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DAILY MOVEMENT AND HABITAT UTILIZATION OF RUFFED GROUSE IN THE CHEROKEE NATIONAL FOREST

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Eric C. Pelren

May 1991

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ABSTRACT

Daily movements and habitat utilization of 7 radio-telemetered ruffed grouse (Bonasa umbellus) were studied on 2 study units of the Tellico Ranger District in the Cherokee National Forest, Monroe County, Tennessee. The study was a segment of an effort initiated in 1984 to determine effects of forestry practices on grouse populations in the southern Appalachians. The objectives of this portion of the study were to: (1) measure daily movement rates and habitat utilization of ruffed grouse, (2) relate rate of movement to hour, season, and weather patterns, including temperature, precipitation, and cloud cover, and (3) determine effects of hour, month, and weather conditions, including temperature, precipitation, and cloud cover on habitat utilization. The major hypotheses tested were: (1) that weather, time, and season affect grouse movement rates, and (2) that weather, time and season affect habitat utilization. Movement was depressed by high and low temperatures and heavy cloud cover. Utilization of vegetative cover, slope aspect, position on the slope, roads and clearcut edges differed at different seasons, day periods, and weather conditions.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	STUDY AREA	5
	Population Study Units	7
	Big Cove-Queen Cove	7
	Sugar Cove	9
	Habitat Study Units	10
	Habitat Study Unit 1	10
	Habitat Study Unit 2	15
III.	MATERIALS AND METHODS	18
	Population Estimation	18
	Trapping	19
	Radio Telemetry	21
	Home Range Determination	22
	Daily Movement Analysis	23
	Habitat Utilization Analysis	23
IV.	RESULTS	26
	Population Estimation	26
	Big Cove-Queen Cove	26
	Sugar Cove	30
	Trapping	30
	Big Cove-Queen Cove	32
	Sugar Cove	32
	Radio Telemetry	34
	Big Cove-Queen Cove	34
	Sugar Cove	37
	Home Ranges	37
	Daily Movement	46
	Habitat Utilization	48
	Vegetative Cover	49
	Slope Aspect	51
	Position on Slope	52
	Distance from Roads	54
	Distance from Clearcut Edges	56
V.	DISCUSSION	60
	Population Estimation	60
	Trapping	63
	Radio Telemetry	64
	Home Ranges	65
	Daily Movements	66
	Habitat Utilization	68
	Vegetative Cover	68
	Slope Aspect	70

CHAPTER PAGE

V. (Continued)
Position on Slope..... 71
Distance from Roads and Clearcut Edges..... 72

VI. SUMMARY AND CONCLUSIONS..... 75

LITERATURE CITED..... 78

APPENDIX..... 84

VITA..... 87

LIST OF TABLES

TABLE		PAGE
1.	Habitat types delineated for Habitat Study Unit 1, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	14
2.	Habitat types delineated for Habitat Study Unit 2, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	17
3.	1989 trap nights in Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	20
4.	Percent availability of the measured classes of each habitat variable in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	24
5.	Results of ruffed grouse drumming censuses on Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1984-1990.....	27
6.	Clearcut specifications and corresponding grouse densities in Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	29
7.	1989 trap success rates in the Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	31
8.	Individual capture and telemetry data of grouse monitored during 1989 and 1990, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	36
9.	Effects of weather conditions on grouse movement rates by season, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990.....	47

TABLE PAGE

10. Mean daily movements of ruffed grouse by month, hour, temperature, precipitation, and cloud cover, Tellico Ranger District, Cherokee National Forest, Madison County, Tennessee..... 85

LIST OF FIGURES

FIGURE		PAGE
1.	Present range of ruffed grouse in Tennessee (White and Dimmick 1979) including re-introductions: 1 - (Jones 1979), 2 - (White and Dimmick 1979) and (Gudlin and Dimmick 1984), 3 - (Kalla and Dimmick 1987). Adapted from Boyd (1990).....	2
2.	General location of the study area within the Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	6
3.	The Big Cove-Queen Cove Population Study Unit (1) and the Sugar Cove Population Study Unit (2), Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee. Adapted from Boyd (1990).....	8
4.	Habitat Study Units 1 and 2, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	11
5.	Habitat types delineated within Habitat Study Unit 01, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	12
6.	Habitat types delineated within Habitat Study Unit 2, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	16
7.	Ruffed grouse population estimates on the Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	28
8.	Drumming logs and capture sites on the Big Cove-Queen Cove Population Study Unit, 1989-1990, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	33
9.	Drumming logs and capture sites on the Sugar Cove Population Study Unit, 1989-1990, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.....	35

FIGURE PAGE

10. Home range and telemetry locations of adult male grouse 721, monitored in Big Cove-Queen Cove from 4/16/89 until 2/18/90..... 38

11. Home range and telemetry locations of adult male grouse 046, monitored in Big Cove-Queen Cove from 4/25/89 until 5/31/90..... 39

12. Home range and telemetry locations of adult male grouse 542, monitored in Big Cove-Queen Cove from 5/6/89 until 5/31/90..... 41

13. Home range and telemetry locations of adult male grouse 039, monitored in Big Cove-Queen Cove from 5/8/89 until 7/10/89..... 42

14. Home range and telemetry locations of juvenile male grouse 120, monitored in Big Cove-Queen Cove from 8/8/89 until 10/21/89..... 43

15. Home range and telemetry locations of adult female grouse 138, monitored in Big Cove-Queen Cove from 8/14/89 until 11/28/89..... 44

16. Home range and telemetry locations of juvenile female grouse 320, monitored in Sugar Cove from 8/15/89 until 10/31/89..... 45

17. Utilization of vegetative cover by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990..... 50

18. Utilization of slope aspect by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990..... 53

19. Utilization of slope position by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990..... 55

FIGURE PAGE

20. Utilization of roads by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990..... 57

21. Utilization of clearcut edges by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990..... 58

CHAPTER I

INTRODUCTION

Tennessee is near the southern limit of the range of the ruffed grouse (Bonasa umbellus). Natural populations in this state are limited to the eastern segment, with the western edge of the Cumberland Plateau being more or less the western limit of its range (White and Dimmick 1979)(Figure 1). The habitat of the ruffed grouse in this region is quite different from that in the northeastern states, where aspen (Populus sp.) and early forest succession are predominant aspects of grouse habitat (Bump et al. 1947, Gullion and Marshall 1968). A lack of aspen, a scarcity of large areas of early forest succession, and an abundance of shrubby, viny, and herbaceous evergreens characterize the forested habitats of ruffed grouse in the southern Appalachians. Few studies have been conducted on the ruffed grouse in the southern extent of its range. Hale et al. (1981) examined drumming site characteristics in Georgia. The effects of hunting on grouse populations were analyzed in North Carolina (Monschein 1973). Reintroduction attempts were examined in the western segment of Tennessee (White and Dimmick 1978, Gudlin and Dimmick 1984, Kalla and Dimmick 1987). Food and nutrition studies were conducted in several areas of the southern Appalachians (Stafford and

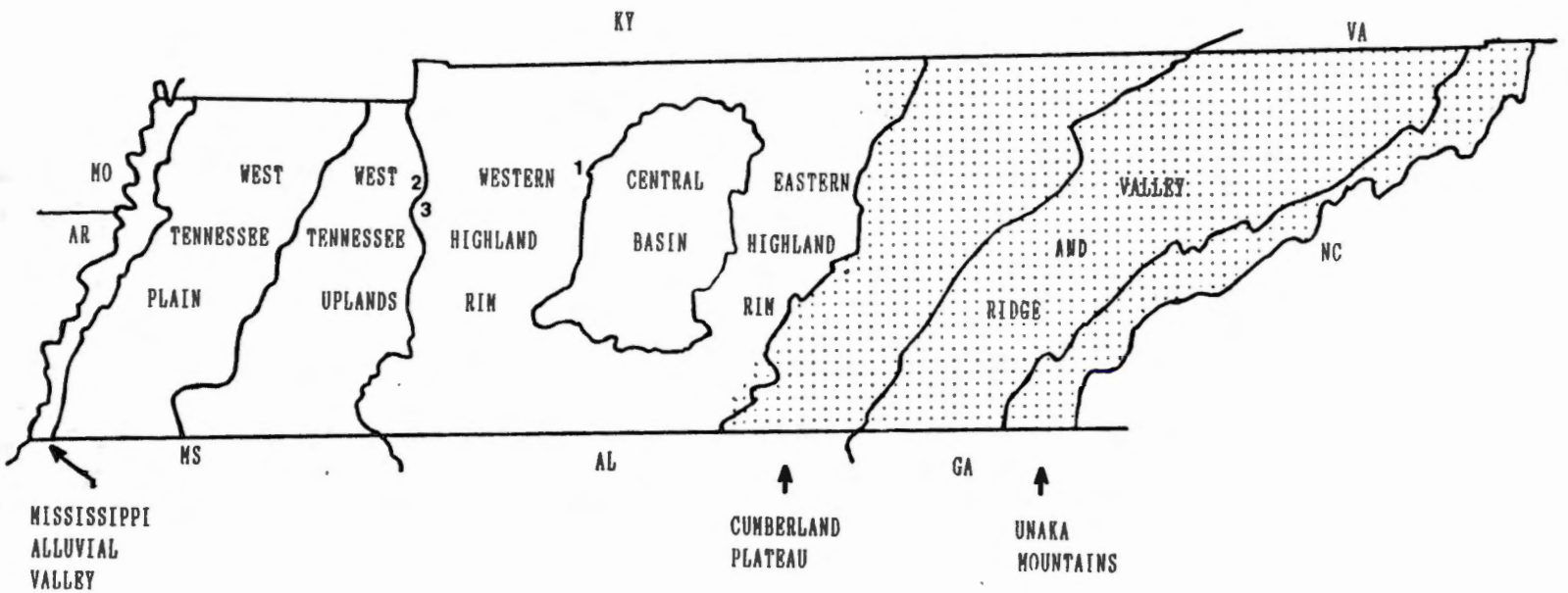


Figure 1. Present range of ruffed grouse in Tennessee (White and Dimmick 1979) including reintroductions: 1 - (Jones 1979), 2 - (White and Dimmick 1979) and (Gudlin and Dimmick 1984), 3 - (Kalla and Dimmick 1987). Adapted from Boyd (1990).

Dimmick 1979, Seehorn et al. 1981, Norman and Kirkpatrick 1984, Servello and Kirkpatrick 1987). Blood parasites of ruffed grouse from areas including Kentucky and West Virginia were studied by Eve and Davidson (1976). Research into ruffed grouse daily movement and habitat utilization, however, has been nominal in the southern Appalachians.

In 1984 a project was initiated on 2 study units in the Catoosa Wildlife Management Area in Tennessee to 1) measure proportional amounts of the ruffed grouse's usage of clearcuts and other forest vegetation types, and 2) determine what beneficial or detrimental effects clearcutting has on grouse survival and population size (Longwitz 1985, Epperson 1988). This study was expanded in 1984 to include two study units in the Cherokee National Forest (Boyd 1990). The following work is an extension of that ongoing segment of the study, emphasizing diurnal movements and habitat utilization. The 3 major objectives of my study were:

1) To measure daily movement rates and habitat utilization of ruffed grouse,

2) To relate rate of movement to hour, season, and weather patterns, including temperature, precipitation, and cloud cover, and

3) To determine effects of hour, month, and weather conditions, including temperature, precipitation, and cloud cover on habitat utilization.

These data were analyzed to detect the effects of weather, time of day, and season of year on ruffed grouse habitat utilization and diurnal movements. The major hypotheses tested were:

1) That weather, time, and season affect grouse movement rates, and

2) That weather, time and season affect habitat utilization.

Answers to these questions should provide a greater understanding of ruffed grouse ecology and habitat requirements in the Southeast.

CHAPTER II

STUDY AREA

The Cherokee National Forest lies in Tennessee, on its eastern border with North Carolina. It is divided into a northern and a southern portion by Great Smoky Mountains National Park. The study was conducted in the southern portion of the forest, within the Tellico Ranger District, approximately 26 km east of Tellico Plains, Tennessee, in Monroe County (Figure 2).

The climate of this area is generally mild, with temperatures averaging 23° C. Humidity is relatively high. Average annual precipitation is 140 cm at lower elevations, with 230 cm possible at higher elevations (USDA Forest Service 1976).

The study area is characterized by steep slopes with frequent outcroppings and abundant drainages. Geology is described as K11; Ditney-Jeffrey-Brookshire: Steep and very steep, shallow to deep, loamy and stony soils from sandstone, graywacke, schist, slate and colluvium (Springer and Elder 1980).

Vegetation consists largely of upland hardwoods with frequent clearcut regeneration. Major game species present in the area include black bear (Ursus americanus), European wild hog (Sus scrofa), white-tailed deer (Odocoileus

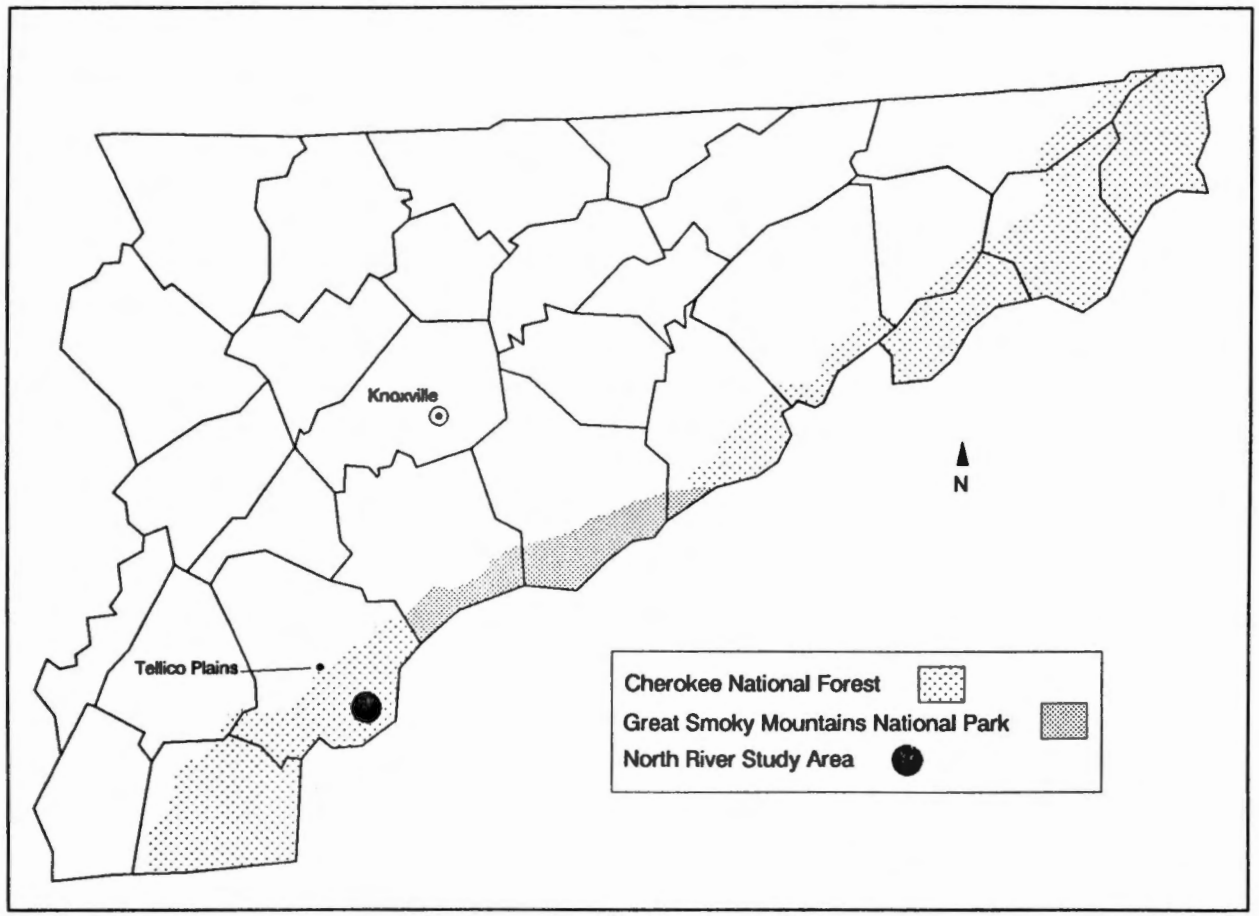


Figure 2. General location of the study area within the Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

virginianus), gray squirrel (Sciurus carolinensis), eastern cottontail (Sylvilagus floridanus), wild turkey (Meleagris gallopavo), and ruffed grouse.

The major objective of the Forest Service in managing the Cherokee National Forest is to maintain the multiple-use system of sustained yield, with emphasis on managing resources for timber, wilderness, wildlife, fish, water, soils, minerals, cultural resources, and recreation (USDA Forest Service 1985). A more detailed description of the study area was given in Boyd (1990).

I. Population Study Units

The study area was divided into 2 population study units (PSUs), Big Cove-Queen Cove and Sugar Cove, which were located on North River Road (Figure 3). A description of each follows. A more detailed description was presented in Boyd (1990).

Big Cove-Queen Cove

This study unit was approximately 495 ha in size. It was bordered on the north by North River Road, and on the south by a portion of Whigg Ridge. The majority of the unit had a northern slope aspect. The North River, Big Cove Branch, and several smaller tributaries flowed through the

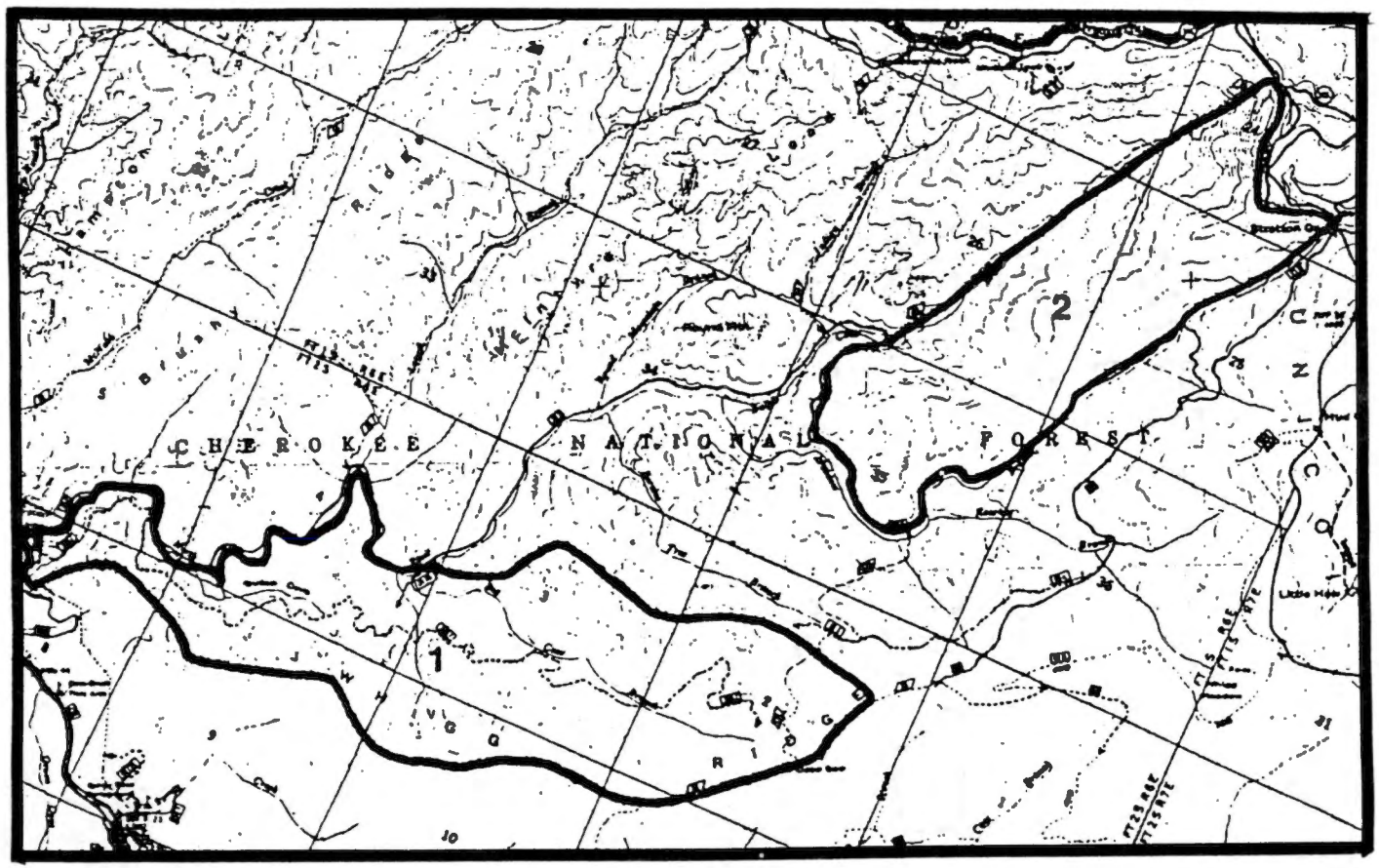


Figure 3. The Big Cove-Queen Cove Population Study Unit (1) and the Sugar Cove Population Study Unit (2), Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee. Adapted from Boyd (1990).

area. Elevation rose from 585 to 1097 m ASL. Two Forest Service compartments comprised the unit. Compartment 81 was entirely within the unit. Stands 7 through 11, 13 through 20, and half of 24, 26, and 27 of Compartment 417 also lay in the unit. Overstory composition included 56.8% immature sawtimber, 20.9% immature poletimber, 18.5% clearcuts, 2.3% sparse sawtimber, and 1.2% non-forested lands. Overstory species composition included 72% yellow poplar (Liriodendron tulipifera)-white oak (Quercus alba)-red oak (Quercus rubra) associations. Dense stands of rhododendron (Rhododendron maximum) occupied the understory in the drainages, and mountain laurel (Kalmia latifolia) was found in the understory on most of the ridges.

Sugar Cove

This study unit was 372.6 ha in size, and was bordered on the south and west by North River Road, on the east by U.S. Highway 165, and on the north by a portion of Sugar Cove Branch. Elevation ranged from 792 to 1341 m ASL. A ridge traversed the length of the unit, from northeast to southwest, giving the area approximately equal northern and southern exposure. Portions of Forest Service Compartments 70 and 80 were inside the boundaries of the unit. The habitat included 59.5% immature sawtimber, 17.3% clearcuts, 13.4% low quality sawtimber, 4.2% immature poletimber, 3.9%

low quality poletimber, and 1.7% non-forested lands. Three major overstory associations were present on the unit. White oak-red oak-hickory (Carya sp.) comprised 33% of the unit. Yellow poplar-white oak-red oak constituted 23%, and sugar maple (Acer saccharum)-American beech (Fagus grandifolia)-yellow birch (Betula allegheniensis) was present to a smaller degree. Understory vegetation included predominant rhododendron and mountain laurel thickets.

II. Habitat Study Units

The birds captured within each PSU were monitored for approximately 1 year, after which time the outer periphery of their home ranges were connected to form the habitat study units (HSUs)(Figure 4). This allowed a more accurate analysis of habitat utilization-availability than the population study units would, because the PSUs covered a much greater area than the home ranges of the grouse monitored. A description of each HSU follows.

Habitat Study Unit 1

This unit was almost entirely within the Big Cove-Queen Cove PSU (Figure 5), and was composed of the home ranges of 6 grouse. It encompassed 263 ha of Forest Service Compartments 417 and 81, and was divided into 5 major cover

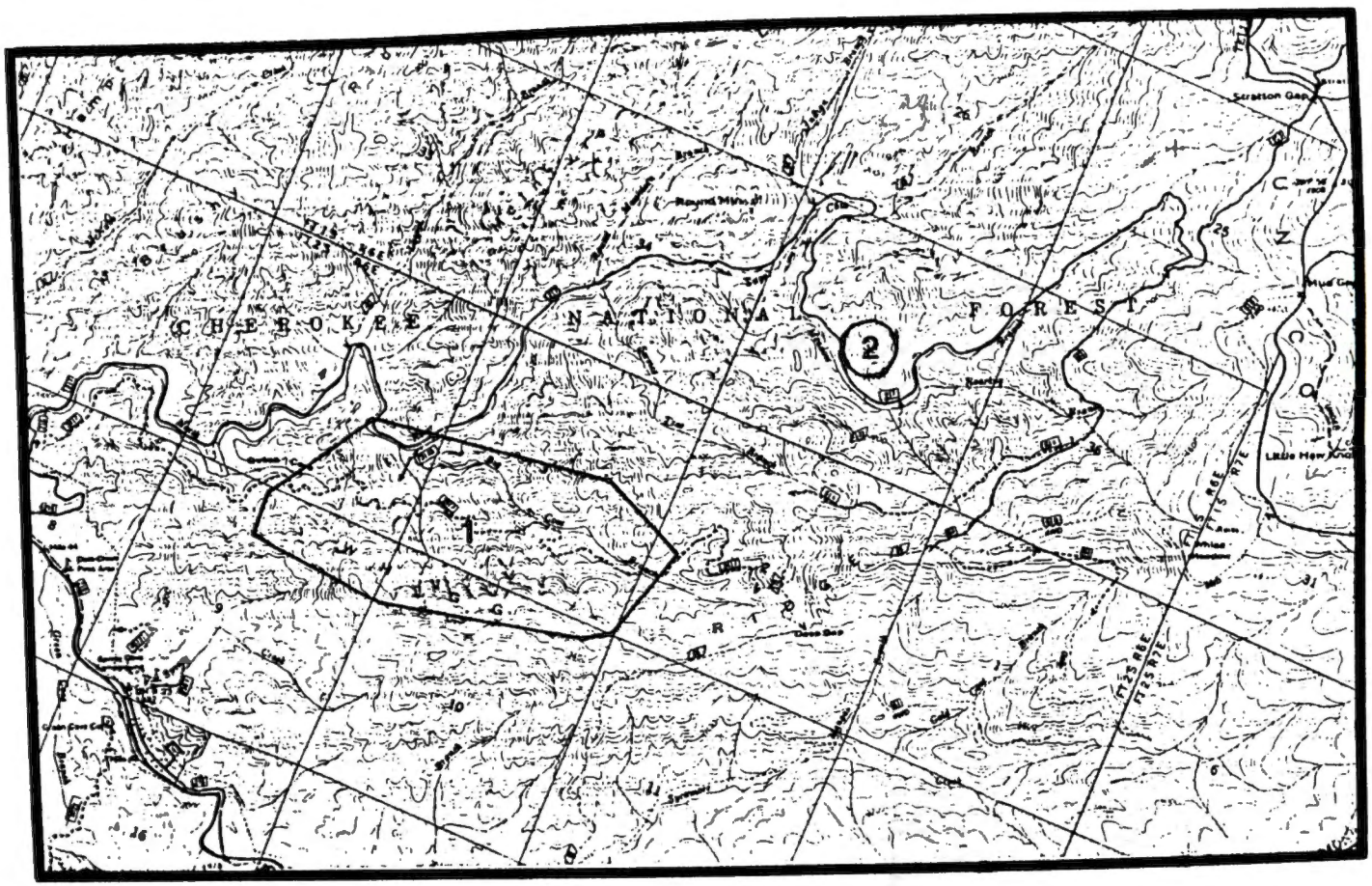


Figure 4. Habitat Study Units 1 and 2, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

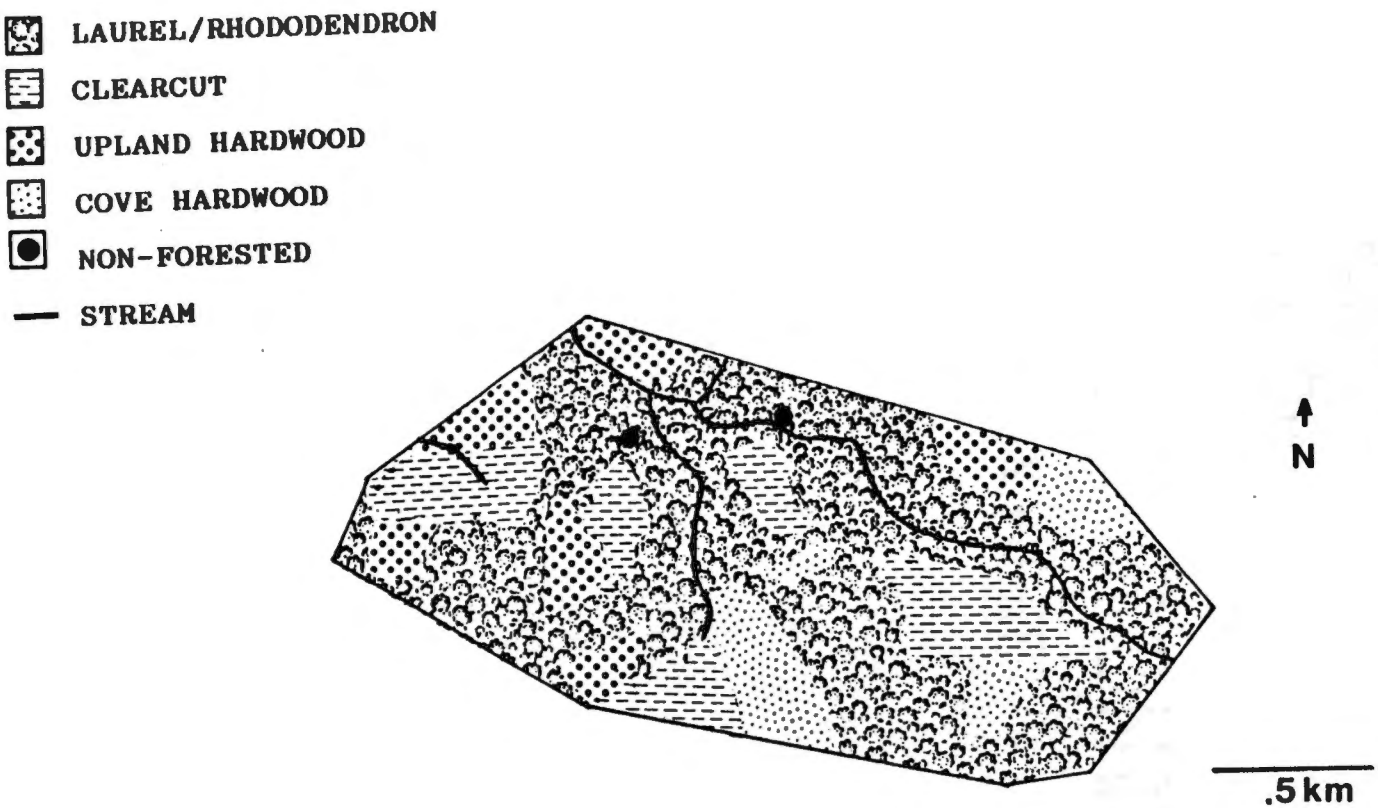


Figure 5. Habitat types delineated within Habitat Study Unit 1, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

types (Table 1).

Dense thickets of mountain laurel on the ridges and rhododendron in the drainages encompassed 58% of the unit understory. Although the overstory in these areas consisted primarily of cove and upland hardwoods, dense mountain laurel and rhododendron were put in a separate class due to heavy grouse utilization of this component in the Southeast (Stafford and Dimmick 1979).

Eighteen percent of the unit had been clearcut when the study was initiated. This included 5 stands ranging in age from 8 to 14 years, and in size from 4.5 to 16.2 ha. These clearcuts were in various stages of hardwood regeneration, and were vegetated with dense stands of blackberries (Rubus spp.), Christmas fern (Polystichum achrosticoides) and other herbaceous understory components. Upland hardwoods such as white oak, red oak and hickory comprised 10% of the unit. Although mountain laurel and rhododendron were present in many of these stands, they were not primary understory components. Greenbriar (Smilax spp.) and blueberries (Vaccinium spp.) were often in the understory.

Cove hardwoods such as yellow poplar, white oak and red oak populated 9% of the area. Scant mountain laurel and rhododendron, as well as grape (Vitis spp.) and Vaccinium were found in the understory.

There were also a few non-forested areas, comprising approximately 5% of the unit. These included roads, 2

Table 1. Habitat types delineated for Habitat Study Unit 1, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

Habitat Type	Total Area (ha)	% of Area	Description
Mtn. Laurel/ Rhododendron	153	58	Cove and upland hardwood overstory; dense laurel, rhododendron understory.
Clearcut	47	18	Dense young hardwood regeneration, ferns, blackberries.
Upland Hardwood	27	10	Oak and hickory overstory; scant greenbriar and Vaccinium understory.
Cove Hardwood	24	9	Yellow poplar, oak overstory; scant grape and Vaccinium understory.
Non-Forested	12	5	Roads, grassy fields.
Total	263	100	

grassy fields managed for wildlife, and a small clearing surrounding an unoccupied cabin.

Habitat Study Unit 2

Since only one bird was monitored in the Sugar Cove PSU, Habitat Study Unit 2 was obtained by outlining a circle around the center of the bird's home range, with the 2 outermost locations defining the diameter and location of the unit (Figure 6). The entire HSU was in Compartment 80, and was characterized by 2 habitat types (Table 2). Dense mountain laurel and rhododendron occupied 46% of the unit, and a 4-year old clearcut, predominated by hardwood regeneration, occupied 54%. The total area of the unit was 13 ha.

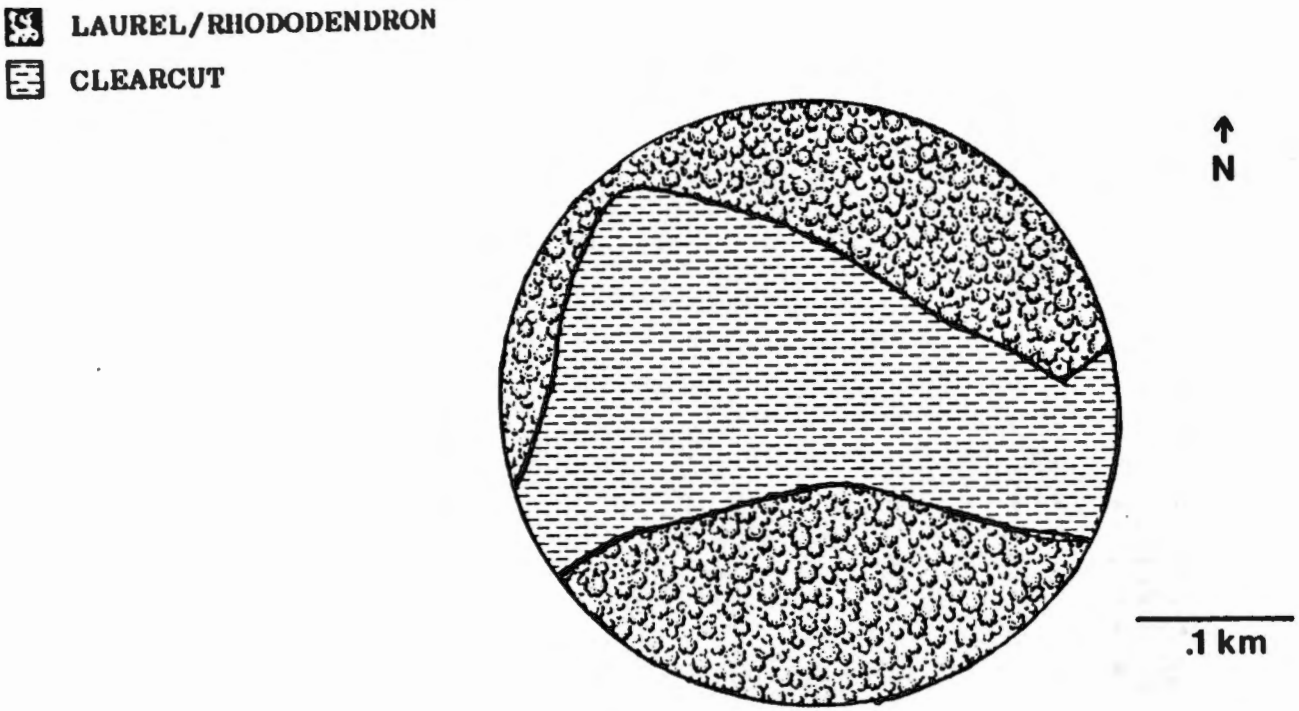


Figure 6. Habitat types delineated within Habitat Study Unit 2, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

Table 2. Habitat types delineated for Habitat Study Unit 2, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

Habitat Type	Total Area (ha)	% of Area	Description
Mtn. Laurel/ Rhododendron	6	46	Cove and upland hardwood overstory; dense laurel, rhodo-dendron understory.
Clearcut	7	54	Dense young hardwood regeneration, ferns, blackberries.
Total	13	100	

CHAPTER III

MATERIALS AND METHODS

I. Population Estimation

Grouse drumming censuses were initiated in March of 1989 and 1990 utilizing techniques described by Gullion (1966). Five census routes were mapped along ridges or logging roads in each PSU in order to locate every drumming grouse on the study units. Two or 3 censuses were conducted each week until early May. When drummers were heard, the time, weather conditions, and direction of the drummer from the observer's location, in compass degrees, were recorded. Location was noted on a United States Geological Survey (USGS) 1:24000 scale topographical map of the study unit, and plastic marking tape with the recorded azimuth was left at the site. If an azimuth could be taken from 2 locations on the same drummer within a short time, an attempt was later made to find the drumming log by triangulation. Logs were identified by droppings, feathers, displaced leaves, and observing the drumming grouse. Verified logs were marked with metal numbered tags for future reference.

II. Trapping

Mirror traps were set on drumming logs according to the technique described by Gullion (1965) in the spring of 1989 in an effort to capture drumming males. Interception traps described by Backs et al. (1985) also were placed near several of the logs in attempts to capture either the drummers or approaching females. Traps were checked daily until mid-May, when all traps were removed.

A late summer trapping season for broods was initiated in August 1989. Interception traps were placed in saddles of ridges and along roadsides where broods were often witnessed. These traps were closed after approximately 2 weeks. Total trap effort for spring and summer is given in Table 3.

Trapped birds were aged by a combination of weight and primary wear and shape of outer primary feathers (Davis 1969), sexed by completeness of tail band (Davis 1969) and number of dots per rump feather (Roussel and Ouellet 1975). Each bird was weighed with a Pesola spring scale, examined for general condition, banded with aluminum numbered leg bands, and fitted with battery-powered radio transmitters. These transmitters were constructed by AVM Instrument Company (Livermore, CA). Average weight was 23 grams. Each transmitter operated in the 150 Mhz range. Transmitters were glued to a brown vinyl collar in the shape of a bib

Table 3. 1989 Trap nights in Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

	Trap Type		
Study Area	Interception	Mirror	Combined
(Spring)			
Big Cove-Queen Cove	40	124	164
Sugar Cove	31	56	87
Total	71	180	251
(Summer)			
Big Cove-Queen Cove	59	-	59
Sugar Cove	13	-	13
Total	72	-	72
(Overall)			
Big Cove-Queen Cove	99	124	223
Sugar Cove	44	56	100
Total	143	180	323

that rested on the bird's breast, with the antenna extended above the right side of the head. Each bird's head was measured, and an appropriate-sized hole was cut in the collar for the head to insure a proper fit.

Weather conditions, time of day, and location were recorded where each bird was released. Behavior upon release was also recorded. Each bird was closely monitored immediately following release to observe initial direction of travel and to verify proper transmitter operation.

III. Radio Telemetry

Each radio-collared bird was located up to 3 days per week using a portable Telonics TR-2 telemetry receiver (Telonics, Inc., Mesa, AZ) and yagi unidirectional hand-held 4-element antenna with earphones. Collared birds were located by triangulation, using the "loudest signal" method to obtain azimuths (Springer 1979). Homing was practiced to insure that the bird was alive when it showed no movement over a period of several hours.

Specified points in each PSU were established for radio tracking. These points were usually in ridge saddles and/or prominent curves in logging roads, in order to be easily located on topographic maps. Points were selected also to receive the clearest signal possible. The Universal Transverse Mercator (UTM) grid coordinates were determined

for each of these points to calculate home ranges.

Weekly readings were taken on each bird. Single daily locations were taken at least once a week. Diels, or all-day locations, also were conducted on each bird approximately once a week. Each time a bird was located the following data were collected: date, time, signal azimuths, receiver locations, signal strengths, temperature, percent cloud cover, and precipitation. With diels, each bird was monitored at approximately 1-2 hour intervals from dawn to dusk, with occasional pre-dawn and post-dusk readings.

Two readings were used for triangulation. Azimuths intersecting at angles of as close to 90 degrees as possible were preferred for statistical accuracy. These location data were collected and plotted on an enlarged copy of a United States Geological Survey topographical map. The slope aspect, position on the slope, and distance from the nearest road and clearcut edge were noted.

Testing for directional accuracy was conducted in June 1989 according to techniques described by Springer (1979). An average of 50 readings was used to calculate an error arc.

IV. Home Range Determination

The azimuths obtained through triangulation and the locations from which these azimuths were taken for each

grouse were entered into the program TELEM (Koeln 1983) along with the UTM grid coordinates of each receiver location. The output from this program, consisting of the UTM grid coordinates of every location analyzed for each grouse, was entered into the program McPAAL (Stuwe and Blohowiak 1985), which plotted these locations and measured the minimum convex polygon (Hayne 1949) for each bird. This is calculated by connecting the outermost points where 3 consecutive points of the polygon form an angle of 180 degrees or less. This method of home range determination was chosen for comparison purposes with other ruffed grouse studies (Epperson 1988, Boyd 1990).

V. Daily Movement Analysis

The locations of each bird were plotted on a copy of a USGS 1:24000 scale topographical map of the study area. Distance was measured between consecutive locations for each bird during diels, and stored for analysis.

VI. Habitat Utilization Analysis

Five aspects of the habitat were classified and measured in the habitat study units (Table 4). Vegetative cover was defined as either hardwood regeneration, or clearcuts; mountain laurel and rhododendron understory; cove

Table 4. Percent availability of the measured classes of each habitat variable in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

Habitat Variable	Availability
Vegetative Cover	
Mountain laurel/rhododendron	58%
Clearcuts	21%
Upland hardwoods	11%
Cove hardwoods	10%
Slope Aspect	
North, northwest	51%
East, northeast	34%
West, southwest	14%
South, southeast	1%
Position on Slope	
Mid slopes	58%
Lower slopes	24%
Upper slopes	18%
Distance from Road	
Greater than 50 meters	85%
11 to 50 meters	12%
0 to 10 meters	3%
Distance from Clearcut Edge	
Greater than 50 meters	68%
11 to 50 meters	26%
0 to 10 meters	6%

hardwoods; or upland hardwoods. The mountain laurel and rhododendron understory class was chosen because of its significance to ruffed grouse. Although it is an understory association, it is believed to influence grouse habitat use more than the accompanying overstory forest type. These cover types were similar to those used by Boyd (1990) with the exception of pine and upland hardwood-pine associations, which were not present on the habitat study units. Although the inclusion of a category for Vaccinium such as used by Epperson (1988) would have been desirable, lack of accurate vegetation maps or photographs made this impractical. Slope aspect was categorized as north and northwest, west and southwest, south and southeast, and east and northeast. Position on the slope was classed as high slopes, or ridgetops; mid slopes; and lower slopes, or valleys. Three area classes were defined in relation to roads and clearcut edges: areas 0 to 10 m, 11 to 50 m, and greater than 50 m from the road or clearcut edge. Every telemetry location was classified for each of the above habitat variables.

CHAPTER IV

RESULTS

I. Population Estimation

Estimates of the breeding population were based on the assumptions that: (1) every male on each of the PSUs drummed, (2) every drummer was heard, and (3) there was an equal sex ratio. The total grouse population on each study area was assumed to be twice the number of drummers identified (Gullion 1966). Drumming census results from 1984 through 1988 (Boyd 1990) were incorporated into this study (Table 5) to illustrate longer term population trends (Figure 7). Results indicated that the grouse population increased from 1984 to 1990, except for short term declines in 1987 and 1988 on the Big Cove-Queen Cove Unit, and in 1988 on the Sugar Cove Unit (Table 6). The increase in grouse numbers paralleled a cumulative increase in the proportion of each area converted to hardwood regeneration by clearcutting.

Big Cove-Queen Cove

An average of 7 censuses per year were conducted on the Big Cove-Queen Cove PSU in 1989 and 1990. Nine (1989) and

Table 5. Results of ruffed grouse drumming censuses on Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1984-1990.*

	Year						
	1984	1985	1986	1987	1988	1989	1990
(Big Cove-Queen Cove)							
Number of Censuses:	0	5	7	8	8	8	6
Drummers Identified:	-	9	10	7	3	9	13
Population Estimation: (grouse/100 ha, both sexes)	-	3.6	4.0	2.8	1.2	3.6	5.2
(Sugar Cove)							
Number of Censuses:	7	4	6	7	5	5	4
Drummers Identified:	3	1	3	4	2	5	10
Population Estimation: (grouse/100 ha, both sexes)	-	0.5	1.6	2.1	1.1	2.7	5.4

* Data from 1984 through 1988 provided by Boyd (1990).

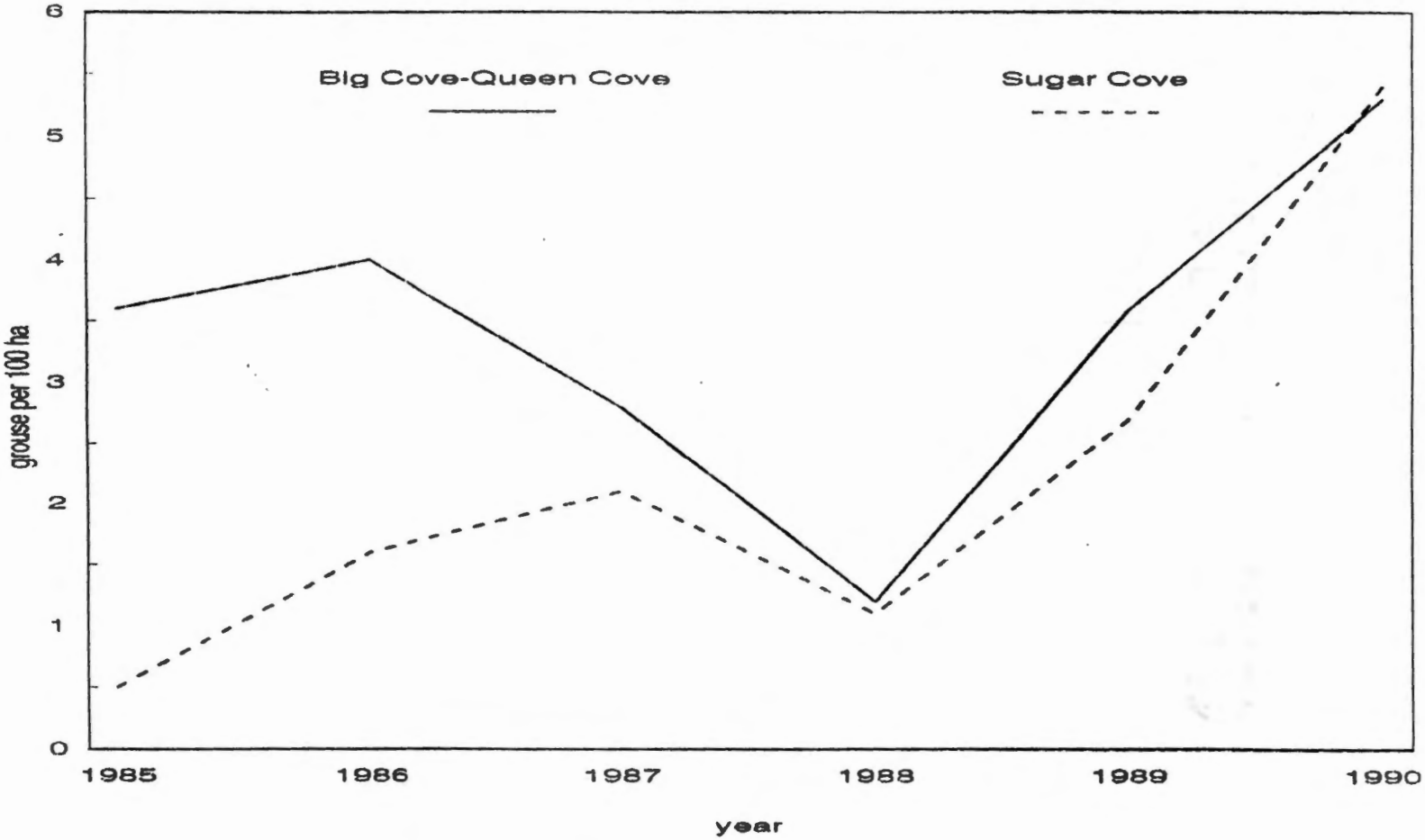


Figure 7. Ruffed grouse population estimates on the Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

Table 6. Clearcut specifications and corresponding grouse densities in Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

Year	Clearcuts Completed	Cumulative Area	Cumulative % of PSU	Grouse Density
		---Big Cove-Queen Cove---		
1981	2	11.7 ha	2	-
1982	1	21.0 ha	4	-
1983	1	36.2 ha	7	-
1984	1	45.5 ha	9	-
1985	1	58.0 ha	12	3.6/100 ha
1986	0	58.0 ha	12	4.0/100 ha
1987	0	58.0 ha	12	2.8/100 ha
1988	3	90.8.ha	18	1.2/100 ha
1989	0	90.8 ha	18	3.6/100 ha
1990	0	90.8 ha	18	5.2/100 ha
		---Sugar Cove---		
1985	0	0.0 ha	0	0.5/100 ha
1986	1	7.3 ha	2	1.6/100 ha
1987	1	19.4 ha	5	2.1/100 ha
1988	4	63.9 ha	17	1.1/100 ha
1989	0	63.9 ha	17	2.7/100 ha
1990	0	63.9 ha	17	5.4/100 ha

13 (1990) drummers were identified, yielding an estimated 3.6 and 5.2 grouse per 100 ha in spring 1989 and 1990, respectively. Thirteen drumming logs were in clearcuts, 6 were in mountain laurel thickets, and 3 were in dense undergrowth directly adjacent to logging roads. Drumming peaked in mid-April in 1989, and in early April, 1990.

Sugar Cove

Approximately 5 drumming censuses were conducted per year in the Sugar Cove PSU in 1989 and 1990. Five (1989) and 10 (1990) drummers were located, yielding an estimated 2.7 and 5.4 birds per 100 ha, respectively. Two drummers were in clearcuts, 9 were in mountain laurel or rhododendron thickets, and 4 were in dense brush adjacent to logging roads. As on the Big Cove-Queen Cove unit, drumming peaked in mid-April, 1989, and early April, 1990.

II. Trapping

During spring and summer, 1989, trapping yielded an average of 1 grouse capture per 29 trap nights. Spring trapping produced 1 capture per 35 trap nights, and summer trapping yielded 1 capture per 18 trap nights (Table 7). The spring trapping season also yielded several incidental captures for other species. Three deer mice (Peromyscus

Table 7. 1989 Trap success rates* in the Big Cove-Queen Cove and Sugar Cove Population Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

	Trap Type		
Study Area	Interception	Mirror	Combined
(Spring)			
Big Cove-Queen Cove	20.00	41.33	32.80
Sugar Cove	0.00	28.00	43.50
Total	35.50	36.00	35.86
(Summer)			
Big Cove-Queen Cove	19.66	-	19.66
Sugar Cove	13.00	-	13.00
Total	18.00	-	18.00
(Overall)			
Big Cove-Queen Cove	19.80	41.33	27.87
Sugar Cove	44.00	28.00	33.33
Total	23.83	36.00	29.36

* expressed as number of trap nights per capture.

maniculatus), 2 eastern cottontails, 2 eastern chipmunks (Tamias striatus) and 1 wood thrush (Hylocichla mustelina) were captured in mirror traps, and 1 eastern cottontail and 1 box turtle (Terrapene carolina) were captured in interception traps.

Big Cove-Queen Cove

Five adult male grouse, 1 of which was predated in the trap, were captured during spring. Three of the birds were captured in mirror traps, and 2 in interception traps situated near their drumming logs.

Three birds were captured in summer. A juvenile male and a juvenile female were captured simultaneously in an interception trap situated directly adjacent to a logging road where a brood repeatedly had been observed. An adult female also was captured in an interception trap adjacent to a logging road where a brood had been observed on several occasions. Capture sites and drumming logs are indicated in Figure 8.

Sugar Cove

One adult male grouse was captured during spring from a mirror trap situated in a mountain laurel thicket on a ridgetop. This bird was recaptured 2 days later in a mirror

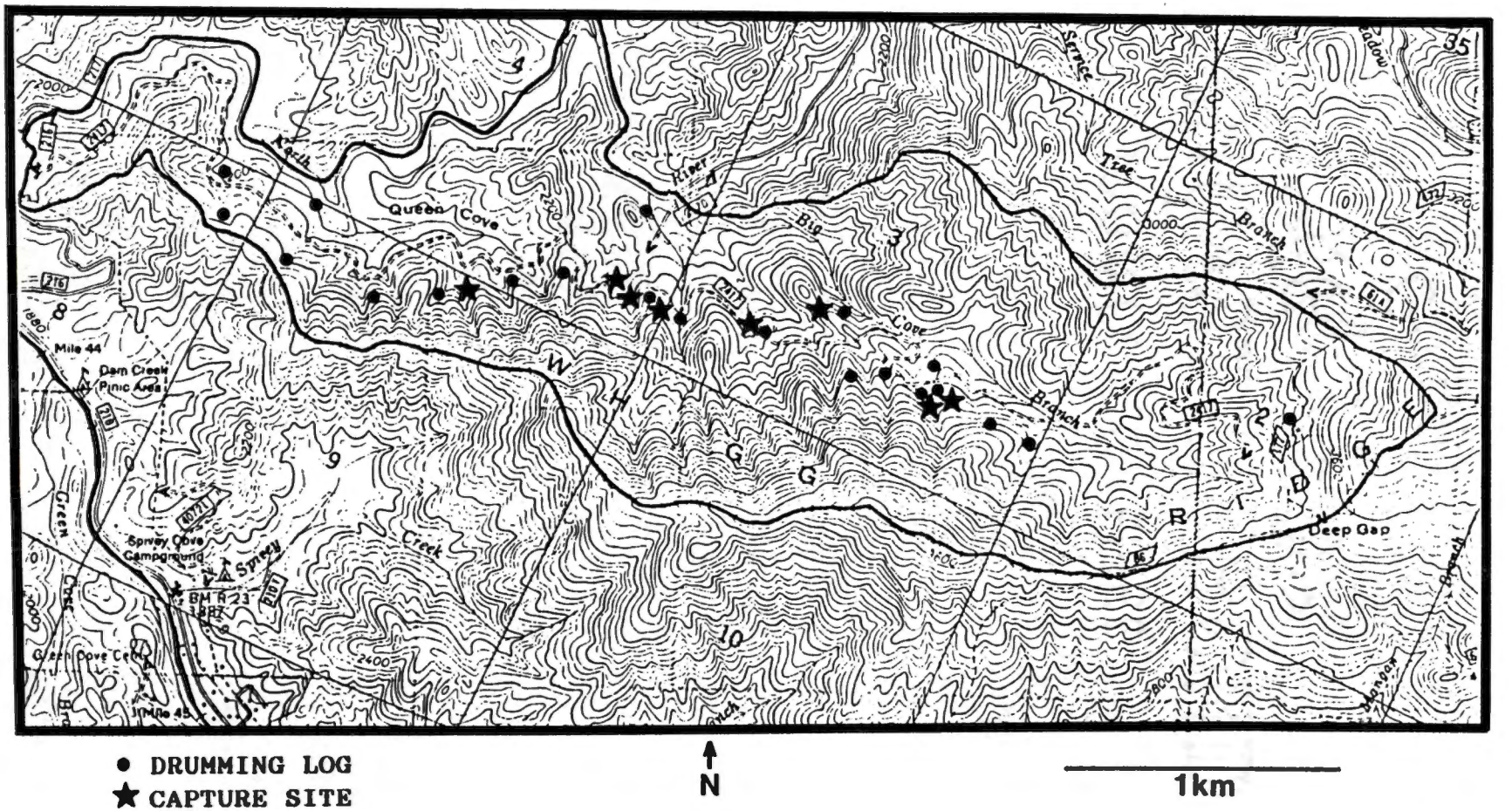


Figure 8. Drumming logs and capture sites on the Big Cove-Queen Cove Population Study Unit, 1989-1990, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

trap on the same ridgetop, approximately 200 m from the first capture site.

One juvenile female was captured in the summer 1989 from an interception trap on a knob in a mountain laurel thicket. Capture sites and drumming logs are indicated in Figure 9.

III. Radio Telemetry

Monitoring of each bird began immediately following its capture. Telemetry data for 7 grouse were utilized in the final statistical analysis. One thousand ninety-nine locations were analyzed, with locations per bird ranging from 61 to 308. The monitoring period for a single bird ranged from 74 to 389 days (Table 8). Testing for accuracy indicated 12.75 degrees of error at an average distance of 300 m, which resulted in an average error of 62 linear m in location estimates.

Big Cove-Queen Cove

Each of the 4 adult male grouse released with transmitters in this PSU provided sufficient data for analyzing their use of habitat. The adult female and the juvenile male captured in the summer also were utilized. The radio signal from the juvenile female was lost for

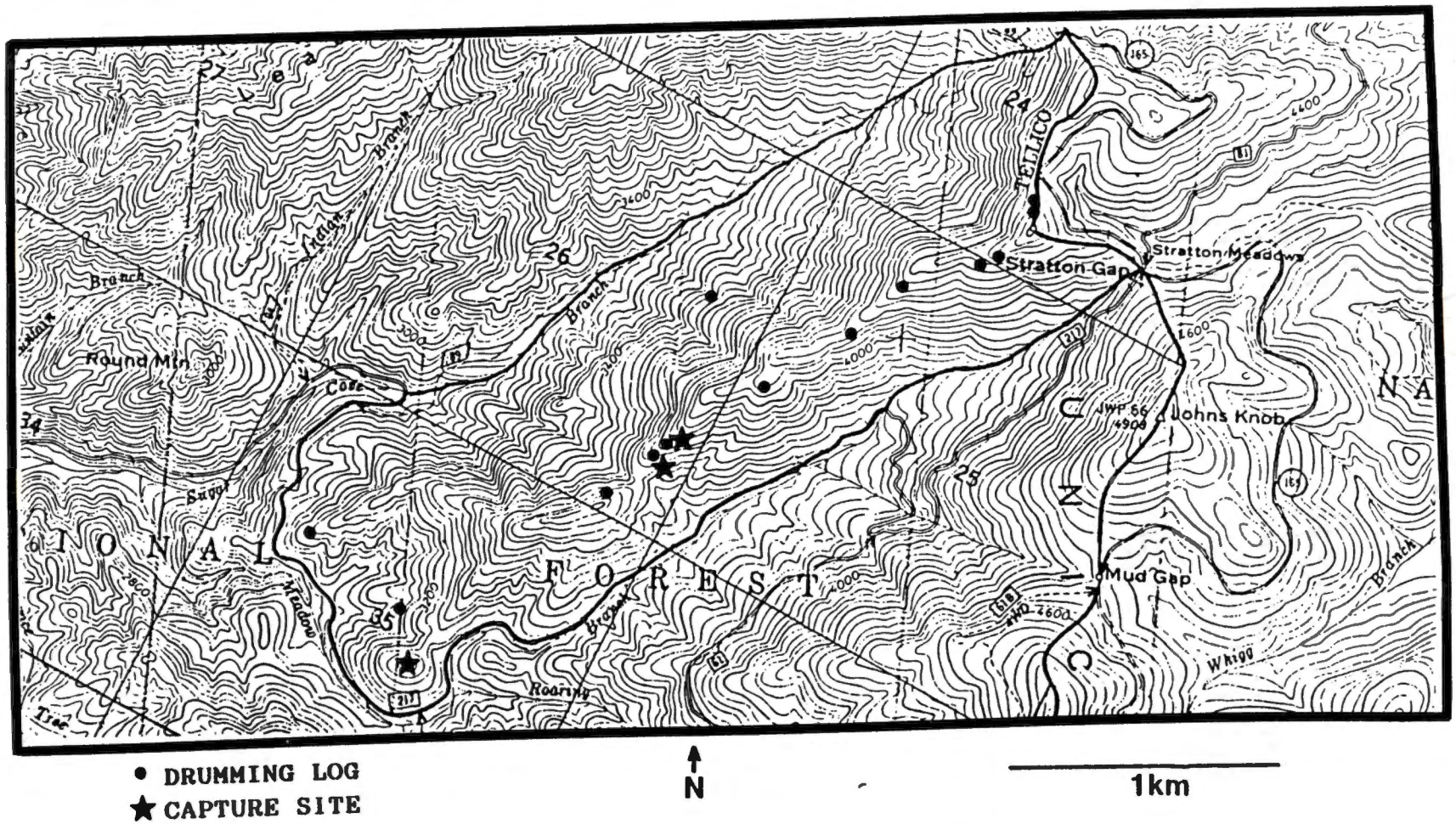


Figure 9. Drumming logs and capture sites on the Sugar Cove Population Study Unit, 1989-1990, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

Table 8. Individual capture and telemetry data of grouse monitored during 1989 and 1990, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

Bird #	Capture Date	Study Area	Age, Sex	Weight (grams)	# of Locs.	# Days Monitored	Monitoring Period AMJJASONDJFMAM
721*	4/16/89	Big	a,m	690	232	282	----------T
488	4/21/89	Sugar	a,m	600	2	2	S
046*	4/23/89 4/25/89	Big	a,m	700	252	395	----------A
-	4/25/89	Big	a,m	-	-	0	P
542*	5/06/89	Big	a,m	600	308	380	----------A
039*	5/08/89	Big	a,m	600	94	90	--L
120*	8/08/89	Big	j,m	492	61	68	--T
177	8/08/89	Big	j,f	422	3	12	T
138*	8/14/89	Big	a,f	588	76	100	---S
320*	8/15/89	Sugar	j,f	428	76	67	--T

* indicates birds that were included in the statistical analysis.
T: Lost transmitter; S: Lost transmitter signal; A: Alive;
P: Killed in trap by a predator; L: Left the area.

several weeks after her release; her transmitter was found later.

Sugar Cove

The adult male captured in this PSU was lost after his second capture. The juvenile female was monitored for 77 days. Seventy-six locations were obtained from her.

IV. Home Ranges

Four of the 7 estimated home ranges were of adult male grouse (bird numbers 721, 046, 542, and 039) in Big Cove-Queen Cove. A juvenile male bird (170) and an adult female (138) were also monitored in Big Cove-Queen Cove. A juvenile female (320) was monitored in the Sugar Cove unit.

Adult male 721 was monitored over a period of 282 days. His home range was calculated at 56.3 ha (Figure 10). Most of these locations were centered closely around his drumming area, with no great seasonal variations.

Bird 046 was telemetered over 396 days and occupied 56.5 ha (Figure 11). Although the majority of his locations were in the vicinity of his drumming area, this bird made excursions during summer 1989 that greatly increased his home range size.

Bird 542, monitored over 380 days, occupied 37.3 ha

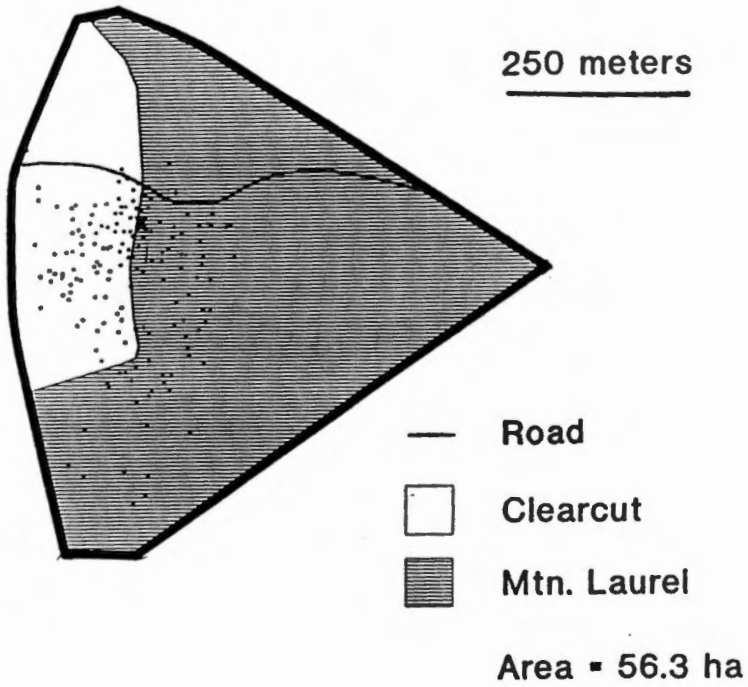


Figure 10. Home range and telemetry locations of adult male grouse 721, monitored in Big Cove-Queen Cove from 4/16/89 until 2/18/90.

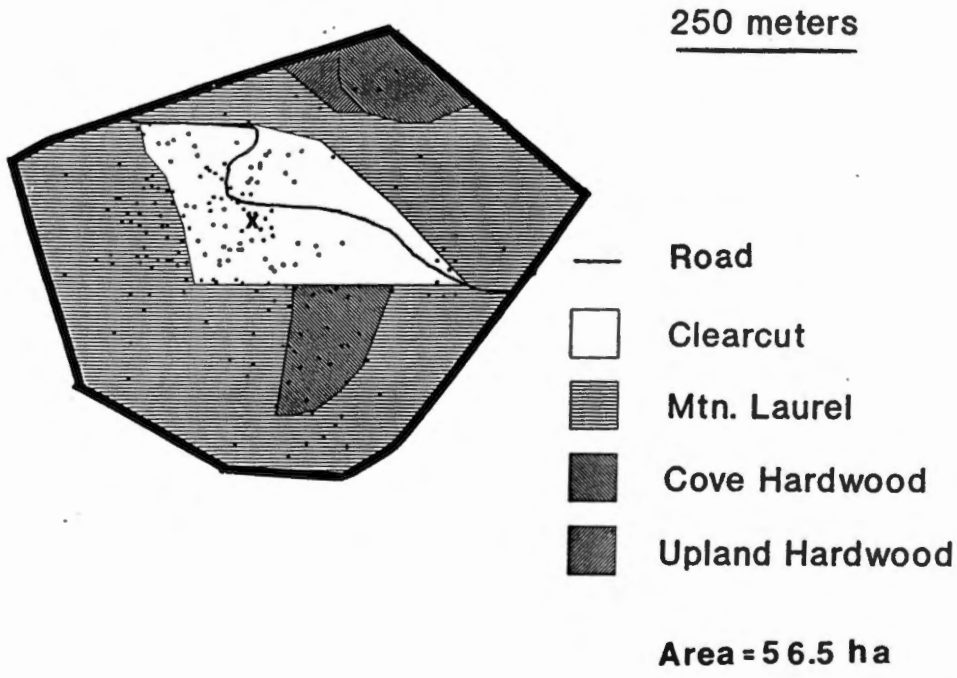


Figure 11. Home range and telemetry locations of adult male grouse 046, monitored in Big Cove-Queen Cove from 4/25/89 until 5/31/90.

(Figure 12). His location was consistently close to his drumming stage.

Bird 039, monitored over 90 days through the summer of 1989, occupied 56.3 ha (Figure 13). Most locations were extremely concentrated around the drumming area. Several lengthy excursions, however, greatly increased the home range size shortly before his transmitter signal was lost in early August. He was discovered by aerial homing in late August, approximately 4 miles northwest of his original home range.

Juvenile male 120 was located over a period of 80 days in late summer and early fall 1989. His home range during this time was 7.6 ha (Figure 14). Loss of the transmitter prohibited further telemetry.

Adult female 138 was monitored for 100 days in the late summer and fall of 1989. Her home range encompassed 23.2 ha (Figure 15). A brood was seen in the immediate vicinity of her trap site during the time that she was trapped. It was assumed that it was her brood although none of the young were trapped. Her home range, fairly restricted the first few weeks after capture, grew steadily larger through the late fall, until contact with her transmitter signal was lost.

Juvenile female 320 was monitored in Sugar Cove over 172 days in the late summer, fall and winter of 1989 and 1990. Her home range was 86.8 ha (Figure 16), with the area

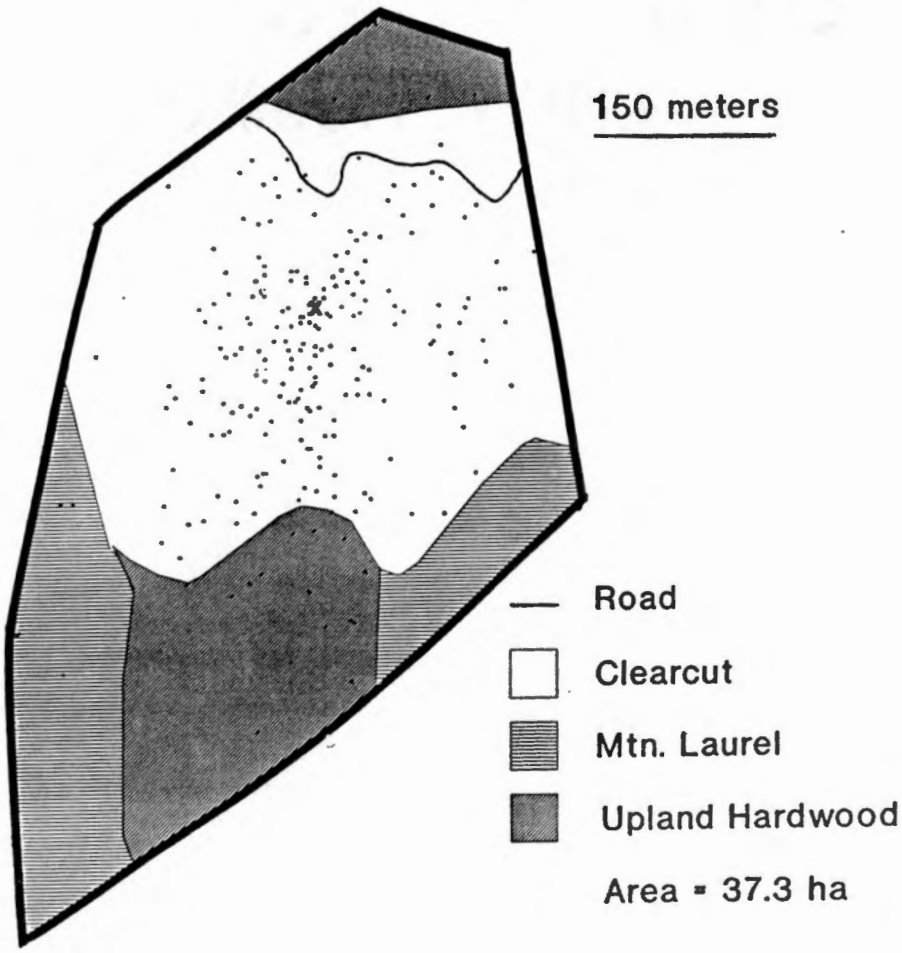


Figure 12. Home range and telemetry locations of adult male grouse 542, monitored in Big Cove-Queen Cove from 5/6/89 until 5/31/90.

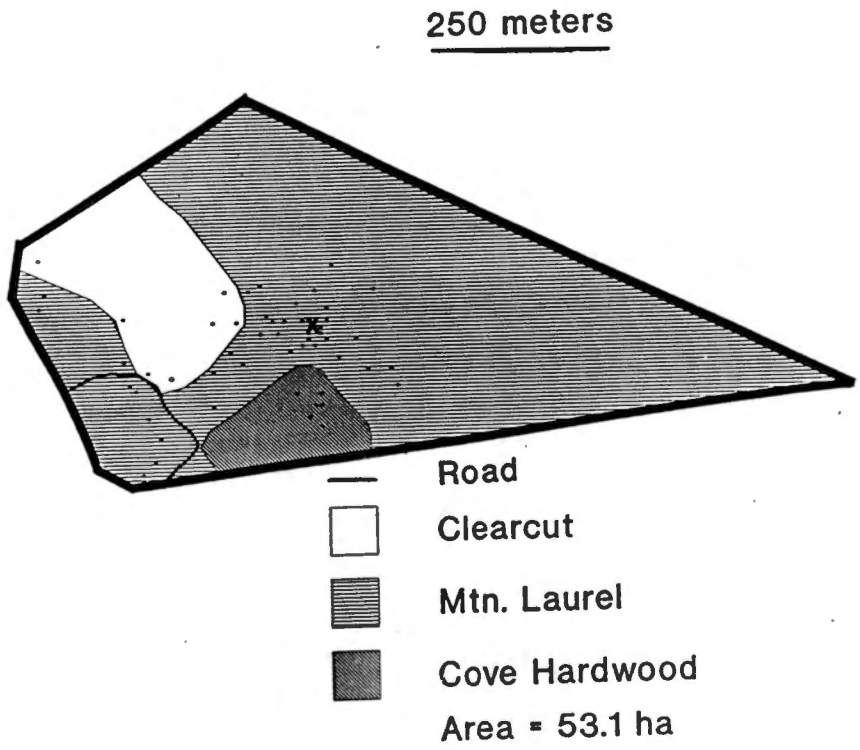


Figure 13. Home range and telemetry locations of adult male grouse 039, monitored in Big Cove-Queen Cove from 5/8/89 until 7/10/89.

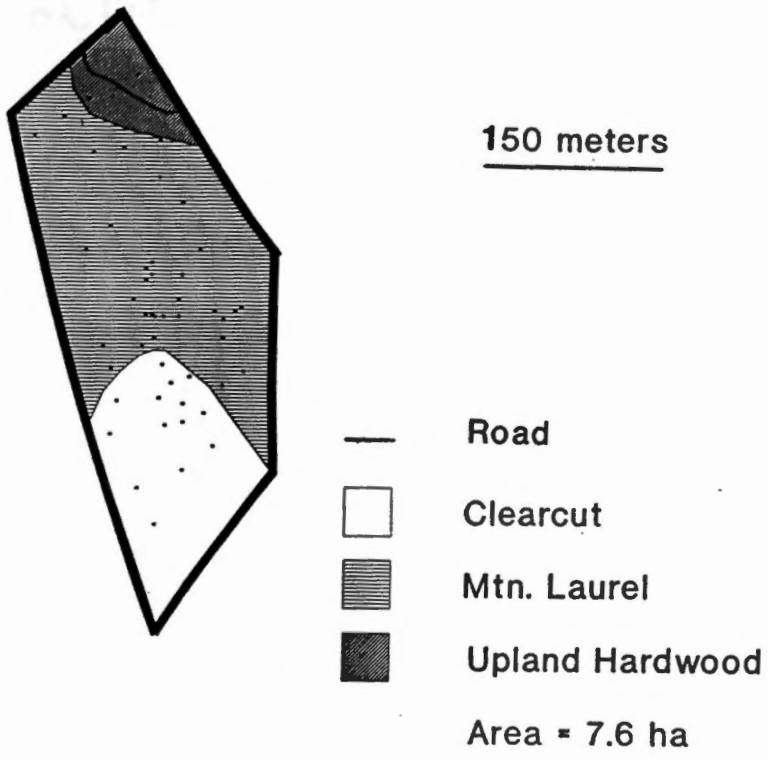


Figure 14. Home range and telemetry locations of juvenile male grouse 120, monitored in Big Cove-Queen Cove from 8/8/89 until 10/21/89.

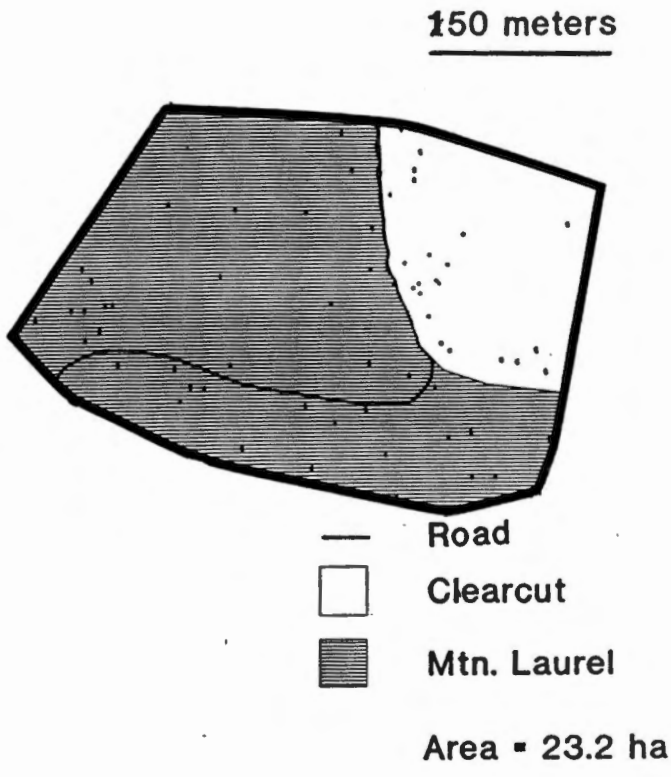


Figure 15. Home range and telemetry locations of adult female grouse 138, monitored in Big Cove-Queen Cove from 8/14/89 until 11/28/89.

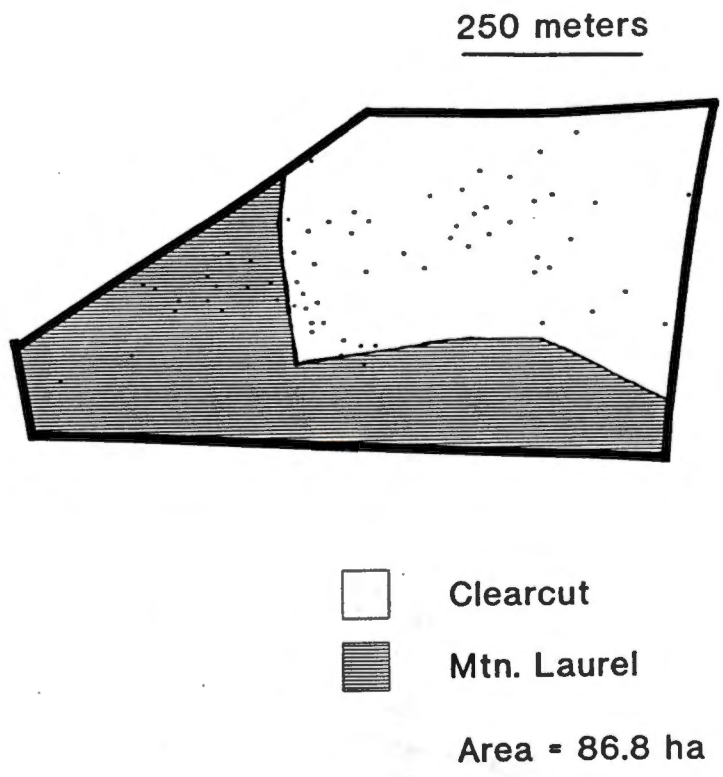


Figure 16. Home range and telemetry locations of juvenile female grouse 320, monitored in Sugar Cove from 8/15/89 until 10/31/89.

covered relatively consistent throughout the monitoring period.

V. Daily Movement

Data obtained from weekly diels were utilized to determine average movement per hour. Movements less than 62 m were considered insignificant due to telemetry error. This information was related to the variables of time of year, time of day, temperature, precipitation and cloud cover (Table 9). Data were entered into a Statistical Analysis System (SAS) program (SAS Institute, Inc. 1985) and general linear models (GLMs) were used to determine the effects of these variables on grouse mobility (Table 9). Movement was analyzed with the weather variables from the prior location of each bird in order to determine the effect of these conditions on movement.

Residual plots indicated a bias in the data due to the utilization of contiguous grouse locations. When analyzing the effect of environmental variables on movement, the prior location seemed to affect the movement of grouse. The results, therefore, were divided into 2 categories: effect of variables on whether or not the birds moved significantly; and effects of the variables on the movement, given that the birds were moving. This distinction in the analysis eliminated the bias shown in the residual plots.

Table 9. Effects of weather conditions on grouse movement rates, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990.

	Temperature	Cloud Cover	Precipitation
Did variable affect movement?			
Spring	*	*	-
Summer	P=0.12 (neg. corr.)	*	-
Fall	*	*	-
Winter	P=0.06 (pos. corr.)	P=0.11 (neg. corr.)	-
Overall	-	-	*
What was the effect?			
Spring	P=0.12 (>in 60's)	P=0.07 (neg. corr.)	-
Summer	*	P=0.02 (neg. corr.)	-
Fall	P=0.03 (>in 20's)	*	-
Winter	*	*	-
Overall	-	-	*

* indicates no correlation.

Time of year and time of day had no effect on the daily movement rates of the telemetered birds (Table 10). General linear models and categorical models showed complete randomness of mobility.

The likelihood that grouse would move increased with warming temperatures in the winter (P=0.06). Temperature did not have a significant influence on the likelihood of grouse moving during any other season (Table 9). If the grouse were moving, the likelihood that temperature would affect their movement rates was highest in the fall, when temperatures were between -6.5 and -1.5^{0}C (P=0.03). Temperature was not a significant influence on movement during any other season.

When grouse were moving, cloud cover greater than 50% had a prohibitive effect on movement rates in the spring (P=0.07) and summer (P=0.02). Cloud cover did not affect movement rates during any other season, nor the likelihood that grouse would move.

The effects of precipitation were examined year round. Precipitation had no effect on the likelihood that grouse would move, nor on the movement rates when they were moving.

VI. Habitat Utilization

Use by ruffed grouse of vegetative cover, slope aspect, position on the slope, distance from the nearest road, and

distance from the nearest clearcut edge, was evaluated with chi-square tests of utilization vs. availability (Neu et al. 1974). Season, time of day, and the parameters temperature, precipitation, and cloud cover were examined to determine the effects of these variables on habitat utilization.

Vegetative Cover

Clearcuts, which made up 21% of the area, were used in 57% of the locations. Twenty-one percent of grouse locations were in mountain laurel and rhododendron, which constituted 58% of the area. Upland hardwoods made up 11% of the area, and were the vegetative cover in 13% of the locations. Cove hardwoods comprised 10% of the area, and were utilized in 9% of the locations.

Cover was utilized disproportionately to its availability during every season, time period, and weather condition ($P<.01$). Clearcuts were utilized in greater proportion than their availability, mountain laurel and rhododendron were utilized in smaller proportions than their availability, and cove and upland hardwoods were utilized in proportion to their availability (Figure 17).

Additionally, ruffed grouse used clearcuts more in spring and winter than in summer and fall, mountain laurel and rhododendron more in summer and fall than in winter and spring, and cove hardwoods more in spring than during other

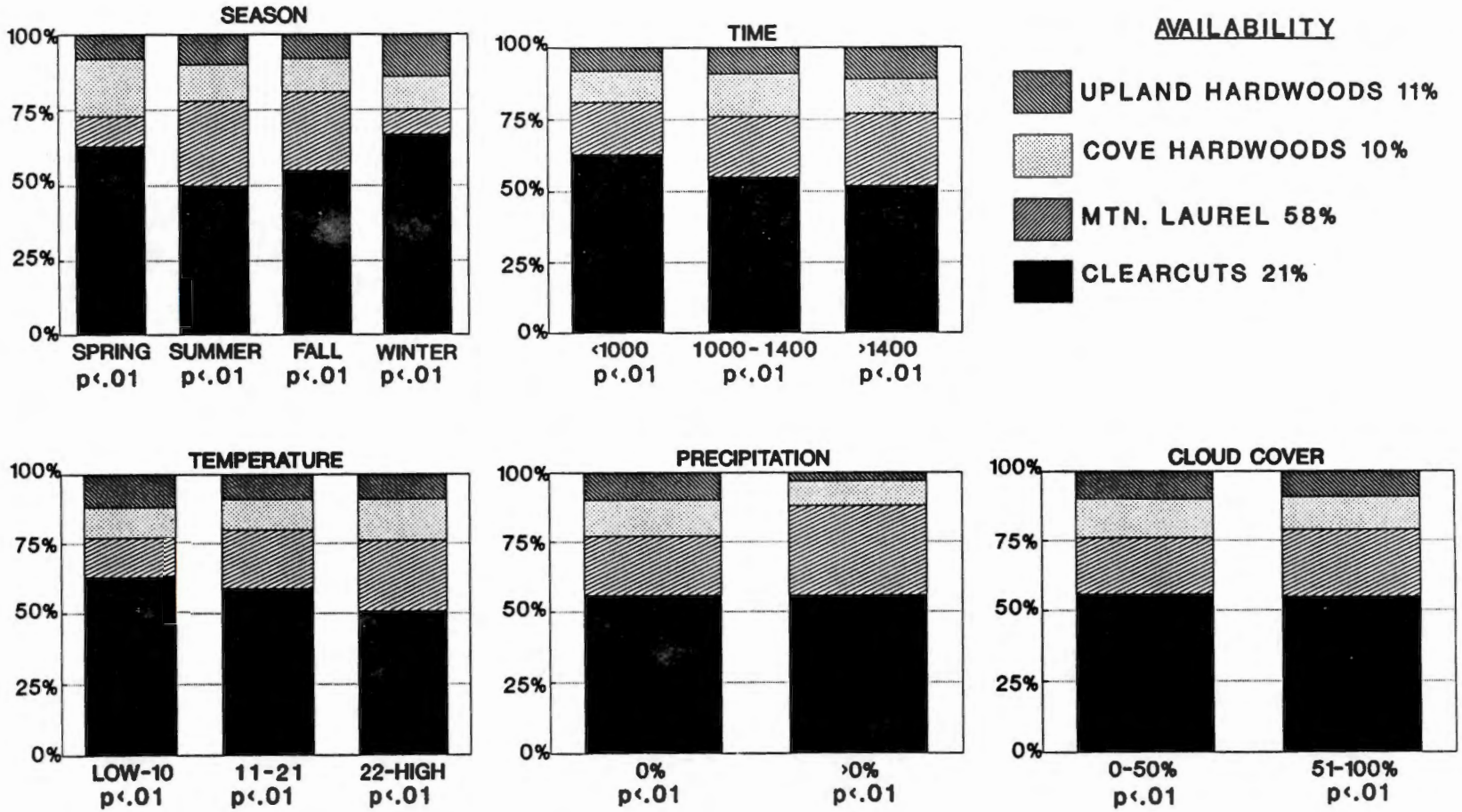


Figure 17. Utilization of vegetative cover by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990.

seasons (Figure 17).

Utilization of clearcuts by ruffed grouse declined as the day progressed, whereas use of mountain laurel and rhododendron increased (Figure 17). These results corresponded with the trend in utilization by temperature gradients. Grouse visitation of clearcuts decreased with increased temperature, while mountain laurel and rhododendron usage increased with increasing temperatures (Figure 17).

Precipitation caused a decline in utilization of upland hardwoods. Mountain laurel and rhododendron were visited more heavily during periods of precipitation than during other times (Figure 17).

Slope Aspect

North and northwest slopes comprised 51% of the study area, and were utilized by grouse in 67% of the locations. East and northeast slopes made up 34% of the area, and were utilized in 25% of grouse locations. Grouse were found on west and southwest slopes in 8% of the locations. These slope aspects comprised 14% of the area. South and southeast slopes made up 1% of the area. Less than 1% of grouse locations were on these slopes.

Ruffed grouse frequented different slope aspects disproportionately to their availability during every season

(P=0.03), time period (P=0.05), temperature class (P=0.03), precipitation class (P=0.05), and cloud cover percentage (P=0.05)(Figure 18). North and northwest slopes were utilized in greater proportion than their availability (Figure 18). East and northeast slopes were utilized either less than or in proportion to their availability (Figure 18). West and southwest, and south and southeast slopes were utilized in proportion to their availability (Figure 18).

East and northeast slopes were utilized increasingly from summer through spring. West and southwest slopes were more heavily visited in the warmer months (Figure 18).

Increasing temperature corresponded with increased usage of west and southwest slopes. Occupancy of east and northeast slopes nominally increased during periods of precipitation and heavy cloud cover (Figure 18).

Position on Slope

Low slopes constituted 24% of the area, and were used by grouse in 13% of the locations. Mid slopes were used in 66% of grouse locations, and comprised 58% of the area. High slopes made up 18% of the area, and were utilized in 21% of grouse locations.

Grouse utilization of various slope positions was significantly affected by season (P<0.01), time of day

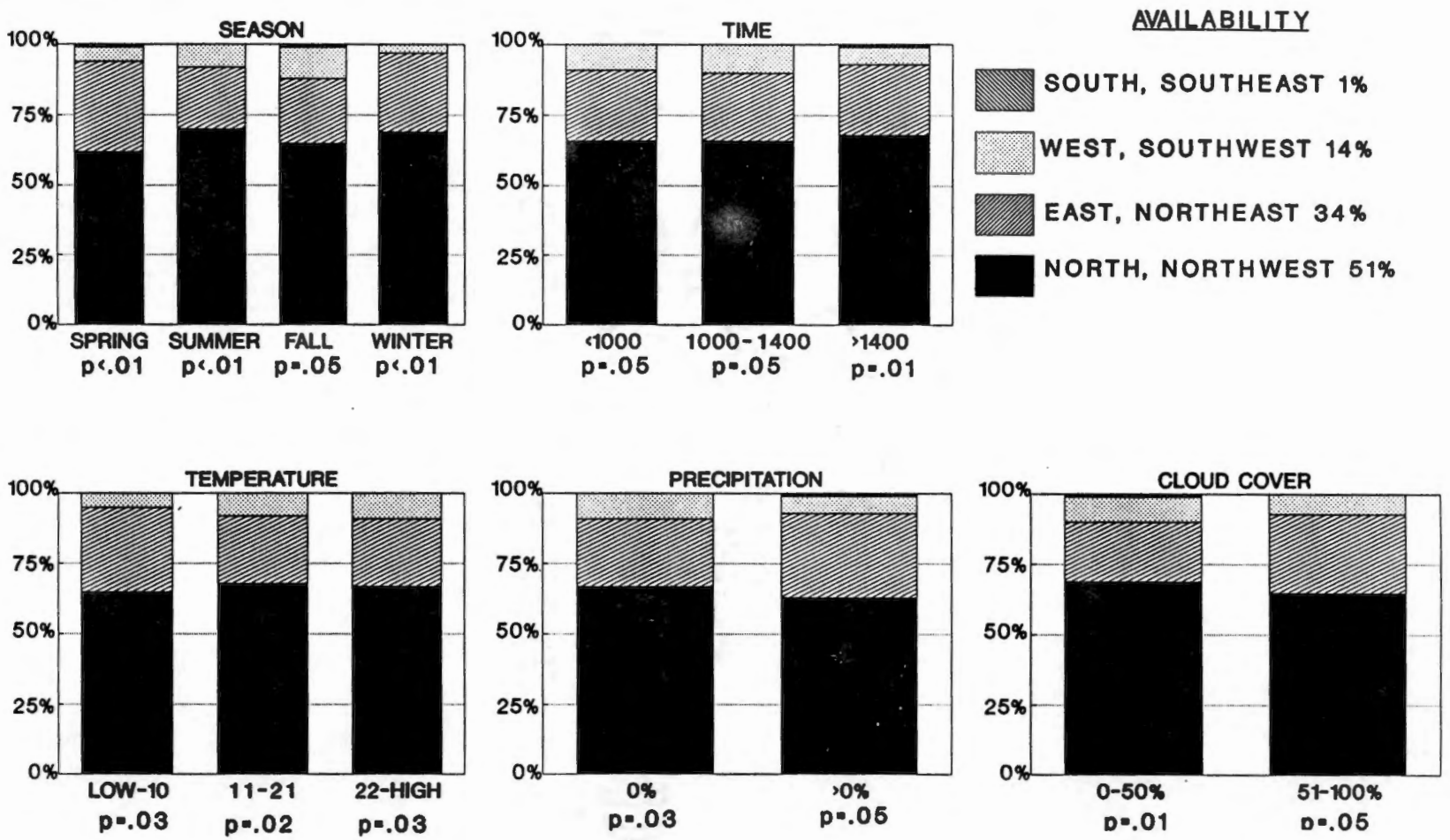


Figure 18. Utilization of slope aspect by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990.

(P=0.05), temperature (P=0.05), and precipitation (P=0.03). Cloud cover did not significantly affect utilization of various slope positions (Figure 19).

Season did not affect grouse visitation of various slope positions in summer or fall. High slopes, however, were avoided during winter and spring. Furthermore, grouse exhibited a preference for mid slopes in the spring (Figure 19).

Grouse frequented various slope positions in accordance with their availability during mid-day and later. During the morning, however, grouse showed a preference for mid slopes (Figure 19).

Grouse preferred mid slopes and avoided lower slopes when the temperature was between 10^0C and 21^0C. Mid and lower slopes were visited in greater proportion than their availability during periods of precipitation. No preference for slope position was shown during dry periods (Figure 19).

Distance from Roads

Grouse were located within 10 m of roads in 10% of their locations. Three percent of the area was within 10 m of a road. Twelve percent of the area was from 11 m to 50 m from a road, and 21% of the grouse locations were in these areas. Land farther than 50 m from roads made up 85% of the area, and grouse utilized this land in 69% of the

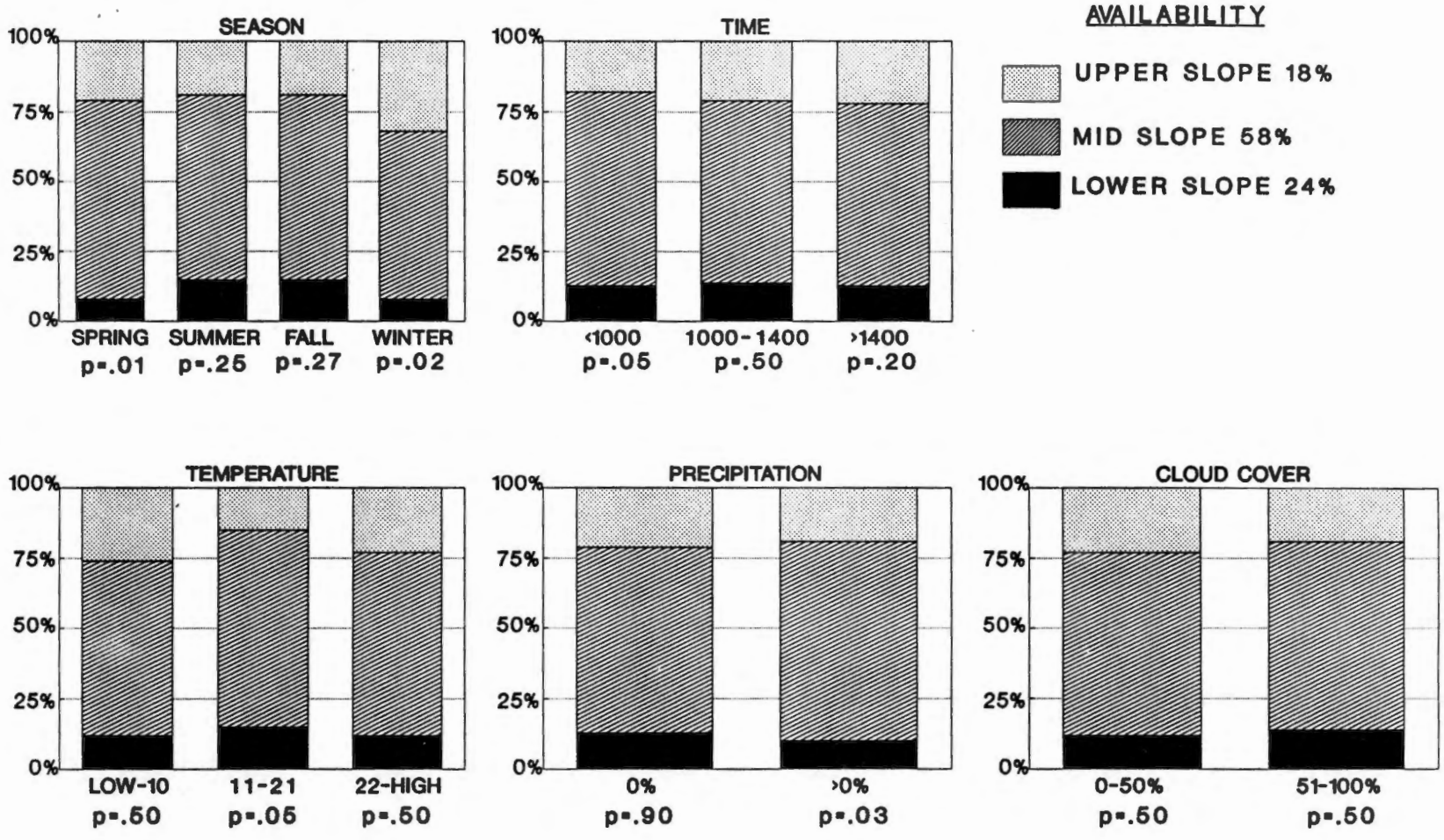


Figure 19. Utilization of slope positions by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990.

locations.

Ruffed grouse frequented areas within 50 m of roads more than other areas ($P<0.01$) except in the spring, during which time utilization was marginally proportional to availability ($P=0.08$)(Figure 20). Areas near roads were utilized more when the temperature was below 10^0C than during times of warmer temperatures. Areas greater than 50 m from roads were utilized more when temperatures were above 21^0C than during colder times (Figure 20).

Distance from Clearcut Edges

Six percent of the study area was within 10 m of a clearcut edge. Grouse were found in these areas in 16% of their locations. Twenty-six percent of the area was between 11 m and 50 m from a clearcut edge. Thirty-four percent of grouse locations were in these areas. Sixty-eight percent of the study area was farther than 50 m from a clearcut edge, and grouse were located in these areas 50% of the time.

Except during winter, grouse were found near clearcut edges in greater proportion than their availability ($P<.01$) (Figure 21). However, use was marginally proportional to availability when temperatures were below 10^0C ($P=0.05$) (Figure 21). When temperatures were above 10^0C, use of areas within 50 m of clearcut edges exceeded availability,

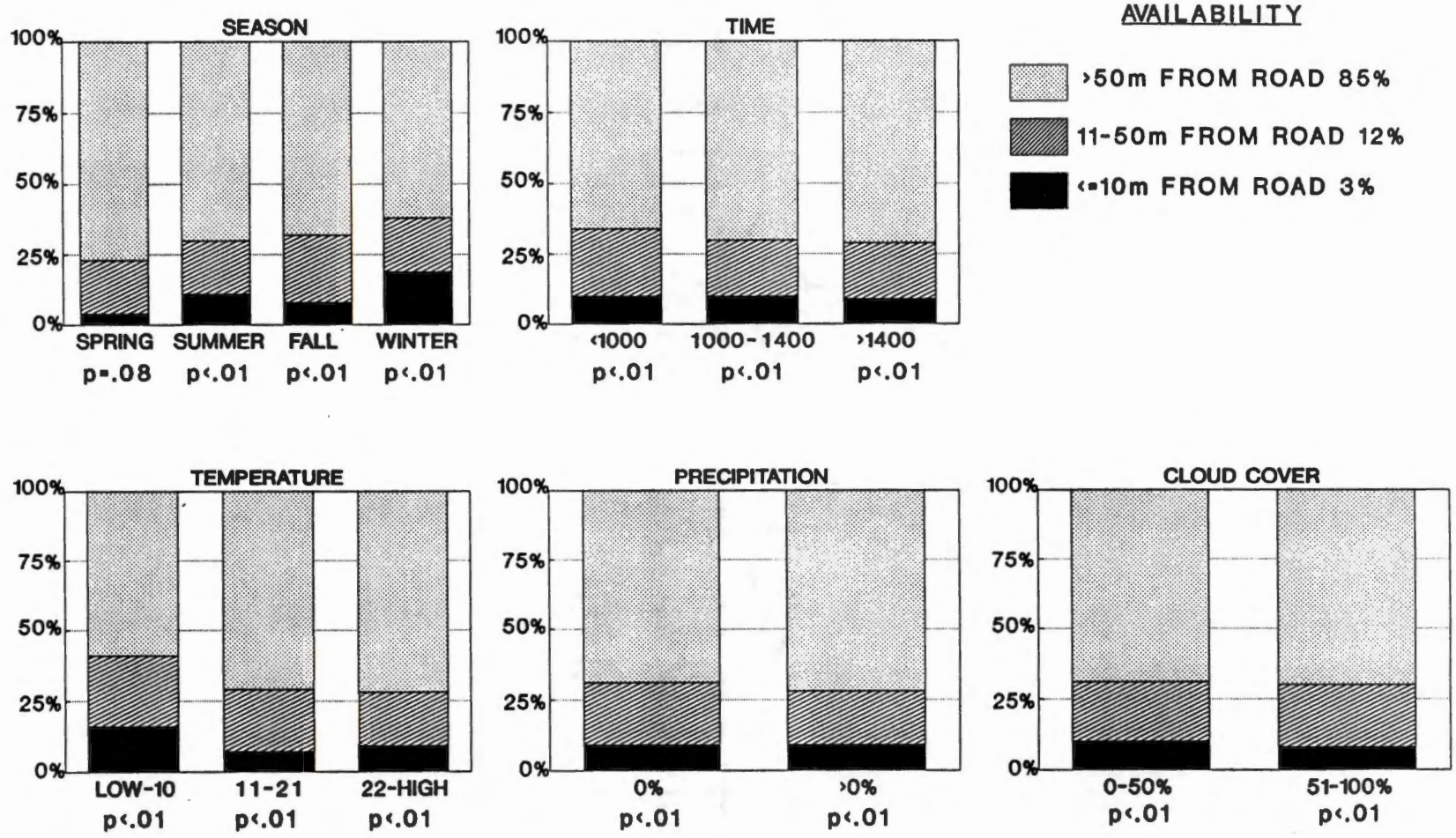


Figure 20. Utilization of roads by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990.

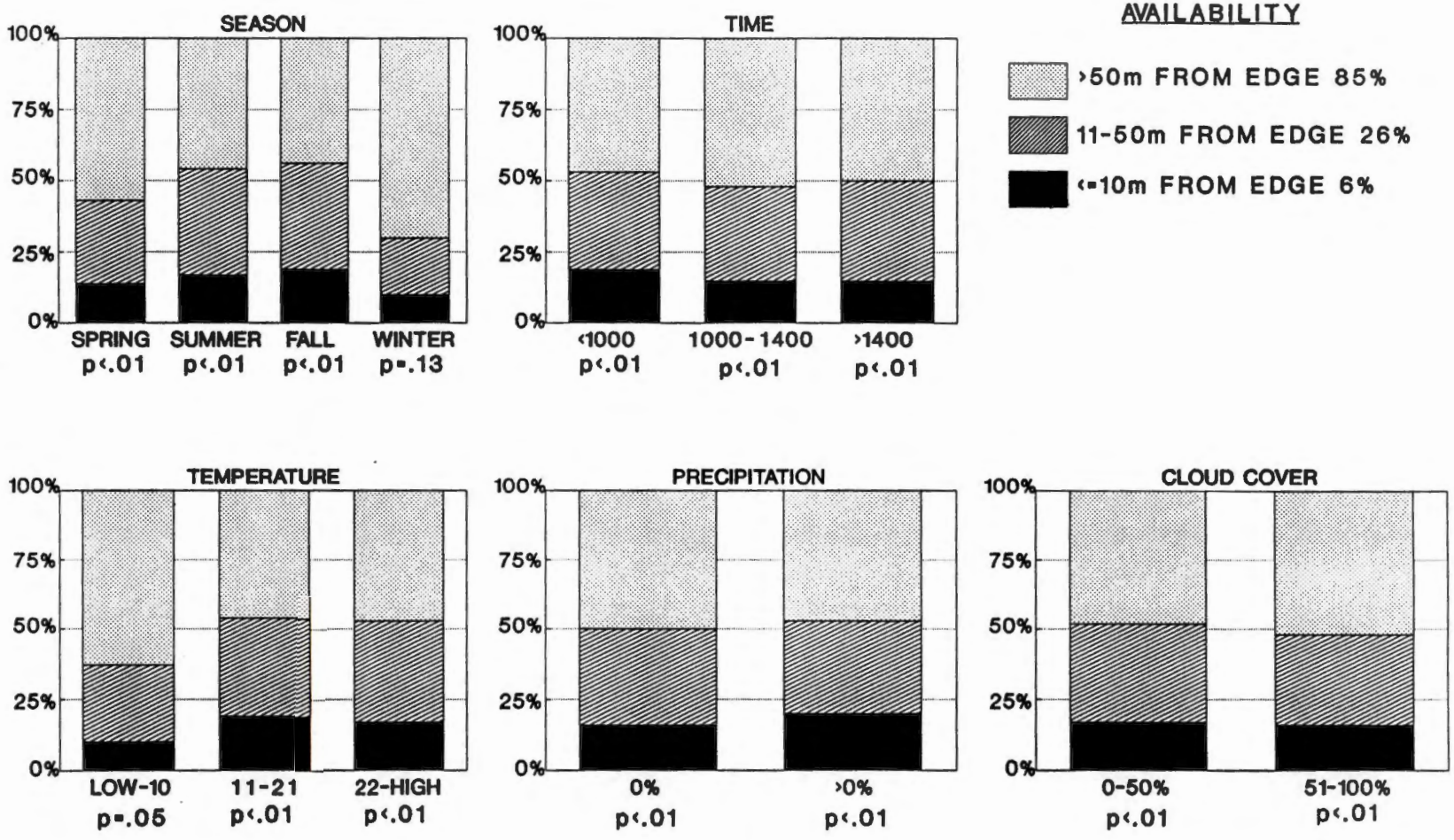


Figure 21. Utilization of clearcut edges by ruffed grouse by season, time of day, temperature, precipitation, and cloud cover in Big Cove-Queen Cove and Sugar Cove Habitat Study Units, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee, 1989-1990.

while areas greater than 50 m from clearcut edges were utilized in smaller proportions than their availability (Figure 21).

CHAPTER V

DISCUSSION

I. Population Estimation

Censuses of drumming male ruffed grouse are believed to provide the most accurate population estimates that can be obtained for the species (Gullion 1966). However, these should be considered minimum estimates of the breeding population (Gullion 1966) for several reasons:

1) Some male grouse do not drum (Gullion 1981).

2) Males drumming in close proximity to one another may sound like the same bird. Two or more drumming grouse were observed within 100m of each other throughout the study.

3) Wind, topography, and stream noise can inhibit hearing. The study area was characterized by steep topography and numerous drainages. This, along with wind noise, often impaired hearing.

4) The sex ratio of ruffed grouse may be unevenly skewed toward females, resulting in an inaccurate population estimate due to the assumption of a 1:1 sex ratio.

Overestimation of grouse density is also possible due to such factors as:

1) the sex ratio being skewed unevenly toward males, and

2) drumming males with more than 1 drumming stage. One

grouse was captured on 2 logs approximately 150m apart within 2 days in April 1989. Despite the factors limiting the accuracy of the drumming censuses, numerous censuses likely do reflect general population trends if conducted consistently over time.

Results of 1989 and 1990 drumming censuses indicated that many of the drumming males were tightly grouped, and in areas not inhabited by grouse during previous years of the study (Boyd 1990). Furthermore, those areas that contained high grouse densities during the earlier years of the study were nearly void of drumming males in 1989 and 1990. Possible reasons for this include that: 1) researcher disturbance of grouse during the prior study caused grouse to vacate the area, 2) grouse carrying transmitters in previous years experienced higher mortality due to entanglement, emaciation, predation or some other factor, and 3) transmittered grouse did not breed to the extent that they usually would. Researcher bias or some other factor should not be ruled out as a possible cause.

Cade and Sousa (1985) indicated that ruffed grouse population densities may reach as low as 2 males per 100 ha in the southern portion of their range. Grouse population densities on the study units were estimated to be 3.6 and 5.2 grouse per 100 ha in Big Cove-Queen Cove in 1989 and 1990, respectively, and 2.7 and 5.4 grouse per 100 ha in Sugar Cove in 1989 and 1990, respectively. These estimates

are lower than reported in northern forests, where densities of 35 drumming males per 100 ha have been recorded (Gullion 1984). Many researchers emphasize the importance of aspen to ruffed grouse when discussing the relatively low grouse population densities found in the southeastern states (Gullion 1977, Thompson and Fritzell 1989). Furthermore, the quality of the winter food that is available for ruffed grouse in the South may be a limiting factor (Servello and Kirkpatrick 1987). Lack of sufficient high quality food resources on the study area may contribute to its low grouse densities.

Predation is another possible cause of the relatively low population density on the study area. Over 80% of grouse mortality has been attributed to predation (Gullion 1971). However, Gullion further suggested that predation is not a limiting factor so much as a consequence of environmental stresses, habitat inadequacies, and/or social behavior. The combination of these factors is likely significantly more detrimental along the perimeter of a species' range than in the center of its distribution. Low population densities at the periphery of a species' range is a typical occurrence (Woolf et al. 1984).

Ruffed grouse populations were substantially higher on the Big Cove-Queen Cove PSU (3.6 grouse/100 ha) than on the Sugar Cove PSU (.5 grouse/100 ha) in 1985. This difference is likely due to the greater number of clearcuts on the Big

Cove-Queen Cove PSU than on the Sugar Cove PSU during this period (Table 6). Increasing area in hardwood regeneration, and the increasing age of these clearcuts in Big Cove-Queen Cove and Sugar Cove throughout the study period, corresponded with and likely caused the upward trend in grouse numbers on both study units. Populations seemed to decline on the Big Cove-Queen Cove PSU in 1987 and 1988, and on the Sugar Cove PSU in 1988, but resumed their increase in 1989 and 1990. Below average precipitation in the mid 1980's (National Oceanic and Atmospheric Administration 1988) may have contributed to the observed decline.

II. Trapping

Mirror trapping success (1 grouse per 36 trap nights) was comparable to other mirror trapping efforts in Tennessee (Epperson 1988, Boyd 1990). Most male grouse utilized drumming logs in clearcut areas of high log densities. Consequently, it was difficult to determine the log most frequently used by an individual. Attempts were made to improve the likelihood of capture by placing the trap on what appeared to be the most heavily utilized log and piling brush over other logs that appeared to have been used for drumming. No increase in trapping success was observed.

Interception traps were placed near drumming logs in the spring to capture females visiting drumming males. Only

males were captured in these traps, however, at a rate of 1 bird per 36 trap nights. Trapping for broods was attempted in August 1989. Interception traps were placed along logging roads where broods had recently been observed. Four birds were trapped at a rate of 1 bird per 18 trap nights. The above technique was significantly more successful than that achieved by placing traps in mountain laurel along drainages, which produced capture rates of approximately 1 bird per 50 trap nights (Jones 1979), 122 trap nights (Epperson 1988), and 51 trap nights (Boyd 1990). Additionally, the time and energy required for trap placement along roads is considerably less than in mountain laurel thickets.

III. Radio Telemetry

The transmitters utilized in this project were battery-operated to decrease signal loss associated with solar-operated transmitters in overcast conditions (Boyd 1990). They were mounted on ponchos; grouse adjusted to these more quickly than to backpack-mounted transmitters (Small and Rusch 1985). The average weight of the transmitter packages was 20.5 g, less than 4% of the body weight of the captured grouse, which is the maximum recommended weight (Brander and Cochran 1971).

The loudest signal method was used to obtain azimuths.

The average error of 12.75 degrees in this study was significantly higher than the 3.9 degrees observed by Springer (1979). This difference was likely due to the weak nature of the transmitter signals resulting from their small size, as well as to the steep terrain in the study area, which often caused weak signals and signal bounce. Additionally, triangulations were occasionally utilized with azimuths intersecting at angles as narrow as 20 degrees and as broad as 160 degrees. Although angles nearer 90 degrees are more accurate (Springer 1979), obtaining these angles was often impossible due to scarcity of roads as well as the limited time between readings necessary to determine a location before the bird traveled far enough to bias the results. These broad and narrow angles of intersection were only accepted, however, when the location of the grouse was assured.

IV. Home Ranges

The minumum convex polygon method of home range determination was used in this study. This method allowed comparison with ruffed grouse home ranges in other studies, many of which also used this technique. Furthermore, movements were a major focus of this project, and the minimum convex polygon method included all of the area in which the birds were located.

The longer a bird was monitored in this study, the

larger its home range became. Sporadic excursions in various directions throughout the year are largely responsible for the larger home ranges. The territory of an individual of a species is a fixed area that may change slightly with time (Brown and Orians 1970). Gullion (1967) defined an activity center as an unspecified area around a primary, and in some instances alternate, drumming log used in the present or recent past by drumming grouse. The majority of the locations for each bird were tightly grouped around drumming logs, in the case of the adult males, and near the point of capture of the females and juveniles.

The home ranges of the monitored grouse averaged 44.9 ha, slightly higher than in other grouse studies in the Appalachians (Longwitz 1985, Epperson 1988, Boyd 1990). Two of these 7 birds were juveniles with no settled ranges or activity centers. They were each monitored for 1 season. The remaining 5 grouse, an adult female and 4 adult males, were monitored for lengths of time ranging from a season to a full year.

V. Daily Movements

Male grouse movements are generally centered closely around the bird's drumming logs (Eng 1959, Hale and Dorney 1963). Bakke (1980) indicated that in North Dakota over 90% of the locations for 8 of 11 male ruffed grouse were within

200 m of each bird's drumming site. A movement study in Minnesota indicated that male grouse are usually in close proximity to their drumming logs, making sporadic excursions to the perimeters of their ranges (Archibald 1975). Despite the relatively large home ranges of the grouse in this study, the findings were comparable to those in the aforementioned works.

Three of the grouse made occasional movements outside of their normal activity area. Juvenile male 120, whose transmission was lost soon after capture, made frequent excursions of several hundred meters. The 2 birds with activity centers not located within clearcuts also exhibited long excursions. Bird 039, an adult male, whose activity center was in a patch of rhododendron, made periodic excursions of several hundred meters. He eventually traveled approximately 4 km and did not return to his original range. Attempts to monitor him in his new range failed. Bird 138, an adult female inhabiting an area of cove hardwoods, behaved similarly. Her transmission was lost after a short monitoring period. The birds with core areas in clearcuts, and particularly the adult males, seldom ventured far from the clearcuts, although 2 birds did make fairly extensive moves within the clearcuts in which each resided.

The effects of season, time of day, and precipitation on grouse movement were insignificant. Temperature and

cloud cover did affect the amount that the birds moved. Garshelis and Pelton (1980) indicated that cloud cover may indirectly affect bear activity through associated elements of the weather, including temperature, humidity, and precipitation. This effect also might hold true for ruffed grouse. Temperatures below -7^0C are believed to require ruffed grouse to increase their metabolic rates in order to maintain sufficient body temperature for survival (Gullion 1971). Bump et al. (1947) indicated that extremely low temperatures might increase the likelihood of ruffed grouse mortality. Cold temperatures in winter corresponded with decreased movement. Grouse likely tended to remain stationary during these periods in order to conserve energy necessary to maintain sufficient body temperatures. Furthermore, warmer temperatures in summer and fall marginally corresponded with decreased grouse movement rates. Ruffed grouse are well-suited to cold environments, as their northern distribution indicates. Extremely warm temperatures might stress grouse and depress movement.

VI. Habitat Utilization

Vegetative Cover

Grouse in the northern portion of their range utilize aspen as an important food resource (Svoboda and Gullion

1972, Kubisiak 1985). Gullion (1977) defined this utilization as a "nearly obligatory relationship". Furthermore, grouse prefer areas of high stem density, often characterized by rejuvenating clearcuts (Boag 1976, Thompson et al. 1987).

Clearcuts were utilized more heavily during winter and spring, hours before 1000, and periods of temperatures below 10^0C than during other times. Mountain laurel and rhododendron were used more in summer and fall, hours after 1400, temperatures above 21^0C, periods of precipitation and greater than 50% cloud cover than during other periods. This utilization is in direct contrast to grouse habits in more northern climes (Bump et al. 1947), where extreme winter temperatures have a greater effect on habitat selected than do mild summers. The protective cover that dense evergreen understories of mountain laurel and rhododendron offer from sunlight and precipitation in the summer, and the exposure to sunlight available in clearcuts after leaf fall in the winter might explain these trends in vegetative use.

Ruffed grouse in the southern Appalachians utilize 30% herbaceous annuals and perennials of the forest floor, 35% leaves and fruits of vines, and 20% foliage of woody shrubs in fall and winter diets (Stafford and Dimmick 1979). Clearcuts likely offer available food resources for grouse in all of the above categories year round, while mountain

laurel thickets probably contain a limited variety of foods for grouse in winter months and a broader range of succulent vegetation in the summer. Although mountain laurel is one of the most heavily used foods for ruffed grouse in Tennessee, rhododendron is little used (Stafford and Dimmick 1979). Mountain laurel on the study area grows predominantly on ridges, which grouse use to a lesser degree in winter than during summer. Grouse avoidance in winter of high slopes where mountain laurel typically grows, and nonuse of rhododendron as a food resource, might further explain decreased grouse utilization of evergreen thickets in the winter.

Slope Aspect

Utilization of slope aspect by ruffed grouse might be largely a product of habitat variables found on various slope aspects. Since effects of environmental conditions on slope aspect were nominal, and effects of environmental conditions on grouse utilization of other habitat variables were more significant, slopes were likely used in accordance with the abundance of various vegetative and edge components found on different slope aspects. West and southwest slopes were used more during summer and fall than during winter and spring, and more when temperatures were above 21^{0}C than below. These findings were contradictory to the trends

noted by Boyd (1990). This could be due partly to the availability of various habitat resources on each HSU.

Position on Slope

Drumming sites of male ruffed grouse in Missouri oak-hickory forests were higher on the slopes than randomly selected sites. Nesting sites had lower slope positions than randomly selected sites (Thompson et al. 1987). Grouse habitat utilization was not analyzed by sex in this study. Therefore, results of ruffed grouse utilization of slope position may be biased by sex.

Ridgetops were used significantly less in spring and winter than during summer and fall, when they were used in proportion to their availability. Furthermore, lower slopes were used more in winter than during other seasons.

White (1978) and Gudlin (1984) indicated that grouse utilization of topographic features might be due more to the effect of topography on vegetation than to the topographic features themselves. This effect, along with the exposure of the birds to wind and precipitation on the higher slopes in cold months, could explain the observed trends in slope position selected by grouse. The decreased utilization of ridgetops in the spring could be partially due to the location of drumming stages. Three of the 4 known drumming logs of the monitored male grouse were located at mid-slope

positions. Concentration of grouse (both male and female) around drumming logs during the mating season could have caused decreased usage of higher slopes.

Distance from Roads and Clearcut Edges

Edge components have long been considered of primary importance to ruffed grouse (Leopold 1932, Bump et al. 1947). Not all studies, however, support this conclusion. The spatial relationship between ruffed grouse and habitat edges in the Adirondack mountains was found to be considerably overrated (Barick 1950).

The roads on the study units were dirt and gravel logging roads closed to public vehicular travel. U.S. Forest Service personnel and field researchers occasionally used the roads, as did hunters.

Grouse frequented roads and clearcut edges in significantly greater proportions than their availability, except during winter. In winter grouse utilized clearcut edges in proportion to their availability. During all seasons except spring, grouse utilized roads in greater amounts than their availability. Additionally, grouse tended to utilize roads more, and clearcut edges less, when temperatures were below 10^0C than when temperatures were warmer.

Grouse preference for edges is consistent with findings

by Archibald (1975) and others. The decreased usage of edges in winter and during cold temperatures might be explained by the increased metabolic rates of ruffed grouse in order to maintain body temperatures during cold temperature periods (Gullion 1971). This requirement might provoke grouse to conserve energy in dense evergreen understories while overcast, or in open areas when sunny. Clearcut edges often were characterized by dense vegetation and high stem densities. Roads were relatively open, allowing sunlight to ground level. Cold temperatures might have prompted grouse to habituate these open areas for purposes of warmth. Turkeys favored edge components during winter in Virginia (Holbrook et al. 1987). It was postulated that this preference was due partially to the reduced energy expenditure afforded by living near a variety of resources rather than moving long distances to meet daily needs. So could be the case with grouse utilization of roads in cold temperatures; however, it fails to explain the decreased clearcut edge utilization.

Grouse frequently were observed on logging roads. Males used the roads for feeding, strutting, and dusting. Broods were often seen along roads, presumably feeding on the insects along the roadsides. Females and broods additionally were observed dusting in the roads. Grouse also might have obtained gravel from the roads for digestive purposes. Logging roads were closely associated with

clearcuts, and observations of grouse along roads might have been due to the birds usage of nearby clearcuts.

The decreased use of roads by grouse in the spring might be due to mating habits. Male grouse typically remain in close proximity to their drumming logs throughout their drumming periods (Hale and Dorney 1963, Archibald 1975, Theberge and Gauthier 1982). Females tend to move more than males during the mating season (Hale and Dorney 1963, Archibald 1975); however, only male grouse were monitored in the spring, which may account for lack of observed road use by grouse during this time.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The major objectives of this study were to measure daily movement rates and habitat utilization of ruffed grouse, and to determine the effects of time of day, time of year, temperature, precipitation, and cloud cover on grouse daily movement rates and habitat utilization. The null hypotheses were that time and weather parameters had no effect on daily movement rates or on habitat utilization.

The only time or weather parameters that significantly affected grouse daily movement rates were temperature and cloud cover. In the spring, temperatures in the 16-21^{0}C range initiated movement, and increasing cloud cover corresponded with decreasing movements. In the summer, increasing temperature had a negative effect on whether the birds were moving, and cloud cover had a negative effect on movement, given that the birds were moving. In the fall, movement rates were greatest when the temperature was between -2 and -7^{0}C. In winter, warmer temperatures and decreasing cloud cover initiated movements. Cloud cover was likely correlated to temperature, resulting in a positive effect of cloud cover on grouse movement rates. Causes for these movements are probably attributable to processes dealing with thermoregulation and, in the spring, breeding.

Findings concerning grouse habitat utilization indicated that grouse utilized clearcuts to a great degree. The cumulative increase in area in hardwood regeneration generally corresponded with increasing grouse numbers during the period drumming censuses were conducted on the study area. Other heavily utilized habitat components included clearcut edges, logging roads, and mountain laurel and rhododendron thickets. North and northwest slope aspects and mid-slope positions were utilized more than other slope aspects and positions, and generally more than their availability.

The habitat interspersion, roads, and edges created by clearcutting seem to benefit grouse in the Cherokee National Forest. Therefore, grouse in this region would probably benefit from frequent clearcuts of varying sizes creating as much edge as possible. Maintaining lush herbaceous vegetation on unused logging roads and preserving understories of mountain laurel and rhododendron also would be beneficial. These habitat components need not be limited to any particular slope aspects or positions, but would be most beneficial on north and northwest aspects, and mid-slope positions. Although monitored grouse remained largely in concentrated ranges, they occasionally moved several hundred meters outside their established home ranges. The purpose and significance of these excursions is not known, but sufficient area should be allowed on lands managed for

grouse in the Southeast for the birds to move freely over areas as large as 50 to 100 ha per bird.

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Appendix

Table 10. Mean daily movements of ruffed grouse by month, hour, temperature, precipitation, and cloud cover, Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee.

	Movement*		
Month	Mean	Standard Error	Sample Size
May 1989	76	16	34
June 1989	90	9	136
July 1989	68	8	97
August 1989	107	13	74
September 1989	92	8	139
October 1989	87	9	147
November 1989	112	15	69
December 1989	100	46	9
January 1990	82	10	74
February 1990	129	21	16
March 1990	113	17	28
April 1990	113	33	22
May 1990	127	16	62
Hour			
< 0900	94	11	77
0900-1000	98	12	75
1000-1100	104	12	76
1100-1200	90	10	85
1200-1300	91	12	78
1300-1400	106	16	62
1400-1500	99	10	80
1500-1600	86	12	70
1600-1700	103	13	77
1700-1800	87	14	62
1800-1900	81	13	67
1900-2000	70	13	44
2000-2100	94	18	36
> 2100	121	121	2

Table 10. Continued.

Temperature	Movement* Mean	Standard Error	Sample Size
< 20^0 F	134	94	3
20-29^0 F	165	46	15
30-39^0 F	94	15	48
40-49^0 F	101	19	39
50-59^0 F	90	9	119
60-69^0 F	97	7	189
70-79^0 F	88	5	396
≥ 80^0 F	102	12	98
Precipitation			
Absent	97	4	805
Present	54	19	102
Cloud Cover			
0-50%	82	7	296
50-100%	94	5	611

* represented as meters per hour.

VITA

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#63
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