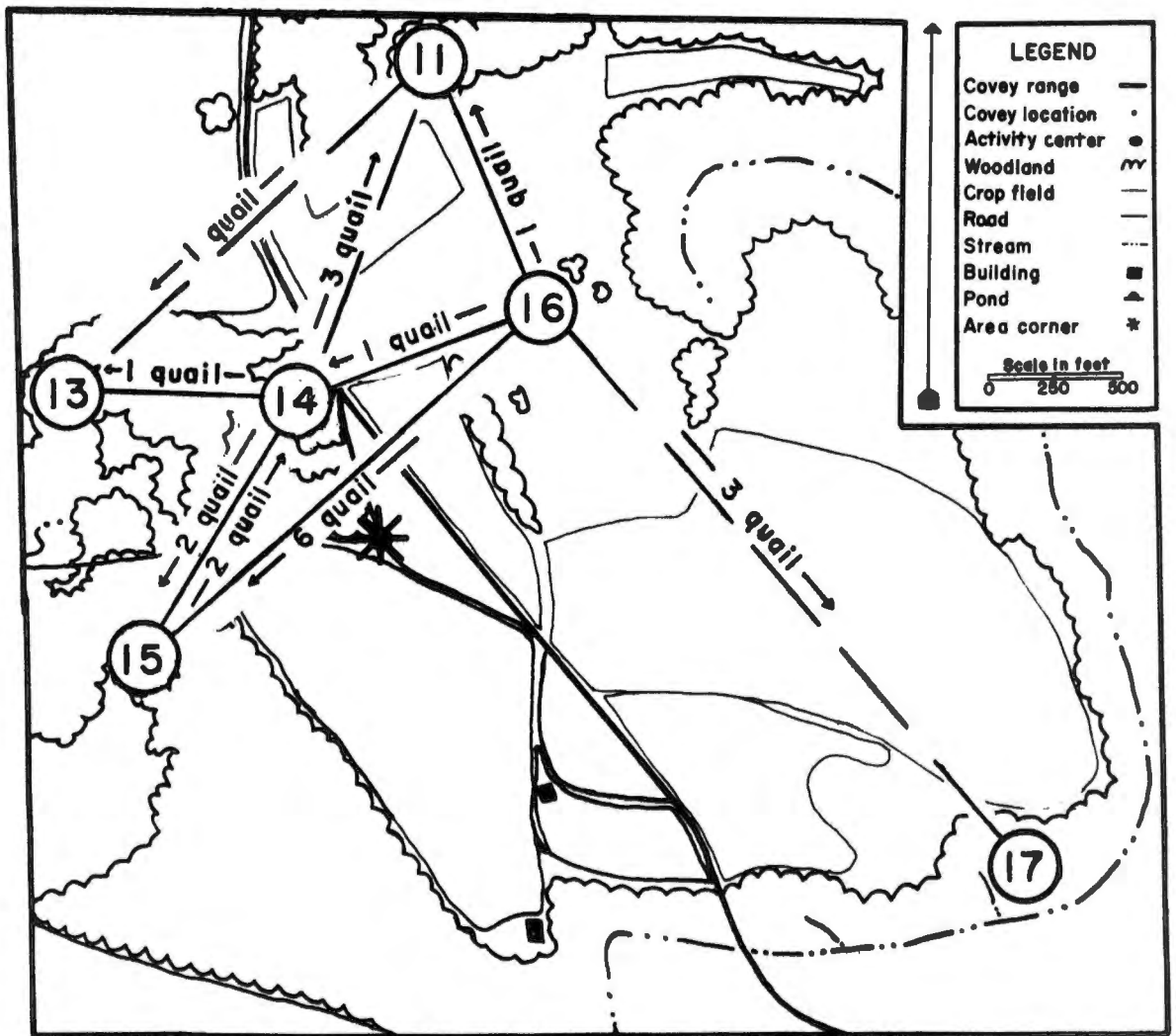


Figure 11. Interchange of color-marked quail between the six coveys in the southeastern portion of the study area during the winter 1969-70, Ames Plantation, Tennessee.

### Changes in Covey Size

The number of birds counted at flush for each covey fluctuated irregularly as winter progressed (Fig. 12). Stoddard (1931, p. 170) and Rosene (1969, p. 96) noted similar changes in size of coveys.

### Changes in Covey Range by Recaptured Quail

Of 32 quail recaptured during the winter, 11 changed coveys. These included four male adults, three male juveniles, three female juveniles, and one female adult. Three quail shifted range twice. The 11 banded quail captured in two or more covey ranges were recaptured over an average span of 37.5 days. Fortunes on the remaining 21 quail were followed over an average of only 17.2 days. Two of three quail released a mile from their original range in covey 1 were recaptured in covey 14 near their release site.

### Changes in Covey Range by Telemetered Quail

Four birds carrying functional transmitters changed coveys. Since behavioral patterns of harnessed quail did not seem to deviate greatly from the norm, a crude estimate of the rate of interchange was obtained. Calculations included dividing the 166 days birds carried transmitters by the four times that harnessed quail changed coveys. These quail then, changed coveys once every 41.5 days. By this estimate an average covey of 13 birds lost, and gained, a bird every three days. However, observations of color-marked quail which changed coveys indicated that small groups, perhaps feeding groups, rather than individuals usually changed coveys.

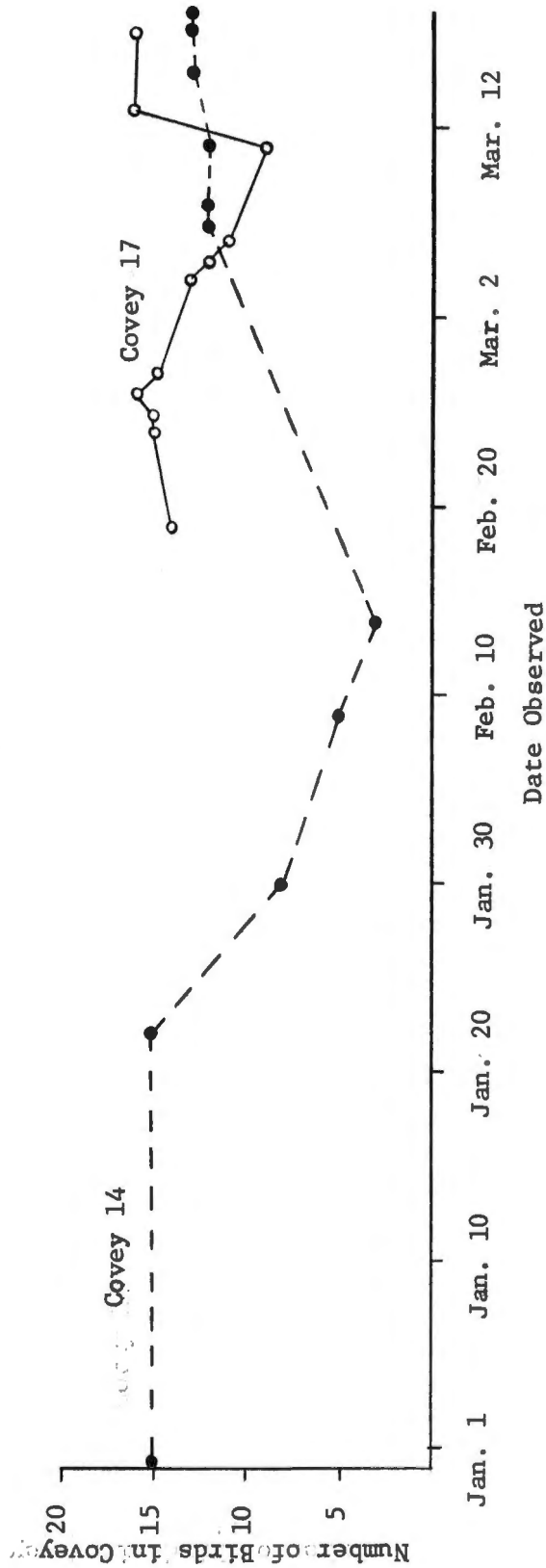
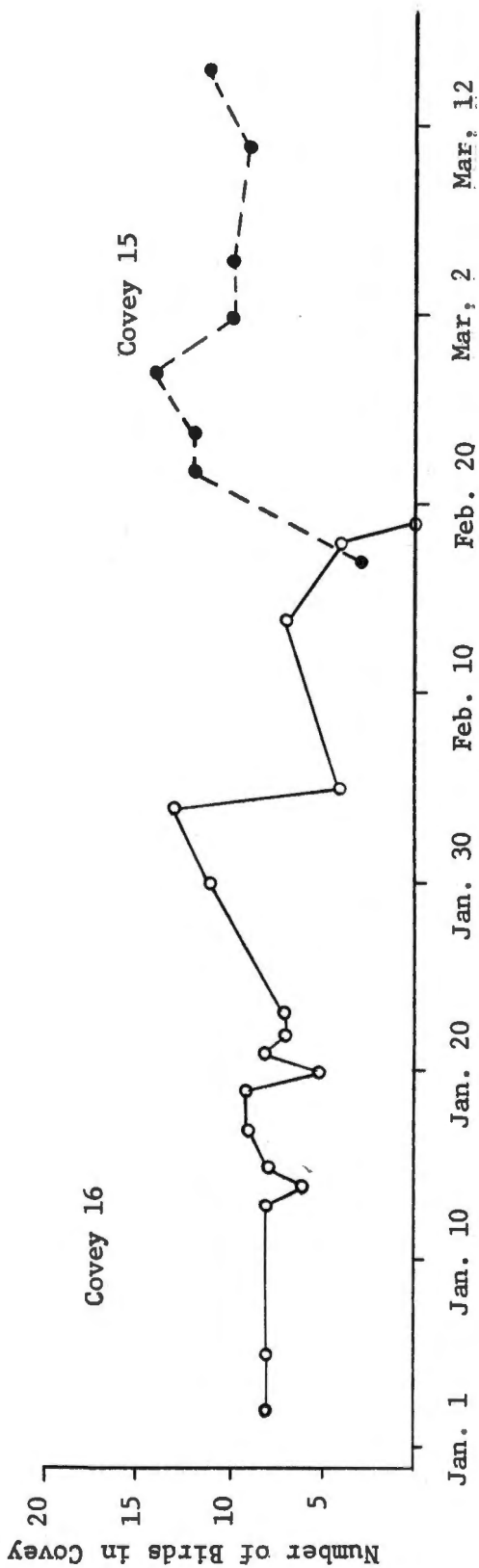


Figure 12. Changes in covey size of the four coveys flushed most frequently during the winter 1969-70, Ames Plantation, Tennessee.

### Factors Complicating Evaluation of Covey Interchange

Evaluation of the extent of covey interchange was complicated by mortality of quail, the presence of feeding groups within coveys, and by the shuffle of birds on the study area resulting from the field trial. The existence of feeding groups masked changing covey sizes. Subsequent observations were necessary to determine whether a decrease in the number of birds observed at a covey flush reflected a real change in that covey's size or whether the absent quail were temporarily acting as a separate unit.

These feeding groups behaved similarly to those observed by Gooden (1952) in Iowa, which separated during the day, but roosted together at night. Paradoxically, Bartholomew (1967) observed coveys which fed together during the day, but separated to roost.

Disturbance from the field trial resulted in a shuffle on the study area which compounded the normal rate of covey interchange. Nevertheless, much information was available prior to the field trial demonstrating covey interchange.

### Mechanism of Covey Interchange

Rapid replacement of missing birds on covey ranges was believed common. On several occasions coveys from which a number of birds were trapped were nearly original size the next day prior to release of trapped members. A marked decrease in the number of color-marked quail often occurred from one day to the next without a corresponding drop in covey size. However, a corresponding increase in the number of these color-marked birds in other coveys was never observed. Quail probably

did not often lose color-markers, but the fate of these birds was not determined.

This rapid replacement or interchange of birds between covey ranges strongly indicates that replacement is facilitated through communication between quail. The fact that communication occurs is well known. Often, members of several coveys give covey calls simultaneously. Possibly members of coveys which have been reduced in size call more intensely or at a faster rate than members of unaltered coveys. Quail separate from coveys at this time may be attracted to these coveys by characteristics of the covey call.

Several selective advantages of systematic replacement of birds are apparent. Systematic replacement would enhance range utilization by quail. Ranges improved after covey formation could support more quail than before the improvement. A systematic influx of birds into those coveys utilizing the improved range would be the most efficient mechanism by which quail could reach carrying capacity in the altered habitat.

Quail in inferior habitat would move toward better habitat as mortality eliminates birds in better ranges. Rosene (1969, p. 96) related a possible example of this mechanism. A covey from which he killed 14 birds and wounded some had 18 birds at the start of the season. The covey had 15 birds at the end of the season and was about the same size at each hunt.

Disturbance in quail ranges, such as intensive predation or hunting pressure, could be avoided by birds. Simply by joining birds on

another range, quail would escape harassment. The influence of the field trial on the quail population at the Ames Plantation was a striking example of this reaction. Similarly, Rosene (1969, p. 94) described an area inhabited by 51 coveys on November 1. The area was worked daily by bird dogs. By February 1 only 18 coveys remained. Too much dog training caused other coveys to leave the area. Hunters commonly know that coveys leave an area hunted too frequently.

Management implications arise if systematic replacement between coveys exists. Managed areas which provide the best quail habitat in an area would attract quail from neighboring poorer habitat. Shooters on this management area could theoretically harvest more quail than the number on the area at the start of the season.

## CHAPTER V

### SUMMARY

The 214 acre study area was located in Fayette County, Tennessee, on the Ames Plantation. In addition to agricultural usage, the area is intensively managed for quail and supports a density of about one bird per two acres in the autumn.

Information on winter behavior of quail was obtained from flushes of coveys and telemetry data gathered during January-March, 1970. Trapping and color-marking of birds supplied supplementary data.

Coveys were most active during the two hours after daybreak. Increased activity after mid-afternoon followed six hours of limited movement. Similar movement patterns to the same portion of the range occurred on successive days.

Weather conditions weakly affected covey movements. Movement increased on warmer days. During mornings or evenings characterized by frequent gusts of wind of more than ten miles per hour, coveys often remained at roost two or more hours after sunset or established roost two or more hours before sunset. During rainy or windy days coveys remained sheltered under dense vegetation much of the time. Weather during the previous night influenced daily movements. Weather did not predictably affect flush behavior of quail.

Several aspects of influences of disturbance on quail behavior were studied. Color-marked quail rapidly recovered from the traumatic experience of capture and marking. Telemetered quail behaved abnormally for one or two days after release.

Coveys in cultivated fields ran into cover offering better concealment when threatened. Coveys in dense vegetation ran into cover allowing a more unobstructed flush. Coveys usually aggregated as an intruder closely approached. This defense reaction allows the covey to flush as a unit, startling the intruder.

No change in flush behavior occurred when coveys were flushed successively during a day. Large coveys tended to fly farther than smaller coveys when flushed. The distance at which coveys flushed did not affect how far they flew.

Often flushed birds remained stationary after landing. Other quail ran up to 40 yards before hiding.

Time to covey reformation varied from 15 minutes to several hours. Scattered coveys usually employed covey calls, often antiphonally, to reform. Covey members did not always respond to covey calls except near sunset.

The impact of field trials on quail behavior was remarkable. Coveys subjected to this harassment responded by remaining stationary or moving extensively. Continued disturbance of covey ranges resulted in quail abandoning most affected ranges. Limited information suggests that most of these coveys disintegrated. Fragments of disintegrated coveys joined birds inhabiting nearby ranges. Since undisturbed coveys remained within their ranges, the shuffle produced an exodus of quail from the field trial course.

Ranges of five coveys accurately described by radio telemetry locations averaged 16.3 acres. Most ranges of coveys on the study area

were overlapping. Coveys moved almost exclusively within home range boundaries, and never flew across range boundaries.

Coveys spent little time in agricultural fields even though 90 percent of winter food of quail on the area consists of soybean and corn (Eubanks, unpublished data). A marsh was used intensively by one covey. Cedar woods, hardwood stands, and old fields were used randomly by the quail population, but non-randomly by some individual coveys. Understory composition greatly influenced use of cedar woods and hardwood stands.

Within ranges of coveys, 50 square yard areas of intensive use were evident. These small activity centers were characterized by honeysuckle understories adjacent to grain or weed fields.

Baiting or trapping within covey ranges did not noticeably influence daily movement of quail. Modification of areas of one-quarter acre or more in covey ranges caused changes in range utilization. Soil disturbance and piled brush resulting from logging in cedar woods resulted in frequent use of these areas by two coveys. Another covey responded to soybean straw used as bedding for several horses.

Flush behavior was greatly influenced by habitat within 200 yards. Nearby vegetation exerted more influence on flush behavior than did vegetation from which birds flushed. Height, species composition, and proximity of neighboring vegetation interacted in affecting flush behavior of coveys.

Bobwhite quail coveys are a loosely knit social group utilizing a unit of habitat, the covey range. Interchange of quail between covey ranges was common throughout winter. Covey sizes fluctuated as winter

progressed. Of 32 quail recaptured during the winter, 11 changed covey ranges. Three birds shifted ranges twice. Of 92 color-marked quail, at least 29 changed covey affiliation during the winter. As estimate of the rate of interchange based on behavior of telemetered quail indicated that an average covey of 13 birds lost and gained a member every three days. However, small groups rather than individuals usually changed covey affiliation. The fact that coveys often split during the day complicated evaluation of covey interchange. Field trial harassment compounded the rate of interchange.

Replacement of birds lost from coveys was rapid. Rapid replacement was attributed to systematic interchange of birds between covey ranges. Selective advantages of systematic interchange between ranges are apparent as habitat utilization would be enhanced.

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## APPENDIX

TABLE III

INFORMATION PERTINENT TO DATA OBTAINED THROUGH RATIO TELEMETRY ON  
THE AMES PLANTATION, WINTER 1969-70

| Band<br>No.     | Age | Sex | Weight<br>Grams | Covey | Release<br>Date | Terminal<br>Date | Days of<br>Function | Days<br>Data | Fate of<br>Quail <sup>a</sup> | Fate of<br>Transmitter <sup>a</sup> |
|-----------------|-----|-----|-----------------|-------|-----------------|------------------|---------------------|--------------|-------------------------------|-------------------------------------|
| 41              | A   | M   | 172             | 2     | Jan. 10         | Jan. 10          | 1                   | 0            | Recovered                     | Recovered                           |
| 41 <sup>b</sup> | A   | M   | 172             | 2     | Jan. 14         | Jan. 14          | 1                   | 0            | Escaped                       | Recovered                           |
| 49              | J   | M   | 183             | 16    | Jan. 14         | Jan. 25          | 12                  | 11           | Escaped                       | Recovered                           |
| 53              | A   | F   | 183             | 1     | Jan. 19         | Jan. 21          | 3                   | 0            | Escaped                       | Recovered                           |
| 62              | J   | M   | 170             | 14    | Jan. 28         | Feb. 11          | 14                  | 7            | Unknown                       | Lost                                |
| 66              | A   | F   | 175             | 16+11 | Jan. 28         | Jan. 31          | 4                   | 3            | Shot                          | Recovered                           |
| 69              | J   | M   | 190             | 16    | Jan. 29         | Feb. 11          | 13                  | 3            | Escaped                       | Recovered                           |
| 69 <sup>b</sup> | J   | M   | 190             | 14    | Mar. 5          | Mar. 17          | 13                  | 11           | Abandoned                     | Abandoned                           |
| 67              | J   | M   | 182             | 14    | Feb. 4          | Feb. 5           | 2                   | 0            | Escaped                       | Recovered                           |
| 70              | A   | M   | 184             | 16    | Feb. 5          | Feb. 9           | 5                   | 4            | Unknown                       | Lost                                |
| 72              | J   | M   | 187             | 8     | Feb. 9          | Feb. 16          | 8                   | 8            | Predator                      | Recovered                           |
| 74              | J   | M   | 177             | 8     | Feb. 10         | Feb. 10          | 1                   | 0            | Unknown                       | Lost                                |
| 77              | A   | M   | 198             | 16+17 | Feb. 16         | Feb. 17          | 30                  | 21           | Abandoned                     | Abandoned                           |

TABLE III (continued)

| Band No.        | Age | Sex | Weight Grams | Covey | Release Date | Terminal Date | Days of Function | Days Data | Fate of Quail <sup>a</sup> | Fate of Transmitter <sup>a</sup> |
|-----------------|-----|-----|--------------|-------|--------------|---------------|------------------|-----------|----------------------------|----------------------------------|
| 80              | J   | M   | 198          | 16→15 | Feb. 17      | Mar. 17       | 29               | 19        | Abandoned                  | Abandoned                        |
| 82              | A   | M   | 168          | 7→4   | Feb. 17      | Feb. 26       | 10               | 4         | Escaped                    | Recovered                        |
| 82 <sup>b</sup> | A   | M   | 168          | 4     | Mar. 4       | Mar. 5        | 2                | 0         | Escaped                    | Recovered                        |

<sup>a</sup>Quail whose fate was unknown were lost while carrying a transmitter during the study. Quail abandoned were carrying functional transmitters at the termination of the study.

<sup>b</sup>Quail 41, 69, and 82 were released with a transmitter on two occasions.

TABLE IV

RELATIVE EFFECT OF ENVIRONMENTAL FACTORS ON DAILY MOVEMENT  
OF COVEYS DURING THE WINTER 1969-70 ON THE AMES PLANTATION,  
TENNESSEE. FACTORS ARE LISTED IN DECREASING ORDER OF  
IMPORTANCE BASED ON CORRELATION COEFFICIENTS ( $n = 88$ ).

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|                                           |          |
|-------------------------------------------|----------|
| Number of observed flushes during the day | -0.2717* |
| Average diurnal temperature               | 0.2364*  |
| Miles of wind passed during the day       | -0.1768  |
| Total rain during the day                 | -0.1546  |
| Average diurnal light intensity           | 0.1437   |
| Hours of diurnal rain                     | -0.1416  |
| Average diurnal wind velocity             | -0.1376  |
| Hours of diurnal snow                     | -0.1086  |
| Day length                                | 0.0651   |
| Wind direction                            | 0.0441   |
| Ground temperature                        | 0.0242   |
| Average diurnal barometric pressure       | -0.0124  |

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TABLE V

RELATIVE EFFECT OF EXAMINED WEATHER FACTORS ON FLUSH  
BEHAVIOR OF COVEYS DURING THE WINTER 1969-70 ON  
THE AMES PLANTATION, TENNESSEE. FACTORS ARE  
LISTED IN DECREASING ORDER OF IMPORTANCE  
BASED ON CORRELATION COEFFICIENTS OF  
FLUSH DISTANCE. NUMBER OF PAIRS  
OF OBSERVATIONS ON WHICH THE  
COEFFICIENT IS BASED ARE  
BRACKETED.

|                               | Distance from observer<br>that coveys flushed | Distance coveys flew<br>after flushed |
|-------------------------------|-----------------------------------------------|---------------------------------------|
| Day length                    | 0.2312*<br>(116)                              | -0.1191<br>(83)                       |
| Ground temperature            | 0.1776<br>(116)                               | -0.1399<br>(83)                       |
| Temperature                   | 0.1348<br>(116)                               | -0.1574<br>(83)                       |
| Light intensity               | -0.0917<br>(116)                              | -0.0389<br>(83)                       |
| Wind direction                | 0.0913<br>(116)                               | 0.0204<br>(83)                        |
| Wind velocity                 | 0.0872<br>(116)                               | -0.0076<br>(83)                       |
| Angle of sun above<br>horizon | -0.0516<br>(116)                              | 0.1257<br>(83)                        |
| Barometric pressure           | -0.0635<br>(116)                              | 0.0267<br>(83)                        |
| Intensity of rainfall         | 0.0113<br>(116)                               | -0.1188<br>(83)                       |
| Depth of snow                 | -0.0046<br>(116)                              | 0.1446<br>(83)                        |
| Intensity of snowfall         | 0.0011<br>(116)                               | 0.1883<br>(83)                        |

TABLE VI

RELATIVE EFFECT OF NON-DISCRETE HABITAT CHARACTERISTICS  
ON FLUSH BEHAVIOR OF COVEYS DURING THE WINTER 1969-70  
ON THE AMES PLANTATION, TENNESSEE. FACTORS ARE  
LISTED IN DECREASING ORDER OF IMPORTANCE BASED  
ON CORRELATION COEFFICIENTS OF FLUSH DISTANCE.  
NUMBER OF PAIRS OF OBSERVATIONS ON WHICH THE  
COEFFICIENT IS BASED ARE BRACKETED.

|                                                      | Distance from observer<br>that coveys flushed | Distance coveys flew<br>after flushed |
|------------------------------------------------------|-----------------------------------------------|---------------------------------------|
| Height of vegetation<br>entered by coveys            | -0.2213*<br>(89)                              | 0.2963*<br>(82)                       |
| Height of vegetation<br>from which coveys<br>flushed | -0.1647<br>(116)                              | 0.0450<br>(83)                        |
| Distance to a different<br>vegetation type           | 0.1616<br>(116)                               | 0.0060<br>(83)                        |
| Distance to a taller<br>vegetation type              | 0.1562<br>(72)                                | 0.1147<br>(54)                        |
| Height of the closest<br>taller vegetation           | -0.0398<br>(72)                               | 0.4458*<br>(54)                       |
| Height of the closest<br>different vegetation        | 0.0303<br>(116)                               | -0.0132<br>(83)                       |

TABLE VII

RELATIVE EFFECT OF COVEY CHARACTERISTICS ON FLUSH BEHAVIOR  
OF COVEYS DURING THE WINTER 1969-70 ON THE AMES PLANTATION,  
TENNESSEE BASED ON CORRELATION COEFFICIENTS. NUMBER OF  
PAIRS OF OBSERVATIONS ON WHICH COEFFICIENT IS BASED  
ARE BRACKETED.

|                                               | Distance from observer<br>that coveys flushed | Distance coveys flew<br>after flushed |
|-----------------------------------------------|-----------------------------------------------|---------------------------------------|
| Number of birds<br>in the covey               | 0.1553<br>(116)                               | 0.2990*<br>(83)                       |
| Number of times the<br>covey was flushed/day  | 0.0527<br>(116)                               | -0.0719<br>(83)                       |
| Distance from observer<br>that coveys flushed | -                                             | -0.1352<br>(81)                       |
| Distance coveys flew<br>after flushed         | -0.1352<br>(81)                               | -                                     |

## VITA

Noel Stewart Yoho, son of Noel Henry Yoho, and Arlene (Wolfe) Yoho, was born in Wheeling, West Virginia October 13, 1946. He attended elementary school in Moundsville, West Virginia, and graduated from Linsly Military Institute in 1964. He entered college in 1964 and received the degree of Bachelor of Science in Forestry in August, 1968 from West Virginia University. In September, 1968, he entered The University of Tennessee on a research assistantship to begin graduate work in forestry. He received a Master of Science in Forestry from The University of Tennessee in August 1970. He is a member of Xi Sigma Phi, national forestry honorary. He is married to the former Sue Ellen Cummins of Waynesburg, Pennsylvania.