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Date August 9, 1988

POPULATION STATUS, MOVEMENTS AND HABITAT UTILIZATION OF RUFFED GROUSE ON THE CATOOSA WILDLIFE MANAGEMENT AREA, CUMBERLAND COUNTY, TENNESSEE

A Thesis

Presented for the

Master of Science

Degree

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Robert G. Epperson, Jr.

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ABSTRACT

The population status and habitat preferences of ruffed grouse were studied on the Catoosa Wildlife Management Area in Cumberland County, Tennessee. The objectives were to establish baseline estimates of population density on a largely unmanaged, upland hardwood forest, and to determine habitat utilization prior to implementation of forest management. Population density was estimated at 0.47 males per 100 ha on the control area, and 0.28 males per 100 ha on the experimental area, based on spring drumming censuses conducted from 1983 through 1986. Drumming activity began in late-March, peaked in late-April, and continued until early-June. Peak drumming activity corresponded with estimated dates of copulation derived by back-dating from nest and brood observations. Twelve ruffed grouse were captured and fitted with radio transmitters. Mirror traps were more successful than interception traps, although overall success rates were low. Battery-powered radios mounted with ponchos were the most reliable transmitter packages. Home range sizes were generally larger than those reported elsewhere. Movements appeared to be habitat dependent for broods. Dispersal occurred in mid- to late-September; distances from point of capture ranged from 1.2 to 4.0 km. Habitat types preferred overall by ruffed grouse were laurel-rhododendron (Kalmia

latifolia-Rhododendron maximum), Vaccinium-pine (Pinus spp.), and hardwood regeneration. Laurel-rhododendron and Vaccinium-pine were important cover types throughout the year for adult males. Hardwood regeneration was preferred by broods during the summer; post-dispersal juveniles favored laurel-rhododendron. Although not a preferred cover type, Vaccinium uplands provided drumming sites in spring and food during summer and fall.

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CHAPTER I

INTRODUCTION

Ruffed grouse (Bonasa umbellus) in Tennessee occur near the southern extremity of their range (Bump et al. 1947). White and Dimmick (1979) determined the present distribution of ruffed grouse in Tennessee to include at least 35 of the state's 95 counties (Figure 1). Although populations are lower in this portion of the range, grouse are found in sufficient numbers to provide recreation to hunters in middle and eastern Tennessee. The popularity of the ruffed grouse as a game bird has increased in recent years (Bowman 1985), but little information is available to manage this species properly in its southern range.

The few studies on the ruffed grouse in the southeastern United States have mainly emphasized characteristics of drumming logs and food habits (Nelson et al. 1938; Taylor 1976; Smith 1977; Stafford and Dimmick 1979; Seehorn et al. 1981; Hale et al. 1982; Norman and Kirkpatrick 1984; Servello 1985). Harris (1981) described the spring and summer ecology of grouse in northern Georgia. Attempts to restore ruffed grouse to their former range in west Tennessee have been reported by White and Dimmick (1978), Jones (1979), and Gudlin and Dimmick (1984). The results of these studies have indicated

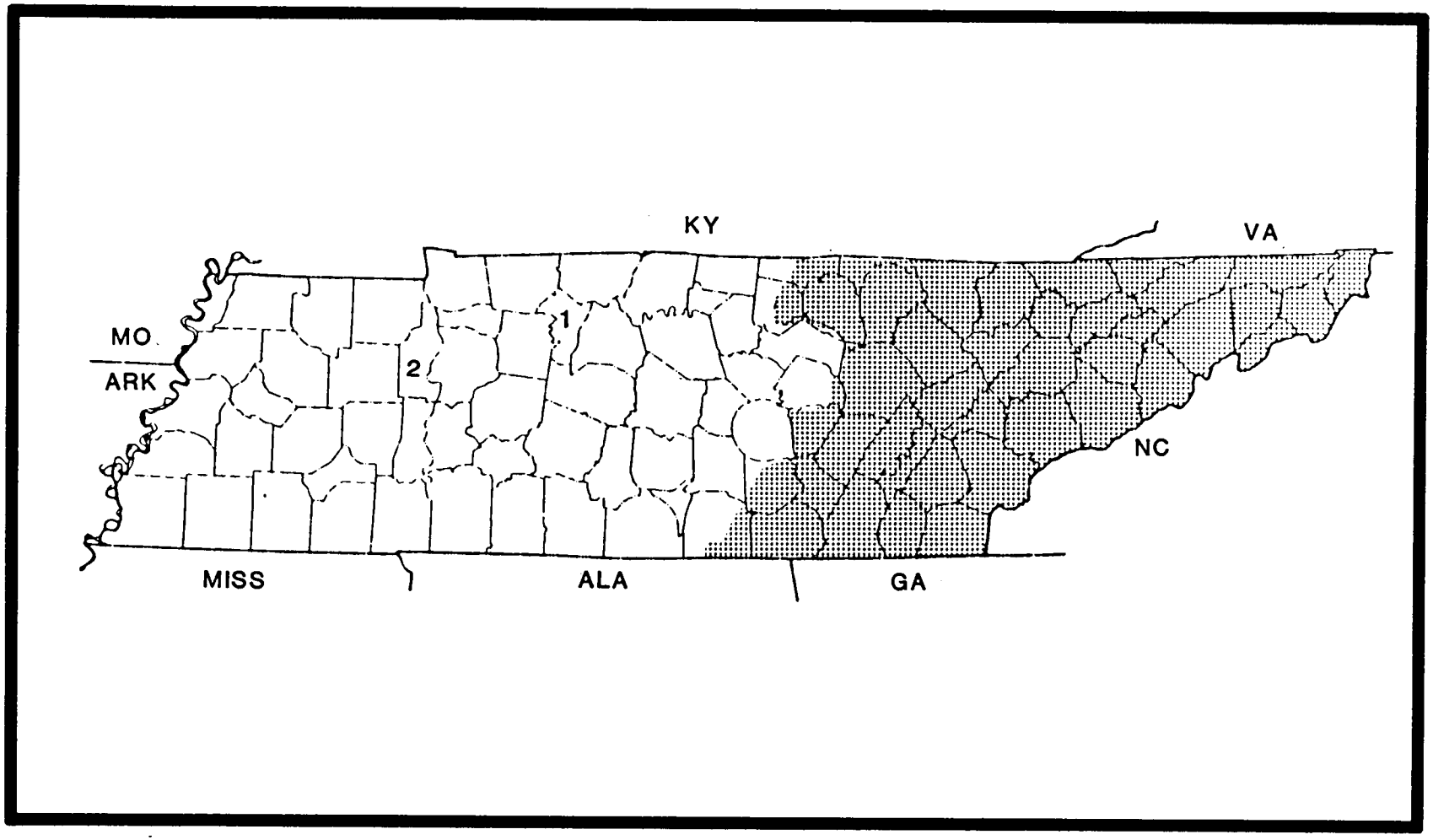


Figure 1. Present Range of Ruffed Grouse in Tennessee (White and Dimmick 1979), Including Restoration Areas: 1-(Jones 1979), 2-(White and Dimmick 1978 and Gudlin and Dimmick 1984).

dissimilarities in the ecology of grouse in the southeastern portion of their range compared to grouse living in aspen (Populus sp.) forests (Gullion 1970, Gullion and Svoboda 1972). Little information is available regarding habitat requirements of ruffed grouse in southeastern forests where aspen is not a major component.

In 1982, the present study was initiated to examine the ecology of the ruffed grouse with a long term objective of determining the impact of forest harvesting practices on grouse population levels and habitat utilization. The study design included a control area where the forest habitat will not be manipulated, and an experimental area that contains 6 stands presently in early regeneration. Three stands totaling 25.2 ha were clearcut 3 to 9 years prior to initiation of the study. During August to November 1986, 2 upland oak stands and 1 pine-oak stand, totaling 28.7 ha, were clearcut. A wildfire burned 3.5 continuous stands of upland oak totaling 35.0 ha. Some of the residual dead and damaged overstory trees were removed from the burned area by firewood cutters, effecting a disturbance that was silviculturally similar to a clearcut. Thus, silvicultural operations have resulted in 88.9 ha of early regeneration, which comprises approximately 19.5% of the experimental area. Baseline data on grouse population density and

habitat selection were gathered prior to completion of forest management on the experimental area. Grouse density and habitat utilization will be monitored up to 10 years following the treatment.

This thesis describes activities and results from the third (1985) and fourth (1986) years of the study, and incorporates results from the first 2 years reported by Longwitz (1985). The main objectives of this portion of the study were:

1) To continue to gather baseline data on the status of the ruffed grouse population.
2) To delineate proportionate use of habitat types by ruffed grouse.

CHAPTER II

DESCRIPTION OF THE STUDY AREAS

The Catoosa Wildlife Management Area (WMA) was chosen as the location for this study. This 32,376-ha state-owned tract is managed by the Tennessee Wildlife Resources Agency (TWRA). The Catoosa WMA is located within Cumberland and Morgan counties, and is situated in the Cumberland Plateau physiographic region of Tennessee (Figure 2). Catoosa is located 16 km north of Crossville, 80 km west of Knoxville, and 177 km east of Nashville.

I. The Cumberland Plateau

The Cumberland Plateau is predominantly flat with elevations generally ranging from 274 to 640 m above sea level (asl). Exceptions occur where some mountainous areas exceed 914 m asl, and deep gorges and ravines cut into the bedrock. The plateau is underlain by shale and sandstone, with sandstone outcrops common on the slopes. It is the largest forested plateau in the United States, covering 1759 km^2.

The Plateau has a warm temperate and humid climate that results in short, mild winters and long, moderately hot summers (Smalley 1982). The mean annual temperature ranges from 13.3 to 14.4 C with mean monthly temperatures

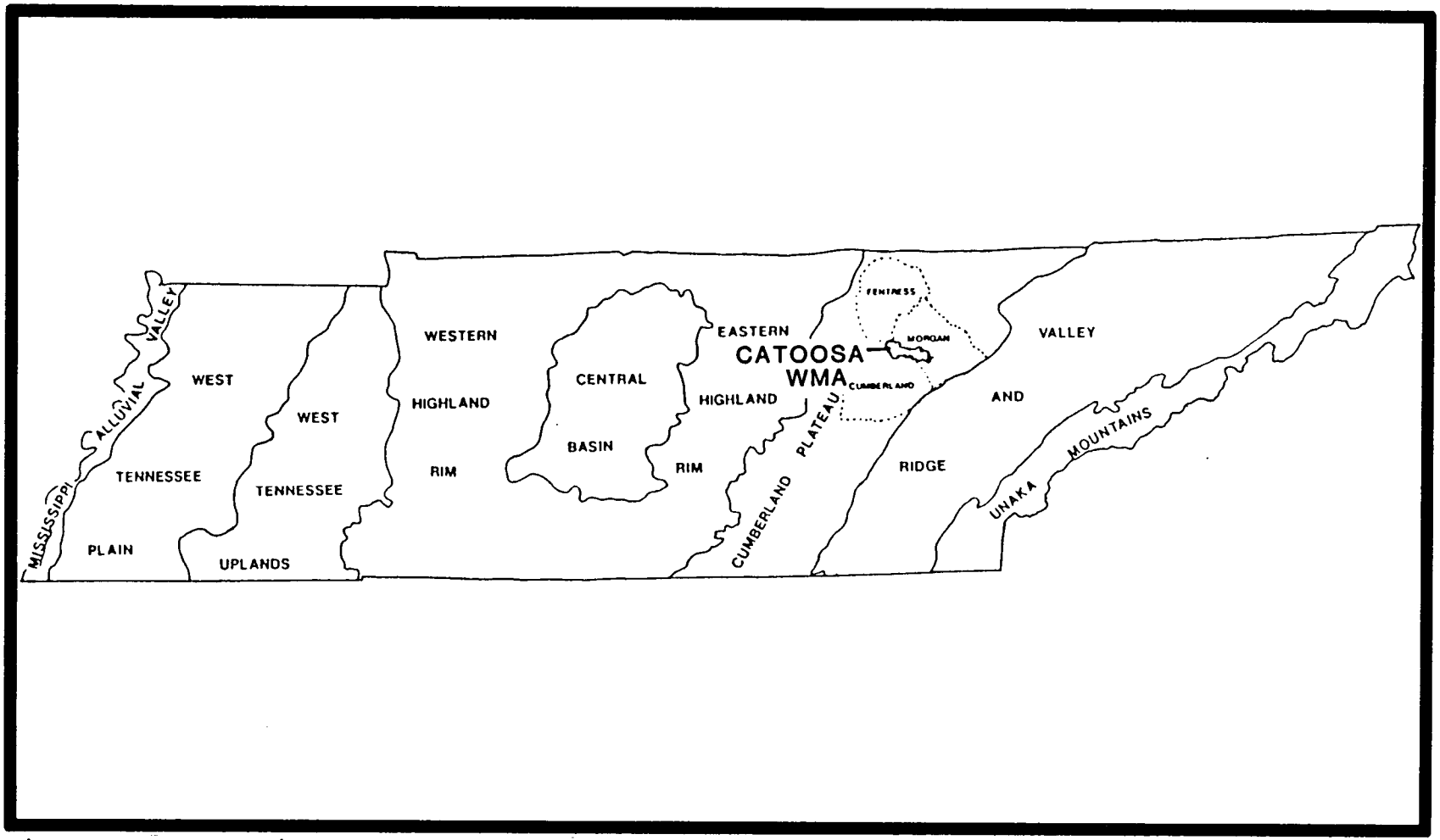


Figure 2. Location of the Catoosa WMA on the Cumberland Plateau, Tennessee.

ranging from 1.7 C in January to 22.8 C in July. The mean annual precipitation varies from 137 to 152 cm with extremes of 15.2 cm in January and 7.6 cm in October (Springer and Elder 1980). The growing season lasts 180 to 228 days.

II. The Catoosa Wildlife Management Area

Catoosa is the largest of Tennessee's 65 wildlife management areas. The topography is representative of the Cumberland Plateau with gently rolling uplands dissected by steep ravines. Major drainages include the Obed and Emory rivers, and Clear and Daddy's creeks. Elevations range from 305 to 640 m asl.

Soils are well drained, loamy, strongly acidic, and low in natural fertility. They are classified in the Lily and Lonewood series (Springer and Elder 1980). Soil depths range from 0.5 to 1.0 m in the Lily series, and from 1.0 to 1.7 m in the Lonewood series.

Catoosa was purchased in 1942 as a Federal Aid in Wildlife Restoration project after a long history of extensive timber harvesting, uncontrolled burning, coal mining, and open grazing. The management area offers recreational opportunities such as hunting, fishing, hiking, canoeing, horseback riding, and bird watching. Forests on Catoosa are capable of producing merchantable

timber, while providing habitat for wildlife, including game species such as white-tailed deer (Odocoileus virginianus), European wild hog (Sus scrofa), eastern gray squirrel (Sciurus carolinensis), wild turkey (Meleagris gallopavo), northern bobwhite (Colinus virginianus), and ruffed grouse.

Catoosa's forests are primarily composed of upland hardwoods of which oaks (Quercus spp.) and hickories (Carya spp.) dominate. Virginia pine (Pinus virginiana), eastern white pine (P. strobus) and shortleaf pine (P. echinata) are the prevalent softwood species found in oak-pine forests that occupy significant acreage in the management area. Overstory species found in the mesic ravines and gorges include white pine, eastern hemlock (Tsuga canadensis), and cove hardwoods such as northern red oak (Q. rubra), white oak (Q. alba), and yellow-poplar (Liriodendron tulipifera). Midstory trees common to most sites are flowering dogwood (Cornus florida), blackgum (Nyssa sylvatica), sassafras (Sassafras albidum), and sourwood (Oxydendron arboreum). Dominate understory species include greenbriar (Smilax sp.), mountain laurel (Kalmia latifolia), deerberry (Vaccinium stamineum), and blueberry (Vaccinium spp.) on drier sites, and rosebay rhododendron (Rhododendron maximum) on cove sites.

The TWRA manages Catoosa for multiple use through federal funds, and state fees from hunting and fishing licenses and user permit fees. Arney and Pugh (1983) listed 4 primary management objectives for Catoosa: (1) to provide opportunity for wildlife enjoyment for both the hunter and the observer; (2) to improve the quality and quantity of wildlife; (3) to improve the quality and quantity of timber within the concepts of sound wildlife management; and (4) to protect and manage threatened and endangered plants and animals. Currently, management plans exist for the white-tailed deer, eastern gray squirrel, and wild turkey. Management for ruffed grouse is incidental to activities conducted for these species.

III. The Study Areas

Two management compartments, identified as having good to excellent ruffed grouse habitat judged by criteria established by the TWRA, were chosen as study areas. The forest cover found on these areas is representative of Catoosa, and the Plateau as a whole. The 2 compartments support similar proportions of mountain laurel, a habitat feature important in the selection criteria. As this study evolved, it became apparent that the original study area, as defined by the 2 compartment boundaries, would require modification to incorporate all movements of ruffed grouse

captured and radio-marked in the compartments. Thus, the compartments described by Longwitz (1985) provided a study area for estimation of population density. The area actually used by radio-tracked grouse provided a study area for delineation of habitat utilization, and was termed the "Habitat Study Area."

Compartment Study Areas

Compartments 4 (528.0 ha) and 6 (444.8 ha) are located in the northwest corner of Catoosa (Figure 3). From Crossville, the compartments are accessible by Genesis Road, to Myatt Creek Road, which passes through the southwest corner of compartment 6 and forms the eastern boundary of compartment 4 (Figure 4). The topography is relatively flat on both compartments with exception of drainages that provide relief. Pine Creek bisects compartment 6, and eventually flows into Myatt Creek, which drains compartment 4. Forest composition is similar on both compartments, and is dominated by upland oak. Forest types and stand conditions for the 2 compartments were described by Longwitz (1985).

Habitat Study Area

During the first 2 years of this study, only 1 radio-equipped grouse traveled beyond the compartment boundaries. Its movements were described by Longwitz (1985), although

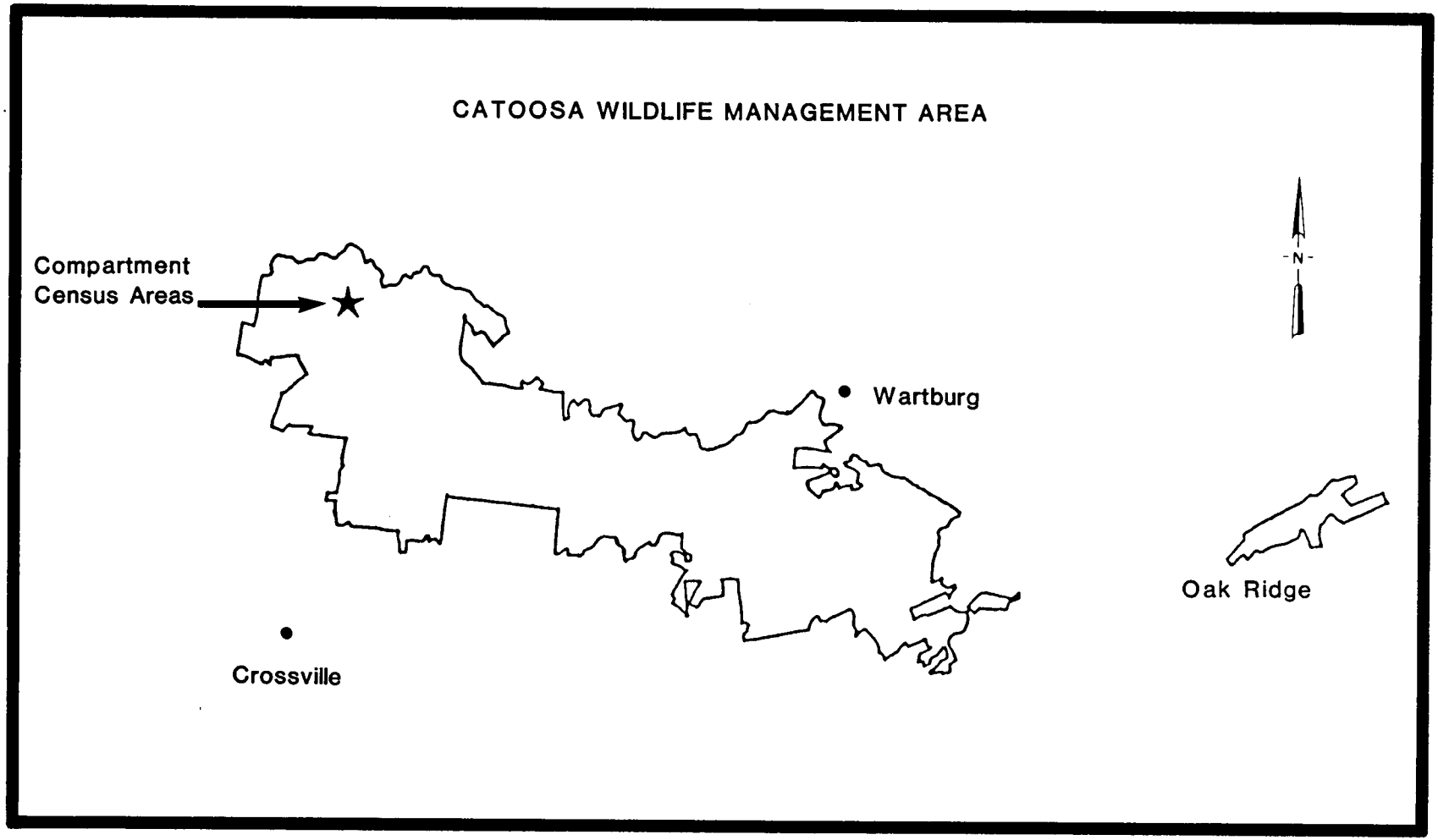


Figure 3. General Location of the Compartment Census Areas within the Catoosa WMA, Tennessee.

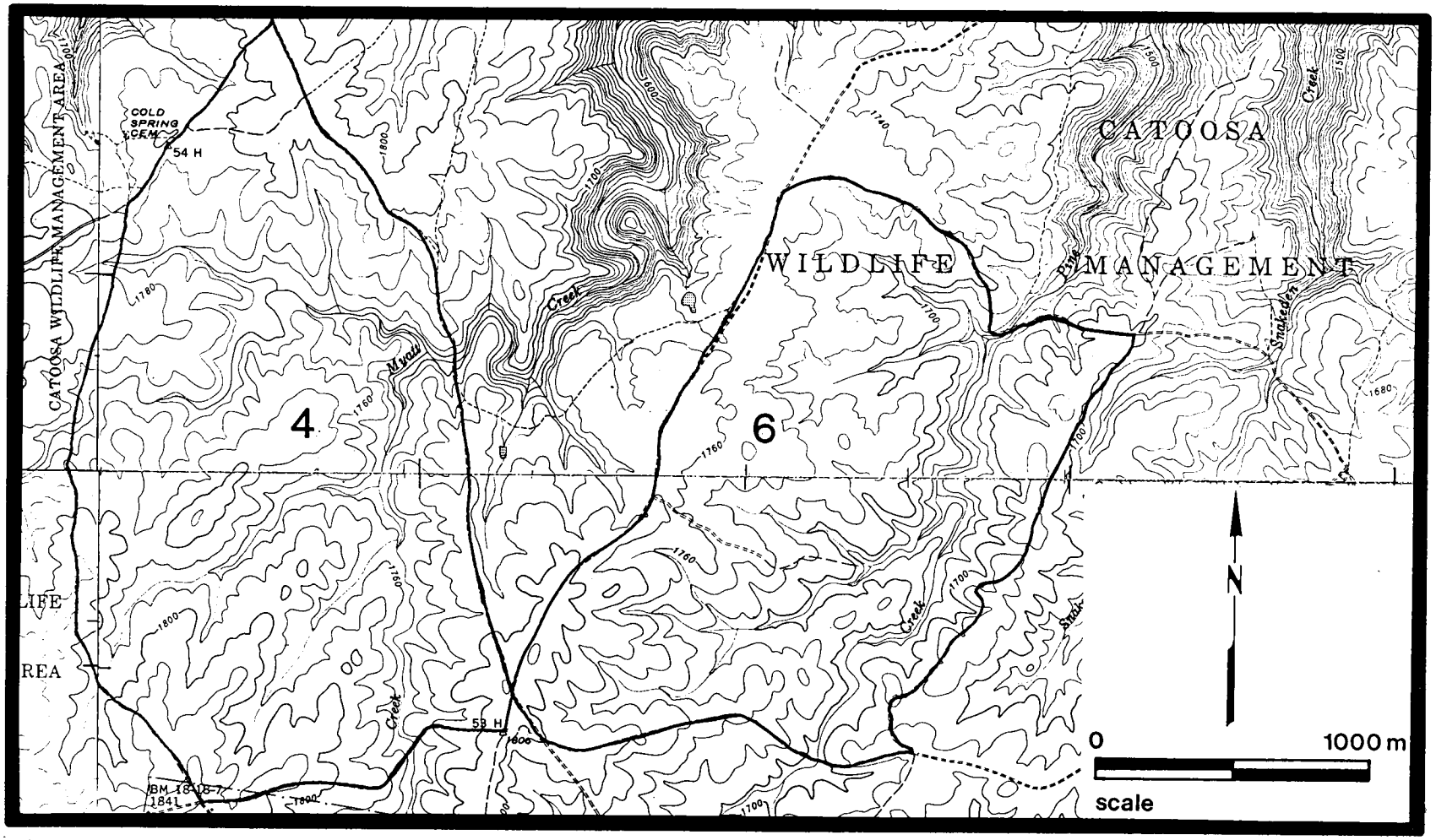


Figure 4. Location of Compartments 4 and 6 of the Census Area on the Catoosa WMA, Tennessee.

the off-site habitat used by the grouse was not delineated by cover type. Seven of 8 grouse monitored in 1985 and 1986 either occasionally peregrinated or dispersed entirely beyond the compartment boundaries. Consequently, a Habitat Study Area was defined to include the movements of radio-equipped grouse in order to determine proportionate use of habitat types (Figure 5).

Six habitat types were chosen to analyze ruffed grouse habitat utilization (Figure 6, Table 1). These habitat types were classified according to their structural characteristics with primary emphasis on the understory. As the ruffed grouse is a ground-dwelling bird, understory density and composition may be the most important factors in habitat selection. The emphasis on understory resulted in several habitat types that included 1 or more of the overstory forest cover types described by Longwitz (1985).

Vaccinium uplands (825.8 ha) was the dominant habitat type totaling 67.9% of the Habitat Study Area (Table 1). This habitat type was found along ridgetops and sideslopes (Figure 6). Understory species included deerberry, blueberry, and huckleberry (Gaylussacia baccata), which occurred in scattered, shrubby thickets. Sassafras, sourwood, flowering dogwood, and greenbriar were common in the generally sparse understory. The overstory was typically well-developed; major canopy species included

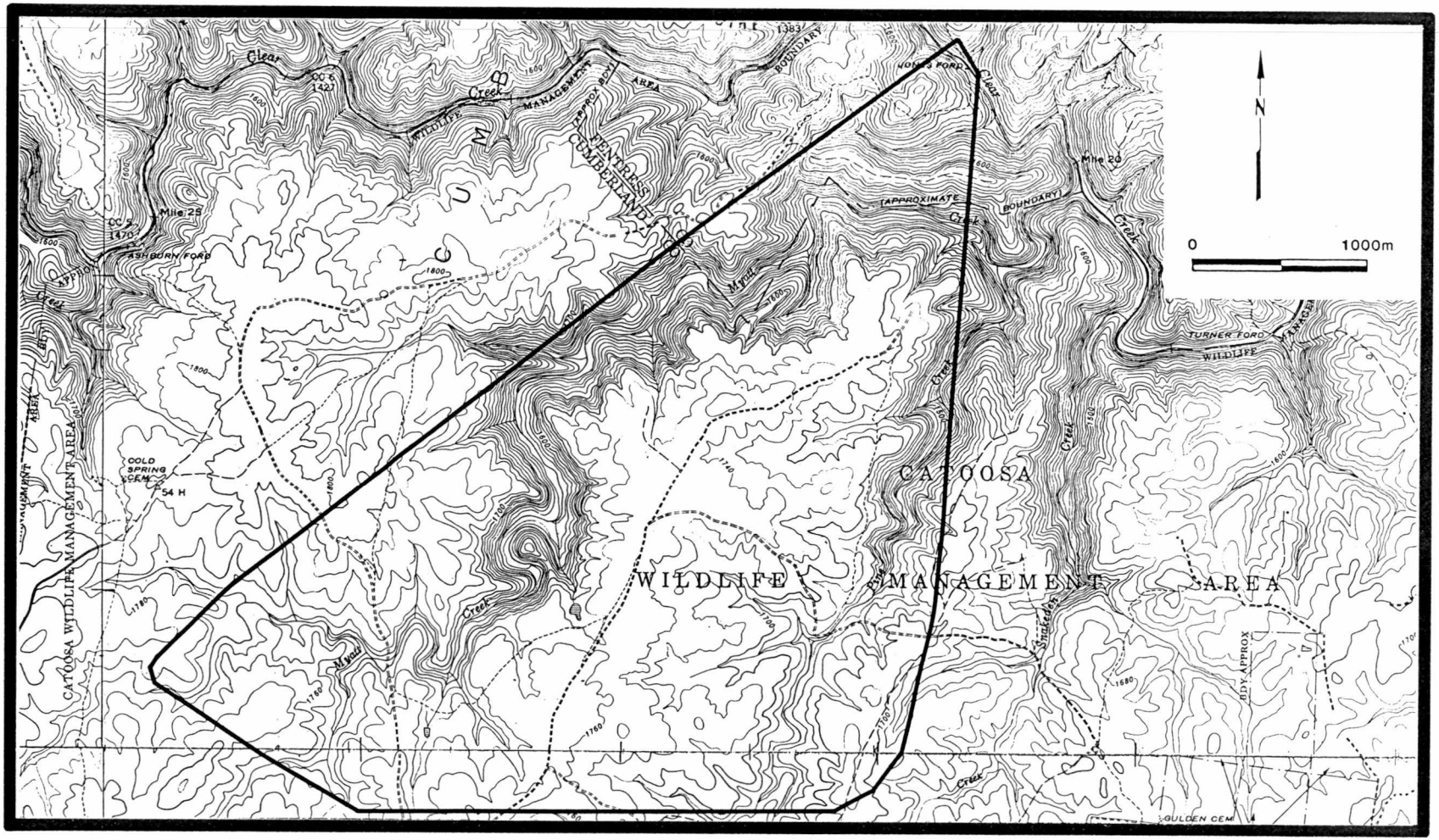


Figure 5. Location of the Habitat Study Area on the Catoosa WMA, Tennessee.

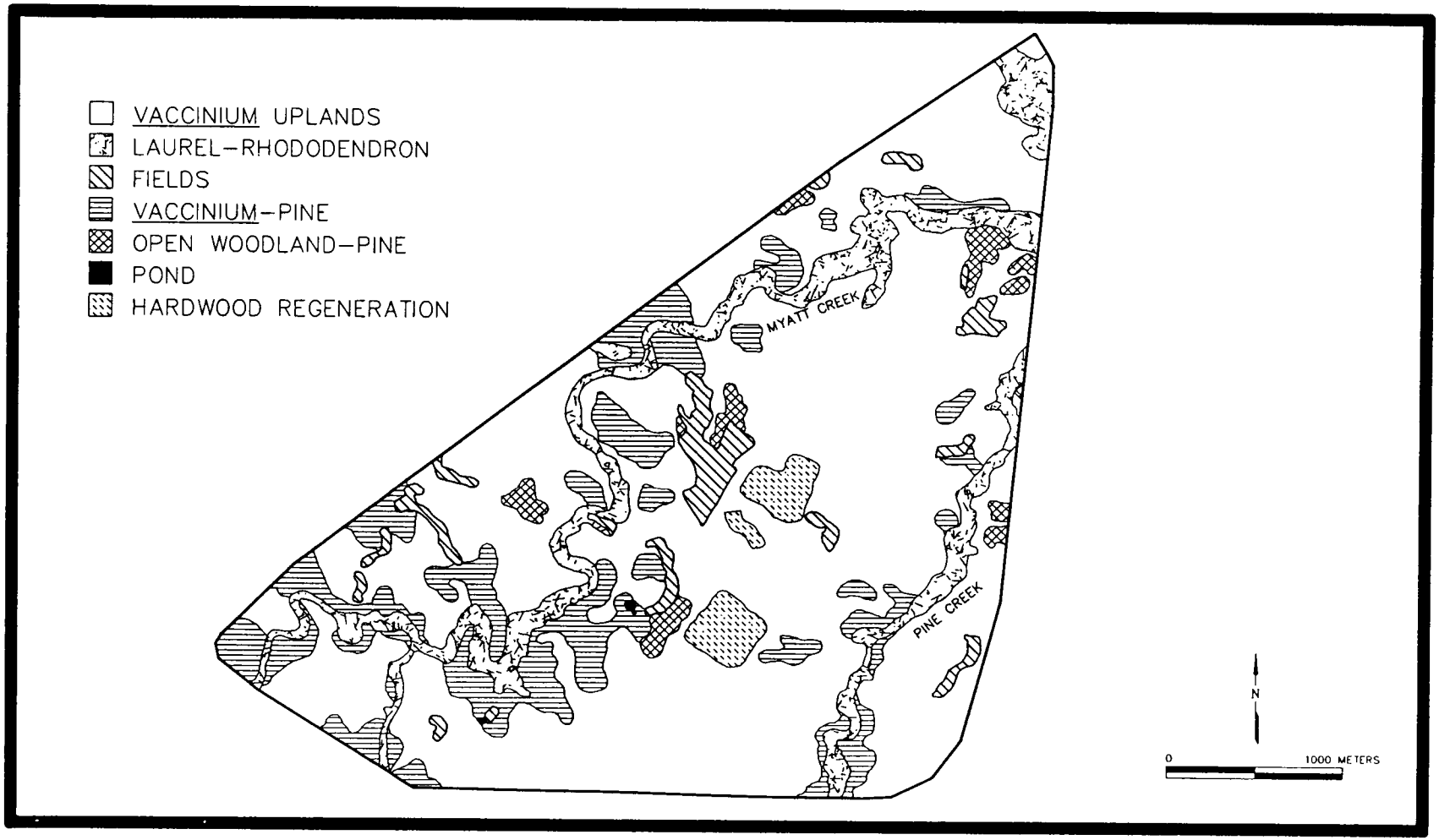


Figure 6. Habitat Types on the Habitat Study Area, Catoosa WMA, Tennessee.

Table 1. Habitat types delineated for the Habitat Study Area on the Catoosa WMA, Tennessee.

Habitat type	Total area (ha)	Percent of total area	Description
Vaccinium uplands	825.8	67.9	Understory dominated by shrub thickets of deerberry, blueberry and huckleberry; oaks dominated the overstory
Vaccinium-pines	164.4	13.5	Understory dominated by Vaccinium shrub thickets and pine seedlings and saplings; overstory contained mixed oak and pine
Laurel-rhododendron	130.8	10.8	Laurel and rhododendron understory; mixed oak and pine in smaller drainages, cove hardwoods in coves and ravines
Fields	42.8	3.5	Cultivated or fallow cropland and wildlife food plots
Hardwood regeneration	26.7	2.2	Clearcuts 6 and 12 years old with dense hardwood saplings and shrubs
Open woodland-pine	25.5	2.1	Widely scattered Vaccinium and blackberry understory beneath pine overstory
Total	1216.0	100.0	

scarlet oak (Q. coccinea), post oak (Q. stellata), black oak (Q. velutina), and southern red oak (Q. falcata). Associates included white oak, chestnut oak (Q. prinus), pignut hickory (C. glabra), mockernut hickory (C. tomentosa), red maple (Acer rubrum), blackgum, Virginia pine and eastern white pine. The following forest types identified by Longwitz (1985) represent the overstory types within the Vaccinium uplands habitat type: white oak-red oak-hickory; scarlet oak; scarlet oak-black oak; post oak-black oak; and white oak.

Vaccinium-pine (164.4 ha) totaled 13.5% of the Habitat Study Area; it occurred on the lower slope position adjacent to drainages (Figure 6, Table 1). Understory species included deerberry and blueberry, along with scattered to dense seedlings of white, shortleaf or Virginia pine. Additional species found in the understory included sassafras, flowering dogwood, greenbriar, serviceberry (Amelanchier arborea), black chokeberry (Aronia melanocarpa), and occasionally scattered mountain laurel. The understory was typically more dense than in Vaccinium uplands, particularly where pine regeneration existed. The overstory was dominated by mixed oak and pine species. The following forest cover types listed by Longwitz (1985) occurred in the overstory of the Vaccinium-pine habitat type: white oak-black oak-yellow

pine; southern red oak-yellow pine; Virginia pine-oak; and black oak-scarlet oak-yellow pine.

Laurel-rhododendron thickets were found along headwater drainages and in steep ravines (Figure 6). This broadleaf evergreen habitat type totaled 130.8 ha, and comprised 10.8% of the Habitat Study Area (Table 1). In the smaller drainages, the understory was dominated by dense mountain laurel with scattered rhododendron on the creek banks. The overstory in these areas was mixed oak and pine; forest cover types included those found in the overstory of the Vaccinium-pine habitat types. The understory in the steep ravines and coves contained dense rhododendron in the bottoms, transitioning to mountain laurel upslope. The overstory was dominated by cove species such as eastern hemlock, white pine, white and northern red oak, yellow-poplar, and American beech (Fagus grandiflora). The combination of dense mountain laurel understory and mixed oak and pine overstory was found mostly along Myatt and Pine creeks within the 2 compartment boundaries. The cove hardwood forest type with rhododendron and mountain laurel understory was located primarily along Myatt and Pine creeks outside of compartments 4 and 6.

Fields comprising 42.8 ha (3.5%) (Table 1) were scattered throughout the Habitat Study Area (Figure 6).

These areas are managed as wildlife food plots, some by sharecropping. Plantings include corn (Zea sp.), wheat (Triticum sp.), millet (Panicum sp.), crimson clover (Trifolium incarnatum), bicolor lespedeza (Lespedeza bicolor), and hairy vetch (Vicia villosa).

Hardwood regeneration totaled 26.7 ha (2.2%) prior to the silvicultural practices implemented during fall 1986 (Table 1). These clearcuts were previously upland oak stands, the type classified as Vaccinium uplands habitat type. They consisted of 3 stands located in the central portion of the Habitat Study Area (Figure 6). All of these stands were clearcut 3 to 9 years prior to initiation of this study. The smaller stand (2.3 ha) was harvested in 1973, and the 2 larger stands (11.3 and 12.9 ha) were harvested in 1979. The larger clearcuts had a high density (7,178.4-10,339.0 stems per ha) of hardwood seedlings and saplings (Waldrop 1983). Dominant overstory tree species in these clearcuts included scarlet, black, southern red, and post oaks, blackgum, and red maple. Dominant understory tree species included sassafras, flowering dogwood, and sourwood. The understory also contained dense blackberry (Rubus sp.), along with pokeweed (Phytolacca americana), deerberry, and blueberry.

Open woodland-pine stands were scattered throughout the Habitat Study Area (Figure 6). This habitat type

totaled 25.5 ha (2.1%) (Table 1). The understory was typically sparse, and contained scattered Vaccinium, Rubus, and pine seedlings. The overstory of this habitat type was dominated by monotypic stands of Virginia pine, eastern white pine, or shortleaf pine. The Virginia pine forest cover type listed by Longwitz (1985) for compartment 4 was the only open woodland-pine habitat type within the 2 compartment boundaries.

CHAPTER III

MATERIALS AND METHODS

I. Population Estimation

Enumeration of male ruffed grouse during the breeding season provided an estimate of the breeding population on the compartment study areas. This method was recommended by Gullion (1966) for estimating ruffed grouse density on areas 405 to 4050 ha in Minnesota. A minimum estimate of the crude density of adult males was obtained by summing the number of drumming males and nondrumming males located on the study areas.

The study areas were systematically searched for the presence of drumming males during early morning hours 1 to 2 days per week from late-March until mid-May. Drumming males were approached with caution to determine the exact location of the stage. Time and direction of drumming were noted to distinguish between adjacent males. Droppings and feathers were removed periodically to detect repeated use of a site. All stages were marked with plastic flagging tied overhead, and numbered, aluminum tags were nailed to the butt end of the log. Locations were plotted on a U.S.G.S. topographic map, and assigned coordinates using the Universal Transverse Mercator (UTM) grid system. At times, drumming stages were located by the accumulation of

droppings, though a drumming male may not have been heard at the log. These sites were catalogued similarly.

II. Chronology of Reproduction

Concurrent with drumming surveys, records were kept on the length and frequency of drumming activity. These data were used to determine the initiation, peak, and cessation of drumming on the study areas. Droppings and feathers were collected from stages as additional evidence. Estimated copulation and nesting dates were calculated by back-dating from a known age nest, and from the age of captured or observed broods (Bump et al. 1947). Length and frequency of drumming activity were recorded during the fall dispersal period.

III. Trapping

Mirror trapping was unsuccessful during the 1983 and 1984 breeding seasons. Male ruffed grouse were captured in the 1985 and 1986 breeding seasons using mirror traps similar to those described by Tanner and Bowers (1948). Modifications on the design, which led to trapping success included a trigger mechanism presented by Bendell and Fowle (1950), a latched cover on the trigger to prevent premature tripping, and use of a plexiglass drop fitted inside aluminum guides. Mirror traps were placed on all known

drumming sites in a male's activity center to increase the likelihood of capture. Traps were set after dark, and covered with conifer limbs to conceal their location and shelter a captured bird during inclement weather. Each trap was checked twice daily.

Interception traps (Liscinsky and Bailey 1955) were used to capture adult females and juveniles during the late summer brood-rearing period in 1985. These traps were used successfully to capture male grouse in their activity centers during 1983 and 1984. The unbaited traps were located near travel lanes, food sources, or flush sites in a variety of habitats. Jones (1979) found mountain laurel thickets to be the most productive trap sites on Catoosa. Traps were set in mountain laurel or Vaccinium thickets where easy access was provided by roads or trails. Initially, the traps were checked twice daily, but this activity was soon restricted to the late daylight hours as the trapping effort intensified.

Captured grouse were weighed to the nearest gram using a spring scale, and banded with aluminum leg bands. Birds were sexed by the number of dots on the rump feather (Roussel and Ouellet 1975), central tail feather length (Hale et al. 1954), and completeness of tail band (Davis 1969). Age was determined by presence of sheathing on the 3 outer primaries (Hale et al. 1954), and wing molt

progression (Bump et al. 1947). The condition and appearance of the grouse was noted, along with coloration of eye patch, ruff, and tail feathers. All birds were fitted with radio transmitters before being released at the capture site. Behavior upon release was recorded to determine the bird's adjustment to the transmitter.

IV. Radio Telemetry

Several configurations using different types of radio transmitters and attachment methods were used during the course of this study. Two different types of radios, each with different attachment techniques were used during 1983 and 1984. In 1983, battery-powered transmitters (Telonics, Inc., Mesa, Arizona) that weighed approximately 30 g were attached to captured grouse using a backpack harness mount (Brander 1968). A solar-powered radio transmitter (AVM Instrument Company, Ltd., Dublin, California) that weighed 13 g was attached to a grouse in 1984 using a vinyl poncho (Amstrup 1980). Two different types of radio transmitters were used during 1985 and 1986; both were attached to the grouse with ponchos. Three ruffed grouse were fitted with the same type of solar-powered transmitter that was used in 1984. Five grouse were equipped with a new style of battery-powered transmitter (AVM Instrument Company, Ltd.,

Dublin, California) that weighed only 19.0 g. The life expectancy of this unit was 18 months.

Radio Tracking

Radio-equipped grouse were located with a portable Telonics TR-2 receiver using a hand-held, 2 element yagi antenna (Telonics, Inc., Mesa, Arizona), and stereo headphones. Locations were obtained by triangulation using the loudest signal method (Springer 1979) to determine azimuths. UTM grid coordinates were determined for all stations used for bearing readings of grouse locations. Bearing azimuth was recorded, along with grouse identification number, date, time, and weather. For each location, 2-4 azimuths were taken from different stations, usually within a 10 minute period. An attempt was made to take readings from ground positions that yielded a pair of azimuths that intersected at right angles. Radio-equipped grouse were located approximately one day each week throughout the study with readings taken 1-4 times daily. In late-summer 1985, diurnal movements were monitored at hourly intervals from sunrise to sunset. An attempt was made to monitor each grouse by this technique at least once during a 4 week period.

Techniques other than triangulation were used to locate grouse at times. Birds were flushed to assess survival when successive daily locations occurred in the

same area. Family groups were occasionally flushed to determine brood size. Aerial tracking was conducted to locate dispersing juveniles whose movements were wide-ranging, and whenever birds could not be located otherwise. In these cases, a Cessna 172 or comparable aircraft with an antenna mounted on the wing strut was used to track grouse.

Directional Accuracy

Data were collected on the directional accuracy of the equipment using procedures described by Springer (1979). Five radio transmitters were placed at known map locations in an area representative of the topographic and vegetative features of the Habitat Study Area. Approximately 75 azimuth readings were taken on these radios from 3 locations. An error arc was calculated along with 95% confidence limits, and later used to construct an error polygon enclosing each telemetry location. Mean error polygon size was calculated for the telemetry locations of each individual bird, and all locations pooled.

V. Habitat Delineation

The Habitat Study Area (1216.0 ha) was defined by enclosing a polygon around the outermost telemetry locations of all grouse that were monitored for 3 or more consecutive readings. Locations for 2 juveniles that were

obtained only 1-2 times after dispersal were not used to define the polygon. Habitat types were mapped by photo-interpretation of a 1:24,000 color infrared photograph taken in 1982. The habitat types were digitized and acreages were calculated using AutoCad software.

VI. Data Analysis

Telemetry Data

Two azimuths taken from different stations were selected from the sample of azimuths for each location. Generally, only azimuths with intersections between 60 and 120 degrees were chosen. These azimuths and their corresponding receiving station UTM grid coordinates were input into the computer program "PLOTEQ" (Brody 1984). The program calculated the intersection of the azimuths and output the UTM grid coordinates for each location. An error polygon was constructed around each location based on the 2 azimuths and the error arc. The mean and standard error of the mean were calculated from error polygons associated with telemetry locations for each radio-equipped grouse, and error polygons for all locations.

Home Range

Home range was calculated using the output from PLOTEQ as input for the micro-computer program "McPAAL" (Stuwe and Blohowiak 1985). The minimum convex polygon (Hayne 1949)

and modified minimum area (Harvey and Barbour 1965) methods provided by McPAAL were chosen for telemetry data analysis. The minimum convex polygon is calculated by connecting the outermost points where 3 consecutive points of the polygon form an angle of 180 degrees or less. The minimum convex polygon may include some areas not frequented by grouse, but this method was selected because it has been widely used in other grouse studies and provides a basis for comparison.

The modified minimum area method calculates a smaller area than the minimum convex polygon method by enclosing all locations within a concave polygon. This method is more conservative because it eliminates those areas in the convex polygon where the grouse was not actually located by telemetry. A modified minimum area home range may omit areas between outermost locations that a grouse actually used, but for which a telemetry reading was not obtained.

The use of either home range method is a trade-off. Home range size (ha) was calculated by both methods to facilitate comparison with future studies. The minimum convex polygon method was used to determine home range shapes to simplify graphical representation, therefore, home range sizes described in the results section were calculated by this method. The discussion includes a comparison of home range sizes based on minimum convex

polygon and modified minimum area home ranges where appropriate data were available in the literature.

Mean home range size and standard error were calculated for both methods. Regression analyses were performed to detect any relationships between home range size and the number of days a grouse was monitored, or the number of locations used to calculate home range.

Diurnal Movements

Diurnal movements were gathered by locating grouse approximately every hour from sunrise to sunset. UTM grid coordinates from diurnal locations were calculated using PLOTEQ. For comparison, all distances between locations were standardized to a 1 hour interval. Diurnal movements were analyzed with respect to total daily movement, rate of travel, net movement, circuity, and daily range length (Garshelis et al. 1981). Total daily movement was calculated as the sum of distances between consecutive hourly locations. Rate of travel was calculated by dividing total daily movement by the number of hourly locations. Net movement was defined as the distance between the first and last hourly locations. Circuity was calculated by dividing the net movement by the total daily movement, where a value of 1 indicates straight line movement, and a value of 0 indicates that the grouse returned to the original location. The daily range length

was defined as the distance between the 2 farthest hourly locations.

SAS (SAS Inst., Inc. 1985) was used to analyze the diurnal data. Descriptive statistics were calculated for each parameter. The Mann-Whitney U-test was used to detect any significant differences between diurnal movements for 2 family groups.

Habitat Utilization

Ruffed grouse utilization of the 6 habitat types was analyzed using Chi-square goodness of fit tests and Bonferroni confidence intervals at the 0.05 level of significance (Neu et al. 1974). This method was used to analyze habitat utilization for all radio-equipped grouse. A Chi-square test of independence was used to determine if a habitat preference existed among the age-sex classes, then the Chi-square goodness of fit test and the Bonferroni confidence intervals were used to analyze the data for adult males, family groups, and post-dispersal juveniles, separately.

A basic assumption of the Chi-square goodness of fit test is independence of observations. Because locations were occasionally taken 1-4 times a day and hourly when studying diurnal movements, the location taken at a particular time may have depended upon the previous location. Using home range and diurnal movement data (this

study, page 70), it was determined that locations taken 3.5 or more hours apart were independent samples, and these data were used in the habitat utilization analysis.

CHAPTER IV

RESULTS

Field studies began on 30 March 1985, and continued to 19 May 1986. Intensive field work was conducted during the 1985 and 1986 spring breeding seasons, and during the late summer brood-rearing period in 1985. During the remainder of this study, field activities were conducted approximately once a week. Data from previous field studies, conducted from 17 March 1983 to 13 September 1984 (Longwitz 1985), were incorporated with data from this study.

I. Population Status

Compartment 4

The number of adult males located on compartment 4 varied widely between 1983 and 1984. During the 1983 breeding season, 5 activity centers were identified on the control area (Longwitz 1985). The location of these 5 adult males yielded a crude density estimate of 0.94 males per 100 ha (1 male per 106 ha) for compartment 4 (Table 2). In 1984, a single male grouse was using 3 of the activity centers on the control area previously occupied by different males in 1983 (Longwitz 1985). The remaining 2 activity centers were not occupied. The crude density

Table 2. Minimum population estimates of adult male ruffed grouse on the Catoosa WMA, Tennessee, 1983 to 1986.

Year	Control area (528.0 ha)			Experimental area (444.8 ha)		
	No. drumming males	No. non-drumming males[1]	Minimum population estimate[2]	No. drumming males	No. non-drumming males[1]	Minimum population estimate[2]
1983	5	0	0.94	0	0	-
1984	1	0	0.19	2	0	0.45
1985	2	0	0.38	1	1	0.45
1986	0	2	0.38	1	0	0.22
Average	2.0	0.5	0.47	1	0.2	0.28

[1]Several adult male grouse were known to reside on the study areas in 1985 and 1986, but were never heard drumming.

[2]Minimum population (males/100 ha) was estimated by totalling the number of drumming males and nondrumming males on the study areas.

estimate for 1984 was 0.19 males per 100 ha (1 male per 528 ha) (Table 2).

In 1985, one adult male was captured in a mirror trap in a new activity center on the control area. This bird occupied a portion of the activity center held by an adult male captured in 1984. An additional drumming male was located, but not captured, on the control area in an activity center that was occupied by a male in 1983. An average of 0.38 males per 100 ha, or 1 male per 263 ha, approximated the density of adult male grouse during the 1985 breeding season on the control area (Table 2).

There were no drumming males located on the control area in 1986. The activity center occupied by the grouse captured in 1985, and previously held by 1 or more birds for 2 preceding years, was vacant. Although no drumming activity was heard, 2 adult grouse were flushed in the northern portion of the control area during drumming surveys. These birds were believed to be males, due to body size and length of the tail feathers, and were included in the density estimate for 1986. The density for the control area was estimated as 0.38 males per 100 ha, or 1 male per 263 ha.

Compartment 6

In 1983, no activity centers were located on the experimental area (Longwitz 1985), nor was there any

drumming detected on this area. Consequently, an estimate of the population could not be obtained. In 1984, 2 activity centers were identified by Longwitz (1985). The density estimate for 1984 was 0.45 males per 100 ha, or 1 male per 222 ha (Table 2).

One drumming male was located on the experimental area in 1985, and captured in a mirror trap. This bird occupied a new activity center, plus 2 logs used by a male in 1984. The other activity center located in 1984 was not occupied in 1985. A nondrumming male was found on the experimental area in the summer of 1985. The data from 1985 suggest a minimum population estimate for the experimental area of 0.45 males per 100 ha, or 1 male per 222 ha (Table 2).

The male previously captured in 1985 was the only known drumming male on the experimental area in 1986. The additional activity center located on the area in 1984 was vacant during 1985 and 1986. The minimum population estimate for 1986 was 0.22 males per 100 ha, or 1 male per 445 ha (Table 2).

II. Breeding Ecology

Spring Drumming

In some cases, drumming activity was determined by the presence of droppings on logs when drumming was not heard. An attempt was made to visit each known drumming log during

every census of the study areas. Droppings were found on drumming logs during the first trip to the study areas each year (Table 3). In 1984, droppings were found on drumming logs as early as 19 March, 11 days before drumming was heard (Longwitz 1985). The earliest date of drumming activity was 27 March 1986, and drumming began on 3 April 1985 and 30 March 1984. In 1983, drumming censuses were not conducted until 25 April at which time grouse were drumming.

Drumming rates were not measured in 1983. Longwitz (1985) determined the frequency and duration of drumming for at least 3 birds during the 1984 breeding season. The shortest average interval between drums occurred on 11 April when 1 bird drummed at approximately 2:40 minute intervals. The peak of drumming activity as estimated by Longwitz (1985) was 11 April. The drumming interval roughly doubled in mid-May and tripled by late-May.

Drumming rates were measured for 3 birds on the study areas in 1985. A drumming interval of 7 minutes was measured for 1 of these birds on 5 April (Table 4). Drumming rates increased as the season progressed, the highest intensity occurring during 15 to 22 April. The interval between individual drumming bouts averaged 3:06 minutes for all birds (Table 4). Although the number of drumming males was small, the estimated peak of drumming

Table 3. Breeding chronology of ruffed grouse on the Catoosa WMA, Tennessee, 1983 to 1986.

Event	Year				Range
	1983	1984	1985	1986	
Earliest detected drumming log use by males	23 March	19 March	30 March	27 March	19-30 March
Spring drumming:					
Initiation	-	30 March	3 April	27 March	27 March
Peak	25 April	11 April	22-29 April	-	11-29 April
Termination	2 June	20 May	6 May	16 April	2 June
Copulation	4-8 April	-	10-14 April	-	4-14 April
Egg Laying	11-28 April	-	17-22 April	-	11-28 April
Incubation	28 April-21 May	-	4 May-1 June	-	28 April-1 June
Hatching	20-22 May	-	27 May-1 June	-	20 May-1 June
Fall drumming log defense/ selection	10-18 October	-	2 October-20 November	-	2 October-20 November

Table 4. Drumming rates observed on the Catoosa WMA, Tennessee, 1985.

Compartment	Date	No. birds heard drumming	No. drumming bouts heard	Average interval between drumming bouts (minutes)
4	3 April	2	N/A[1]	N/A[1]
4	5 April	1	4	7:00
6	6 April	1	1	N/A[2]
6	15 April	1	3	2:30
6	16 April	1	5	4:20
6	17 April	1	3	3:30
4	22 April	1	4	1:47
6	22 April	1	11	6:18
4	29 April	2	5	5:00
4	6 May	1	1	N/A[2]

[1]Drumming rates not measured.

[2]Birds drummed only once.

activity occurred between 22 to 29 April (Table 3). All males known to occupy the study areas were heard drumming during this time period. Drumming continued until 6 May and droppings were found on logs until 17 May 1985.

In 1986, only 1 drumming grouse was located on the study areas. This marked bird occupied an activity center on the experimental area in 1985 at which time 7 drumming logs were frequented. The bird occupied the same activity center in 1986, and was first heard drumming on 27 March. Drumming was heard again on 1 April when 49 droppings were found on 2 logs that were used by this grouse the previous year. The bird was heard drumming only once on each of these dates. The final drumming activity by this bird was recorded on 16 April when a single drum was heard, although censuses continued until 28 April. Consequently, the peak of drumming activity could not be determined for the 1986 breeding season.

Copulation and Nesting

Estimates of the dates of copulation and nesting of grouse on the study area were based on observations of 1 nest and 2 broods in 1983, and 2 broods in 1985 (Table 3). The dates of copulation and nesting were estimated by back-dating from the known ages of nests and broods.

In 1983, 1 ruffed grouse nest was observed approximately 13 km east of the study areas (Longwitz

1985). The nest contained an incomplete clutch of 6 eggs when first observed, and an estimated hatching date was anticipated for May 22. An empty nest was found on 20 May; broken egg shells indicated it was destroyed by a predator. No other nests were observed during the study.

Two broods were observed on the control area in 1983 (Longwitz 1985). The first brood was seen 22 May and contained chicks that appeared to be several hours to 3 days old. The second brood was estimated to be several hours to 3 days old when seen on 24 May. Hatching was back-dated to a range of 20 to 24 May for these broods. Copulation was thought to occur during 4 to 8 April 1983 (Table 3).

Ruffed grouse broods captured during August 1985 provided additional insight concerning the nesting chronology on the study areas. Four juvenile grouse were captured on the experimental area in an interception trap on 24 August. The age of these birds was estimated to be 12 weeks. One juvenile bird was captured on the control area on 26 August. This grouse was estimated to be 13 weeks old. Based on these brood observations and back-dating, dates of copulation were estimated to occur between 10 to 14 April. Hatching dates for these ruffed grouse broods were estimated to have ranged from 27 May to 1 June.

Fall Drumming

Fall drumming rates were obtained on the study areas and adjacent areas from 2 October to 20 November. No drumming surveys were conducted; observations of drumming were incidental to telemetry activities and occurred throughout the daylight hours. Drumming was heard on all 7 visits to Catoosa during this period. Intervals between drums averaged 3:20 minutes in October, increasing to 5:20 minutes in November. Grouse drummed throughout the day in the fall, whereas, in the spring, drumming occurred mostly in the early morning, and throughout the day only during continuous cloud cover.

III. Trapping Success

Four ruffed grouse were captured during 1983 and 1984 (Longwitz 1985) (Table 5). Interception traps were used during late summer 1983 and spring 1984. Six captures, including 2 recaptures were made with 23 traps set for a total of 437 trap days. Interception trapping resulted in a capture rate of 1 bird per 73 trap days. In 1983 and 1984, 4 mirror traps set for 43 trap days were unsuccessful.

Mirror trapping was conducted from 3 April to 22 May 1985. Traps were set in the activity centers of 3 males; 2 of the 3 were captured and equipped with radio transmitters

Table 5. Physical characteristics of 12 ruffed grouse captured and fitted with radio transmitters on the Catoosa WMA, Tennessee, 1983 to 1985.

Bird no.	Age	Sex	Date captured	Method of capture[1]	Body weight	No. dots per rump feather	Central tail feather length	Ruff length
146	Adult	M	21 Aug 1983	I	610 g	3	Molted	72 mm
147	Adult	M	6 Sep 1983	I	617 g	3	180 mm	90 mm
148	Adult	M	13 Sep 1983	I	660 g	3	188 mm	85 mm
149	Adult	M	4 Apr 1984	I	620 g	2	191 mm	88 mm
498	Adult	M	24 Apr 1985	M	612 g	2	187 mm	83 mm
495	Adult	M	8 May 1985	M	650 g	2	186 mm	87 mm
494	Adult	F	23 Aug 1985	I	590 g	1	155 mm	63 mm
470	Juv	F	24 Aug 1985	I	500 g	1	Molted	None
468	Juv	F	24 Aug 1985	I	485 g	1	Molted	None
466	Juv	F	24 Aug 1985	I	515 g	1	Molted	None
464	Juv	M	24 Aug 1985	I	530 g	2	Molted	None
491	Juv	M	26 Aug 1985	I	510 g	2	143 mm	69 mm

[1]Method of capture is either mirror trap (M) or interception trap (I).

(Table 5). Grouse 495 was captured twice on different drumming logs in an effort to determine the number of males and activity centers on the experimental area. During this period, 60 trap days yielded a success rate of 1 bird per 20 trap days (Table 6). Mirror trapping was conducted on 7 April 1986 in the activity center of adult male 495 on the experimental area. Three traps were set and the bird was captured the following morning. This grouse was re-captured for the purpose of removing a solar-powered radio that had lost its antenna. The defective transmitter was replaced with a battery-powered radio.

A brood of grouse was located on 8 August 1985. Efforts were initiated on 13 August to capture those and other grouse on the study areas by setting interception traps. Twenty-two traps were set from 13 August to 22 September for a total of 729 trap days. Six grouse (Table 5) believed to represent portions of 3 different families were captured, which yielded a success rate of 1 bird per 122 trap days (Table 6). Grouse broods were captured in a variety of habitats, as 1 bird was trapped by a mountain laurel thicket, another adjacent to a clearcut, and a multiple capture was made in a deerberry thicket in the uplands. All captures were made over a 4-day interval in late August, during a period of steady rain accompanying landfall of a hurricane on the Gulf coast.

Table 6. Success rate of ruffed grouse trapping using mirror and interception traps on the Catoosa WMA, Tennessee, 1985 and 1986.

Method	Period trapped	Number of trap days	No. of grouse captured	Trap days per capture
Mirror	15 Apr-22 May 1985	60	3	20
Interception	13 Aug-22 Sep 1985	729	6	122
Mirror	7 Apr 1986	3	1	3
Total		792	10	79

IV. Radio Telemetry

Directional Accuracy

The directional accuracy of the telemetry receiving equipment was tested in March 1986. Analysis of 72 directional readings taken on transmitters situated from 218 to 667 m from the receiver resulted in a mean error arc of 6.2 degrees (SE 0.5). At a 95% level of confidence, the mean error arc was between 5.2 and 7.3 degrees. Error polygons were calculated for each telemetry location using the mean error arc, and the azimuth bearings as input for PLOTEQ. The mean error polygon size (N = 379) that enclosed the true location of a grouse was 0.5 ha (SE 0.04) and ranged from 0.0 to 5.7 ha. Thus, on the average, radio-equipped grouse could be located to the nearest 35 m.

The largest mean error polygon from locations for an individual bird was 1.4 ha (SE 0.2), and was calculated from 7 telemetry locations for grouse 470. This bird occupied a home range within a steep drainage where locations had to be taken from widespread ridgetops. The mean error polygon determined from 40 locations taken for grouse 468 was 1.2 ha (SE 0.2). This bird also established a home range in an area of steep topography. In contrast, grouse 498 occupied relatively flat terrain, was easily accessible and could be approached more closely, resulting in smaller error polygons. The mean error

polygon based on 9 locations for this bird was 0.2 ha (SE 0.05). The mean error polygon for all other birds monitored during 1985 and 1986 was 0.5 ha, or less.

Radio Tracking

All ruffed grouse captured on the Catoosa WMA were equipped with radio transmitters and monitored by radio telemetry. During the 4 years of this study, 973 radio locations were obtained from 12 ruffed grouse monitored over periods ranging from 35 to 356 days (Figure 7). The mean tracking period was 141 days (SE 31). A mean of 81 (SE 40) telemetry locations was collected per grouse.

During the first 2 years, Longwitz (1985) collected a total of 261 radio locations on 4 ruffed grouse; the monitoring period ranged from 35 to 162 days (Table 7). A total of 712 locations was obtained from tracking 8 ruffed grouse during 1985 and 1986 (Table 8). These birds were monitored over periods that ranged from 46 to 356 days. The number of telemetry locations ranged from 14 for male 498 to 123 for female 493.

Equipment Performance

Three birds captured in 1983 were equipped with backpack-mounted, battery-powered radios that weighed approximately 30 g. The following year, a fourth bird received a solar transmitter, which was mounted on a

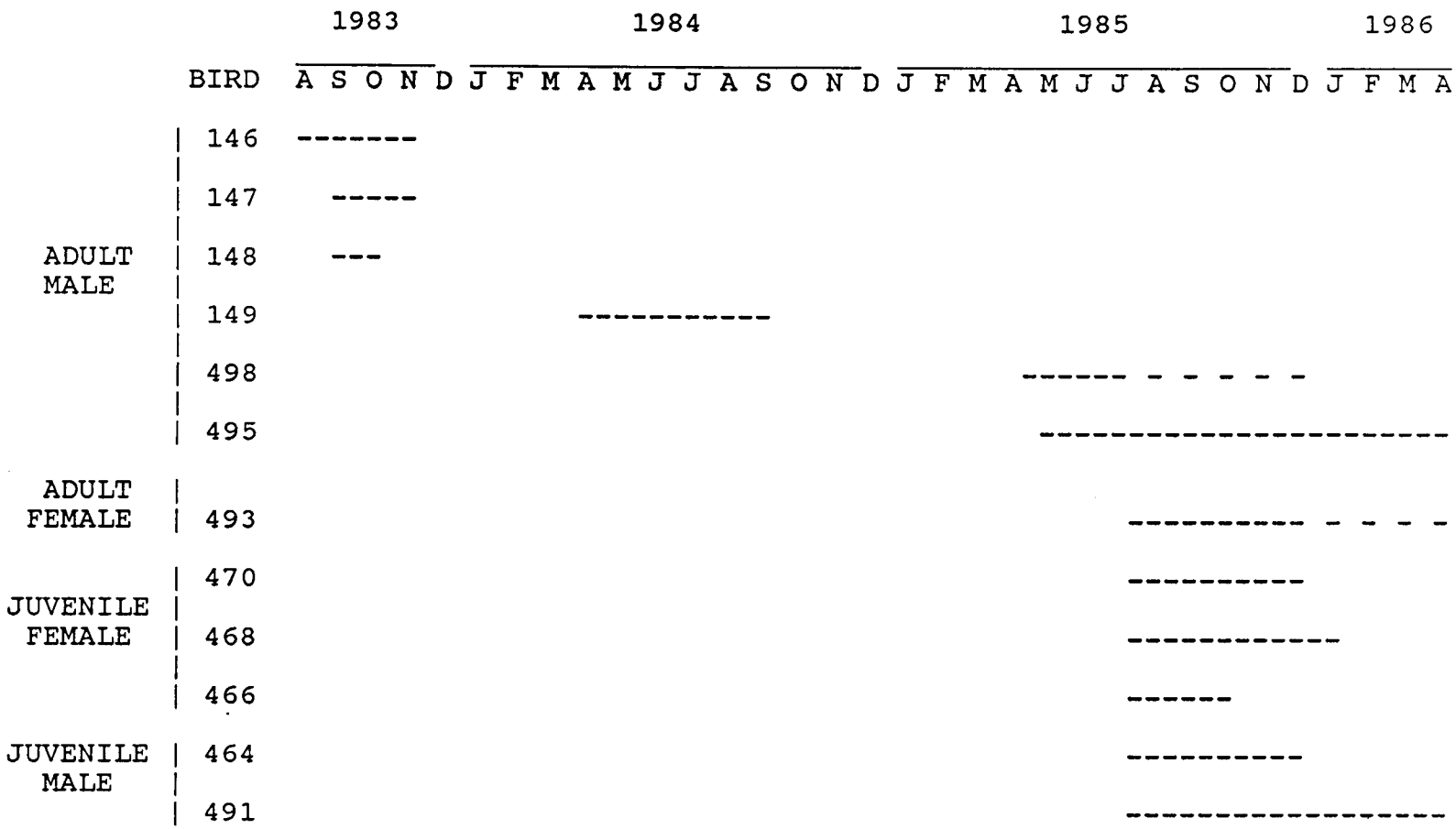


Figure 7. Duration of Telemetry Observations for 12 Radio-equipped Ruffed Grouse on the Catoosa WMA, 1983 to 1986. (-----) Represents Continuous Tracking Period, (- - -) Represents a Period of No Locations with only One Final Location in the Latest Month.

Table 7. Telemetry location data for 4 ruffed grouse captured on the Catoosa WMA, Tennessee, 1983 and 1984 (Longwitz 1985:31).

Bird no.	Age	Sex	Radio type	Period monitored	No. days	No. loc.	Final record
146	Adult	M	Battery	22 Aug 83-18 Nov 83	89	105	Recovered radio on 15 Dec. 1983; fate of bird unknown
147	Adult	M	Battery	6 Sep 83-18 Nov 83	74	83	Recovered radio on 15 Dec. 1983; bird had been predated
148	Adult	M	Battery	14 Sep 83-18 Oct 83	35	52	Found emaciated bird with antenna attached to a stem; bird was dispatched
149	Adult	M	Solar	5 Apr 84-13 Sep 84	162	21	Lost radio contact after 13 Sep. 1984
Totals					360	261	

Table 8. Telemetry location data for 8 ruffed grouse captured on the Catoosa WMA, Tennessee, 1985 to 1986.

Bird no.	Age	Sex	Radio type	Period monitored[1]	No. days	No. loc.	Final record
498	Adult	M	Solar	24 Apr 85- 3 Jul 85	71	14	Killed by hunter on 14 Dec. 1985
495	Adult	M	Solar	8 May 85-28 Apr 86	356	87	Telemetry study ended on 28 Apr. 1986
493	Adult	F	Battery	23 Aug 85- 3 Dec 85	103	123	Recovered radio on 28 Apr. 1986[2]; fate of bird unknown
470	Juv	F	Battery	24 Aug 85-16 Dec 85	115	120	Lost radio contact after 16 Dec. 1985
468	Juv	F	Battery	24 Aug 85-20 Jan 86	150	100	Recovered radio on 24 Jan. 1986[2]; fate of bird unknown
466	Juv	F	Battery	24 Aug 85- 8 Oct 85	46	115	Lost radio contact after 8 Oct. 1985
464	Juv	M	Battery	24 Aug 85- 3 Dec 85	102	116	Lost radio contact after 3 Dec. 1985
491	Juv	M	Solar	26 Aug 85-23 Apr 86	241	37	Lost radio contact after 23 Apr. 1986
Totals					1184	712	

[1]First day of period monitored represents the capture date for each grouse.

[2]Found detached transmitters of each bird along with several body feathers.

poncho. Grouse with battery-powered radios were located more frequently (52-105 locations) than the grouse with the solar-powered radio (21 locations). The monitoring periods totaled 198 days and 162 days for birds equipped with battery-powered and solar-powered radios, respectively. Although total length of the monitoring period was approximately equal, a comparison of the effectiveness of radio packages could not be made because there were fewer attempts to locate the grouse with the solar-powered transmitter.

During 1985 to 1986, battery-powered transmitters were attached to 5 grouse, and solar-powered transmitters were used on 3 birds. The battery-powered radios were smaller in size, weighing 37% less than the battery-powered radios used in 1983. An attempt was made to locate all radio-equipped grouse during each visit to the study area, but grouse with solar-powered radios were more difficult to detect, especially on cloudy days, or when birds were utilizing dense cover. The total number of days monitored was approximately equal for grouse fitted with both types of transmitters, yet the number of locations obtained from battery-powered radios (574) was over 4 times greater than the number of locations from solar-powered radios (138) (Table 9).

Table 9. Comparison of solar-powered and battery-powered transmitters used on ruffed grouse on the Catoosa WMA, Tennessee, 1985 and 1986.

Type of transmitter	Total number of days monitored	Total number of locations	Ratio (days/locations)
Solar-powered	668	138	4.62
Battery-powered	516	574	0.90
Totals	1184	712	

V. Grouse Mobility

Three aspects of ruffed grouse mobility were examined during this study: 1) home range size and shape; 2) daily movement characteristics; and 3) brood break-up and subsequent patterns of dispersal among juveniles. Grouse movements were not restricted to the predetermined study areas. Consequently, the boundary of the 1216 ha Habitat Study Area was formed by the outermost locations of radio-equipped birds.

Home Range Size

Home ranges were calculated for 6 adult male ruffed grouse, 1 adult female, 1 family group, and 2 post-dispersal juveniles (Table 10). Additionally, home range size of broods was determined for juvenile male 491 and adult female 493 by including only those locations taken prior to the date of dispersal for brood 460. Locations obtained after the dispersal date (see page 66) were used to calculate a post-dispersal home range for bird 491.

Home range size calculated by the modified minimum area ranged from 31.0% to 79.1% of the size of minimum convex polygon home ranges. Regression analyses indicated no relationship ($P = 0.15$) between the minimum convex polygon home range size and the number of telemetry

Table 10. Home range data for 12 ruffed grouse captured on the Catoosa WMA, Tennessee, 1983 to 1986.

Bird No.	Age	Sex	Period monitored	No. days	No. loc.	Home Range (ha)	
						Modified minimum area	Minimum convex polygon
146	Adult	M	22 Aug 83 - 18 Nov 83	89	105	52.7	96.4
147	Adult	M	6 Sep 83 - 18 Nov 83	74	83	12.5	15.8
148	Adult	M	14 Sep 83 - 18 Oct 83	35	53	20.7	28.6
149	Adult	M	5 Apr 84 - 13 Sep 84	162	21	16.8	54.2
N/A[1]	Brood	M,F	24 Aug 85 - 20 Sep 85	27	106	54.5	99.0
468	Juv	F	7 Sep 85 - 20 Jan 86	136	26	29.1	52.8
470	Juv	F	20 Sep 85 - 16 Dec 85	88	9	19.3	24.7
491	Brood	M	26 Aug 85 - 20 Sep 85	26	25	2.4	15.5
491	Juv	M	21 Sep 85 - 23 Apr 86	214	11	6.4	26.5
493	Brood	F	23 Aug 85 - 20 Sep 85	29	108	9.9	15.3
493	Adult	F	23 Aug 85 - 3 Dec 85	103	122	23.4	49.0
495	Adult	M	8 May 85 - 28 Apr 86	356	87	14.7	20.9
498	Adult	M	24 Apr 85 - 14 Dec 85	235	14	4.5	12.6

[1]Includes birds 464, 466, 468, and 470 that were monitored as a brood.

locations. Further analysis also indicated no relationship ($P = 0.21$) between the minimum convex polygon home range size and the number of days a bird was monitored. Similar results were obtained for the modified minimum area home ranges of all birds and for both home range calculations of adult male grouse as a subset of the data.

Adult males. The average range size for adult males was 38.1 ha (SE 13.2), based on the minimum convex polygon method. Data obtained from Longwitz (1985) was used in the home range calculations for birds 146, 147, 148 and 149. Adult male 146 traveled through several activity centers, and wandered over an area encompassing approximately one-third of its home range during the first 2 weeks of monitoring (Longwitz 1985). Consequently, those movements resulted in the largest individual range size (96.4 ha) (Figure 8). Home ranges of males 147 (15.8 ha) and 148 (28.6 ha) monitored on the control area during the same period were much smaller. The home ranges of all 3 males centered in laurel-rhododendron habitat.

The range size of the remaining 3 males, monitored in 1984, 1985 and 1986, varied from 12.6 to 54.2 ha (Table 10). Adult male 149 was the only grouse monitored on the control area in 1984, occupying a home range of 54.2 ha. The center of this home range was located in the activity

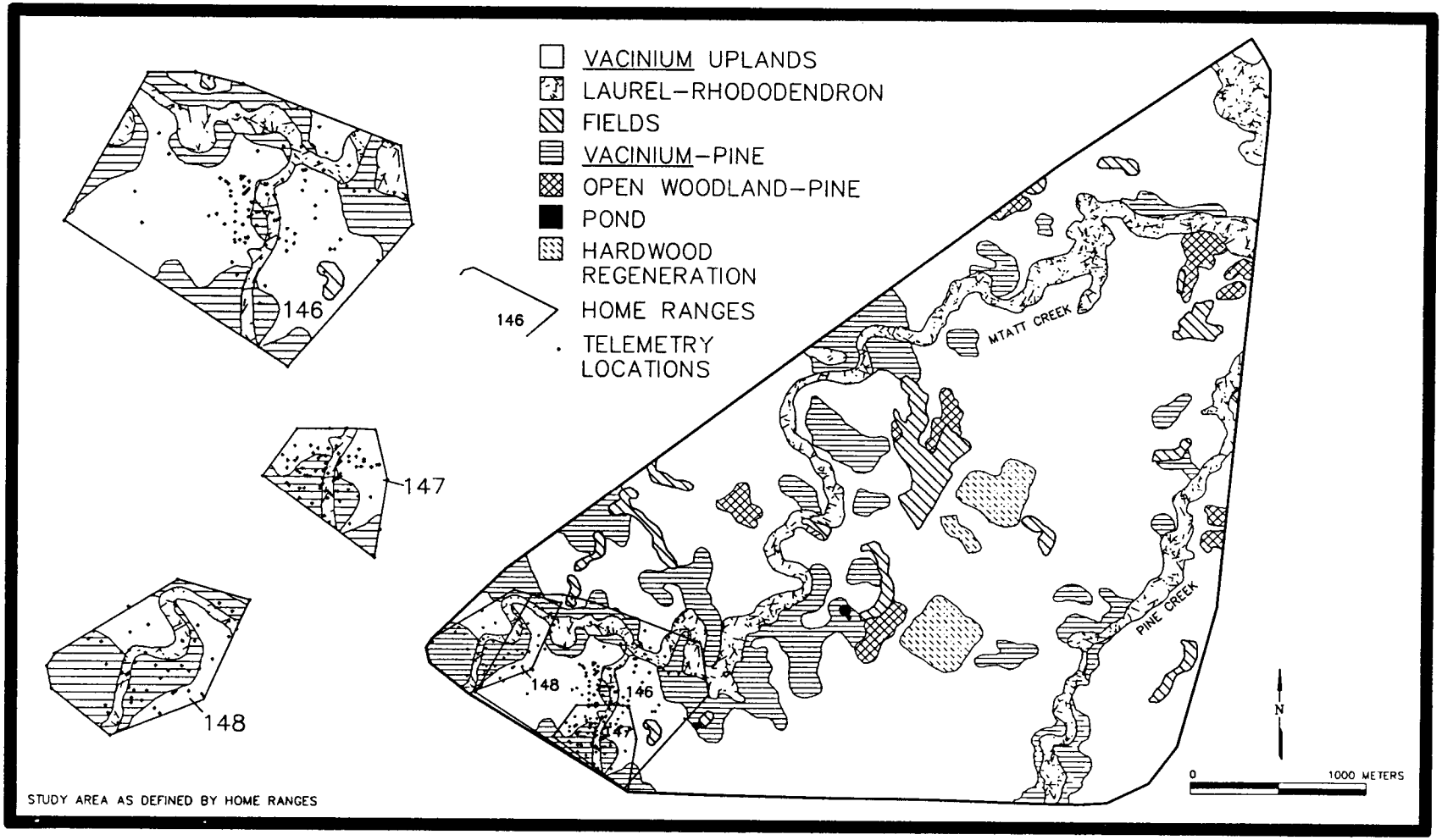


Figure 8. Home Ranges of Adult Male Ruffed Grouse 146, 147, and 148 on the Habitat Study Area, Catoosa WMA, Tennessee, 1983.

center used the previous year by bird 148 (Longwitz 1985) (Figure 9). The 12.6 ha home range of male 498 was the smallest in area of any bird monitored throughout the study, and was centered in laurel-rhododendron habitat. Adult male 495 was monitored for almost an entire year, but occupied a small home range totaling 20.9 ha. The center of activity was located in Vaccinium uplands habitat.

Family groups. The mean home range of 3 family groups monitored during the summer was 43.2 ha (SE 27.9). Brood 460, which consisted of grouse 464, 466, 468, and 470, travelled throughout the largest home range among family groups (99.0 ha) (Figure 10). This brood range was located in an extensive area of Vaccinium uplands. Family groups represented by juvenile male 491 and adult female 493 monitored during the same period inhabited smaller home ranges, totaling 15.5 and 15.3 ha, respectively (Figure 10). Female 493 was monitored after the brood period until 3 December 1985 when her radio was found along with several feathers. Her cumulative home range size was 49.0 ha.

Post-dispersal juveniles. Individual home ranges were not determined for juveniles 464 and 466 due to loss of radio contact during dispersal. Juveniles 468, 470 and 491 occupied a mean post-dispersal home range of 34.7 ha (SE = 9.1). Grouse 470 was tracked until radio contact was lost on 16 December 1985, and inhabited the smallest post-

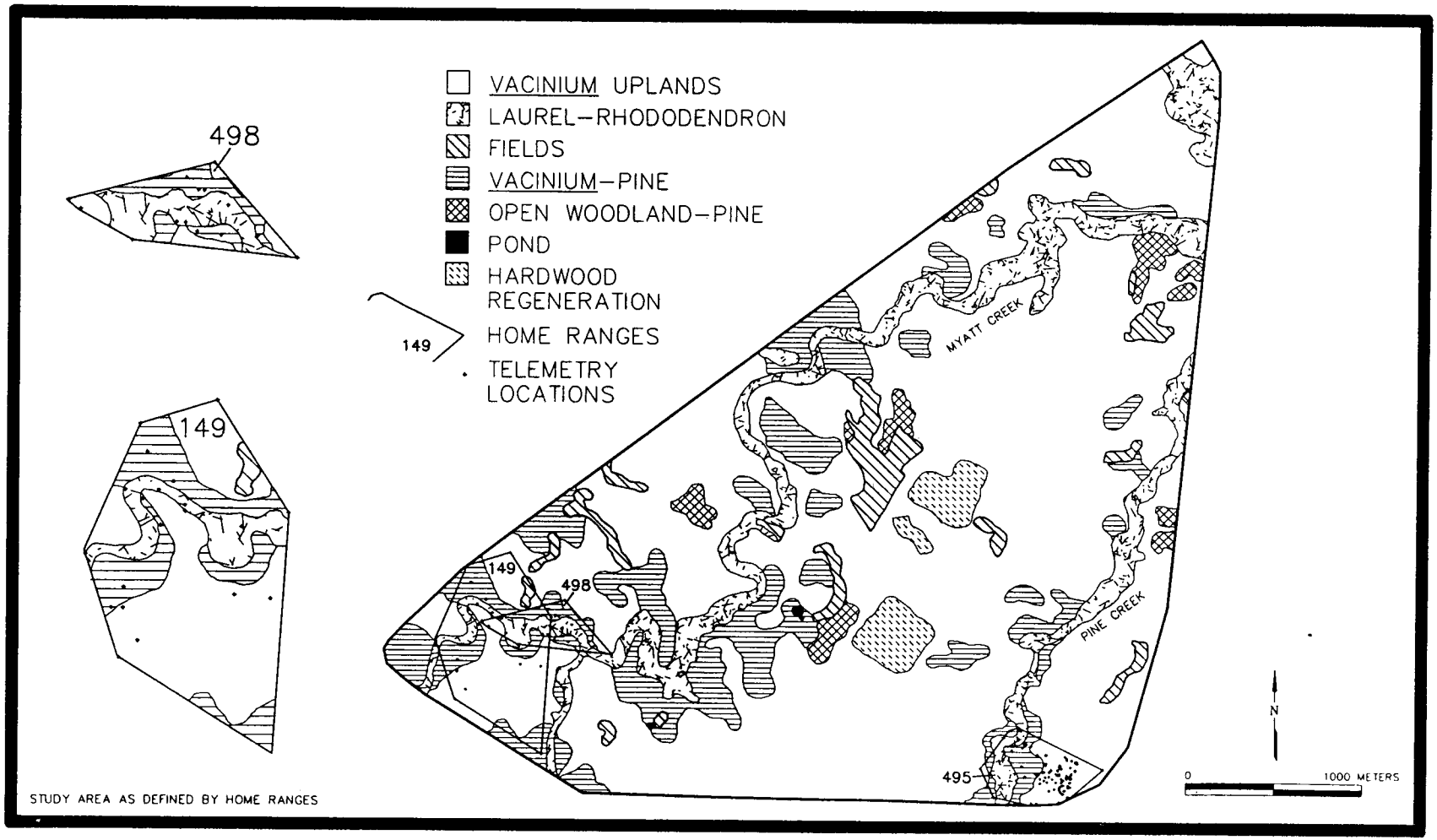


Figure 9. Home Ranges of Adult Male Ruffed Grouse 149, 495, and 498 on the Habitat Study Area, Catoosa WMA, Tennessee, 1984 to 1986.

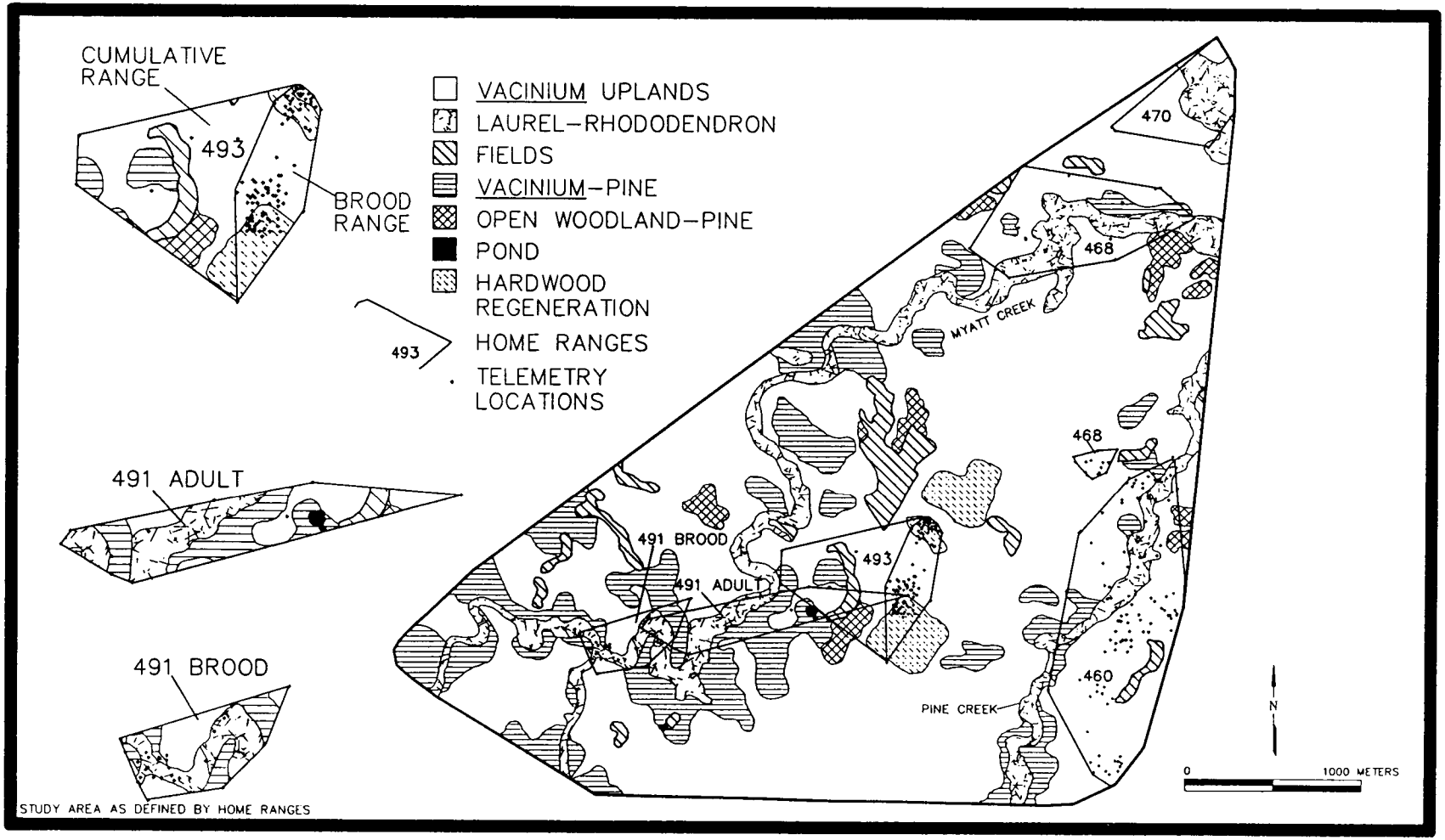


Figure 10. Home Ranges of Family Groups and Dispersed Juvenile Ruffed Grouse on the Habitat Study Area, Catoosa WMA, Tennessee, 1985 and 1986.

dispersal home range (24.7 ha) (Figure 10). Grouse 468, monitored until 20 January 1986 (136 days), utilized the largest home range (52.8 ha). Grouse 491 occupied a post-dispersal home range of 26.5 ha that slightly overlapped its brood range.

Diurnal Movements

Daily movements of ruffed grouse typically have been studied by examination of locations taken approximately 24 hours apart. Movements of this type were analyzed by White (1978) in Tennessee, and later defined as "consecutive day locations" by Gudlin (1984). These day-to-day movements were calculated as the straight line distance between consecutive locations and did not represent the distance actually travelled during the 24 hour period. Gudlin (1984) examined daily movements more closely by reducing the sampling interval to 2 locations obtained within a 4-11 hour period, which resulted in "same day locations." Neither method allows analysis of consecutive movements within a day, which can be termed "diurnal movements."

Diurnal locations taken approximately hourly from sunrise to sunset were obtained for 7 ruffed grouse on 13 occasions in late summer 1985. Family groups 460 and 493 were successfully monitored for diurnal movements on 5 days during the period 29 August to 18 September. Poor performance of their solar-powered radios permitted

recording diurnal movements only once for birds 491 and 493. Diurnal locations were obtained for grouse 468 during brood break-up.

The mean total daily movement was 946.1 m, and ranged from 514.2 m for family group 493 to 1554.8 m for family group 460 (Table 11). The mean rate of travel was 76.0 m/hr with a minimum of 39.6 m/hr for family group 493 and a maximum of 111.1 m/hr for family group 460. The mean net movement, circuity and daily range length (Table 11) all indicated that grouse tended to move in "irregular wanderings," a term used by Godfrey and Marshall (1969) to describe daily movements of grouse within their home range. The wandering movements of grouse on the study area were exemplified by a low mean circuity value of 0.15, and mean net movement of 160.7 m.

The most circuitous (0.04) travel was recorded for juvenile female 468 on 11 September 1985, and although the total daily movement was 817 m, the net movement was only 32 m (Figure 11). The least circuitous (0.39) movement was observed for family group 460, also on 11 September 1985 (Figure 11). The minimum values for total daily movement (514.2 m) and rate of travel (39.6 m/hr) were recorded for family group 493 that travelled a net of 36 m on 11 September (Figure 11).

Table 11. Diurnal movement statistics determined for 7 ruffed grouse over 13 days on the Catoosa WMA, Tennessee, 1985.

Variable	Mean[1]	Standard deviation	Standard error	Minimum	Maximum	Range
Total daily movement	946.1	282.8	78.4	514.2	1554.8	1040.6
Rate of travel	76.0	21.2	5.9	39.6	111.1	71.5
Net movement	160.7	149.3	41.4	31.6	461.7	430.1
Circuity	0.15	0.12	0.03	0.04	0.39	0.35
Daily range length	268.7	122.6	34.0	116.6	520.1	403.5

[1]Values are in meters, except rate of travel (m/hr) and circuity (value of 1 = straight line movement and 0 = return to original location).

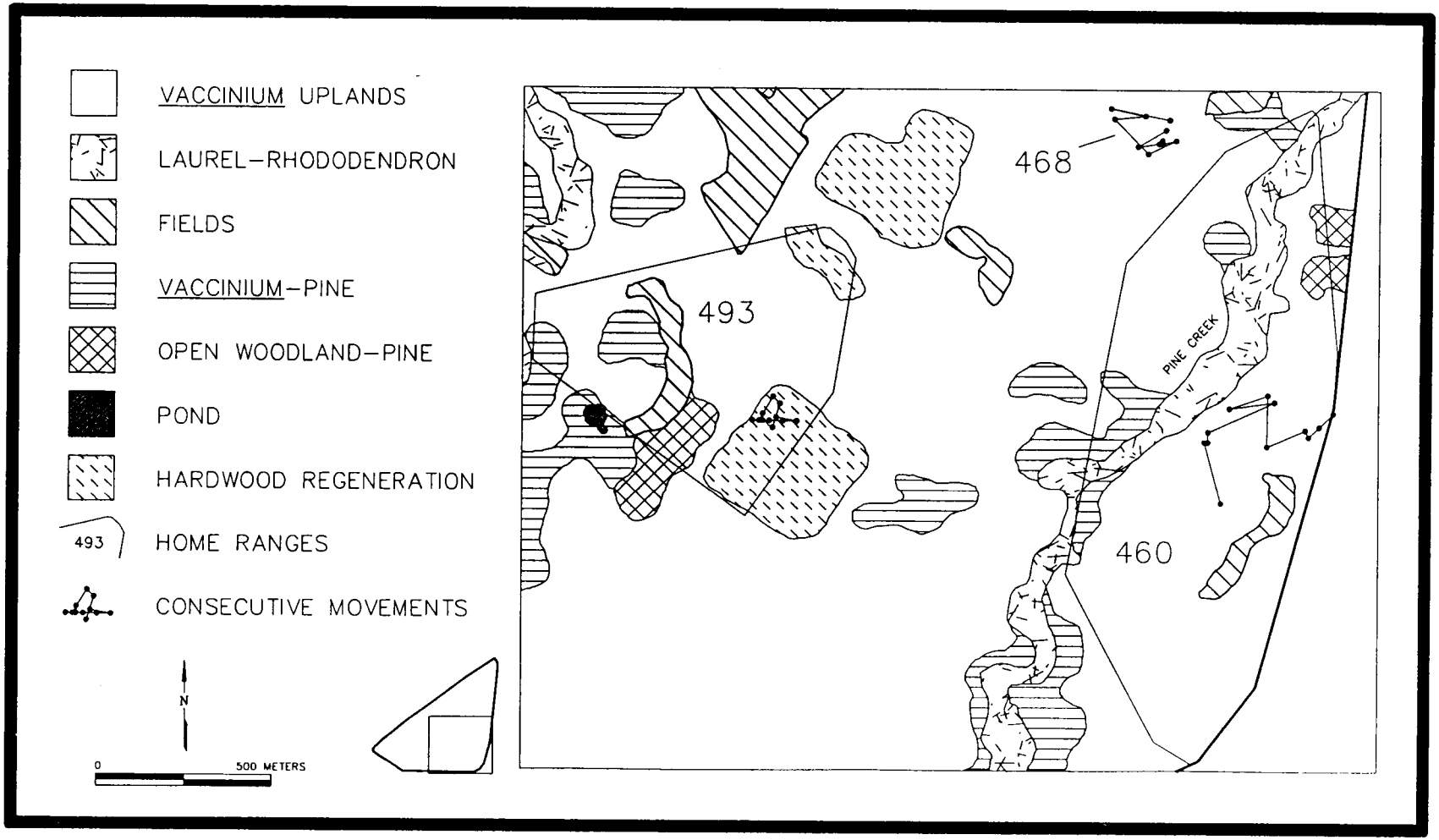


Figure 11. Diurnal Movements of Family Groups 460 and 493 and Juvenile 468 During 11 September 1985 on the Catoosa WMA, Tennessee.

Diurnal movements of family groups 460 and 493 were significantly ($P < 0.05$) different for all parameters (Table 12). Mean total daily movement observed for family group 493 (786 m) equalled 66% of the mean for family group 460 (1189 m). Net movement and daily range length were also considerably smaller for family group 493 (Table 12) (Figure 11). The average daily range size determined by the minimum convex polygon method for diurnal movements of family group 460 was 6.8 ha, whereas, the range size of family group 493 averaged 1.3 ha.

Brood Break-up and Dispersal

The brood of 4 juveniles in family group 460 traveled together for 2 weeks after their initial capture on 24 August 1985 until 6 September, when female 468 separated from the others. The intact brood was last located prior to sunset on 5 September in Vaccinium uplands habitat east of Pine Creek, and north of the experimental area (Figure 12). The brood moved about 380 m (all distances are approximate) northwest to Pine Creek and radio signals were received for all birds except female 468 on the evening of 6 September, indicating that brood break-up had begun earlier that day. At 12:30 p.m. CDT on 7 September, grouse 468 was located in Vaccinium-pine habitat west of Pine Creek, 430 m northwest of her last location on 5 September. The remaining 3 were located at 12:42 p.m. on 7

Table 12. Comparison of movement variables for 2 broods of ruffed grouse occupying different habitats on the Catoosa WMA, Tennessee, August to September 1985.

	Brood 460		Brood 493		
Variable	Mean[1]	SE	Mean[1]	SE	P-value[2]
Total daily movement (m)	1189	102.8	786	94.2	0.01
Rate of Travel (m/hr)	93	6.8	61	8.0	0.01
Net movement (m)	302	66.4	94	24.7	0.01
Circuity[2]	0.3	0.06	0.1	0.03	0.01
Daily range length (m)	379	48.9	200	40.8	0.01

[1]Number of observations for both broods = 5.

[2]Significance level obtained from 2-tailed Mann-Whitney U-test.

3Calculated from net movement/total daily movement.

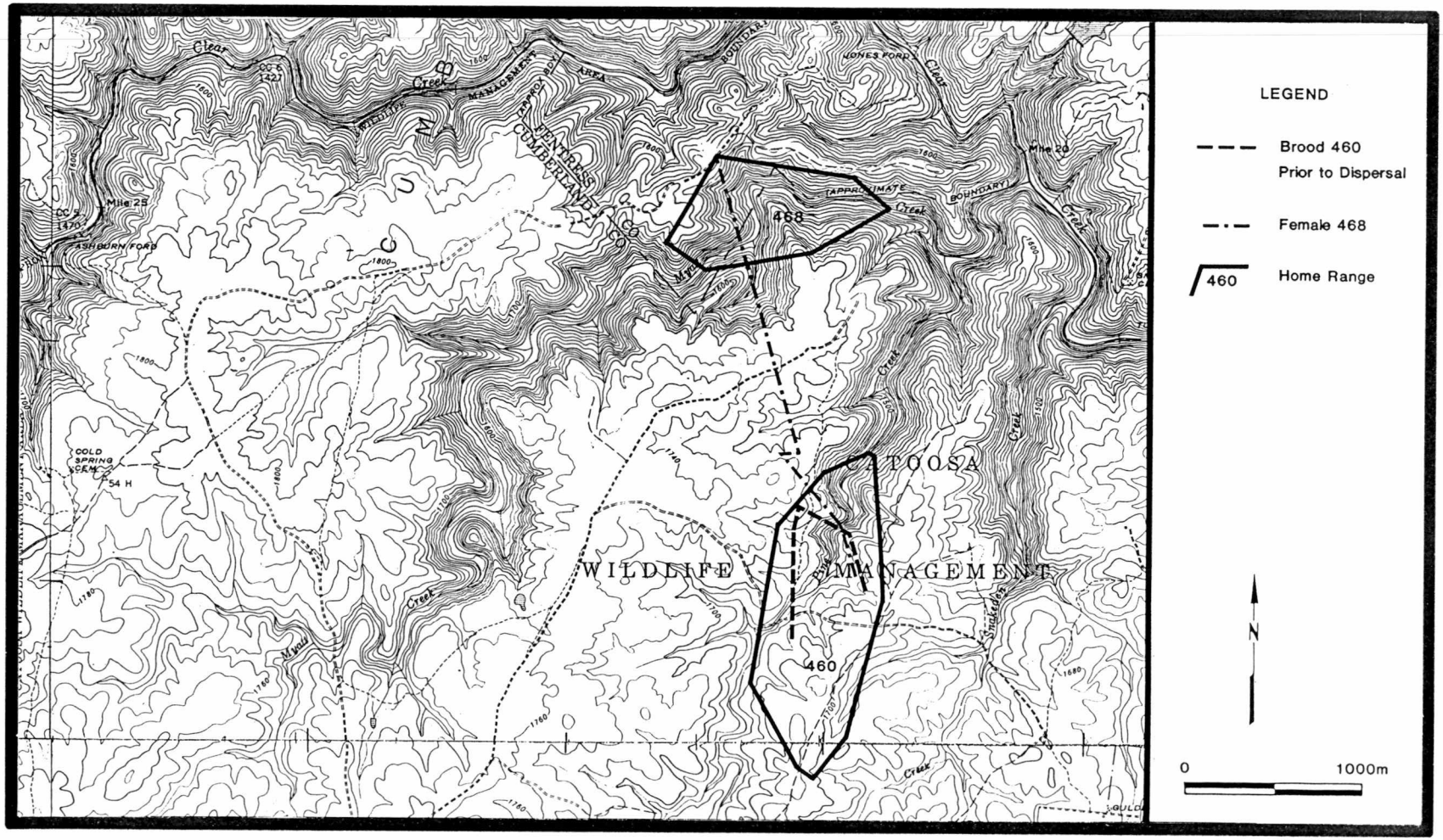


Figure 12. Movements of Juvenile Female 468 During Brood Break-up and Dispersal on the Catoosa WMA, Tennessee, 1985.

September in Vaccinium uplands habitat 200 m west of grouse 468.

Juvenile 468 then moved 490 m north-northwest on 8 September to Vaccinium uplands habitat where she remained through 11 September (Figure 12). During this period, she used the Vaccinium uplands habitat type exclusively, within an area encompassing 2.6 ha. This break-up range (Godfrey and Marshall 1969) was based on 17 locations, including diurnal movements on 11 September. Juvenile 468 was next relocated 17 September 1.8 km north-northwest from her break-up range. Grouse 468 remained within her 52.8 ha post-dispersal range until 20 January 1986 when the transmitter and remains of the bird were found. From point of capture, the center of her post-dispersal home range was 3.2 km.

The 3 remaining members of family group 460 travelled together within the brood range until the evening of 18 September when they were located in the northern corner of the range (Figure 13). These grouse then began moving north, and were last located together at 9:30 a.m. CDT, 20 September, north of the junction of Pine and Myatt Creeks, a straight-line movement of 1.5 km from the last location within the brood range. The brood began final break-up after the morning of 20 September. That evening, bird 464 was located 300 m to the southwest, and bird 470 was found

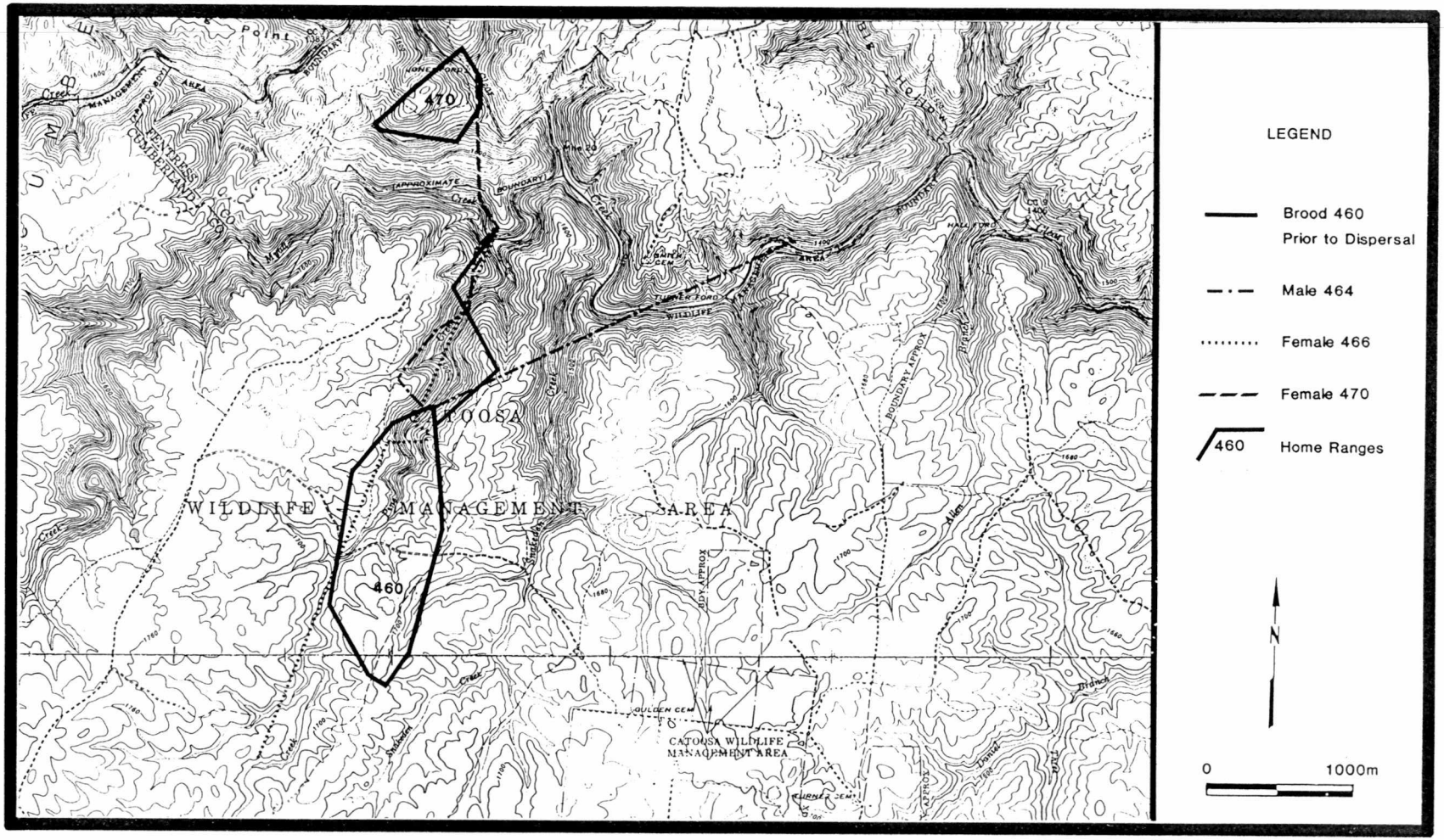


Figure 13. Movements of Juvenile Grouse 464, 466, and 470 During Brood Break-up and Dispersal on the Catoosa WMA, Tennessee, 1985.

220 m to the northwest of their previous location (Figure 13). Juvenile 466 was not located until the following day when it had returned to its former brood range, 1.5 km from the point of brood break-up.

During the next 2 to 3 days, movements of these juveniles were wide-ranging as they travelled through temporary break-up ranges in route to final dispersal locations (Figure 13). The exception was juvenile female 470 that did not appear to establish a break-up range. She travelled 900 m north to an area that become her post-dispersal home range. The distance moved was 980 m from the point of brood break-up, and 4.0 km from point of capture to the center of the bird's post-dispersal home range. Juvenile male 464 moved randomly to the west and southwest in a break-up range, and was last located in this area on 22 September, 1.4 km from the point of brood break-up. The bird was not located again until 8 October after dispersing 2.1 km east of the brood break-up location, and 2.9 km northeast of the capture location. One final location was obtained in the same vicinity for this bird before radio contact was lost. Juvenile female 466 was located 3 times on the former brood range during 21 and 22 September before radio contact was lost temporarily. A final observation of bird 466 was obtained 8 October on the experimental area 4.0 km from the point of brood break-up,

and 1.0 km from point of capture. Radio contact was lost afterwards.

Juvenile grouse 468 and 470 exhibited unidirectional movements from point of brood break-up to their chosen post-dispersal home ranges. Although the destination of grouse 466 was unknown due to loss of radio contact, unidirectional movements were observed from the point of brood break-up to its last location.

Rate of movement and duration of dispersal were not determined due to difficulties in locating the wide-ranging juveniles. Radio contact was temporarily lost for all dispersing juveniles after 22 September, and was not reestablished until 8 October, when an airplane was used to locate the birds. The juveniles eventually dispersed north-northwest (468), north (470), and northeast (464) of their point of capture into steep ravines located along creeks. From point of capture to the center of post-dispersal home ranges, the distance dispersed ranged from 2.9 to 4.0 km for these birds.

Juvenile male 491 did not exhibit obvious dispersal movements, but gradually shifted his range east into a steep ravine dominated by laurel-rhododendron. It was not determined if this bird established a break-up range. The distance between the center of its brood range and the center of its post-dispersal range was 760 m. From point

of capture, the center of the post-dispersal range was 1.2 km.

VI. Habitat Utilization

Preference or avoidance of cover types was determined using selected locational data from all ruffed grouse that were monitored by radio telemetry from 1983 to 1986. Due to the short time interval between some telemetry locations, a lack of independence of observations would bias the results obtained from the Chi-square goodness of fit test. Therefore, redundant locations were eliminated from the data set based on a technique used by Garshelis (1978).

The average range length, or distance between the 2 farthest points, for all home ranges of individual grouse was 1035 m (SE 78). Based on the mean total daily movement of 946.1 m, which was a minimum due to the measurement of straight-line distances between hourly locations, a grouse was capable of traversing its home range in a single day. Although a grouse could travel across its home range in 1 day, most bird's moved in a circular pattern. Thus, using data from recorded diurnal movements, the time period necessary for a grouse to move between the 2 farthest points in its daily range was 3.5 hours (mean daily range length (268.7 m) divided by the mean rate of travel (76.0

m/hr)). Therefore, locations taken at least 3.5 hours apart should represent a fair sampling of a bird's utilization of its habitat. Locations taken within a shorter time period were omitted from the analyses, except for when the cover type differed between successive locations. Locations in different cover types were considered to be independent movements, and these data were used in the analysis.

A Chi-square goodness of fit test revealed that habitat types were not used by ruffed grouse in proportion to their availability (Chi-square = 166.7, df = 5, $\underline{P}$ = 0.005). Habitat type utilization and preference was determined from 534 observations from all radio-equipped birds on the study area from 1983 to 1986 (Table 13). Fields and open woodland-pine habitats were usually avoided by ruffed grouse. Vaccinium uplands was used less than expected. A preference was exhibited for laurel-rhododendron, hardwood regeneration, and Vaccinium-pine habitats.

A Chi-square test of independence indicated significant differences (Chi-square = 134.7, df = 10, $\underline{P}$ = 0.005) in habitat utilization between the age-sex groups. Thus, additional Chi-square goodness of fit tests were performed to determine if habitat preferences existed among adult males, family groups, and post-dispersal juveniles.

Table 13. Habitat type utilization and preference for 12 ruffed grouse on the Catoosa WMA, Tennessee, 1983 to 1986.

Habitat type	Total area (ha)	No. loc. observed	Proportion of obs. loc. (P_i)	P_j[1]	95% C.I.[2]	Preference
Vaccinium uplands	825.8	278	0.521	0.679	$0.464<P_i<0.578$	-
Vaccinium-pine	164.4	96	0.180	0.135	$0.136<P_i<0.224$	+
Laurel-rhododendron	130.8	119	0.223	0.108	$0.175<P_i<0.270$	+
Fields	42.8	2	0.004	0.035	$0<P_i<0.011$	-
Hardwood regeneration	26.7	37	0.069	0.022	$0.040<P_i<0.098$	+
Open Woodlands-pine	25.5	2	0.004	0.021	$0<P_i<0.011$	-
Total	1216.0	534	1.001	1.000		

[1]Theoretical proportion of occurence expected as if grouse were located in each habitat type in proportion to availability.

[2]Simultaneous interval estimate on the proportion observed, and is compared to the corresponding P_j to determine preference.

Adult Males

Utilization of the 6 habitat types was significantly different (Chi-square = 125.4, df = 5, P = 0.005) for adult males. Analysis of 324 locations of 6 adult male ruffed grouse monitored from 1983 to 1986 revealed a preference for Vaccinium-pine and laurel-rhododendron habitat types (Table 14). Vaccinium uplands and fields habitats were used less than expected, based on availability. There were no observations of adult males in hardwood regeneration or open woodland-pine cover types. Adult male ruffed grouse frequented areas near drumming logs located in laurel-rhododendron and Vaccinium-pine habitats throughout most of the year. Utilization of these habitat types in the vicinity of drumming logs occurred from March through November. In December 1985, 5-8 cm of snow blanketed the ground during 2 visits to the study area, and adult male grouse were located in Vaccinium-pine habitat.

Seasonal use of habitat types was exhibited by grouse 495 based on its movement from a spring and summer range to a fall and winter range. The bird utilized Vaccinium uplands for most of the spring and summer with occasional travel to Vaccinium-pine. In late fall, the bird was found in Vaccinium-pine and laurel-rhododendron habitats. During winter he used primarily laurel-rhododendron, with secondary use of Vaccinium-pine habitat. Several secondary

Table 14. Habitat type utilization and preference for 6 adult male ruffed grouse on the Catoosa WMA, Tennessee, 1983 to 1986.

Habitat type	Total area (ha)	No. loc. observed	Proportion of obs. loc. (P_i)	P_j[1]	95% C.I.[2]	Preference
Vaccinium uplands	825.8	160	0.494	0.679	$0.424<P_i<0.563$	-
Vaccinium-pine	164.4	86	0.265	0.135	$0.204<P_i<0.327$	+
Laurel-rhododendron	130.8	76	0.235	0.108	$0.176<P_i<0.293$	+
Fields	42.8	2	0.006	0.035	$0<P_i<0.017$	-
Hardwood regeneration	26.7	0	0.000	0.022	N/A	N/A
Open woodland-pine	25.5	0	0.000	0.021	N/A	N/A
Total	1216.0	324	1.000	1.000		

[1]Theoretical proportion of occurence expected as if grouse were located in each habitat type in proportion to availability.

[2]Simultaneous interval estimate on the proportion observed, and is compared to the corresponding P_j to determine preference.

drumming logs were situated within the fall and winter range. Grouse 495 returned to the Vaccinium uplands habitat in the spring of 1986 where he utilized several drumming logs.

Family Groups

Habitat utilization by family groups was significantly different (Chi-square = 318.7, df = 5, P = 0.005). Analysis of 144 telemetry locations of 3 family groups revealed a preference for hardwood regeneration areas (Table 15). Vaccinium uplands and laurel-rhododendron were used in proportion to their availability. Vaccinium-pine and open woodland-pine habitat types were used less than expected based on availability. No broods were observed in the fields cover type.

Although analysis of habitat use revealed a preference for hardwood regeneration, only family group 493 utilized this habitat type. Adult female 493 was captured in Vaccinium uplands habitat adjacent to a 6-year-old clearcut. She had a brood of at least 2 young when captured. The hen and her brood spent the next several weeks in the clearcut. The family group then traveled through Vaccinium uplands habitat to a 12-year-old clearcut located approximately 0.4 km north. During the remainder of the summer and the early fall, the adult female travelled to and from the 2 clearcuts. The female was

Table 15. Habitat type utilization and preference for 3 ruffed grouse family groups on the Catoosa WMA, Tennessee, 1985.

Habitat type	Total area (ha)	No. loc. observed	Proportion of obs. loc. (P_i)	P_j[1]	95% C.I.[2]	Preference
Vaccinium uplands	825.8	86	0.579	0.679	$0.492<P_i<0.702$	0
Vaccinium-pine	164.4	5	0.035	0.135	$0<P_i<0.074$	-
Laurel-rhododendron	130.8	19	0.132	0.108	$0.059<P_i<0.205$	0
Fields	42.8	0	0.000	0.035	N/A	N/A
Hardwood regeneration	26.7	33	0.229	0.022	$0.139<P_i<0.319$	+
Open woodland-pine	25.5	1	0.007	0.021	$0<P_i<0.028$	0
Total	1216.0	144	1.000	1.000		

[1]Theoretical proportion of occurence expected as if grouse were located in each habitat type in proportion to availability.

[2]Simultaneous interval estimate on the proportion observed, and is compared to the corresponding P_j to determine preference.

flushed from her night roost on 4 September in the 12-year-old clearcut, and was accompanied by a single juvenile. The dispersal date of this juvenile was unknown, therefore, locations taken for grouse 493 through 20 September, which was the dispersal date for brood 460, were used in the habitat analysis.

Family group 460 was captured in a deerberry thicket in Vaccinium uplands habitat adjacent to the experimental area on 24 August 1985. These birds spent about a week moving through several Vaccinium uplands areas adjacent to, and on, the experimental area. The brood then moved 500 m north, travelled in the vicinity for several days, then returned to the experimental area. The habitat utilized during this period was composed of Vaccinium uplands with occasional movement into laurel-rhododendron and Vaccinium-pine habitat types. After approximately a week, the brood again headed north through the ravine country and began break-up and dispersal movements.

Juvenile male 491 was captured on the control area on 26 August 1985 in an interception trap set at the edge of a mountain laurel thicket. The number of family members travelling with this bird, if any, was unknown. This grouse utilized a laurel-rhododendron thicket for about 2 weeks, then moved east into a steep ravine area dominated by laurel-rhododendron. The majority of the 17 locations

(53%) obtained during the brood period were in laurel-rhododendron, with the remainder equally divided between the Vaccinium-pine and Vaccinium uplands habitat types.

Post Dispersal Juveniles

Juvenile females 468 and 470 and juvenile male 491 were monitored after dispersal from their brood ranges. Their use of habitat types was derived from 45 locations obtained during the period 21 September 1985 to 23 April 1986 (Table 16). A Chi-square goodness of fit test revealed a significant difference in habitat use (Chi-square = 46.7, df =5, $P = 0.005$). Laurel-rhododendron was used more than expected based upon availability. Vaccinium-pine and open woodland-pine habitats were used in proportion to their availability. Vaccinium uplands was used less than expected, although 35.6% of the locations were in this habitat type. There were no locations in fields or hardwood regeneration.

Laurel-rhododendron occurred on only 10.8% of the study area, yet 40.0% of the post-dispersal locations were in this habitat type. Dispersal of juveniles occurred in late-September, and their establishment of home ranges began in mid- to late-October. At this time, there was little deciduous leaf cover or annual herbaceous plants, which may have prompted movement into drainages where adequate cover was provided by dense thickets of laurel-

Table 16. Habitat type utilization and preference for 3 post-dispersal juvenile ruffed grouse on the Catoosa WMA, Tennessee, 1985 to 1986.

Habitat type	Total area (ha)	No. loc. observed	Proportion of obs. loc. (P_i)	P_j[1]	95% C.I.[2]	Preference
Vaccinium uplands	825.8	16	0.356	0.679	$0.177<P_i<0.534$	-
Vaccinium-pine	164.4	10	0.222	0.135	$0.067<P_i<0.377$	0
Laurel-rhododendron	130.8	18	0.400	0.108	$0.217<P_i<0.583$	+
Fields	42.8	0	0.000	0.035	N/A	N/A
Hardwood regeneration	26.7	0	0.000	0.022	N/A	N/A
Open woodland-pine	25.5	1	0.022	0.021	$0<P_i<0.077$	0
Total	1216.0	45	1.000	1.000		

[1]Theoretical proportion of occurence expected as if grouse were located in each habitat type in proportion to availability.

[2]Simultaneous interval estimate on the proportion observed, and is compared to the corresponding P_j to determine preference.

rhododendron along the creek bottoms. The fall-winter home ranges of juveniles were centered in these broadleaf evergreen thickets (Figure 10, page 58).

CHAPTER V

DISCUSSION AND CONCLUSIONS

I. Population Status

Minimum population estimates of ruffed grouse on the control area ranged from 0.19 to 0.94 males per 100 ha from 1983 through 1986. The minimum population estimate on the experimental area ranged from 0 to 0.45 males per 100 ha. These figures are suggested as a minimum, as the census technique cannot account for non-drumming males unless they happen to be observed repeatedly in the same area. A nondrumming adult male was located on the southern portion of the experimental area in summer and fall 1985. This bird was assumed to reside on compartment 6 in the spring of 1985 as adult male grouse are typically sedentary once they establish a post-dispersal home range (Eng 1959; Gullion and Marshall 1960; Hale and Dorney 1963). Two adult males were located on the control area in the spring of 1986; no drumming activity was detected. All 3 birds were included in the minimum population estimates for their respective areas.

Breeding densities of ruffed grouse on the study areas were low. A range from 0.19 to 0.94 males per 100 ha represents some of the lowest reported densities for this species. Cade and Sousa (1985) summarized data from

several studies that calculated minimum densities ranging from 1.0 to 20.5 breeding males per 100 ha. Population densities are typically lower along the periphery of an animal's range. A minimum density of 1.8 breeding males per 100 ha was reported for northern Georgia (Hale et al. 1982). Hunyadi (1984) reported breeding densities in Missouri to range from 1.8 to 4.6 males per 100 ha.

Although grouse densities are lower in the southern portion of its range, the main contributing factor to the low density on the Catoosa study areas may be the absence of early successional vegetation. Grouse densities are highest in forests managed to provide a diversity of age classes (Gullion 1977). Major logging of Catoosa occurred between 1879 and 1945 (Schmalzer 1988), and the second-growth forests that exist presently are at least 40 years old. Limited timber harvesting since Catoosa was acquired by the TWRA has resulted in a paucity of young forests. Gullion (1984) stated that a density of 35 males per 100 ha can be obtained in well-managed forests in Minnesota. Forest management practices designed to increase the diversity of age classes, particularly early successional vegetation, should benefit the grouse population on the Catoosa WMA.

II. Breeding Ecology

The peak of drumming activity on the study areas for the 1983 to 1986 breeding seasons was estimated to occur between 11 and 25 April. Harris (1981) reported peak drumming activity between 29 March and 17 April in north Georgia. The peak of drumming for grouse on Catoosa occurred somewhat later, but the range of spring drumming activity closely matched the 29 March to 12 June period reported for north Georgia. Hale et al. (1982) determined the range for drumming grouse in Georgia to occur from 13 March to 19 May, which is earlier than the drumming period estimated for the study areas.

The estimated dates of copulation occurred between 4 to 14 April, which is immediately prior to the estimated peak of drumming activity. Porath and Vohs (1972) found a correlation between estimated dates of copulation and peak of drumming in Iowa.

III. Trapping

Compared to interception trapping, mirror trapping was highly successful on the study area. Hunyadi (1978) reported capturing 10 of 11 known drumming males in mirror traps during the spring breeding season on a study area in Missouri. The eleventh bird was captured in a mirror trap the following fall. Similar to the Catoosa study area,

trapping success with interception traps was not as fruitful in Missouri. Trapping success varied from 1 grouse per 22 trap days to 1 grouse per 68 trap days (Hunyadi 1978). Jones (1979) captured a total of 5 ruffed grouse on the Catoosa WMA during 248 trap days, resulting in a success rate of 1 bird per 50 trap days. All birds were caught in mid- to late-summer in interception traps located in, or very near, mountain laurel thickets. Poor trapping success with interception traps was probably related to the low density of grouse on the study areas.

IV. Radio Telemetry

Monitoring of radio-equipped grouse in 1983 may have been prematurely terminated due to equipment inadequacies. Grouse 148 tangled its transmitter antenna around a small woody stem 35 days after capture (Longwitz 1985). The bird was emaciated and was promptly dispatched. Grouse 147 was predated after its radio antenna became attached to a woody stem. Grouse 146 made several seemingly disoriented movements during the first 2 weeks after attachment of the radio. The radio and shredded harness were found after 105 days of tracking. The fate of the bird was unknown, but it may have been similar to that of grouse 147 and 148.

The problems associated with transmitters used in 1983 were likely related to both the harness and the weight of

the radio. Brander and Cochran (1971) recommended that the transmitter package not exceed 4% of the body weight for birds. The average weight of grouse equipped with battery-powered transmitters in 1983 was 629 g. Thus, the 30 g radios equalled 4.7 % of the average body weight. Ruffed grouse equipped with backpack-mounted radios were found to "possibly require a longer adjustment period" than for grouse fitted with poncho transmitter packages (Small and Rusch 1985). These researchers reported greater survival for grouse equipped with ponchos than those with backpacks.

The backpack harness was discarded in 1984 in favor of ponchos. Amstrup (1980) listed the following advantages of the radio collar: minimal handling is required for attachment; absence of straps eliminates restrictions on body movement and reduces the potential for skin irritation; the poncho is lightweight and the radio is positioned near the crop where birds normally carry variable weights; and the antenna is upright, which enhances transmission. There were no detectable problems with the ponchos used from 1984 to 1986, although there was a difference in transmitter performance.

Battery-powered radios were over 5 times more "efficient" than the solar-powered radios used in 1985 and 1986. For every location obtained, birds with solar-powered radios were monitored for 4.6 days, whereas, birds

with battery-powered radios were monitored 0.9 days. The solar-powered radios had the advantage of lighter weight, but the transmission was sporadic. Therefore, the combination of the vinyl poncho and the 19 g battery-powered radio provided the most reliable transmitter package for monitoring ruffed grouse on the Catoosa WMA study area.

V. Grouse Mobility

Home Range

Spatial overlap of home ranges was observed on the control area in 1983. Home ranges occupied by adult males 146, 147 and 148 overlapped, but did not extend past each bird's respective primary drumming log (Longwitz 1985). Simultaneous monitoring of all 3 grouse during a 6 week period in the fall of 1983 revealed that birds 146 and 147 shared a 4.0 ha area along the periphery of their respective ranges.

Analysis of home range shape for adult males on the control area revealed consistent use of activity centers from year-to-year. Adult male 149 was the only grouse monitored on the control area in 1984. This bird's home range was centered around the activity center used the previous year by bird 148 (Longwitz 1985). Grouse 149 was tracked until 13 September 1984 at which time the

transmitter was still active, but numerous attempts to locate this bird during April 1985 were unsuccessful. Adult male 498 was captured 24 April 1985 on a drumming log east of the home range previously occupied by grouse 149. Grouse 498 was monitored from April to July 1985 with one final location on 14 December 1985. The 12.6 ha home range of this bird overlapped the primary drumming log used by grouse 149 the previous year. Additional evidence of year-to-year occupancy of activity centers was observed on the experimental area; one activity center was used by adult male 495 in both 1985 and 1986.

The mean home range size of adult male ruffed grouse was larger compared to home range sizes in northern forests (Bump et al. 1947; Chambers and Sharp 1958; Archibald 1975; Bakke 1980). Home range sizes for re-introduced birds in Tennessee were greater than those of northern grouse (Jones 1979; White and Dimmick 1979; Gudlin 1984), but few comparable data exist for native grouse in the southeast. Male ruffed grouse monitored by Harris (1981) in northern Georgia in spring and summer had a mean home range of 31.4 ha, as calculated by an approximation of the modified minimum area method. Harris (1981) postulated that the increase in home range size was related to habitat quality. Although mean home range size of males was greater on the study area than in northern regions, it was

less than the mean home range size delineated for broods. This trend was comparable to results from other studies.

Size of brood home ranges was variable, but the 43.2 ha mean range size was similar to those reported from other studies. Maxson (1978) found that weekly brood range size increased the first few weeks after hatching, but decreased as hens settled into a defined range by 4 weeks. The mean home range size for broods in Minnesota as determined by the minimum convex polygon method was 12.9 ha, and ranged from 6.3 to 18.9 ha (Godfrey 1975). These broods were tracked for different time periods between 3 and 11 weeks of age, which occurred earlier in the brood period than in this study. Brood 460 continually expanded its range during the first 3 weeks of monitoring when the brood was 12- to 14-weeks-old. Other studies conducted farther into the brood rearing period delineated home range sizes comparable to, if not larger than, those determined during this study. The mean home range size for ruffed grouse broods was 47.8 ha in New York, as calculated by the modified minimum area method (Lyons 1981). In that study, at least 2 distinct activity centers were utilized by each brood, and once a new activity center was established, broods did not return to the old activity center. In Georgia, hens with broods had a mean range size of 71.3 ha,

as calculated by an approximation of the modified minimum area method (Harris 1981).

The 34.7 ha home range size for post-dispersal juveniles includes only one bird (491) that was tracked past mid-winter, and may underestimate actual range size. Comparative data for post-dispersal home range size in the southeast was not found in the literature.

Diurnal Movements

Diurnal movements, based on 10-14 hourly locations per day, were obtained primarily from family groups 460 and 491. The mean total daily movement (946.1 m) was similar to movements observed by Godfrey (1975) for hens with broods in Minnesota. The average minimum total distance travelled per day for those broods was 377 m with a range of 80 to 966 m. Although the mean minimum total distance travelled by broods in Minnesota appears smaller, this mean was based on only 3 locations per day. Similar to the results obtained by Godfrey (1975), there was no apparent trend in total daily movement over time for broods on the Catoosa study area.

Diurnal movements for family groups 460 and 493 that occupied different portions of the Habitat Study Area were significantly different. The smaller range size and movement parameters for family group 493 are probably related to habitat quality. The concentrated food source

in the clearcuts used by family group 493 limited the need for wide-ranging movements.

Brood Break-up and Dispersal

The brood break-up period lasted 16 days, over which juveniles 464, 466, and 468 appeared to establish break-up ranges. The break-up period for grouse 468 occurred from 6 September to 18 September. This bird was not monitored between 11 to 18 September. Consequently, the 2.6 ha break-up range may have been larger, although it was similar to ranges in Minnesota that averaged 5.4 and 3.1 ha for males and females, respectively (Godfrey and Marshall 1969).

Grouse 468 dispersed from its break-up range sometime between 11 and 18 September. The remaining members of its brood dispersed from their respective break-up ranges on, or after, 22 September. Break-up and dispersal movements for 4 of 5 juvenile grouse were unidirectional. Godfrey and Marshall (1969) noted significant unidirectional movements for dispersing grouse in Minnesota. Grouse 464 did not fit this pattern; it first travelled west and southwest during the break-up period , then moved east during dispersal.

Juvenile grouse on the study area dispersed 1.2 to 4.0 km from point of capture. Mean dispersal movements reported in the literature generally range from 1.0 to 3.0

km, although movements greater than 4 km are not uncommon (Chambers and Sharp 1958; Gullion and Marshall 1960; Hale and Dorney 1963; Godfrey and Marshall 1969). Godfrey and Marshall (1969) found that juvenile females disperse farther than juvenile males. Although limited by sample size, results from the Catoosa study are similar. Juvenile females 468 and 470 dispersed 3.2 and 4.0 km, respectively, compared to 1.2 and 2.9 km dispersal movements for juvenile males 491 and 464, respectively. Juvenile female 466 was not tracked to her final dispersal location due to loss of radio contact.

VI. Habitat Utilization

The 3 habitat types preferred by ruffed grouse on the Catoosa study area were laurel-rhododendron, Vaccinium-pine and hardwood regeneration. Vaccinium uplands was used less than expected by most grouse, except for family groups, which used the habitat type in proportion to its availability. Open woodland-pine was used in proportion to its availability by family groups and post-dispersal juveniles. The fields habitat type was generally avoided.

Adult males preferred Vaccinium-pine and laurel-rhododendron habitats. Vaccinium-pine typically was situated adjacent to the drainages where laurel-rhododendron was found (Figure 6, page 15). The pine

component served as shelter during the winter period as evidenced by grouse 491, who roosted in a small clump of white pines on 2 occasions when snowfall covered the ground in 1986. Longwitz (1985) also observed the use of pine trees as roost sites. The relative frequency of Virginia pine in the overstory of 8 occupied drumming logs on the study area was 100% (Longwitz 1985). This species also occurred in the understory with a high relative frequency along with mountain laurel, and probably functioned as early spring cover before leaf emergence. Bump et al. (1947) reported that mature mixed hardwood and conifer was a preferred cover type during the spring in New York.

Although most adult males preferred Vaccinium-pine and laurel-rhododendron during the spring breeding season, grouse 495 was an exception. This adult male drummed from primary and secondary drumming logs located in Vaccinium uplands habitat. Similar to grouse 495, adult males in Georgia preferred upland hardwood sawtimber during the spring (Harris 1981).

Adult males in late-summer and fall primarily used Vaccinium uplands and Vaccinium-pine habitats. Longwitz (1985) noted that in summer grouse 149 moved to blueberry and huckleberry thickets located in these upland cover types. During fall, adult males characteristically selected upland sites containing fruiting dogwood.

Adult male use of fields was minimal, although Longwitz (1985) obtained 2 locations in this habitat type. On several occasions during early spring 1985, unmarked birds were observed feeding in strip fields adjacent to roads. Jones (1979) reported extensive use, by transplanted grouse, of a field during the spring when it was plowed and seeded to grass (Poaceae) and clover (Trifolium sp.) on a study area in west Tennessee.

Adult male ruffed grouse on the study area used a variety of habitats throughout the year. Although the life requisites of food, shelter, and reproductive cover were met to some degree by each of the 4 cover types used by adult males, laurel-rhododendron was judged as the most important. Home ranges of all adult males centered in this cover type (Figures 8 and 9, pages 55 and 57, respectively). White and Dimmick (1978) reported that mountain laurel thickets were used by 44% of the radio-equipped grouse in west Tennessee. The significance of these broadleaf evergreen thickets as breeding habitat (Harris 1981; Hale et al. 1982) and for fall to winter cover (White and Dimmick 1978) in the southeast suggests that laurel-rhododendron provides similar seasonal habitat requirements to those supplied by aspen in the north (Gullion and Svoboda 1972; Gullion 1977).

Family groups preferred hardwood regeneration, and used Vaccinium uplands, laurel-rhododendron, and open woodland-pine in proportion to their availability. Harris (1981) found that broods preferred upland hardwood sapling and poletimber habitats, but avoided very young clearcuts. The hardwood regeneration areas used by family group 493 were 5 and 12 years old, and did not contain the dense slashings described by Harris (1981). Grouse broods require dense habitats for food and cover during the summer. In northern forests, they begin using these areas 1-2 years after forest disturbance and continue until the stand is 7 to 10 years old (Bump et al. 1947; Sharp 1963; Gullion 1977).

The limited movements of family group 493 probably reflected favorable habitat conditions in their home range. The dense, young regeneration found in the 2 clearcuts provided ample cover and the variety of shrubs and saplings (Waldrop 1983) supplied a constant food source. In contrast, movements of brood 460 were more extensive (Table 12, page 64). The blueberry, deerberry, and huckleberry fruits favored by grouse in the summer (Longwitz 1985) were widespread in the Vaccinium upland habitat used by family group 460. The far-ranging travels of this brood resulted in the largest home range delineated during this study.

Godfrey (1975) found a significant difference in sequential movements for a grouse brood that occupied a homogeneous community type. Regression analysis indicated a negative relationship between age and movement, suggesting that the brood travelled more efficiently as it gained familiarity with its home range. Family group 493 followed this pattern, while brood 460 continued its range expansion during the summer, rarely returning to the same vicinity. The range expansion may have been necessary to locate the widespread food source in the Vaccinium uplands habitat.

Post-dispersal juveniles preferred laurel-rhododendron, and used Vaccinium-pine and open woodland-pine in proportion to their availability. Habitat utilization of post-dispersal juveniles during fall and winter has not been documented in the southeast, however 33-80% of all observations of transplanted juveniles in west Tennessee were in farkleberry (Vaccinium arboreum) and mountain laurel thickets (White 1978). Mountain laurel provided the densest cover with an average of 15,000 stems per ha. In addition to providing winter cover, mountain laurel is a major food of ruffed grouse in Tennessee (Stafford and Dimmick 1978).

CHAPTER VI

SUMMARY

The objectives of this study were to gather baseline data on the status of the ruffed grouse population, and to delineate proportionate use of habitat types in a largely unmanaged hardwood forest. Ancillary to these activities, aspects of the breeding ecology and mobility of ruffed grouse were identified. Two overlapping study areas were established on the Catoosa WMA in Cumberland County, Tennessee. Estimates of the population density were obtained on 2 compartments that will serve as control and experimental areas during the 10 to 12 year study. Movements and habitat utilization were determined within a 1216 ha Habitat Study Area that was defined by the movements of radio-equipped grouse.

Spring drumming censuses conducted from 1983 to 1986 resulted in the identification of 1 to 5 adult males per year on the control area, and 0 to 2 adult males per year on the experimental area. The average crude density throughout the study period ranged from 0.19 to 0.94 males per 100 ha. The presence of a high proportion of nondrumming males may have resulted in a lower population estimate than actually existed. However, even if the population were doubled, it would still be one of the

lowest reported for ruffed grouse throughout its range. The proximity of the study area to the southern extent of the range of ruffed grouse and absence of aspen as a staple food source may contribute to the low density. More importantly, density was probably limited by inadequate habitat due the absence of early successional vegetation on the study area. Forest management practices implemented after this portion of the study was completed may produce an increase in the grouse population.

The breeding ecology of ruffed grouse was examined in terms of spring drumming activity, copulation and nesting chronology, and fall drumming. Adult males initiated spring drumming in late-March and continued until early-June. The peak of drumming activity occurred in mid-April, and coincided with estimated dates of copulation, which were determined by back-dating from a known age of nest and broods. Fall drumming activity was similar in intensity to spring drumming.

Twelve ruffed grouse were captured during 1,229 trap days. Trapping success rates were low overall, although the use of mirror traps in 1985 and 1986 resulted in high capture rates. The low density of grouse on the study area reduced the likelihood of capture for interception traps.

All grouse captured during this study were fitted with radio transmitters. Tests of the directional accuracy of the receiving equipment revealed that grouse could be located within 35 m. As distance between the grouse and receiver increased, accuracy decreased. In areas of steep topography, the homing technique may be a preferred alternative to triangulation.

Several different types of transmitters and attachment methods were used with varying degrees of success. The use of backpack harnesses should be avoided due to the negative effect on grouse survival. Battery-powered radios were more reliable than solar-powered radios. Use of these radios is recommended, although the weight should be less than 4% of a bird's body weight. The battery-powered radio with poncho attachment resulted in the highest number of locations per bird, and was the preferred transmitter package combination.

A total of 973 locations was obtained from 1983 to 1986. Home range size calculated from these observations varied from 12.6 to 99.0 ha. Adult males utilized home ranges much larger in size than those reported for northern birds. Low habitat quality on the study area probably resulted in increased movements, which inflated home range sizes for adult males. Brood home range size was highly variable, and appeared to be habitat dependent. Post-

dispersal home range sizes calculated for 3 juveniles were comparable in size to those of adult males.

Diurnal movements were obtained for an adult male, 3 family groups, and for a juvenile after brood break-up. The maximum distance travelled was approximately 1.6 km per day, although most grouse travelled in a highly circular pattern. Diurnal movements appeared to be habitat dependent; broods occupying hardwood regeneration travelled less than broods found in Vaccinium uplands.

Break-up of juvenile grouse from brood 460 began over a 2 week period from 6 to 20 September. Establishment of break-up ranges was observed for 3 grouse, and these temporary ranges were occupied for at least 3 to 12 days before dispersal. Unidirectional dispersal characterized the movements of juveniles to their fall and winter ranges. Dispersal movements of 2.9 to 4.0 km from point of capture were observed for members of 1 brood, and the distances were similar to those reported for northern grouse. Seemingly atypical dispersal movements were found for a juvenile male that gradually shifted his range during the fall.

Habitat utilization of 6 habitat types was determined from 534 locations of radio-equipped grouse. Vaccinium-pine, laurel-rhododendron, and hardwood regeneration were preferred, while Vaccinium uplands was used less in

proportion to its availability. Adult males preferred Vaccinium-pine and laurel-rhododendron, and most drumming logs were found in these 2 habitat types. Laurel-rhododendron appeared to be the most important habitat type for post-dispersal juveniles and adult males. Activity centers located in this cover type were occupied by the same male, or a succession of males, throughout the study. Hardwood regeneration was the preferred brood range, while Vaccinium uplands was used in proportion to its availability. Home range size and movements were greatly reduced for a brood that utilized hardwood regeneration compared to a brood found in the Vaccinium uplands habitat type. Future management plans for grouse on the Catoosa WMA should be designed to preserve laurel-rhododendron thickets, and increase the amount of hardwood regeneration while providing an interspersion of habitat types.

LITERATURE CITED

LITERATURE CITED

Amstrup, S. C. 1980. A radio-collar for game birds. J. Wildl. Manage. 44(1):214-217.

Archibald, H. L. 1975. Temporal patterns of spring space use by ruffed grouse. J. Wildl. Manage. 39(3):472-481.

Arney, K., and B. Pugh. 1983. Showcase for wildlife: Catoosa. Tennessee Wildlife 6(5):20-24.

Bakke, E. L. 1980. Movements and habitat use of ruffed grouse in the Turtle Mountains, North Dakota. North Dakota State Game and Fish Department, Report No. B-313 (Supplement). 81 pp.

Bendell, J. F. S., and C. D. Fowle. 1950. Some methods for trapping and marking ruffed grouse. J. Wildl. Manage. 14(4):480-482.

Bowman, L. 1985. Tennessee ruffed grouse survey report, 1984-1985. Tennessee Wildl. Res. Agency, Nashville, Tennessee. 4 pp.

Brander, R. B. 1968. A radio-package harness for game birds. J. Wildl. Manage. 32(3):630-632.

_____, and W. W. Cochran. 1971. Radio-location telemetry. Pp. 95-103 in Wildlife Management Techniques (R. H. Giles, ed.). Wildl. Society, Wash., D.C. 633 pp.

Brody, A. J. 1984. A manual for four computer programs used in processing and analyzing animal telemetry data at The University of Tennessee. Unpublished manuscript, Dept. of For., Wildl. and Fish., The Univ. of Tennessee, Knoxville. 45 pp.

Bump, G., R. W. Darrow, F. C. Edminister, and W. F. Crissey. 1947. The ruffed grouse: life history, propagation, management. New York State Conserv. Dept. 915 pp.

Cade, B. S., and P. J. Sousa. 1985. Habitat suitability index models: Ruffed grouse. U.S.Fish Wildl. Serv. Biol. Rep. 82(10.86). 31 pp.

Chambers, R. E., and W. M. Sharp. 1958. Movement and dispersal within a population of ruffed grouse. J. Wildl. Manage. 22(3):231-239.

Davis, J. A. 1969. Aging and sexing criteria for Ohio ruffed grouse. J. Wildl. Manage. 33(3):628-636.

Eng, R. L. 1959. A study of the ecology of male ruffed grouse (Bonasa umbellus L.) on the Cloquet Forest Research Center, Minnesota. Ph. D. Dissertation. Univ. of Minnesota. 119pp.

Garshelis, D. L. 1978. Movement ecology and activity behavior of black bears in the Great Smoky Mountains National Park. M. S. Thesis. The Univ. of Tennessee, Knoxville. 117pp.

_____, H. B. Quigley, C. R. Villarrubia, and M. R. Pelton. 1981. Diel movements of black bears in the southern Appalachians. Int. Conf. Bear Res. and Manage. 5:11-19.

Godfrey, G. A. 1975. Home range characteristics of ruffed grouse broods in Minnesota. J. Wildl. Manage. 39(2): 287-298.

_____, and W. H. Marshall. 1969. Brood break-up and dispersal of ruffed grouse. J. Wildl. Manage. 33(3):609-620.

Gudlin, M. J. 1984. Evaluation of a second ruffed grouse restoration attempt in Benton County, Tennessee. Tenn. Wildl. Res. Agency Tech. Rep. No. 84-6. 66 pp.

_____, and Dimmick R. W. 1984. Habitat utilization by ruffed grouse transplanted from Wisconsin to west Tennessee. Pp. 75-78 in Ruffed grouse management; state of the art in the early 1980's (W. L. Robinson, ed.). North Central Section. The Wildl. Soc. 181 pp.

Gullion, G. W. 1966. The use of drumming behavior in ruffed grouse population studies. J. Wildl. Manage. 30(4):717-729.

_____. 1970. Factors influencing ruffed grouse populations. Trans. N. Am. Wildl. and Nat. Res. Conf. 35:93-105.

_____. 1977. Forest manipulation for ruffed grouse. Trans. N. Am. Wildl. and Nat. Res. Conf. 42:449-458.

_____. 1984. Managing northern forests for wildlife. Minnesota Agr. Expt. Sta. Publ. No. 13,442. St. Paul, Minn. 72 pp.

_____, and W. H. Marshall. 1960. Ruffed grouse management. Minn. Conserv. Vol. 23:51-55.

_____, and Svoboda. 1972. The basic habitat resource for ruffed grouse. Aspen: Symposium Proc. U.S. Forest Service. Gen. Tech. Rep. NC-L:113-119.

Hale, J. B., and R. S. Dorney. 1963. Seasonal movements of ruffed grouse in Wisconsin. J. Wildl. Manage. 27(4):648-656.

_____, R. F. Wendt, and G. C. Halazon. 1954. Sea and age criteria for Wisconsin ruffed grouse. Wisc. Cons. Bull. No. 9:5-24.

Hale, P. E., A. S. Johnson, and J. L. Landers. 1982. Characteristics of ruffed grouse drumming sites in Georgia. J. Wildl. Manage. 46(1):115-123.

Harris, M. J. 1981. Spring and summer ecology of ruffed grouse in northern Georgia. M. S. Thesis. The Univ. of Georgia, Athens. 133 pp.

Harvey, M. J., and R. W. Barbour. 1965. Home range of Microtus ochrogaster as determined by a modified minimum area method. J. Mammalogy 46(3):398-402.

Hayne, D. W. 1949. Calculation size of home range. J. Mammal. 30:1-18.

Hunyadi, B. W. 1978. Analysis of ruffed grouse habitat in central Missouri. M. S. Thesis. University of Missouri- Columbia. 145 pp.

_____. 1984. Ruffed grouse restoration in Missouri. Pp. 21-35 in Ruffed grouse management; state of the art in the early 1980's (W. L. Robinson, ed.). North Central Section. The Wildl. Soc. 181 pp.

Jones, L. F. 1979. Evaluation of a ruffed grouse restoration attempt on the western highland rim in Tennessee. M. S. Thesis. The Univ. of Tennessee, Knoxville. 64 pp.

Liscinsky, S. A., and W. J. Bailey. 1955. A modified shorebird trap for capturing woodcock and grouse. J. Wildl. Manage. 19(3):405-408.

Longwitz, R. J. 1985. Some aspects of the ecology of ruffed grouse in unmanaged hardwood forests of the Cumberland Plateau, Tennessee. M. S. Thesis. The Univ. of Tennessee, Knoxville. 114 pp.

Lyons, K. L. 1981. Ruffed grouse brood ranges and habitat preferences. M. S. Thesis. State University of New York, Syracuse. 73 pp.

Maxson, S. J. 1978. Spring home range and habitat use by female ruffed grouse. J. Wildl. Manage. 42(1):61-71.

Nelson, A. L., T. E. Clarke, and W. W. Bailey. 1938. Early winter food of ruffed grouse on the George Washington National Forest. U.S. Dept. Agric. Circ. No.504. 37 pp.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38(3):541-545.

Norman, G. W., and R. L. Kirkpatrick. 1984. Foods, nutrition, and condition of ruffed grouse in southwestern Virginia. J. Wildl. Manage. 48(1):183-187.

Porath, W. R., and P. A. Vohs. 1972. Population ecology of ruffed grouse in northeastern Iowa. J. Wildl. Manage. 36(2):793-802.

Roussel, Y. E., and R. Ouellet. 1975. A new criterion for sexing Quebec ruffed grouse. J. Wildl. Manage. 39(2): 443-445.

SAS Institute, Inc. 1985. SAS user's guide: statistics. 1985 ed. SAS Inst., Inc., Cary, N. C. 956 pp.

Schmalzer, P. A. 1988. Vegetation of the Obed River Gorge System, Cumberland Plateau, Tennessee. J. South. Appal. Botan. Club 53(1):1-32.

Seehorn, M. E., R. F. Harlow, and M. T. Mengak. 1981. Foods of ruffed grouse from three locations in the southern Appalachian mountains. Proc. Ann. Conf. S.E. Assoc. Fish and Wildl. Agencies 35:216-224.

Servello, F. A. 1985. Regional variation in the nutritional ecology of ruffed grouse. Ph.D. Dissertation. Virginia Tech., Blacksburg. 205pp.

Sharp, W. M. 1963. The effects of habitat manipulation and forest succession on ruffed grouse. J. Wildl. Manage. 27(4):664-671.

Small, R. J., and D. H. Rusch. 1985. Backpacks vs. ponchos: survival and movements of radio-marked ruffed grouse. Wildl. Soc. Bull. 13(2):163-165.

Smalley, G. W. 1982. Classification and evaluation of forest sites on the Mid-Cumberland Plateau. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. SO-38. South. For. Exp. Stn., New Orleans, La. 58 pp.

Smith, A. F. 1977. Fall and winter food habits of the ruffed grouse in Georgia. M. S. Thesis. The Univ. of Georgia, Athens. 76 pp.

Springer, J. T. 1979. Some sources of bias and sampling error in radio triangulation. J. Wildl. Manage. 43(4):926-935.

Springer, M. E., and J. A. Elder. 1980. Soils of Tennessee. The Univ. of Tenn. Agric. Expt. Station, Knoxville, and U.S. Dept. of Agric. Soil Conserv. Service. Bull. No. 596. 66 pp.

Stafford, S. K., and R. W. Dimmick. 1979. Autumn and winter foods of ruffed grouse in the southern Appalachians. J. Wildl. Manage. 43(1):121-127.

Stuwe, M., and C. E. Blohowiak. 1985. McPAAL: Micro-computer programs for the analysis of animal locations. Conservation and Research Center. National Zoological Park, Smithsonian Institution, Front Royal, Va. 20 pp.

Tanner, W. D., and G. L. Bowers. 1948. A method for trapping male ruffed grouse. J. Wildl. Manage. 12(3):330-331.

Taylor, D. A. 1976. An analysis of some physical characteristics of ruffed grouse (Bonasa umbellus) drumming sites and logs in middle and eastern Tennessee. TWRA Tech. Rept. 75-25. 72 pp.

Waldrop, T. A. 1983. The development of FORCAT: A spatial gap model of stand dynamics for forests of the Catoosa Wildlife Management Area. Ph. D. Dissertation. The Univ. of Tennessee, Knoxville. 110 pp.

White, D. W. 1978. Evaluation of a ruffed grouse restoration attempt in western Tennessee. M. S. Thesis. The Univ. of Tennessee, Knoxville. 85 pp.

_____, and R. W. Dimmick. 1978. Survival and habitat use of northern ruffed grouse introduced into west Tennessee. Proc. Ann. Conf. S. E. Assoc. Fish and Wildl. Agencies 32:1-7.

_____, _____. 1979. The distribution of ruffed grouse in Tennessee. J. Tenn. Acad. Sci. 54(3):114-115.

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