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Population density and habitat utilization of ruffed grouse in the southern Appalachians

Ruth A. Boyd

To the Graduate Council:

I am submitting herewith a thesis written by Ruth A. Boyd entitled "Population density and habitat utilization of ruffed grouse in the southern Appalachians." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Ralph W. Dimmick, Major Professor

We have read this thesis and recommend its acceptance:

Michael R. Pelton, Ronald L. Hay

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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C. W. Minkel

Vice Provost
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POPULATION DENSITY AND HABITAT UTILIZATION OF RUFFED GROUSE IN THE SOUTHERN APPALACHIANS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Ruth A. Boyd

May 1990

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ABSTRACT

Ruffed grouse (Bonasa umbellus) population density and habitat utilization were studied on the Tellico Ranger District of the Cherokee National Forest in eastern Monroe County, Tennessee. The overall objective of the project, which was initiated in 1984, was to determine how ruffed grouse populations are affected by clearcutting small stands of Southern Appalachian hardwoods. Population densities were estimated by drumming censuses conducted each spring from 1984-1988 on 2 study units. The Big Cove unit contained 9 small regenerating clearcuts, which comprised 18% of the unit and ranged in age from 2 to 9 years at the initiation of the project. Except for 1 clearcut made in 1986, the Sugar Cove unit lacked early successional vegetation until late 1987. Average spring density on the Big Cove unit was estimated at 2.9 grouse per 100 ha, which was significantly higher than density on the Sugar Cove unit, estimated at 1.2 grouse per 100 ha. Drumming activity began in late March, peaked in mid-April, and continued until mid-May. Twenty-six grouse were captured in interception traps, 9 in mirror traps. Mirror traps were more efficient (1 capture per 37.5 trap-nights) than interception traps (1 capture per 50.9 trap-nights). Thirty-one of the 35 captured grouse were fitted with radiocollars and monitored by radiotelemetry. Transmittered

grouse were located 3-4 times per day, 3 days per week by triangulation and/or homing. Twenty-one of the grouse were monitored long enough for home range to be measured. Male home ranges averaged 23.9 ha; female home ranges averaged 36.9 ha. Home range sizes varied seasonally. The smallest ranges were measured during winter, when the grouse were very sedentary, the largest during autumn, when they made large movements while searching for fattening foods and a suitable wintering range. Radio-telemetry monitoring yielded 1017 grouse locations; 690 of these were used in the analysis of habitat utilization. Each location was mapped and assigned to 1 of 8 habitat types based upon structural characteristics, and to 1 of 7 topographical position categories. Habitat preference was determined by a utilization-availability analysis. The single habitat type utilized more than expected based on its availability was regenerating clearcuts. Forested areas with open understories, and pine or pine-hardwood stands were generally underutilized. Mountain laurel and rhododendron thickets were utilized heavily, but not more than expected due to their almost ubiquitous presence. The radiocollared grouse utilized different habitat types and topographical positions according to season. Home range size and habitat utilization were influenced by seasonal changes within habitat types.

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

CHAPTER I

INTRODUCTION

The ruffed grouse is the most widely distributed species of the Tetraonidae in North America (Cade and Sousa 1985). Typically occupying sub-climax deciduous forests, the ruffed grouse occurs from central Alaska, across southern Canada and the northern United States to New England, and in the Appalachian Mountains from Pennsylvania to northern Georgia (Aldrich 1963).

Despite its increasing importance as a wildlife resource, relatively little is known about the ecological relationships of ruffed grouse in the southeastern extension of their range; an extensive amount of literature details their biology in the ecological center of their distribution. The range of the ruffed grouse in the southeast receded early in this century due primarily to the conversion of forests to agricultural lands (Hamerstrom and Hamerstrom 1961). Currently, the primary range of ruffed grouse in Tennessee consists of the Cumberland Plateau, the Upper Valley of Tennessee, and the Unaka Mountain Range (Schultz 1953, White and Dimmick 1979); these areas remain mostly forested due to the steep and rugged terrain which makes them largely unsuitable for agriculture (Figure 1).

It has been well documented that in the aspen (Populus sp.) portion of its range ruffed grouse typically utilize

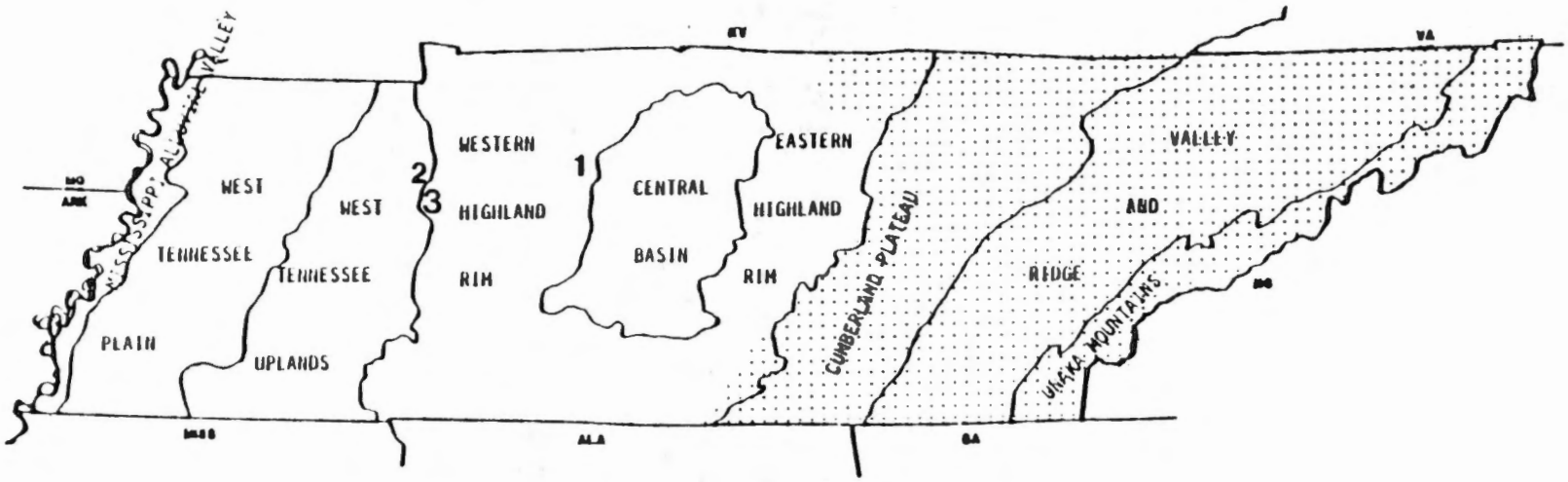

Figure 1. Present range of ruffed grouse in Tennessee (White and Dimmick 1979) including reintroductions: 1 - (Jones 1979), 2 - (White and Dimmick 1979) and (Gudlin and Dimmick 1984), 3 - (Kalla and Dimmick 1987).

young, dense stages of forest succession (Bump et al. 1947, Hamerstrom and Hamerstrom 1961, Aldrich 1963, Gullion and Marshall 1968), but little information is available concerning habitat needs and preferences of ruffed grouse in the southeastern United States, particularly in the Southern Appalachians Mountains. Habitat utilization, population status, and movements have been studied on the Cumberland Plateau (Longwitz 1985, Epperson 1988), and on the Western Highland Rim of Tennessee following 3 reintroduction attempts (White and Dimmick 1978, Gudlin and Dimmick 1984, Kalla and Dimmick 1987), but information about Southern Appalachian grouse in native habitat is scarce.

Information concerning habitat utilization of Southern Appalachian ruffed grouse is particularly important in order to assess potential impacts on the species due to current forest management practices. At present, timber is being harvested by clearcutting in areas inhabited by the ruffed grouse. The purpose of this study, initiated in 1984, was to determine the effect clearcutting has on Southern Appalachian ruffed grouse populations. The study design includes 1 unit which has experienced clearcutting over the past 14 years, and 1 unit which was mostly unmanipulated until late 1987. Patterns of ruffed grouse habitat utilization were delineated by monitoring the movements of radio-collared grouse; population status was monitored by censusing.

The major objectives of this study were:

1) to measure ruffed grouse utilization of different habitat types in proportion to their availability, and
2) to compare density of ruffed grouse in forest compartments which are managed by clearcutting with density on areas prior to clearcutting.

CHAPTER II

DESCRIPTION OF STUDY AREAS

The Cherokee National Forest stretches along the eastern border of Tennessee within the Unaka Mountain Range of the Southern Appalachian Highlands (Luther 1977, Smith and Linnartz 1980). The Unaka Mountains are situated in a northeast-southwest direction and delineate the Tennessee-North Carolina border for much of its length. Much of the topography is characterized by steep, rugged mountains dissected by numerous fast-flowing streams. The Cherokee is divided into 2 sections by the Great Smoky Mountains National Park; it comprises 253,040 hectares in Carter, Cocke, Greene, Johnson, McMinn, Monroe, Polk, Sullivan, Unicoi, and Washington Counties in Tennessee and is administered by the U. S. Forest Service (USDA Forest Service 1985).

The renowned scenic beauty of the Cherokee attracts much of the region's substantial recreation use. More than 2.5 million visitor-days are recorded annually on the Forest. This unique and valuable resource provides significant economic benefits to the local region. The numerous river gorges support a growing, recreation-based economy; commercial rafting operations on the Ocoee River alone bring over 100,000 visitors to the area annually. In addition, the Forest Service currently sells an average of 34 million

board feet of timber per year from the Cherokee National Forest, and returns 25% of all proceeds from timber harvesting, recreation fees, and special use permit fees to the counties containing National Forest land to use for schools and roads (USDA Forest Service 1985).

An extraordinarily diverse group of plants and animals inhabit the Cherokee. More than 1,000 species of flowering plants occur in the area, including a variety of tree species unrivaled outside the tropics. Approximately 120 species of birds, 47 mammal species, 30 reptile, 46 amphibian, and 135 species of fish occur within the Forest (USDA Forest Service 1985). Wildlife on the Cherokee is managed jointly by the Forest Service and the Tennessee Wildlife Resources Agency (TWRA). The Forest Service has the responsibility for managing habitat for both fish and wildlife, and TWRA oversees the stocking programs and the hunting and fishing regulations. Thousands of hunters and fishermen from across the nation visit the Forest each year. Large game species such as black bear (Ursus americanus), white-tailed deer (Odocoileus virginianus), European wild boar (Sus scrofa), and wild turkey (Meleagris gallopavo) are present, as are raccoon (Procyon lotor), ruffed grouse, and gray squirrel (Sciurus carolinensis). The streams support abundant populations of trout, including rainbow (Salmo gairdneri), brown (S. trutta), and the native brook trout (Salvelinus fontinalis).

This wealth of biological diversity is due in part to the combination of the area's climate, topography, and geologic history. The history of human use has also played an important role in creating today's forest. In the early 1900's, the ecological communities within the region were disrupted as the timber industry expanded and began to log the mountainous regions of east Tennessee intensively. To further compound the effects, a severe drought which lasted the entire summer of 1925 culminated in a series of destructive wildfires which burned thousands of acres from south of Cleveland to north of Johnson City (Malter 1977).

Coincident with the expanding timber interests, conservation forces were organizing and began to lobby Congress to protect the remaining forests and waterways of east Tennessee. In 1911, Congress appropriated funds for the purchase of private lands on the western slopes of the Unaka Mountains (National Forest Reservation Commission 1920). Ironically, by the time that the forest lands were finally purchased and consolidated into Cherokee National Forest in 1936, virtually all of the Cherokee had been logged. The area was covered primarily with young timber stands, scattered pockets of old growth, and cull trees.

Due in part to its past destruction, today's Cherokee National Forest is a dynamic, diverse, and productive forest. The Forest Service manages the Forest under the multiple use sustained yield philosophy for its timber,

wildlife, water, soils, minerals, cultural resources, wilderness, and recreational resources.

Cherokee National Forest is divided into 6 ranger districts; 3 are located in the section north of the Great Smoky Mountains National Park and 3 are south of the Park. A portion of one of the 3 southern districts, the Tellico Ranger District, was chosen as the location for this study.

I. The Tellico Ranger District

The Tellico Ranger District is located in Monroe County, Tennessee, southwest of the Great Smoky Mountains National Park. The District is roughly bordered by the Tennessee-North Carolina line, the Little Tennessee River, and the Tellico River (Figure 2). The major drainages within the area include the Tellico River, Citico Creek, Bald River, and North River. Elevations range from 230 m ASL at the confluence of the Tellico and Little Tennessee rivers to 1667 m ASL at Haw Knob.

Most of the area is underlain with igneous, metamorphic, and highly deformed sedimentary rocks, which range in age from Pre-Cambrian to Mississipian. The area contains extensive folding and numerous faults which are thought to be inactive, although small tremors are occasionally felt. Acid-producing formations, such as Anakeesta and Whilhite, are found within the District (USDA Forest Service 1985).

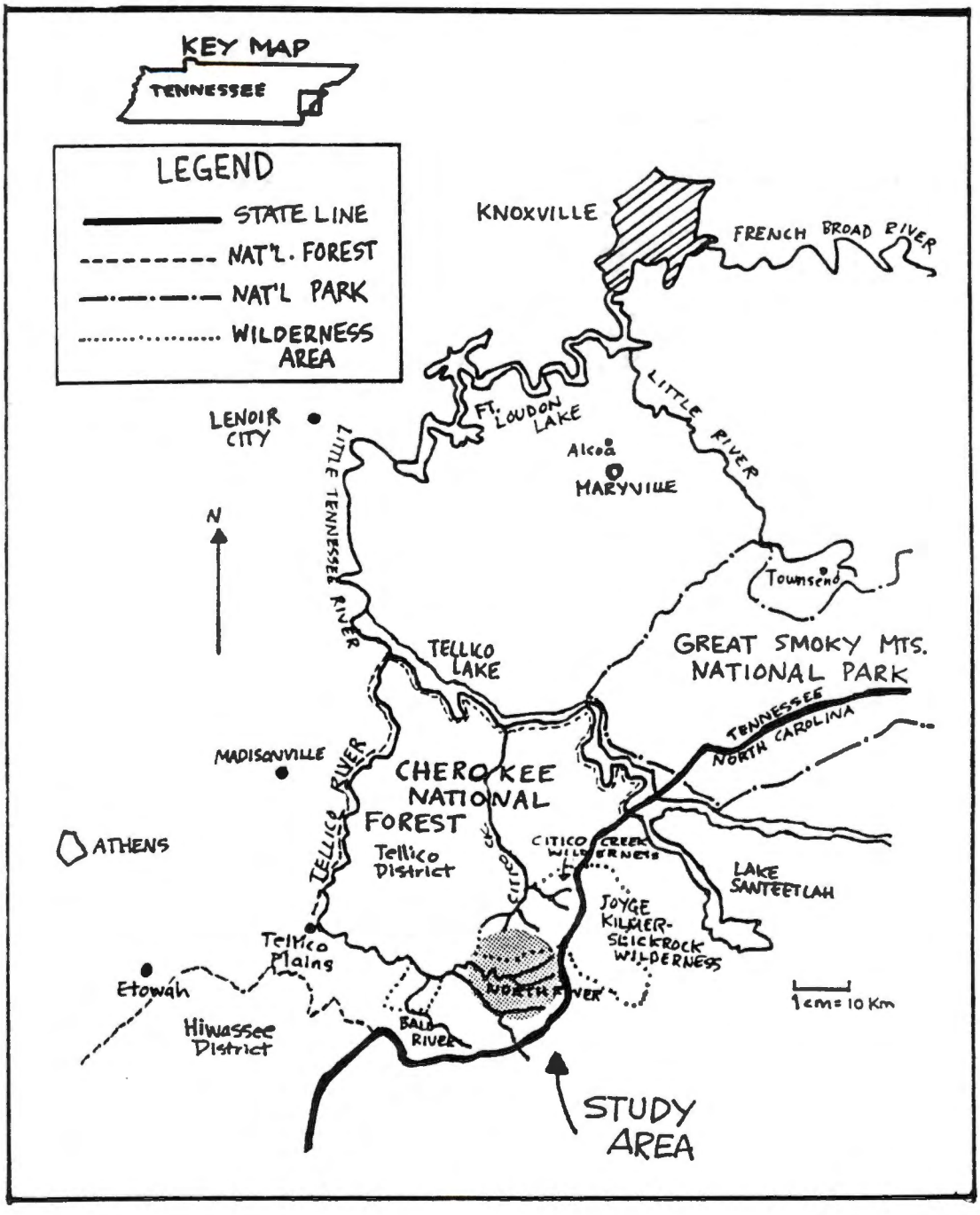

Figure 2. General location of study area within Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

Soils are usually strongly acidic (pH 4.5 to 5.5) and are derived from sandstone and shale (Smith and Linnartz 1980). The deeper soils occur along drainages as deposits at the base of slopes; shallow soils are associated with narrow ridges and southern aspects (TVA et al. 1972). The soils typically have moderate fertility for browse, mast, and forage production, moderate to low productivity for pine production, and low productivity for hardwood production (USDA Forest Service 1985).

The area's climate is characterized as mesothermal perhumid (Thornthwaite 1948). Precipitation averages 140 cm annually at low elevations; higher areas can receive over 230 cm per year. The average temperature is 23° C; monthly averages are highest in July and lowest in February. The average number of frost-free days per year is 151 (USDA Forest Service 1976), but as with temperature and precipitation, this varies greatly with differences in elevation, aspect, and topography (Tanner 1963).

The combination of highly variable physiographic features and diverse local climatic conditions have resulted in high ecological amplitude and diversity. More than 70 commercially important tree species occur in the area (Smith and Linnartz 1980). Mixed oak forests occupy all extremes of slope, aspect, and elevation; a wide variety of species and mixtures are present. It is common to find 10 to 15

overstory species as well as numerous understory species within a few acres (Smith and Linnartz 1980).

Five major forest types are recognized on the Tellico District (USDA Forest Service 1976). The **cove hardwood** type consists primarily of yellow poplar (Liriodendron tulipifera), white oak (Quercus alba), northern red oak (Q. rubra), and eastern hemlock (Tsuga canadensis). This type usually occurs between 230 m and 1,220 m on moist flats, northern slopes, and in coves and ravines. The **oak-hickory** forest type consists of southern red oak (Q. falcata), white oak, hickories (Carya spp.), post oak (Q. stellata), black oak (Q. velutina), chestnut oak (Q. prinus), scarlet oak (Q. coccinea), shortleaf pine (Pinus echinata), Virginia pine (P. virginiana), and pitch pine (P. rigida). This type occurs on upper slopes, in coves, and on flat ridgetops. The **pine** type consists of white pine (P. strobus), shortleaf pine, Virginia pine, table mountain pine (P. pungens), and pitch pine. This type occurs on dry ridges and flats, and in old fields. The **mesic-hemlock** type includes white pine, hemlock, yellow birch (Betula allegheniensis), yellow poplar, basswood (Tilia americana), blackgum (Nyssa sylvatica), northern red oak, and cucumbertree (Magnolia acuminata). It generally occurs above 457 m in elevation on northern slopes and in moist coves. The **northern hardwood** type includes sugar maple (Acer saccharum), American beech (Fagus grandifolia), yellow birch, basswood, red maple (A.

rubrum), hemlock, northern red oak, black cherry (Prunus serotina), and sweet birch (B. lenta). This type occurs above 1066 m on relatively moist sites (USDA Forest Service 1976).

One of the most characteristic features of Southern Appalachian forests is the abundance of ericaceous species in the understory. These include rhododendron (Rhododendron maximum), mountain laurel (Kalmia latifolia), and various blueberry species (Vaccinium spp.) (Smith and Linnartz 1980).

II. The Population Study Units

The 2 study units for this project are located in the southeastern portion of the Tellico District, in the watershed of the North River, a tributary of the Tellico River. The units are similar in physiography, size and appearance. The Big Cove-Queen Cove unit, however, has experienced timber harvest during the past 14 years; only 1 stand of the Sugar Cove unit was harvested prior to October 1987. The 2 units are separated by approximately 4 km.

i. The Big Cove - Queen Cove Unit

The Big Cove-Queen Cove unit is 495.4 ha in size and lies between the elevational levels of 585 to 1097 m ASL (Figure 3). Compartment 81 and part of Compartment 417

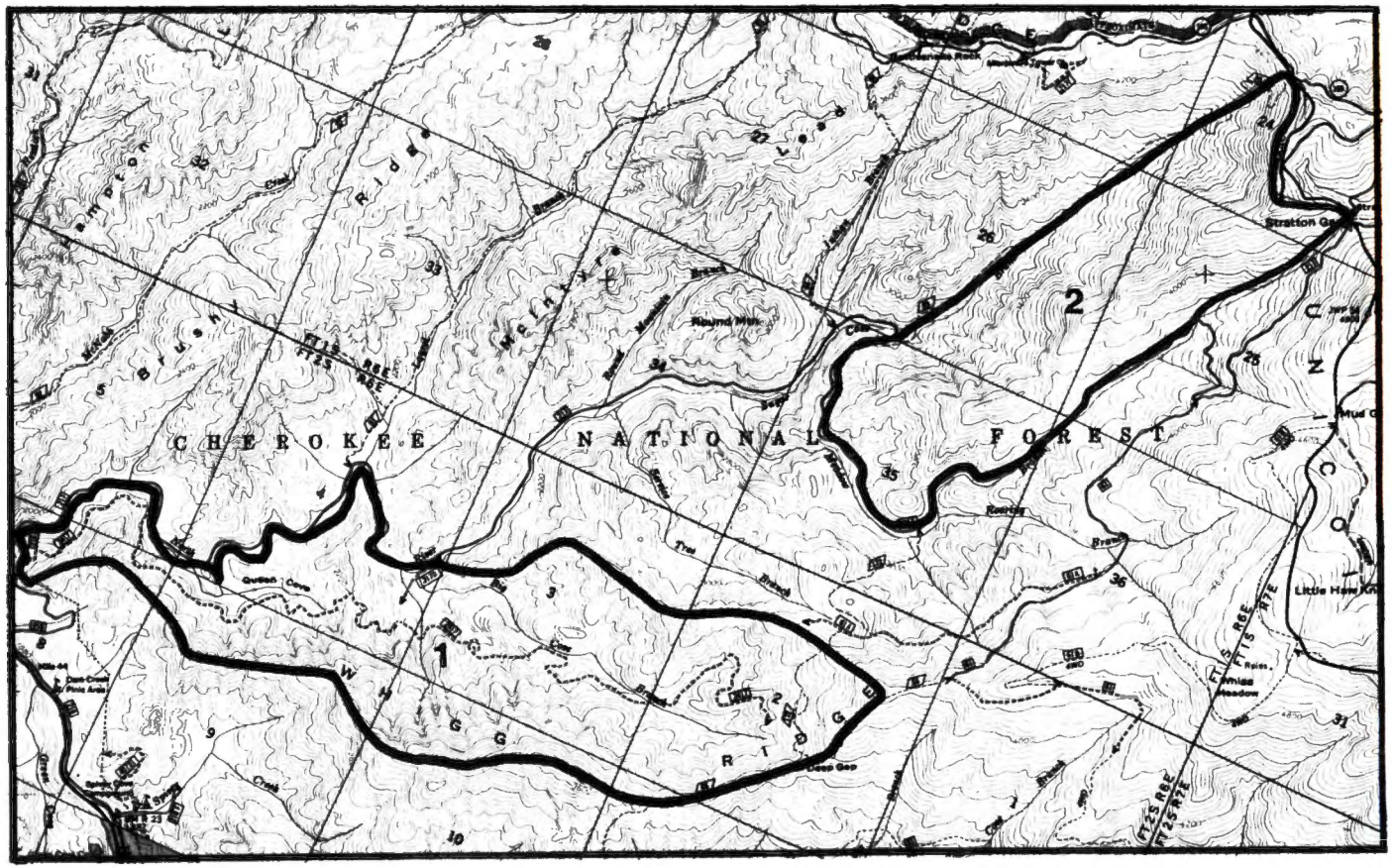

Figure 3. The Big Cove-Queen Cove Unit (1) and the Sugar Cove Unit (2), Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

(stands 7-11, 13-20, approximately 1/2 of 24, 26-27) make up the unit.

This unit is comprised of:

1) 56.8% immature sawtimber
2) 20.9% immature poletimber
3) 18.5% clearcut areas
4) 2.3% sparse sawtimber
5) 1.2% non-forested areas.

Seventy-two percent of the overstory is yellow poplar - white oak - northern red oak association (Table 1). The most common coniferous species on the unit are pitch pine, white pine, and eastern hemlock. The majority of the unit has a dense understory. Extensive stands of rhododenron occur along the North River and each creek and in moist coves. The drier areas are almost uniformly covered with mountain laurel. Blackberry (Rubus allegheniensis), huckleberry, blueberry, and various herbaceous plants such as Christmas fern (Polystichum acrostichoides) are also common.

The clearcut areas were all 9 years old or less when the study was initiated in 1984 (Table 2). Important species regenerating the clearcuts include yellow poplar and red maple. Blackberry and herbaceous plants are present in the understory.

Table 1. Cover types within the Big Cove-Queen Cove Study Unit, Compartments 417 and 81, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

Cover Type	Condition Class	# of Stands	Area (ha)	Percent of Total
yellow poplar-white oak-northern red oak	12	10	267.1	54.0
	13	9	91.9	18.5
chestnut oak	11	1	44.5	9.0
pitch pine-oak	11	1	32.4	6.5
white oak-red oak-hickory	11	2	26.7	5.4
cove hardwoods-white pine-hemlock	12	1	14.7	2.9
pitch pine	06	1	11.7	2.4
Subtotal		25	489.0	98.7
non-forested areas		5	6.4	1.3
Total		30	495.4	100.0

Stand condition classes:
06 - sparse sawtimber
11 - immature poletimber
12 - immature sawtimber
13 - seedling & sapling, adequately stocked

Table 2. Cover type, size and age of clearcuts in the Big Cove-Queen Cove Study Unit, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

Compartment	Stand	Cover Type	Age (y)*	Size (ha)
417	08	56	9	9.7
417	15	56	5	12.5
417	19	56	8	9.3
417	20	56	6	9.3
81	03	56	2	21.4
81	05	56	2	4.5
81	06	56	7	16.2
81	09	56	2	6.9
81	13	56	9	2.0
TOTAL				91.9

Cover type classes: 56 - yellow poplar-white oak-northern red oak

* Age of clearcut when study was initiated in 1984.

ii. The Sugar Cove Unit

The Sugar Cove Unit is comprised of 372.6 ha and has an elevational range of 792 to 1341 m ASL (Figure 3). It includes portions of Compartments 70 and 80.

The unit is comprised of:

1) 68.6% immature sawtimber
2) 13.5% low quality sawtimber
3) 6.3% sparse sawtimber
4) 4.2% immature poletimber
5) 3.9% low quality poletimber
6) 1.9% clearcut areas
7) 1.7% non-forested areas.

The white oak - red oak - hickory overstory association comprises approximately 33% of the unit; yellow poplar - white oak - northern red oak constitutes 23% (Table 3). The sugar maple - beech - yellow birch cover type is also present.

Sugar Cove is characterized by a more open understory than Big Cove-Queen Cove. Existing understory varies from herbaceous vegetation to clusters of rhododendron and mountain laurel.

When the study was initiated in 1984, five stands within the Sugar Cove unit were scheduled for harvest by clearcutting (Table 4). Three were to be made in sugar maple-beech-yellow birch stands, 2 in yellow poplar-white

Table 3. Cover types within the Sugar Cove Study Unit, Compartments 70 and 80, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

Cover Type	Condition Class	# of Stands	Area (ha)	Percent of Total
white oak-red oak-hickory	12	2	87.4	23.5
	11	1	15.5	4.2
	07	1	14.5	3.9
yellow poplar-white oak-northern red oak	12	7	87.3	23.4
sugar maple-beech-yellow birch	06	2	23.4	6.3
	08	1	13.3	3.6
	13	1	7.3	1.9
chestnut oak	08	4	36.8	9.9
yellow poplar	12	3	36.3	9.8
hemlock-hardwood	12	2	34.7	9.3
white pine	12	1	9.7	2.6
Subtotal		25	366.2	98.3
non-forested areas		3	6.4	1.7
Total		28	372.6	100.0

Stand condition classes:

06 - sparse sawtimber
07 - low quality poletimber
08 - low quality sawtimber
11 - immature poletimber
12 - immature sawtimber
13 - seedling & sapling, adequately stocked

Table 4. Cover type, size and age of clearcuts in the Sugar Cove Study Unit, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

Compartment	Stand	Cover Type	Month/Year Completed	Size (ha)
70	11	56	11/88	14.6
70	13	56	10/87	12.1
70	14	81	5/88	7.7
70	16	81	1/88	13.7
70	01*	50	5/88	8.5
80	03	81	?/86	7.3
TOTAL				63.9

Cover type classes: 56 - yellow poplar-white oak-n. red oak
81 - white oak-red oak-hickory
50 - yellow poplar

* A section of stand 01 was thinned.

oak-northern red oak stands. One cut was completed during 1986; the other 4 were completed during the period October 1987 - November 1988. Additionally, a yellow poplar stand was thinned during late 1987.

III. The Habitat Study Areas

Six of the 8 grouse monitored during 1987 and 1988 either occasionally dispersed or completely left the 2 study unit boundaries. In order to encompass the movements of the radiocollared grouse and determine utilization of available habitat types, 2 Habitat Study Areas (HSAs) were delineated (Figure 4).

i. Habitat Study Area 1

Habitat Study Area 1 was established in the vicinity of the Big Cove-Queen Cove unit (Figure 5). Its boundaries were delineated by connecting the outermost Universal Transverse Mercator (UTM) grid coordinate locations of all radio-telemetered grouse in the area. Within the 364 ha HSA1, 7 habitat types were incorporated in the analysis of habitat utilization (Table 5).

Laurel/rhododendron thickets covered the largest percentage of HSA1, totalling 200 ha (54.9%). Rhododendron was usually found on creek banks and in moist low areas; mountain laurel became dense on upper slopes. Overstory was dominated by the cove hardwood type, but these dense

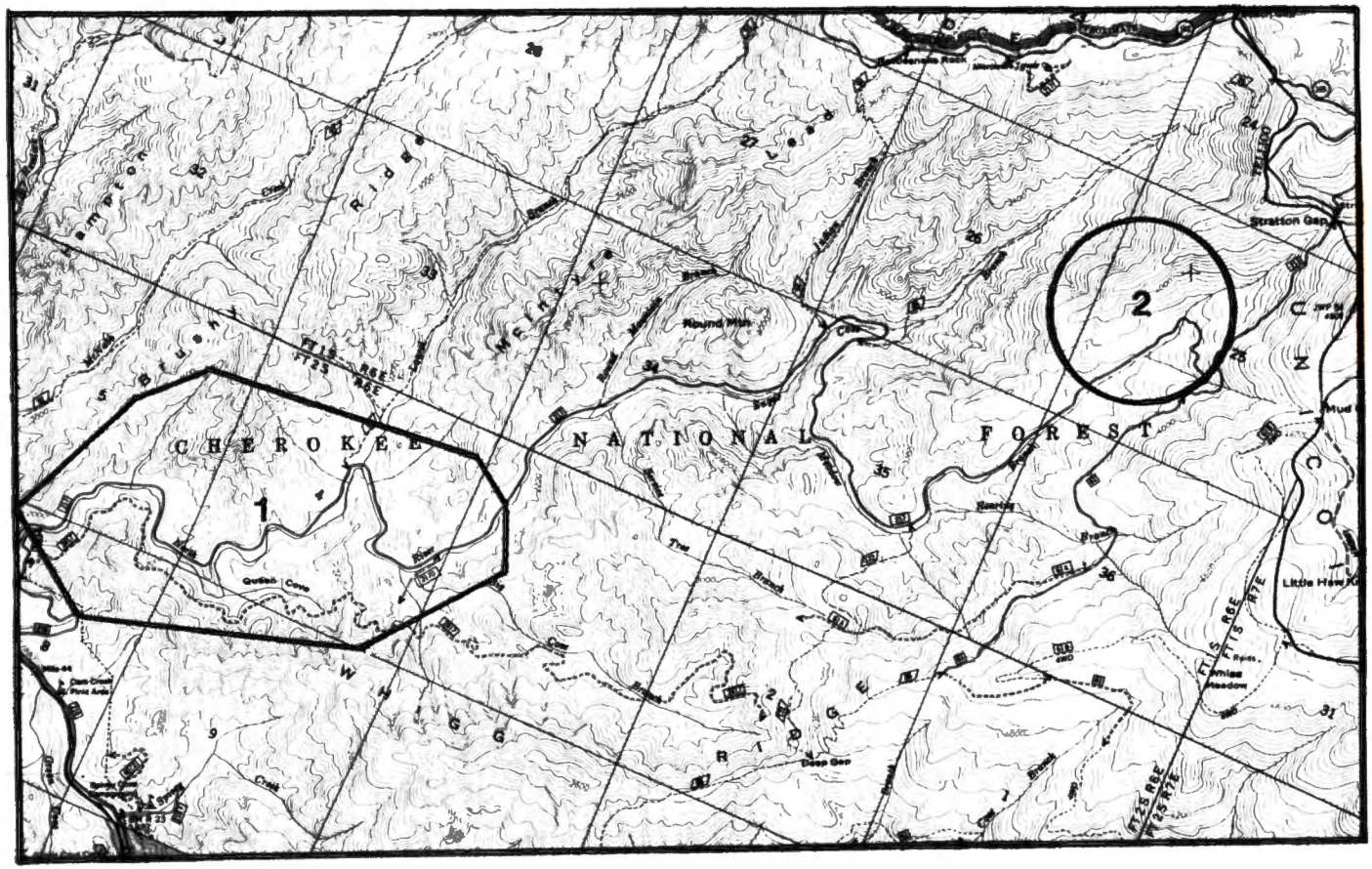

Figure 4. Habitat Study Area 1 (1) and Habitat Study Area 2 (2), Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

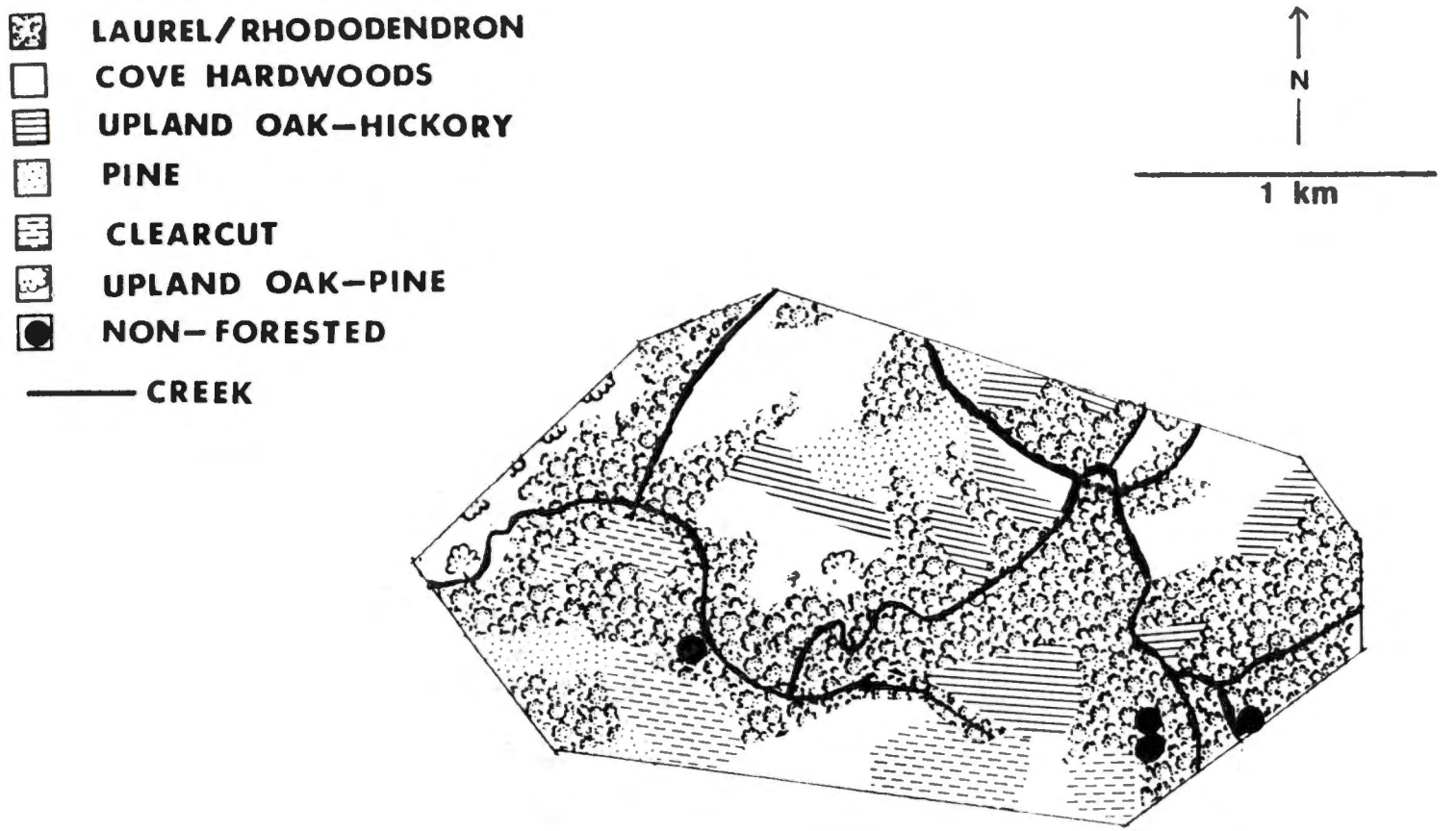

Figure 5. Habitat types delineated within Habitat Study Area 1, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

Table 5. Habitat types delineated for Habitat Study Area 1 on Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

Habitat Type	Total Area (ha)	% of Area	Description
Laurel/ Rhododendron	200	55.0	Overstory: cove and upland hardwoods Understory:dense laurel, rhododendron
Cove Hardwoods	49	13.5	Understory patchy; Vaccinium, grape
Upland Oak-Hickory	34	9.3	Sparse understory; Vaccinium, greenbriar
Hardwood Regeneration	31	8.5	Dense saplings, blackberry, ferns
Pine	26	7.1	Scattered laurel, pine seedlings
Upland Hardwood-Pine	20	5.5	Patchy understory; Vaccinium, pine
Non-forested Areas	4	1.1	Roads, grassy fields
Total	364	100.0	

evergreen understory thickets also occurred within oak-hickory stands.

The **cove hardwood** habitat type totalled 13.5% of HSA1 (49 ha). The understory within this type included clusters of rhododendron and/or mountain laurel, but was generally more open than within the **laurel/rhododendron** type. Scattered shrubby patches of Vaccinium were also present, as were spicebush (Lindera benzoin) and grape (Vitis spp). Forest types represented in the **cove hardwood** habitat portion of HSA1 included yellow poplar - white oak - northern red oak, and northern red oak.

The **upland oak-hickory** habitat type comprised 9.3% of HSA1 (34 ha). This type was found along ridgetops and on steep, dry slopes. The generally sparse understory included species such as blueberry, huckleberry, greenbriar (Smilax spp.) and flowering dogwood (Cornus florida). Forest types occurring within this classification included chestnut oak, scarlet oak, and white oak - red oak - hickory.

The **pine** habitat type totalled 7.1% of HSA1 (26 ha). This type had an open understory which included widely scattered Vaccinium, seedlings of pine, and occasional clusters of mountain laurel. The only forest type included was pitch pine.

Hardwood regeneration comprised 8.5% of HSA1 (31 ha). Four clearcuts ranged in age from 1 to 14 years. All were of the yellow poplar - white oak - northern red oak type

prior to cutting, and species important in the regeneration include yellow poplar and red maple. Dense seedlings and saplings, blackberry and ferns characterize the understory of this habitat type. There is no typical overstory because of the young age of the stands.

Upland hardwood-pine habitat type makes up 5.5% of HSA1 (20 ha). Overstory forest types include upland hardwood - white pine, and pitch pine - oak. Understory includes thickets of blueberry, huckleberry, and scattered mountain laurel as well as pine seedlings.

Several **non-forested areas** occur on HSA1; they comprise 1.1% of the area (4 ha). Included in this designation is a daylighted logging road, 2 wildlife openings, and a clearing around an old cabin.

ii. Habitat Study Area 2

Habitat Study Area 2 (HSA2) was established near the Sugar Cove Study Unit, and was defined to analyze habitat utilization of the 1 telemetered grouse in the area (Figure 6). HSA2 was designated as a circle with a radius equal to the distance from the grouse's most distant location to the center of its home range; total area was 120 ha.

Five habitat types were classified within HSA2 (Table 6). The most abundant type was **laurel/rhododendron**, which covered 62.5% of HSA2 (75 ha). An extensive rhododendron thicket covered the moist low areas along the North River

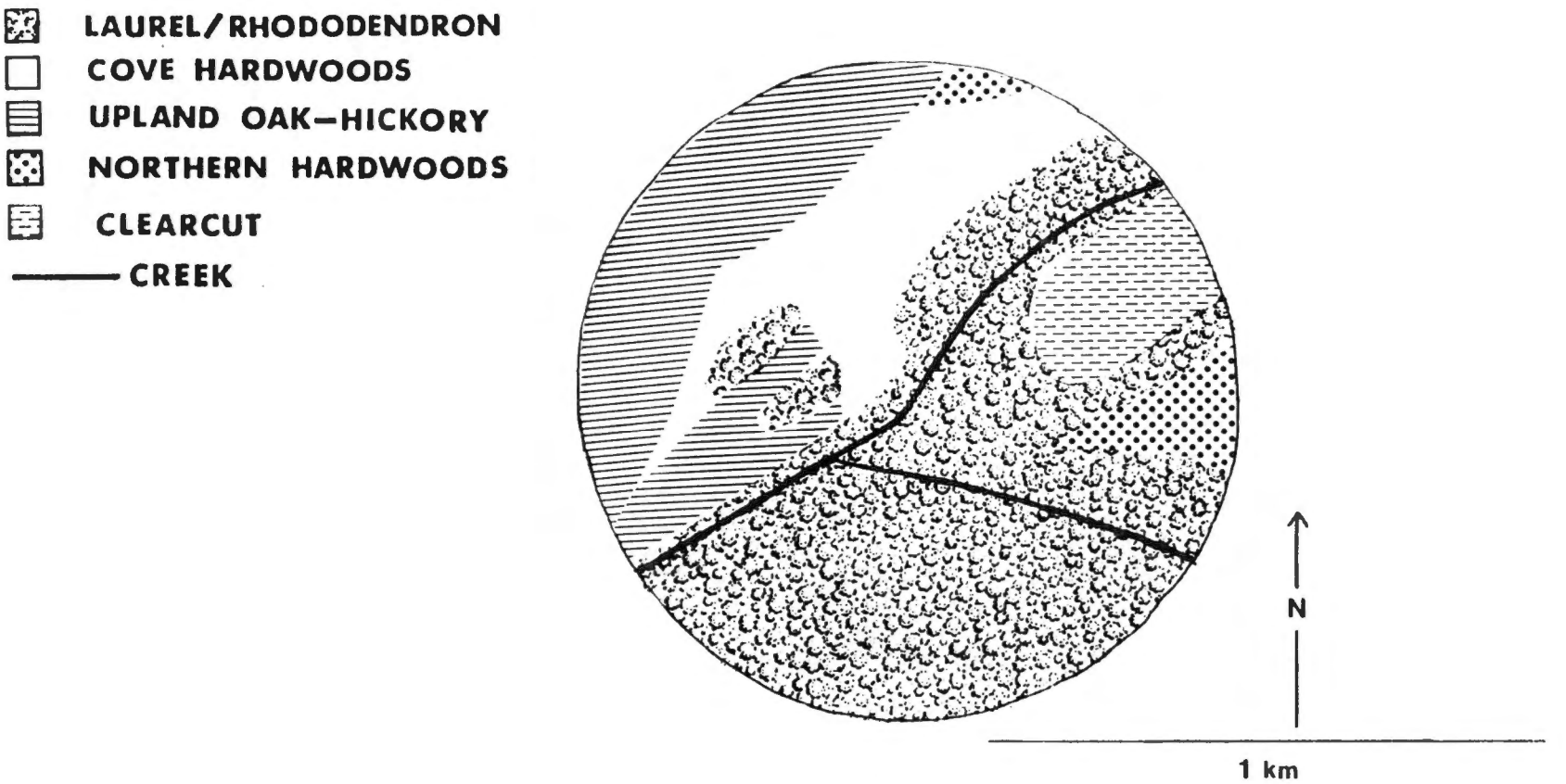

Figure 6. Habitat types delineated within Habitat Study Area 2, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

Table 6. Habitat types delineated for Habitat Study Area 2 on Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee.

Habitat Type	Total Area (ha)	% of Area	Description
Laurel/ Rhododendron	75	62.5	Overstory: cove and northern hardwoods Understory: dense laurel, rhododendron
Cove Hardwoods	15	12.5	Clusters of laurel, rhododendron, and Vaccinium
Upland Oak-Hickory	15	12.5	Sparse understory; scattered laurel and Vaccinium
Hardwood Regeneration	10	8.3	Saplings, ferns, greenbriar
Northern Hardwoods	5	4.2	Maple seedlings, Viburnum, ferns
Total	120	100.0	

and the other creeks; mountain laurel became dense upslope. Overstory was dominated by cove hardwoods, but a hemlock-hardwood stand and several sugar maple - beech - yellow birch stands were present in the overstory as well.

The **cove hardwood** habitat type comprised 12.5% of the area (15 ha). Understory included rhododendron and mountain laurel thickets and scattered Vaccinium, but was relatively open. The single forest type was yellow poplar - white oak - northern red oak.

Upland oak-hickory habitat totalled 12.5% of HSA2 (15 ha). Understory was composed of scattered laurel and Vaccinium. The forest types included were white oak -red oak - hickory and chestnut oak.

Hardwood regeneration amounts to 8.3% of HSA2 (10 ha). This habitat type includes one 24-year-old clearcut, which is regenerating in these species: fire cherry (Prunus pennsylvanica), American beech, yellow birch, sugar maple, sweet birch, and a small amount of American chestnut (Castanea dentata). A dense layer of ferns covers much of the ground.

The least common component of HSA2 is the **northern hardwood** habitat type, which totalled 4.2% of the area (5 ha). The overstory forest type sugar maple - beech - yellow birch is the only one present. Understory includes sugar maple seedlings, Viburnum, and various ferns.

CHAPTER III

METHODS AND MATERIALS

I. Population Estimation

In order to estimate ruffed grouse density in each Study Unit, enumeration of drumming males was attempted during each breeding season from 1984 to 1988. This method of population estimation was recommended for estimating ruffed grouse density on areas 405 to 4050 ha in Minnesota (Gullion 1966).

Drumming censuses were conducted 3-4 times per week from late March to mid-May. Census routes, usually portions of logging roads, trails or ridgetops, were chosen for maximum coverage of each unit; each predetermined route was traversed by a crew member at 0.25 to 0.50 miles/hour beginning at sunrise, while he/she listened for drumming grouse. The time, number of repetitions, and rate of repetition were recorded for each observation. Drumming males were then approached cautiously in an attempt to locate the drumming log. Utilized logs were identified by the presence of droppings, feathers, or leaves blown aside. The log was then tagged with a metal ID number, and its location recorded on a United States Geologic Survey topographic map.

II. Reproductive Chronology

The initiation of drumming activity was determined by visits to the Study Units beginning in late February. The peak of drumming was defined as the date when the drumming rate - the interval between drums of an individual grouse - was highest (i.e. the interval was shortest), and the intensity - the number of grouse drumming in a morning - was highest. Censusing was discontinued when the intensity of drumming decreased to less than 1 drummer per morning. The approximate dates of copulation, nesting, and hatching were calculated by backdating estimated ages of observed broods (Bump et al. 1947).

III. Trapping

Mirror trapping for ruffed grouse was attempted during the drumming seasons of 1986, 1987, and 1988. When the log (or logs) of a drumming grouse was located, a mirror trap as described by Gullion (1965) was set on the log adjacent to the drumming stage (the part of the log the grouse stands on to drum, identified by droppings, etc.). The trap was nailed to the log and covered with evergreen branches to conceal its location and provide protection for the captured grouse. Traps were checked daily at mid-morning.

Interception traps - wire catch boxes with chicken-wire lead fences as described by Liscinsky and Bailey (1955) -

were used in trapping attempts during the late summer/fall of 1984 - 1988, and in conjunction with mirror traps in the spring of 1986 and 1987. Interception traps were set in food sources (such as blackberry thickets), in travel lanes, or in evergreen thickets to capture female grouse and their broods during the late summer brood-rearing period, and again during fall, when broods break up and disperse. Traps were set near occupied drumming logs in spring in an attempt to capture females visiting drumming males. Interception traps were checked daily at dusk.

Captured ruffed grouse were weighed with a Pesola spring scale, sexed by tail band completeness (Davis 1969) and the number of spots on the rump feathers (Roussel and Ouellet 1975), legbanded with a numbered metal band on each leg, and fitted with a radiotransmitter before release.

IV. Radio Telemetry

Both solar and battery-powered transmitters were used during the course of the study. Seven grouse (a female and her brood of 4 caught in July 1985, an adult male captured in August 1985, and an adult male captured in April 1986) were fitted with solar-powered transmitters (AVM Instrument Co., Dublin, CA). The solar transmitters proved unreliable during periods of adverse weather and their use was discontinued. Battery-powered transmitters (AVM Instrument Co.) were utilized during the remainder of the study.

Both types of transmitters were affixed to a vinyl poncho with epoxy. A hole approximately 1" in diameter was made in the poncho, and it was placed over the bird's head. The transmitter hung down over the grouse's breast and a thin, flexible antenna extended up from it past the bird's head. The total weight of the transmitter packages ranged from 18 g (solar) to 23 g (battery). Life expectancies for the transmitters were 24 and 18 months, respectively. During 1985 and 1986, all transmitters broadcast individual frequencies in the 161.131 to 164.883 Mhz range and a portable AVM LA-12 DS receiver and 3-element, hand-held, yagi directional antenna were used. During 1987 and 1988, AVM transmitters operating in the 150.056 to 151.843 Mhz range were used. A portable Telonics TR-2 telemetry receiver (Telonics, Inc., Mesa, AZ) and hand-held, 4-element antenna were used for monitoring the transmittered grouse. The directional accuracy of the telemetry system was tested by methods recommended by Springer (1979). Transmitters were placed at known map locations in the study area, and azimuths were taken from receiving stations. An average error arc was calculated.

Grouse locations were determined by triangulation; the "loudest signal" method (Springer 1979) was utilized to obtain azimuths. Attempts were made to locate each grouse 3-4 times a day, 3 days a week. Between 2 and 4 azimuths were taken from different receiving stations for each

location; the 2 azimuths that intersected at an angle closest to 90° were chosen for the analysis. UTM grid coordinates were determined for each receiving station used to take azimuths.

The 2 azimuths chosen for each grouse location and their corresponding receiving station UTM coordinates were input into a micro-computer program, "TELEM" (Koeln 1983), along with the grouse's identification number, the date, and the time. "TELEM" operated by calculating the intersection of the 2 azimuths; it output the UTM coordinates of each grouse location. Each location was plotted on a 1:24,000 USGS topographic map overlaid with the relevant Habitat Study Area map; locations were then categorized into 1 of the 8 habitat types and into a topographic position category.

V. Data Analysis

i. Home Range Measurement

The minimum convex polygon method (Hayne 1949) was used to measure home range size of each radiocollared ruffed grouse on a seasonal and annual basis. This method was selected because it is utilized in most ruffed grouse studies and can be used for comparison. The minimum convex polygon method uses the UTM grid coordinates of a grouse's

outermost telemetry locations to construct a least-sided polygon.

During 1985 and 1986, home range sizes were calculated with a mathematical formula using the outermost UTM coordinates. Home range sizes for grouse captured in 1987 and 1988 were calculated by the micro-computer program, "MCPAAL" (Stuwe and Blohowiak 1985), which also used the minimum convex polygon method.

ii. Habitat Utilization

Habitat Study Areas were delineated in order to encompass telemetry locations and determine habitat availability for utilization analyses. Two HSAs were necessary due to the 4 km separation of the Big Cove-Queen Cove and Sugar Cove Study Unit groups of telemetered grouse.

Habitat types within the HSAs were identified and mapped by interpretation of true-color aerial photographs, USFS stand identification maps, and ground truthing. The area of each HSA was calculated by the micro-computer program, "MCPAAL" (Stuwe and Blohowiak 1985). Area of the 8 habitat types within each HSA were measured with a planimeter and dot-grid.

Each grouse location was categorized into 1 of the 8 habitat types. Utilization of each habitat type was calculated by a Chi-square test of utilization versus availability (Neu et. al 1974). Preference and avoidance

were determined for each habitat type by construction of a 95% confidence interval. Habitat utilization was also analyzed by season.

Grouse locations were also classified by topographic position. Categories included:

1. creek (within 40 m),
2. low moist area (>40 m from creek),
3. north or east-facing slope,
   a. upper (<40 m from ridgetop)
   b. lower (>40 m from ridgetop)
4. south or west-facing slope,
   a. upper (<40 m from ridgetop)
   b. lower (>40 m from ridgetop)
5. ridgetop.

Topographic position was analyzed by season and percent utilization of each topographic category was calculated.

Independence of observations, a basic premise of the Chi-square test, was assured by eliminating redundant observations. Grouse locations taken 3.5 hours or more apart were considered "independent" and were used in the analysis (Garshelis 1978, Epperson 1988). Locations taken less than 3.5 hours apart were included in the analysis if a change of habitat type was made in the interim.

CHAPTER IV

RESULTS

I. Population Estimation

Population density of ruffed grouse in spring was estimated by doubling the number of drumming males counted within each study unit. This method required 2 major assumptions: that the sex ratio of ruffed grouse in the area is 1:1, and that all male grouse drum (Gullion 1966). Data from years prior to 1987 were obtained from records and annual reports (Minser, W. G. 1984. Annual report to USDA Forest Service. Unpublished, 2 pp.; Everett, J. E. 1986. Annual report to USDA Forest Service. Unpublished, 28 pp.).

Big Cove-Queen Cove Unit. Censusing was not conducted in the Big Cove-Queen Cove Unit during 1984. Five to 8 censuses were conducted each spring during 1985-1988 (Table 7). An average spring density of 2.9 grouse per 100 ha was recorded; a range of 3 (1988) to 10 (1986) drummers was identified. Ten activity centers (1 or more drumming logs used by a single grouse) were located within the Study Unit boundaries. Three centers were within 9 to 11-year-old clearcuts; 5 were on knobs or ridgetops beside clearcuts; 2 were found in low, moist areas dominated by rhododendron thickets. Three drummers were identified outside the

Table 7. Results of ruffed grouse drumming censuses on Big Cove-Queen Cove and Sugar Cove Study Units, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1984-1988.

	Big Cove-Queen Cove					Sugar Cove				
	1984	1985	1986	1987	1988	1984	1985	1986	1987	1988
Number of Censuses	0	5	7	8	8	7	4	6	7	5
Drummers Identified	-	9	10	7	3	3	1	3	4	2
Population Estimation (grouse/100 ha -either sex)	-	3.6	4.0	2.8	1.2	*	0.5	1.6	2.1	1.1

* Censusing was not uniform; population estimate would be unreliable.

boundaries of the unit, but were not included in density calculations, although they were included in trapping attempts.

Sugar Cove Unit. During 1984-1988, 4 to 6 censuses were conducted each spring. Censusing coverage in 1984 did not include the entire unit, so any density estimate would be unreliable. A range of 1 (1985) to 4 (1987) drummers was recorded, yielding an average spring density of 1.2 grouse per 100 ha. Of the 4 activity centers located in Sugar Cove, 3 were on ridge crests in mountain laurel thickets and 1 bordered a 3-year-old clearcut. Four ruffed grouse activity centers were located outside Sugar Cove boundaries.

Average spring density on the Big Cove-Queen Cove unit was significantly higher ($P < .05$) than that measured on the Sugar Cove unit. During the spring of 1988, however, stands 1 and 14 of Compartment 70 in Sugar Cove were being logged, which may have disturbed drumming males in the area.

II. Reproductive Chronology

i. Drumming Chronology

Initiation of spring drumming season was determined by visits to the study units beginning in late February of each year (Table 8). Drumming logs used during previous years were checked for fresh droppings, and trial censuses were conducted to determine if drumming had begun. Fresh

Table 8. Reproductive chronology of ruffed grouse on the Big Cove-Queen Cove and Sugar Cove Study Units, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1984-1988.

	1984	1985	1986	1987	1988
Earliest log use detected	3/28	3/24	3/24	3/9	3/31
Drumming					
Initiation	3/28	3/29	3/24	3/20	3/31
Peak	4/13-18	4/19-26	4/1-5	4/23-30	4/4-11
Cessation	5/4	5/3	5/9	5/15	5/5
Copulation	-	4/5-10	3/25-31	3/28-30	3/28-30
Egg laying	-	4/13-28	4/2-15	4/1-14	4/1-13
Incubation	-	4/28-5/22	4/15-5/9	4/14-5/11	4/13-5/7
Hatching	-	5/21-22	5/8-10	5/10-11	5/10-11
Period from 1st drumming to hatching	-	55 days	48 days	53 days	42 days
Fall drumming	-	-	10/3-22	10/15-11/10	-

droppings were first noted on dates ranging from 9 March (1987) to 31 March (1988). The date when drumming was first heard ranged from 20 March (1987) to 31 March (1988).

The number of drummers heard each day and the drumming activity of each grouse were recorded. Two data sets were used to delineate the peak drumming period: the number of drummers heard per observer per day, and the interval between drums of each individual grouse (drumming rate). During peak periods, .75 (1984) to 2 (1988) drummers per observer per day were recorded; judged by this criterion peak period occurred as early as 1-5 April (1986) and as late as 23-30 April (1987). The period of peak drumming rates varied among years, ranging from 4-11 April (1988) to 23-30 April (1987). Within peak periods, minimum intervals between drums ranged from 1.5 (1985) to 2.5 (1988) minutes. Drumming rates were not measured in 1984. Regular drumming ceased as early as 3 May (1985) and continued as late as 15 May (1987). Although drumming could be heard sporadically throughout all seasons of the year, regular spring drumming season lasted an average of 43 days.

ii. Copulation, Incubation, and Hatching

Estimated dates of copulation, incubation, and hatching were obtained by back-dating from estimated ages of observed and/or captured broods. Data were scanty; estimated chronology was based on 1 captured brood in 1985, 1 observed

brood and 1 captured juvenile in 1986, 1 captured brood in 1987, and 2 observed broods in 1988. No broods were observed or captured in 1984 (Table 8).

Estimated dates of copulation ranged from 25 March (1986) to 10 April (1985). Egglaying began as early as 1 April (1988) and as late as 13 April (1985). Initiation of incubation occurred as early as 13 April (1988) and as late as 28 April (1985). Earliest hatching occurred from 6 May (1988) to 22 May (1985).

iii. Fall Drumming Observations

Fall drumming was heard on the Big Cove-Queen Cove Unit during October 1986 and October and November 1987. A male grouse was captured on his drumming log on 5 October 1986. Fall drumming was typically heard during the afternoon hours of sunny days. Intervals between drums averaged 4.4 minutes.

III. Trapping

Thirty-five ruffed grouse were captured 38 times on the Big Cove-Queen Cove and Sugar Cove Study Units from July 1985 to May 1988 (Table 15, Appendix A).

1984. No grouse were captured during 1984.

1985. Nine ruffed grouse (1 adult female, 3 adult males, 2 juvenile females, and 3 juvenile males) were captured in interception traps during autumn 1985. One adult male died

during handling; the other 8 grouse were radiocollared and released. One of the juvenile females was found dead near the trap site 2 days after release.

1986. Seven adult male grouse were captured during spring. Four were captured in mirror traps, 3 in interception traps. No deaths were attributed to trapping or handling, and 6 of the grouse were released with radiocollars attached. One bird was leg-banded and released without a transmitter.

Nine ruffed grouse were captured in 16 interception traps and 1 mirror trap set during late summer/autumn 1986. Two were adult males, 1 was an adult female, 3 were juvenile males, and 3 were juvenile females. Eight of the grouse were captured in interception traps. The mirror trap was used in October to determine if fall drumming males are as susceptible to capture as are spring drummers. Three days after the trap was set, the grouse that had been caught on the same log the previous spring was captured and its radio-collar replaced. One of the adult males died during handling, and the other 8 grouse were radio-collared and released.

1987. Spring trapping yielded 4 adult males. Three were captured in mirror traps, 1 in an interception trap. Three additional grouse were captured, but 2 were removed from their traps, possibly by poachers (only feathers remained). One adult female was killed and partially eaten in a trap, probably by a long-tailed weasel (Mustela frenata).

Four juvenile ruffed grouse (2 males, 2 females) were captured in interception traps during late summer/autumn 1987. All were released with transmitters attached. Three of the juveniles were part of a brood and were captured together.

1988. Two adult male grouse were captured in mirror traps during spring. One of the 2 was killed by a dog shortly after release; the other was radio-collared and released.

IV. Radio Telemetry

During the 5 years of this study, 1017 radio locations (690 independent locations) were gathered from 21 of the transmitter-equipped ruffed grouse (Figure 7). The amount of radio contact varied greatly, but enough information was obtained from each individual to be included in the analysis. The number of independent locations gathered per individual ranged from 11 to 171, and the monitoring period for an individual grouse ranged from 17 to 509 days.

A total of 485 radio locations (346 independent locations) were collected from 13 grouse during the first 3 years of this study. The monitoring period for an individual ranged from 30 to 276 days. During 1987 and 1988, 532 locations (344 independent locations) were collected from 8 radio-collared ruffed grouse. The monitoring period ranged from 17 to 509 days.

TRANSMITTER FREQUENCY	1985 JASOND	1986 JFMAMJJASOND	1987 JFMAMJJASOND	1988 JFMAMJJA
Adult Males				
164.662	-------H			
164.455	--L			
164.154		---L		
164.189		---L		
164.803		------U		
164.534		----U		
164.455		---U		
150.485		-*	R--------------U	
150.450			---------H	
151.640			---------U	
150.056				------A
Adult Females				
164.383	--U			
Juvenile Males				
164.783	--U			
164.883	--U			
164.837	--P			
164.430		---L		
150.620			--P	
150.299			--P	
Juvenile Females				
164.131		----------U	R-P	
150.346			----L	
151.843			--L	

H - Shot by hunter.
L - Lost transmitter.
R - Recaptured.
A - Alive.
U - Unknown.
P - Dead by predation.
* - Was not radiocollared.

Figure 7. Duration of telemetry monitoring and terminal disposition of 21 radiocollared ruffed grouse on the Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1985-1988.

The telemetry equipment was found to be accurate to 12.75° at an average distance of 300 meters.

V. Data Analysis

i. Home Range Size

Home range size was determined for 21 radio-collared ruffed grouse monitored during 1985-1988 using the minimum convex polygon method. It was often impossible to maintain radio contact with an individual bird for an extended period; therefore, the locational information for most telemetered grouse was treated on a seasonal basis (Table 9). Annual home ranges were measured for grouse that were monitored for 2 or more seasons. Telemetry data were collected during all seasons, but the quantity of data varied with season. The data were biased toward spring and summer. Seasons were defined as: spring - 16 March to 15 June; summer - 16 June to 15 September; autumn - 16 September to 15 December; and winter - 16 December to 15 March.

Seasonal Home Ranges

Winter. Winter home range was measured for 4 ruffed grouse. Three were adult males with a mean home range of 8.9 ha (range: 5.2 - 11.3 ha). One adult female was in radio contact throughout winter and occupied a 20.4 ha home range.

Table 9. Home range sizes of ruffed grouse captured on Big Cove-Queen Cove and Sugar Cove Study Units, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1985-1988.

SEASON	AGE-SEX	# GROUSE	MEAN HOME RANGE (HA)	STANDARD ERROR	RANGE (HA)
Winter	Adult Male	3	8.9	1.90	5.2 - 11.3
	Adult Female	1	20.4	-	-
Spring	Adult Male	10	12.9	1.32	3.8 - 18.2
	Adult Female	1	37.4	-	-
Summer	Adult Male	5	15.3	2.14	9.2 - 21.0
	Adult Female	1	31.0	-	-
	Juvenile Male	5	22.3	9.53	13.6 - 31.0
	Juvenile Female	1	13.6	-	-
Autumn	Adult Male	6	34.2	3.91	21.4 - 44.7
	Adult Female	2	17.5	2.95	14.5 - 20.4
	Juvenile Female	2	13.8	11.75	2.0 - 25.5
2 or more seasons	Adult Male	5	36.5	7.32	12.6 - 51.7
	Adult Female	1	42.7	-	-

Spring. Spring home range was measured for 10 adult male grouse; a mean home range size of 12.9 ha was determined (range: 3.8 - 18.2 ha). The home range of the adult female expanded to 37.4 ha; during this time she nested and began rearing a brood.

Summer. Five adult males were monitored during summer seasons; they occupied a mean home range of 15.3 ha (range: 9.2 - 21.0 ha). One adult female had a 31.0 ha summer home range; she was rearing a brood during this time. Her brood had a composite home range of 31.0 ha. Another brood occupied a summer home range of 13.6 ha (Figure 8).

Autumn. Autumn home range was determined for 5 adult males. Their mean home range was 34.2 ha (range: 21.4 - 44.7 ha). Two adult females had a mean home range of 17.5 ha (range: 14.5 - 20.4). Two juvenile female ruffed grouse were in radio contact during the fall. Their mean home range was 13.8 ha (range: 2.0 - 25.5 ha) (Figure 9).

Home Ranges of Grouse Monitored for 2 or more seasons

Five adult male and 1 adult female grouse were in radio contact long enough for their home ranges to be delineated across 2 or more seasons. Adult males with radio frequencies 150.056 (Figure 10), 164.662, 151.640 (Figure 11), 150.450 (Figure 12), and 150.485 (Figure 13) were monitored for 4.5, 6, 9, 9.5, and 16 months, respectively. Their mean home range was 36.5 ha (range: 12.6 - 51.7 ha). Female 164.131 was captured as a 16-17 week-old juvenile in

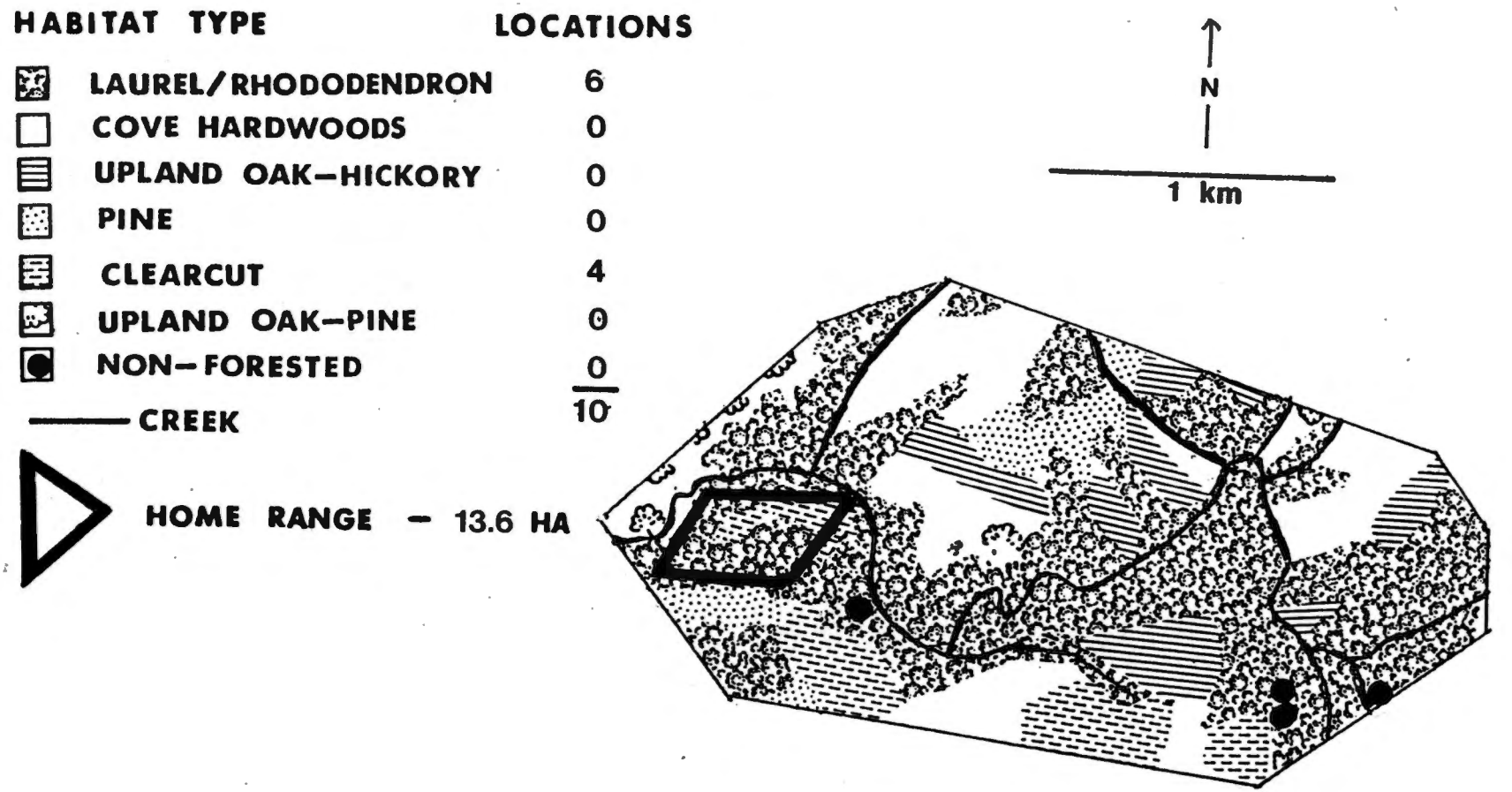

Figure 8. Home range of the brood of 3 juvenile grouse (transmitter frequencies 150.299, 150.620, 151.843) on Habitat Study Area 1, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, August 7-26, 1987.

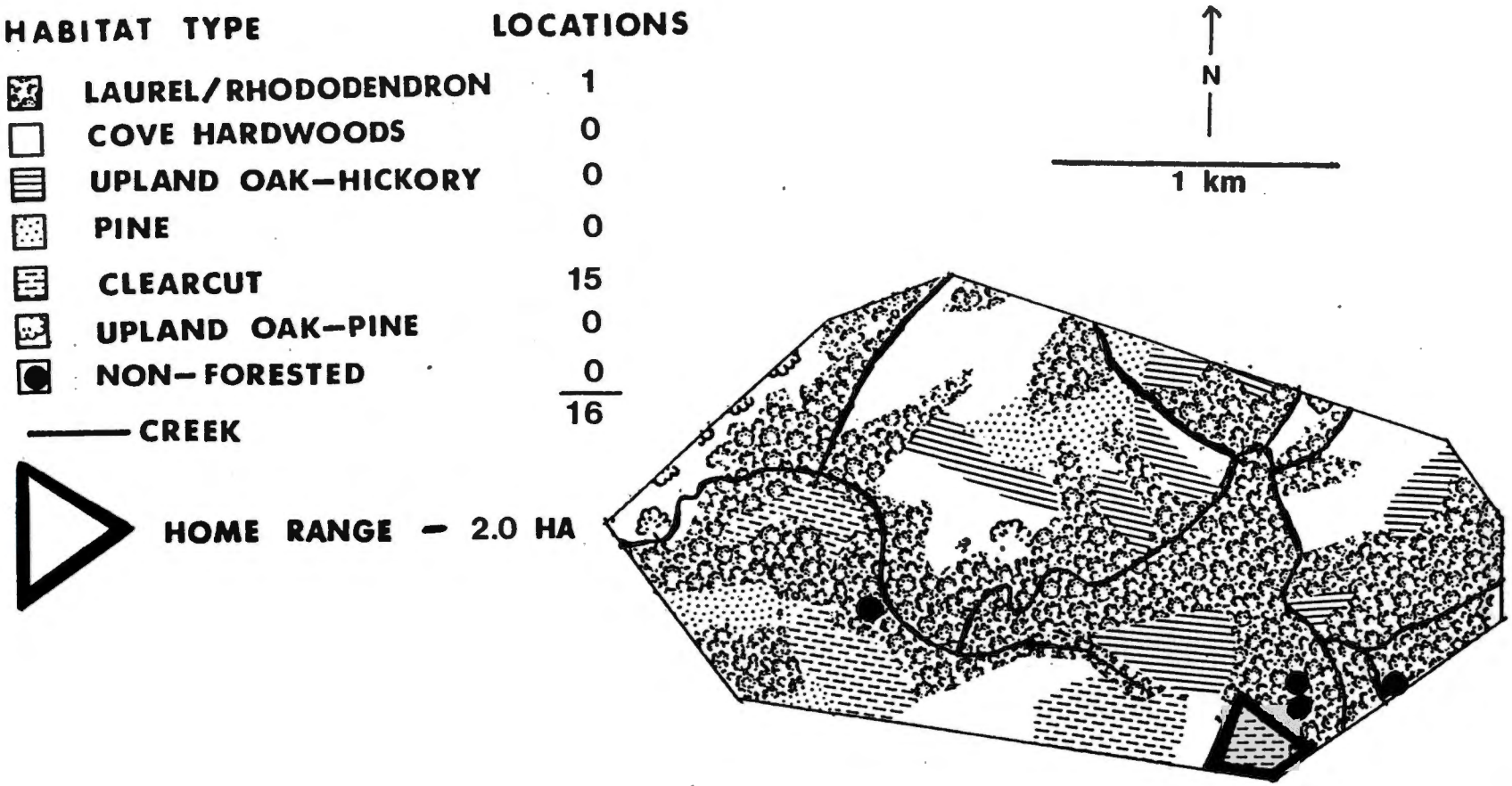

Figure 9. Home range of juvenile female (transmitter frequency 150.346) on Habitat Study Area 1, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, August 12-September 8, 1987.

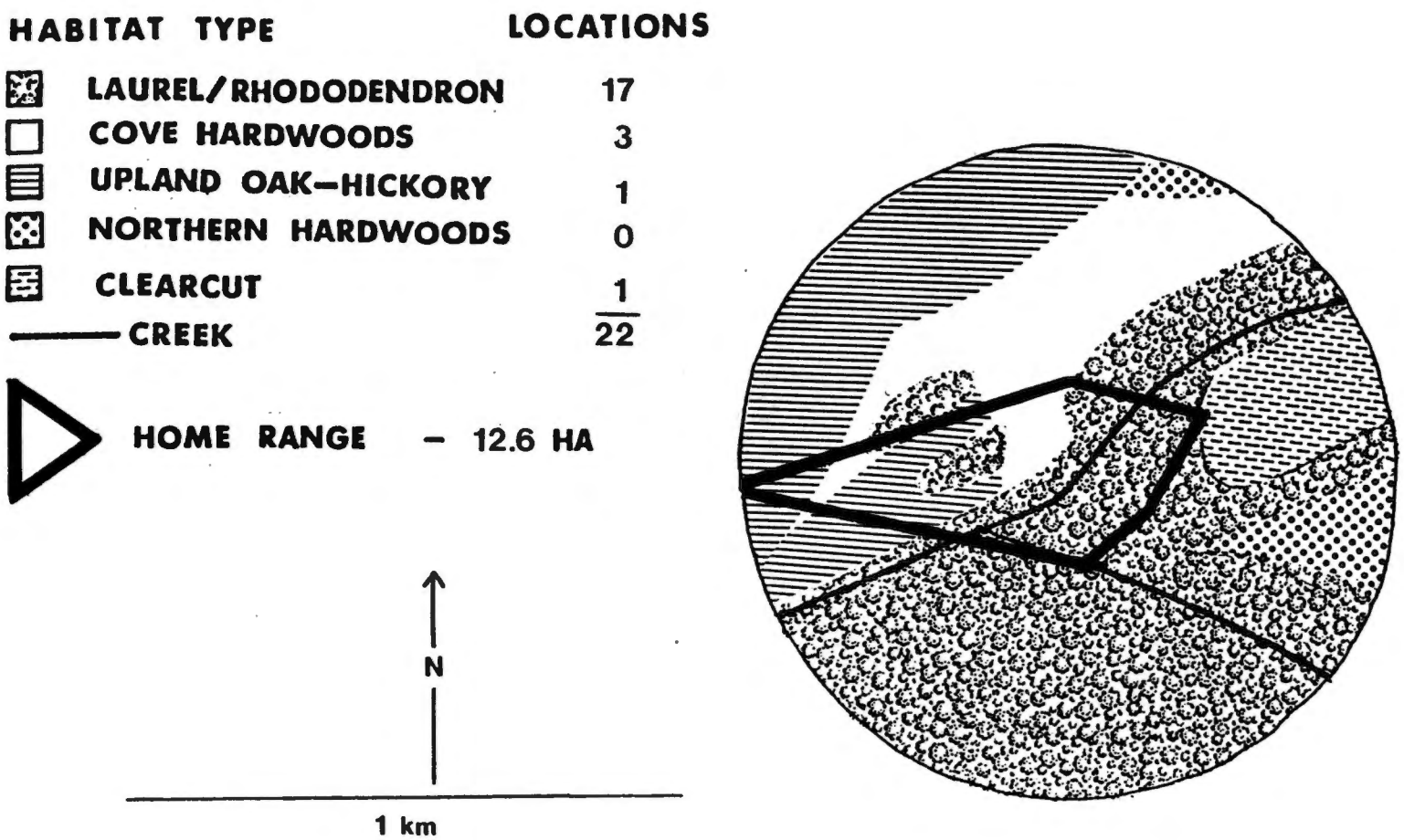

Figure 10. Home range of adult male (transmitter frequency 150.056) on Habitat Study Area 2, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, April 17-August 22, 1988.

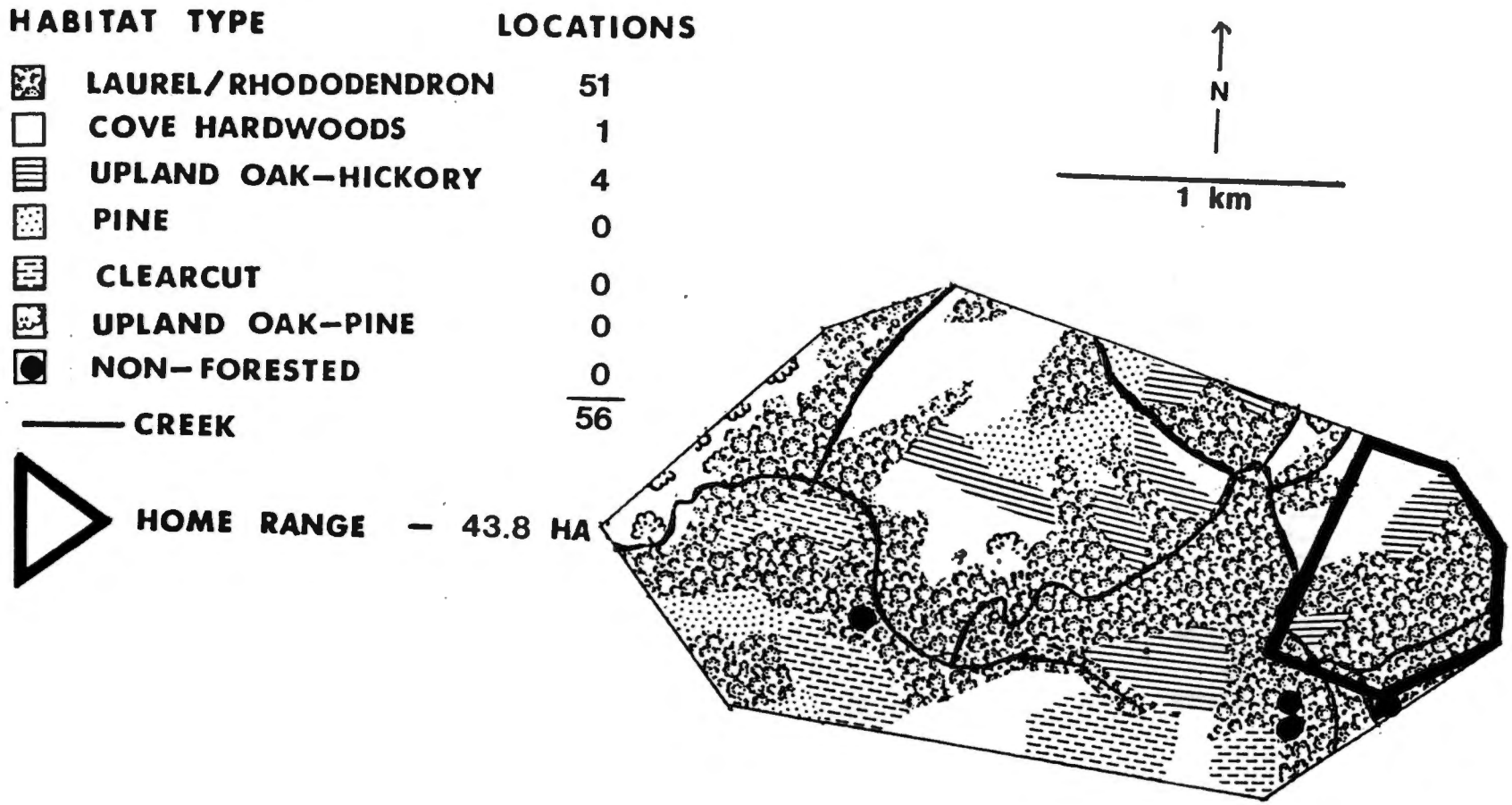

Figure 11. Home range of adult male (transmitter frequency 151.640) on Habitat Study Area 1, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, May 19, 1987-January 8, 1988.

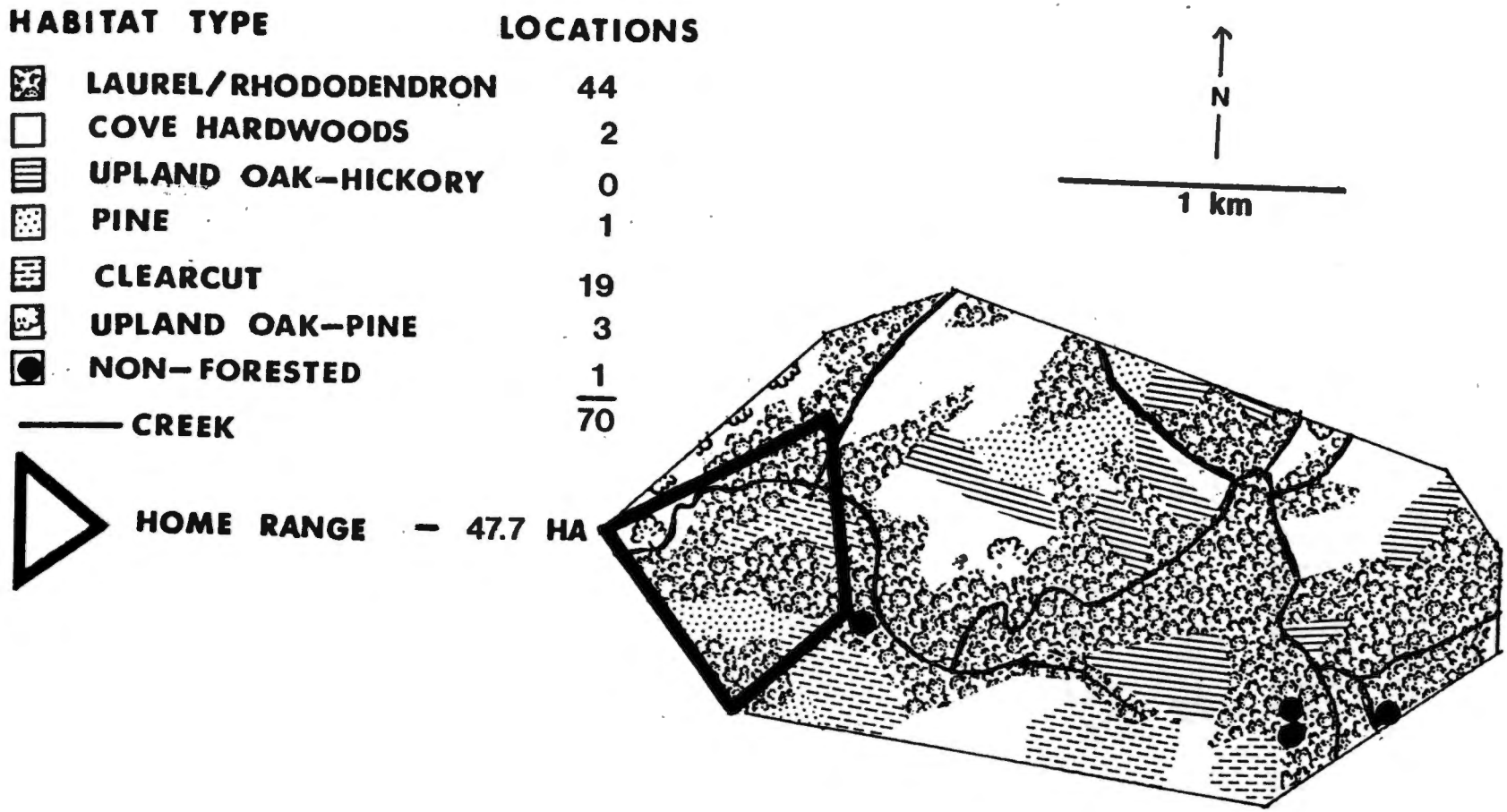

Figure 12. Home range of adult male (transmitter frequency 150.450) on Habitat Study Area 1, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, April 20-December 13, 1987.

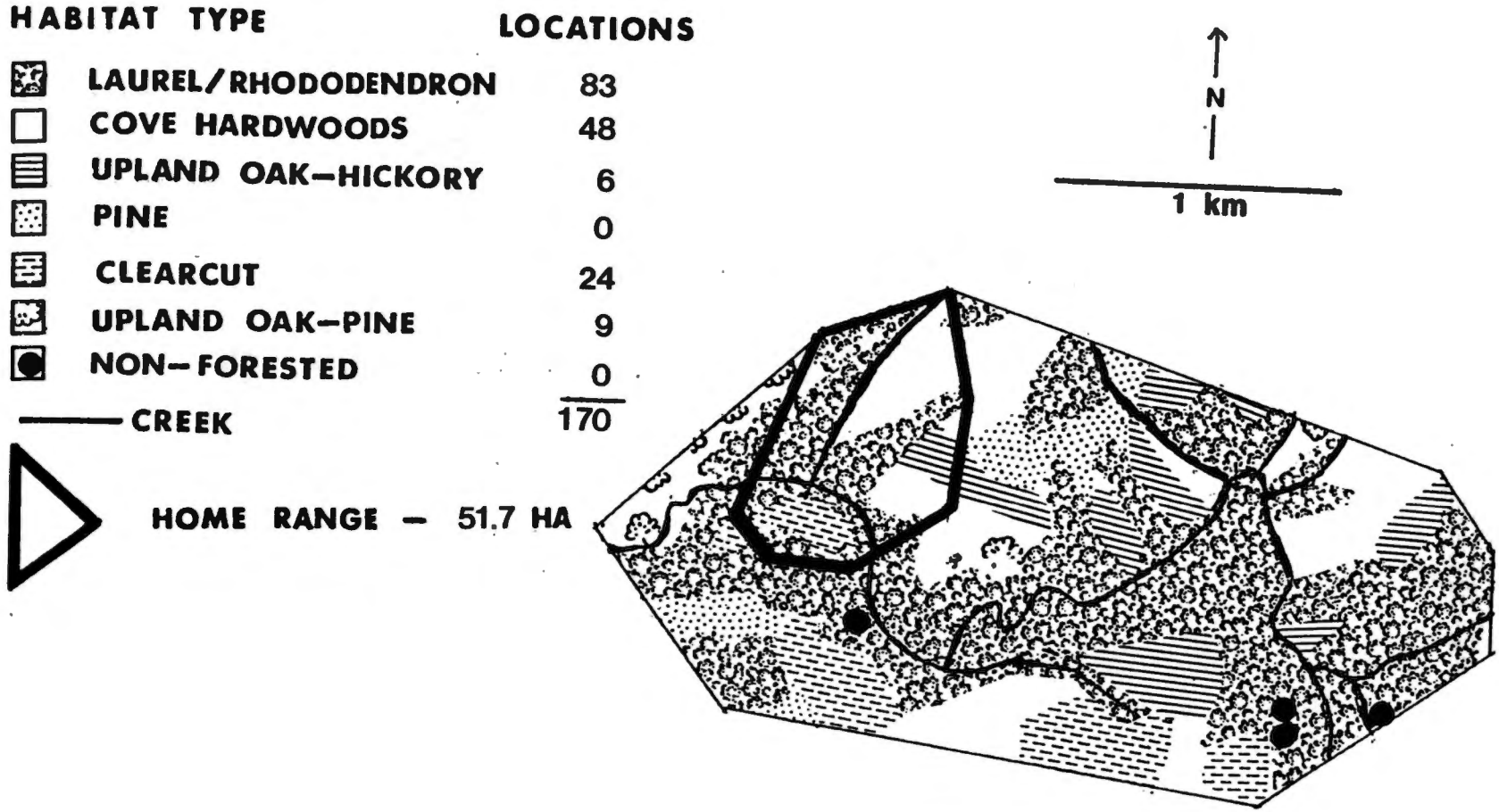

Figure 13. Home range of adult male (transmitter frequency 150.485) on Habitat Study Area 1, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, April 10, 1987-July 30, 1988.

September 1985 and was monitored until June 1986. Her home range comprised 42.7 ha.

ii. Habitat Utilization

Utilization of available habitat types was measured by analyzing selected telemetry data from 13 of the transmitter-equipped grouse monitored in 1985-1986 and 8 of the grouse from 1987-1988.

Different techniques were used to analyze data collected during 1985-1986 and 1987-1988. No Habitat Study Areas (HSAs) were created by connecting outermost telemetry locations collected during 1985-1986; instead, the Study Units and several stands outside their boundaries were used to determine utilization. Understory utilization was analyzed separately. During 1987-1988, 8 habitat categories which were combinations of both overstory and understory types were delineated. Utilization was determined by analysis of telemetry locations within HSA1 and HSA2, created by connecting outermost telemetry locations of all grouse included in the analysis.

1985-1986. Utilization of overstory cover type was determined by analysis of 346 independent telemetry locations in the Big Cove-Queen Cove and Sugar Cove Study Units and environs. Chi-square goodness-of-fit tests revealed that overstory cover types were not utilized in proportion to their availability (X^2 = 112.9, P = .05).

were utilized by the telemetered grouse disproportionately more than their availability would indicate (Table 10). Pine-hardwood, hardwood-pine, and upland hardwood stands were used disproportionately less than expected. Understory comprised of laurel/rhododendron thickets were present at 65% of the locations.

Eleven of the 13 telemetered grouse were males; they yielded 63% of the 237 locations (Table 11). Males preferred clearcut areas and avoided upland hardwood stands. Ninety-nine independent locations were gathered from 2 female grouse. They utilized clearcut areas and pine-hardwood stands more than expected and avoided both upland hardwood and cove hardwood stands (Table 11).

Both sexes utilized laurel/rhododendron thickets to a large degree. The 11 male grouse were located in that understory type 64% of the time. Sixty-nine percent of the females' locations were in laurel/rhododendron thickets (Table 12).

1987-1988. Utilization of the 8 habitat types within HSA1 and HSA2 was determined by analysis of 344 of the total 532 telemetry locations. Chi-square goodness-of-fit tests revealed that the habitat types were not utilized by ruffed grouse in proportion to their availability (X^2 = 83.4, P = .05). A preference was demonstrated for regenerating clearcuts (Table 13). Upland oak-hickory and pine stands

Table 10. Habitat utilization of 13 ruffed grouse in the Big Cove-Queen Cove and Sugar Cove Study Units and environs, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1985-1986.

Habitat	Area (ha)	# Loc.	% of Locations (P_i)	% Expected Locations (P_j)	95% C.I.[1]	Preference
Upland Hardwoods	550.8	82	0.237	0.342	0.192 <P < 0.282	-
Cove Hardwoods	535.0	100	0.289	0.333	0.241 <P < 0.392	0
Pine-Hdwd/Hdwd-Pine[2]	251.3	81	0.234	0.156	0.189 <P < 0.279	-
Clearcuts	150.5	58	0.168	0.094	0.129 <P < 0.207	+
Northern Hardwoods	64.0	20	0.058	0.039	0.033 <P < 0.083	0
Pine	38.0	5	0.014	0.024	0.002 <P < 0.026	0
Non-forested	19.2	0	0.000	0.012	N/A	0
Total	1608.8	346	1.000	1.000		

1 - Simultaneous interval estimate on P_i; is compared to the corresponding P_j to determine preference (+), avoidance (-), or expected utilization (0).

2 - Includes hemlock-hardwood, white pine-upland hardwood, pitch pine-oak, upland hardwood-white pine, and cove hardwoods-white pine-hemlock.

Table 11. Habitat utilization of 13 ruffed grouse, by sex, in the Big Cove-Queen Cove and Sugar Cove Study Units, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1985-1986.

Habitat	Area (ha)	# Locs.	% Locs. (P_i)	% Expected Locs. (P_j)	95% C.I.[1]	Preference
			Males (9)			
Upland Hdwds	550.8	68	0.276	0.342	0.220 <P < 0.332	-
Cove Hdwds	535.0	90	0.364	0.333	0.304 <P < 0.424	0
Pine-Hdwd/ Hdwd-Pine	251.3	29	0.117	0.156	0.077 <P < 0.157	0
Clearcuts	150.5	38	0.154	0.094	0.109 <P < 0.199	+
Northern Hdwds	64.0	17	0.069	0.039	0.037 <P < 0.101	0
Pine	38.0	5	0.020	0.024	0.015 <P < 0.025	0
Non-Forested	19.2	0	0.000	0.012	n/a	n/a
Total	1608.8	247	1.000	1.000		
			Females (2)			
Upland Hdwds	550.8	14	0.141	0.342	0.072 <P < 0.210	-
Cove Hdwds	535.0	10	0.101	0.333	0.042 <P < 0.160	-
Pine-Hdwd/ Hdwd-Pine	251.3	52	0.526	0.156	0.428 <P < 0.624	+
Clearcuts	150.5	20	0.202	0.094	0.123 <P < 0.281	+
Northern Hdwds	64.0	3	0.030	0.039	0.021 <P < 0.039	0
Pine	38.0	0	0.000	0.024	n/a	n/a
Non-Forested	19.2	0	0.000	0.012	n/a	n/a
Total	1608.8	99	1.000	1.000		

1 - Simultaneous interval estimate on P_i; is compared to the corresponding P_j to determine preference (+), avoidance (-), or expected utilization (0).

Table 12. Understory utilized by 13 ruffed grouse in the Big Cove-Queen Cove and Sugar Cove Study Units, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1985-1986.

	Big Cove-Queen Cove		Sugar Cove	
Understory Type	# Locations	% Locations	# Locations	% Locations
	Males (6)		Males (5)	
Laurel/rhododendron	95	0.64	62	0.63
Dense saplings	26	0.17	12	0.13
Hemlock thicket	23	0.15	0	0.00
Moist herbaceous	3	0.02	19	0.19
Dogwood-red maple-sourwood	2	0.01	0	0.00
Moist oak-hickory	0	0.00	4	0.04
Upland oak-hickory	0	0.00	1	0.01
Total	149	1.00	98	1.00
	Females (1)		Females (1)	
Laurel/rhododendron	62	0.70	6	0.55
Dense saplings	19	0.22	1	0.09
Hemlock thicket	1	0.01	0	0.00
Moist herbaceous	0	0.00	4	0.36
Dogwood-red maple-sourwood	6	0.07	0	0.00
Total	88	1.00	11	1.00

Table 13. Habitat utilization of 8 ruffed grouse on Habitat Study Areas 1 and 2, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1987-1988.

Habitat	Area (ha)	# Loc.	% of Locations (P_i)	% Expected Locations (P_j)	95% C.I.[1]	Preference
Laurel/ Rhododendron	275.0	202	0.587	0.568	0.535 <P < 0.639	0
Cove Hdwds	64.0	54	0.157	0.132	0.119 <P < 0.195	0
Uplnd Oak-Hickory	49.0	11	0.032	0.101	0.013 <P < 0.051	-
Clearcuts	41.0	63	0.183	0.085	0.142 <P < 0.224	+
Pine	26.0	1	0.003	0.054	0 <P < 0.009	-
Uplnd Hdwd-Pine	20.0	12	0.035	0.041	0.016 <P < 0.054	0
Northern Hardwood	5.0	0	0.000	0.011	n/a	n/a
Nonforested	4.0	1	0.003	0.008	0 <P < 0.009	0
Total	484.0	344	1.000	1.000		

1 - Simultaneous interval estimate on P_i; is compared to the corresponding P_j to determine preference (+), avoidance (-), or expected utilization (0).

were avoided. Laurel/rhododenron thickets were utilized in proportion to their availability.

Ninety-five percent (n = 326) of the telemetry locations were gathered from male grouse (2 juvenile and 4 adult); therefore male utilization was coincident with overall utilization (Table 14). Eighteen locations were collected from 2 juvenile female grouse; 15 of the locations were in clearcuts, 3 were in laurel/rhododendron thickets.

Seasonal Use of Forest Types

The transmittered grouse utilized different habitat types according to season (Figure 14):

Winter. Telemetered grouse avoided clearcut areas and moist, low areas and utilized dry slopes with mountain laurel and Vaccinium understories and pine and upland hardwood-pine overstories.

Spring. Dense vegetation such as laurel/rhododendron thickets and clearcut areas were utilized heavily by drumming males and nesting females. Drummers also utilized upland hardwood stands.

Summer. Laurel/rhododendron thickets and clearcut areas were utilized in the majority of locations.

Autumn. Although clearcut areas were utilized in 22.7% of the locations, most of these were recorded in early autumn before the regenerating vegetation began to lose its lushness. Laurel/rhododendron thickets and more open cove hardwood stands were utilized when the grouse began their

Table 14. Habitat utilization of 8 ruffed grouse, by sex, on Habitat Study Areas 1 and 2, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1987-1988.

Habitat	Area (ha)	# Locs.	% Locs. (P_i)	% Expected Locs. (P_j)	95% C.I.[1]	Preference
			Males (6)			
Laurel/Rhodo.	275.0	199	0.610	0.568	0.560 <P < 0.660	0
Cove Hdwds	64.0	54	0.166	0.132	0.126 <P < 0.206	0
Upld Oak-Hickory	49.0	11	0.034	0.101	0.015 <P < 0.053	-
Clearcuts	41.0	48	0.147	0.085	0.109 <P < 0.185	+
Pine	26.0	1	0.003	0.054	0.000 <P < 0.008	-
Upld Hdwd-Pine	20.0	12	0.037	0.041	0.017 <P < 0.057	0
Northern Hdwds	5.0	0	0.000	0.010	n/a	n/a
Non-Forested	4.0	1	0.003	0.008	0.000 <P < 0.008	0
Total	484.0	326	1.000	1.000		
			Females (2)			
Laurel/Rhodo.	275.0	3	0.167	0.568	0.000 <P < 0.339	-
Cove Hdwds	64.0	0	0.000	0.132	n/a	n/a
Upld Oak-Hickory	49.0	0	0.000	0.101	n/a	n/a
Clearcuts	41.0	15	0.833	0.085	0.685 <P < 0.981	+
Pine	26.0	0	0.000	0.054	n/a	n/a
Upld Hdwd-Pine	20.0	0	0.000	0.041	n/a	n/a
Northern Hdwds	5.0	0	0.000	0.010	n/a	n/a
Non-Forested	4.0	0	0.000	0.008	n/a	n/a
Total	484.0	18	1.000	1.000		

1 - Simultaneous interval estimate on P_i; is compared to the corresponding P_j to determine preference (+), avoidance (-), or expected utilization (0).

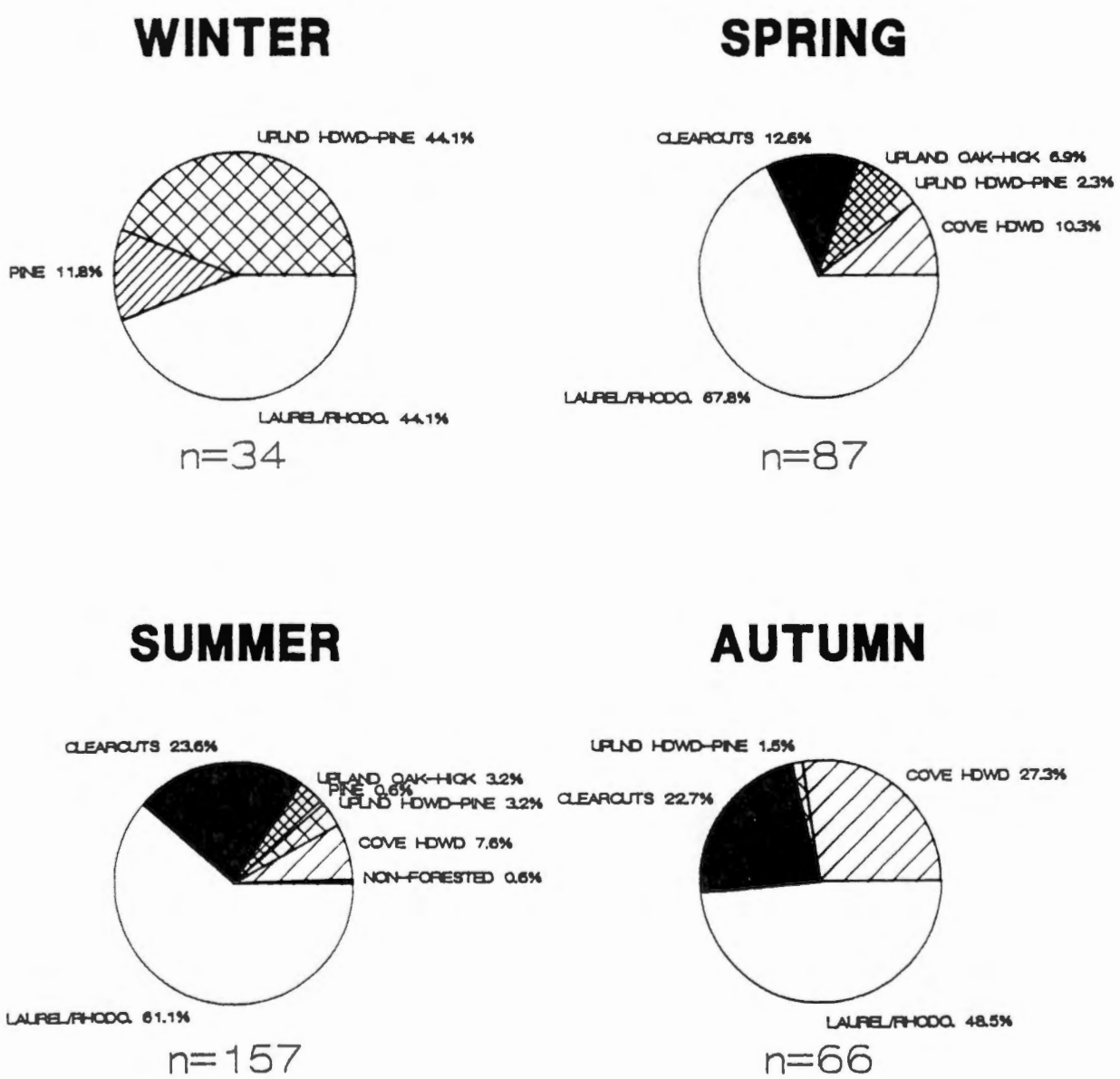

Figure 14. Seasonal utilization of habitat types within Habitat Study Area 1 and Habitat Study Area 2, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1987-1988.

n = number of locations.

annual dispersal in October/November, as documented by telemetry monitoring.

Seasonal Use of Topographical Features

Topographical features were also utilized to different degrees according to season (Figure 15):

Winter. South- and west-facing slopes, which typically receive more sun exposure and are warmer, drier, and more open were utilized heavily during winter (58.8% of winter locations), while north- and east-facing slopes (usually cooler and moister) were avoided. Areas within 40 m of a creek were occupied 32.4% of the time. Upper slopes were utilized more in winter than during any other season.

Spring. Low moist areas and creek-side areas were utilized to a large degree (47.1% of the spring locations). North- and/or east-facing slopes were occupied 21.8% of the time (most of the clearcut areas were located on north-facing lower slopes).

Summer. North- and east-facing slopes were utilized almost twice as much as south- and west-facing slopes. Creek-side and low moist areas were occupied 46.5% of the time.

Autumn. All slope aspects were utilized to a similar degree. During early autumn, grouse occupied moist, low areas, but began moving to dry hollows and slopes after leaf-fall. Ridgetops were occupied minimally, but to a larger degree than during the other seasons.

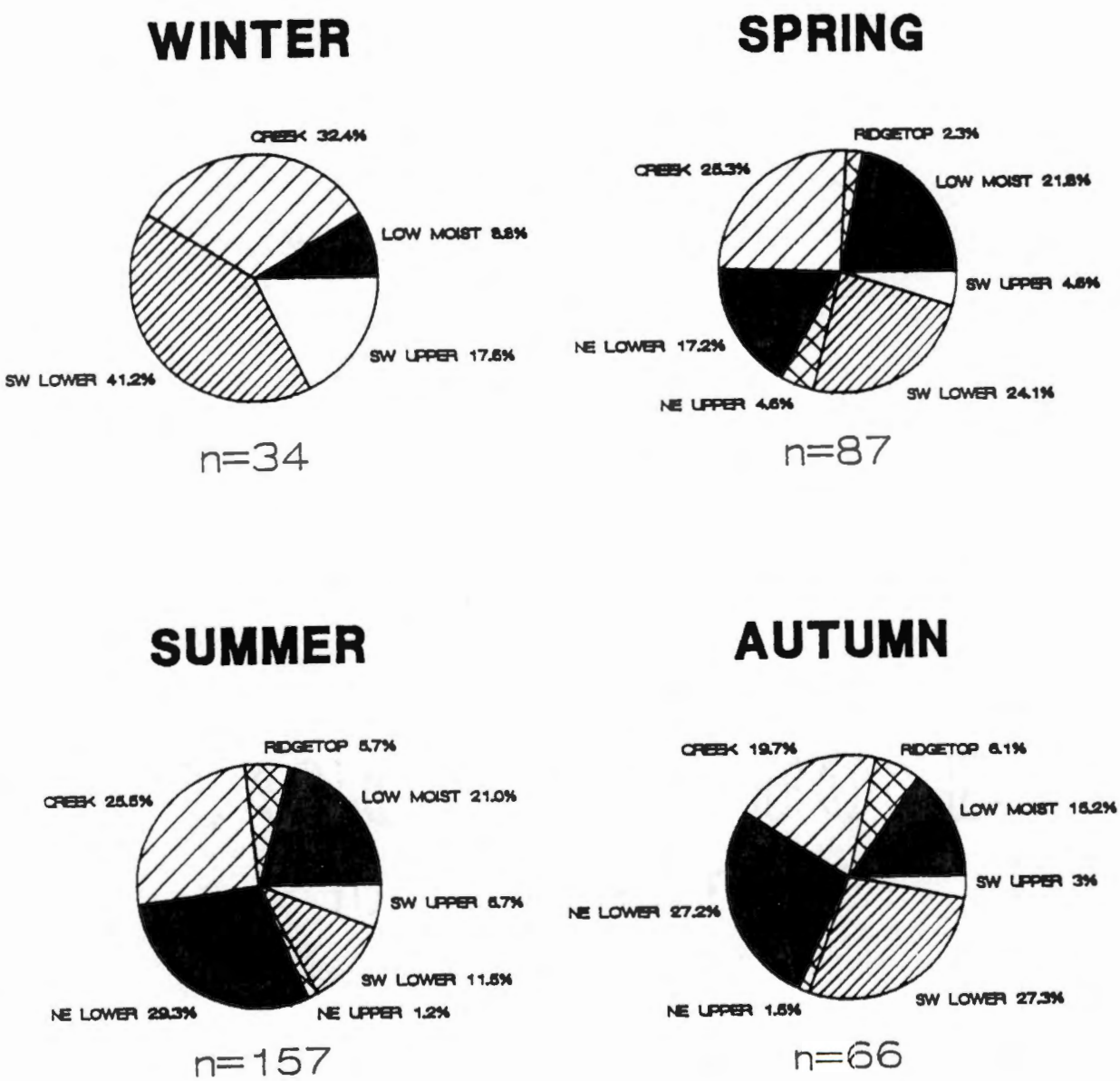

Figure 15. Seasonal utilization of topographical features within Habitat Study Area 1 and Habitat Study Area 2, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1987-1988.

n = number of locations.

CHAPTER V

DISCUSSION

I. Population Estimation

Ruffed grouse populations reach their highest densities in the central part of their range - the northern United States and Canada, where aspen occurs (Thompson and Fritzell 1989). Gullion (1984) reported that a density of 35 drumming males per 100 ha can be achieved in a well-managed Minnesota forest. Grouse densities are typically much lower, ranging from 2 to 8 males/100 ha at the southern limits of their distribution (Cade and Sousa 1985).

Wherever grouse occur, it is the diversity of vegetative cover that determines the number of grouse a forest can support (Bump et al. 1947). The quality of the habitat - its ability to meet food and cover requirements - is measured by the amount and dispersion of early successional and dense understory vegetation.

Average spring grouse density was estimated to be 2.1 grouse (both sexes) per 100 ha during this study. This estimate is comparable to other density estimates of southeastern grouse populations. Epperson (1988) found spring minimum densities to range from 0 to 1.9 grouse/100 ha on the Cumberland Plateau in Tennessee. Hale et al. (1982) reported a spring minimum population density of 3.6

grouse/100 ha in northern Georgia. Spring grouse density in Kentucky was estimated at 4.3 grouse/100 ha (Hardy 1950, in Backs 1984).

Average ruffed grouse density was significantly higher ($P < .05$) on the Big Cove-Queen Cove Unit (2.9 grouse/100 ha) than on the Sugar Cove Unit (1.2 grouse/100 ha) during 1984-1988. The relatively open, unmanipulated Sugar Cove Unit could not support as many grouse as the more diverse Big Cove-Queen Cove Unit, with its mosaic of successional stages and abundance of evergreen understory vegetation.

The relatively low number of drummers (n=3) found within Big Cove-Queen Cove in 1988 (Table 7) may seem to indicate that grouse density was decreasing, but it is believed that it was merely a low year in a naturally fluctuating population, as evidenced by the normal densities estimated in Big Cove-Queen Cove during 1989 and 1990. Such occurrences emphasize the value of long-term studies.

Low ruffed grouse densities in the Southeast are not surprising; population densities are typically lower in the periphery of an animal's range, where climatic and edaphic conditions may produce less than optimum habitats (Woolf et al. 1984). In the Southern Appalachians, grouse densities may be limited by the quality of their habitat. The quality and availability of winter food in this region may be limiting (Servello and Kirkpatrick 1987). Unlike grouse in the central part of their range where buds and catkins are

abundant, grouse in the Southeast rely heavily on fruits, ferns, and leaves of herbaceous and woody plants in winter (Stafford and Dimmick 1979, Seehorn et al. 1981). Forage of sufficient quality such as the leaves of greenbriar, Japanese honeysuckle (Lonicera japonica), and Christmas fern, the fruits of dogwood (Cornus florida) and grape, and acorns are commonly utilized during fall and early winter in Tennessee (Stafford and Dimmick 1979); however, these foods may not be available in sufficient quantities to support a large grouse population throughout winter. Due to declining supplies of quality forage, grouse have little alternative to using low quality forage such as mountain laurel leaves during late winter. Seehorn et al. (1981) found that the amount of mountain laurel consumed by grouse in the southern Appalachians increased steadily each month during winter, reaching a peak in February. Mountain laurel, the most commonly utilized evergreen forage in Tennessee, appears to be poor quality forage for ruffed grouse (Servello and Kirkpatrick 1987). It is low in protein and metabolizable energy, and high in phenols (substances which have a variety of adverse physiological effects on herbivores), and has been found to contain a toxin which may affect grouse behavior, growth rates, and reduce protein digestibility. Although levels of the toxin may not be sufficiently high to cause mortality, population densities could be impacted due to reduced reproduction (Beckerton and Middleton 1982) and

increased predation during foraging for other foods (Servello and Kirkpatrick 1987).

Other factors relating to habitat quality may depress grouse densities in this region. Regeneration cutting has only recently gained acceptance in southern Appalachian hardwood forests. Previously, grouse utilized edges, old fields, and understory vegetation in mature forests (Thompson et al. 1987). A paucity of the ruffed grouse's critical habitat - dense, young hardwoods - prevent it from reaching high densities. As the dispersion of early successional areas improves, ruffed grouse densities may increase.

II. Reproductive Chronology

The chronology of drumming activity, copulation, nesting, incubation, and hatching documented in this study closely correspond to results found in other ruffed grouse investigations. Drumming activity ranged from 20 March to 15 May and lasted an average of 43 days during 1984-1988 in the 2 study units. Similar ranges were recorded by Epperson (1988) on the Cumberland Plateau (27 March-2 June) and by Hale et al. (1982) in Georgia (13 March-19 May).

Drumming activity peaked in April of each year during this study; the average peak date was 14 April. Drumming activity throughout the ruffed grouse's range peaked during April. On the Cumberland Plateau drumming peaked during 11-

25 April (Epperson 1988). In north Georgia, the peak occurred during 29 March-17 April (Harris 1981). In Minnesota, the peak of drumming typically occurs around 29 April (Gullion 1966). This consistent chronology indicates that peak activity is independent of seasonal vegetation conditions, but is dependent upon photoperiod (Backs 1984, Gullion 1966).

Copulation was estimated to have occurred during 25 March-10 April of 1984-1988; this coincides markedly with peak drumming. A correlation between peak drumming periods and copulation dates was also documented on the Cumberland Plateau (Epperson 1988) and in Iowa (Porath and Vohs 1972).

Activities such as egglaying, incubation, and hatching also paralleled chronologies reported in other studies (Epperson 1988, Woolf et al. 1984). The timing of these activities is critical for chick survival. Davies and Bergerud (1988) reported that late hatching can result in slow growth rates and low chick survival due to less and poorer quality food available, such as insects. They also found a correlation between warm weather in June and high chick survival. Late summer weather also seems to affect chick survival. Hot summers may result in high chick mortality, much as cool, wet summers do farther north (Little 1984).

III. Trapping

Mirror trapping was more efficient than interception trapping during this study. The success rate of mirror trapping was 1 capture per 37.5 trap-nights, as compared to 1 capture per 50.9 trap-nights for interception traps. Epperson (1988) also found mirror trapping was more efficient (1 capture per 20 trap-nights) than interception trapping (1 capture per 122 trap-nights) on the Cumberland Plateau in Tennessee. Reasons for the greater success of mirror trapping include the site-specific placement of mirror traps and the increased territoriality of the male grouse during spring mirror trapping. Capture of a drumming male grouse was almost assured if a utilized log could be located. The ease of carrying and setting mirror traps is also much greater than that of interception traps; it takes a matter of minutes to properly place a mirror trap on a log, camouflage it with vegetation, and set the triggering device, while setting a 3-box interception trap can take well over an hour. Capture of non-target species also occurred with interception traps; 4 box turtles (Terrapene carolina), several songbirds and 1 oppossum (Didelphis marsupialis) were captured during the study. Trap-related injuries were minor with both types of traps. Grouse were typically found with skinned scalps resulting from battering

around the trap while trying to escape, or with lost feathers, but none were badly injured.

IV. Radio-telemetry

Battery-powered transmitters were more efficient than solar-powered transmitters during this study. The solar-powered transmitters were not reliable during adverse weather, and their use was discontinued early in the study.

Increased levels of predation on radiocollared sage grouse (Centrocercus urophasianus), sharp-tailed grouse (Pedioecetes phasianellus) (Marks and Marks 1987) and ruffed grouse (Gudlin 1984) have been reported. Risks are somewhat different for the lek-breeding grouse than for solitary woodland grouse such as the ruffed and blue grouse, however. Sage and sharp-tailed grouse populations experience their highest levels of predation while in groups, in the open on their leks (Marks and Marks 1987). Avian predators have been shown to select prey that differ in appearance from the norm (Mueller 1971, in Marks and Marks 1987), thus the radiocollared grouse were preyed on selectively. Ruffed grouse and blue grouse are solitary, do not display in open areas, and make shorter flights to cover. Hines and Zwickel (1985, in Marks and Marks 1987) found that radio- and non-radiocollared blue grouse survive at similar rates, as did White (1978) in regard to ruffed grouse. Although radiocollared woodland grouse experience avian predation at low levels, their major risk appears to lie in the tendency

of their radiocollar or antenna to become entangled in dense vegetation, thus exposing the bird to predation or trauma (White 1978, Gudlin 1984, Longwitz 1985). The use of the "backpack" style of radio-harness in these studies may have significantly increased the chances of a grouse becoming entangled and predated. Small and Rusch (1985) reported that ruffed grouse equipped with backpack harnesses required a longer adjustment period and experienced poorer survival than grouse fitted with poncho-style harnesses.

Transmitter-equipped grouse did not appear to be adversely affected by the presence of the poncho-style radiocollars used in this study. No mortality was attributed to radiocollar entanglement or avian predation. The weight of the radiocollars (18-23 g) did not exceed the 4% of body weight recommended by Brander and Cochran (1971). Flight did not appear restricted after release, nor during subsequent observations.

V. Home Range Size

An animal's home range can be defined as "the area necessary to satisfy the habitat requirements of (an) individual throughout the year" (Bump et al. 1947). The size of an animal's home range is directly related to the quality of its habitat. For an area to be considered high quality ruffed grouse habitat, it must provide winter shelter, spring drumming and nesting habitat, and year-round food and

escape cover within a small area. Northern ruffed grouse, especially those on areas intensively managed by regeneration cutting, have smaller home ranges than grouse in the Southeast, as a rule (Bump et al. 1947, Gullion 1966, Maxson 1978). During this study, however, small home range sizes were measured during certain seasons; this seems to indicate that patches of high quality grouse habitat are present in the Southern Appalachians.

Home range sizes varied seasonally during this study. Habitat usage and seasonal changes within habitats strongly influenced home range size and movements of the radiocollared grouse. Seasonal changes in grouse behavior such as increased territoriality of male grouse during spring and fall brood break-up and dispersal also affected home range sizes.

Winter

The smallest home ranges were recorded during winter (Table 10). Grouse of both sexes exhibited limited movements as suitable food and cover diminished and their need to conserve energy increased. Gudlin (1984) also found that home ranges of reintroduced grouse in west Tennessee were reduced in size during winter, and movements were restricted to areas of structural cover.

Spring

During spring, male home range sizes were relatively smaller ($\bar{x}$ = 12.9 ha) than those reported in other

southeastern and southcentral grouse studies. Harris (1981) reported a 31.4 ha mean spring-summer home range for males in northern Georgia. Male grouse in Missouri had even larger spring-summer ranges (45 + 4.4 ha) (Thompson and Fritzell 1989). In this study, home ranges were only slightly larger than the 8.9 ha average measured in Minnesota (Archibald 1975), which indicates that high quality drumming habitat exists in the southern Appalachians. Movements were limited to small areas surrounding activity centers. One male had a home range of only 3.8 ha; he was believed to be competing with another male for the same territory, and was closely guarding his activity center. Overlap of male spring home ranges was common during this study, but did not extend past either male's primary activity center. Epperson (1988) reported similar behavior on the Cumberland Plateau.

The single adult female monitored during spring had a much larger home range (37.4 ha) than the males. During this period she nested and began rearing a brood. Nesting female grouse in Minnesota occupied a spring home range of only 14.3 ha (Maxson 1978).

Summer

Male grouse are known to be sedentary during summer (Bump et al. 1947); male grouse in this study occupied small summer ranges ($\bar{x}$ = 15.3 ha). The single female grouse utilized a much larger area during this time; she and her

brood of 3 occupied a composite home range of 31.0 ha in the Sugar Cove Unit. A brood in Big Cove-Queen Cove was also monitored during the summer season; its' composite home range size was only 13.6 ha. The difference in home range sizes is likely due to the habitat quality of their ranges. The Sugar Cove brood occupied an area which was lacking in early successional stages. Regenerating areas are well known for being excellent brood habitat (Bump et al. 1947, Thompson et al. 1987). The brood in Big Cove-Queen Cove had a smaller home range due to its superior habitat quality; approximately 1/2 of the home range was within a 13-year-old clearcut, the other 1/2 was dominated by rhododendron thickets.

Autumn

Autumn home range sizes were larger than during any other season. Movements increased as broods of juveniles began to disperse to new territories and adults began searching for good wintering areas. The typically sedentary male grouse exhibited larger movements as they began moving from their moist, low summering ranges to drier ridges and hollows. Only 1 radiocollared grouse, a juvenile female in Big Cove-Queen Cove, did not display a change of habitat usage and home range size during autumn. She continued to occupy a 13-year-old clearcut from the date of her capture (8 August 1987) until she lost her radiocollar in early November 1987, accumulating a home range of only 2.0 ha.

Two or more seasons

Several grouse were monitored throughout 2 or more seasons during this study. Five adult males were monitored for periods ranging from 4.5 to 16 months, and accumulated an average home range of 36.5 ha. This average closely corresponds to the 38.1 ha average determined for male grouse on the Cumberland Plateau (Epperson 1988). One female grouse was monitored for more that 10 months; she was captured as a juvenile on 18 September 1985, and was monitored until radio contact was lost during late July 1986. Her annual home range size was 42.7 ha.

VI. Habitat Utilization

Throughout the range of the ruffed grouse, dense stands of young deciduous trees are considered to be its critical habitat (Bump et al. 1947, Aldrich 1963, Backs 1984, Gudlin and Dimmick 1984, Gullion 1984). Shrubby understory vegetation is also regarded as an important habitat component (White and Dimmick 1978). Although several researchers (Bump et al. 1947, Gullion 1984, and others) have suggested that ruffed grouse habitat quality is marginal in the southern portion of its range, pockets of high quality grouse habitat exist in the southern Appalachians wherever good interspersion of regenerating hardwood stands and evergreen understory vegetation are found.

It is commonly accepted that if certain habitat types were not preferred more than others, each type would be utilized in the proportion that it was available. During this study, habitat types were not utilized in proportion to their availability; those types providing the densest cover were utilized heavily. Regenerating clearcuts were the only habitat type utilized more than expected during the study. Laurel/rhododendron thickets were heavily used, but they were almost uniformly present; they were used to the degree expected due to their availability. Ninety percent of all grouse locations were in either laurel/rhododendron thickets or regenerating clearcuts. Ruffed grouse in all parts of their range utilize habitats with the highest stem densities available (Bump et al. 1947, White 1978, Hunyadi 1984, Backs 1984, Thompson and Fritzell 1989). Gudlin and Dimmick (1984) reported that 7 of 10 reintroduced grouse used hardwood saplings as their primary cover type in west Tennessee. They also reported high survivorship among birds released in regenerating areas. Laurel/rhododendron thickets were judged to be the most important habitat type for adult male grouse on the Cumberland Plateau (Epperson 1988); hardwood regeneration only comprised 2.2% of the study area, and was also used preferentially.

Cove and upland hardwood stands with relatively open understories were used minimally during this study, except during autumn; it is likely that grouse visited these areas

because of the availability of ripe acorns at that time. This habitat type was also used occasionally by drumming males during spring. Bump et al. (1947) reported that grouse concentrate in areas with fattening foods during fall. Reintroduced grouse in west Tennessee also utilized upland oak stands during early autumn (Gudlin and Dimmick 1984).

Pine, pine-hardwood, and hardwood-pine stands were generally underutilized except in winter, when more than 50% of all locations were in pine or upland hardwood-pine stands. Grouse often utilize coniferous cover during winter in parts of their range where deep snow is rarely available for snow roosting (Bump et al. 1947). Thompson and Fritzell (1988) indicated that Missouri grouse preferred conifers as winter roosts, and attributed the usage to the high thermal benefits that conifers offer. Southern Indiana grouse also utilized pine stands during winter (Backs 1984).

The radiocollared grouse were located in evergreen understory thickets or clearcut areas in the majority of their spring locations. A radiocollared female grouse nested in an 11-year-old clearcut in Queen Cove, and was flushed with her brood of week-old chicks in a rhododendron thicket near the clearcut in mid-May. Drumming males often utilized the abundant fallen logs and dense cover clearcut areas provided, or the protective cover rhododendron or laurel thickets could offer. Drummers across the grouse's

range use areas with high stem densities and understory density (Bump et al. 1947, White 1978, Backs 1984, Thompson et al. 1987); protective cover for a bird advertising his location is critical.

Summer grouse locations were also concentrated in laurel/rhododendron thickets and in clearcut areas. Regenerating clearcuts supplied abundant cover and food in the form of leafy vegetation, the highly prized blackberries and huckleberries, and insects. Seastedt and Crossley (1981) found that insects move into thick vegetation seeking cool conditions during summer; the presence of insects is one of the reasons investigators throughout the grouse's range have stressed the importance of clearcut areas as brood habitat. Over 90% of a grouse chick's diet is comprised of insects (Kimmel and Samuel 1984).

Habitat utilization patterns were similar for male and female grouse during this study. It appears that no sex-specific habitat requirements exist for ruffed grouse during any season in this region. Researchers in other areas substantiate this finding; Gullion (1967) found that suitable fall to spring cover for males is suitable for females; females with broods seem to prefer habitats similar to those preferred by drumming males (Porath and Vohs 1972).

VII. Utilization of Topographical Features

Grouse monitored during this study utilized several topographical features to different degrees according to season. Creek-side and low moist areas were utilized to similar degrees during all seasons; those areas were occupied in 35% (autumn) to 47% (summer) of the locations in 1987-1988. Ridgetops were utilized minimally during all seasons. Utilization of south- or west-facing slopes was quite different from that of north- or east-facing slopes. South- or west-facing slopes were utilized 58.8% of the time during winter, apparently for the higher radient temperatures and the higher frequency of pine. The cooler north- and east-facing slopes were avoided. The opposite was true during summer; north- and east-facing slopes were used twice as often as south- or west-facing slopes. Grouse are known to choose a sheltered spot on a north-facing slope to rest quietly at midday during hot weather (Bump et al. 1947). Lower slopes were used much more often than upper slopes during all seasons.

Use of topographical features is more likely a function of topographical influence on vegetation rather than the topographic features themselves (White 1978, Gudlin 1984). For example, all of the clearcut areas were located on north- or east-facing slopes, and their attractive condition during summer was probably the key to their utilization, rather than their topographic position.

CHAPTER VI

MANAGEMENT IMPLICATIONS

Ruffed grouse populations reach their highest densities in forests managed to maintain a variety of age classes (Gullion 1984). The high stem density provided by early successional stage hardwoods is particularly critical for insuring high ruffed grouse population density. Regeneration cuts dispersed throughout a forest improve grouse habitat by providing high quality foods such as berries and lush herbaceous vegetation, thereby decreasing grouse dependence upon low quality forage such as mountain laurel; the densest shelter from predators and foul weather is also provided. High grouse population densities are due in part to high survivorship of grouse occupying a forest with a mosaic of successional stages. Grouse inhabiting areas which lack early successional vegetation typically have larger home ranges and mean daily movements and lower survivorship than grouse occupying more diverse forests (Gudlin and Dimmick 1984, Thompson and Fritzell 1989). Large home ranges and mean daily movements indicate that resources are widely dispersed; the risk of predation is high in this type of habitat.

The importance of regenerating clearcuts as ruffed grouse habitat is widely accepted; however, grouse do exist in areas lacking early seral stage hardwoods. In some

localities, their structural requirements are met by shrub thickets of mountain laurel, rhododendron, or Japanese honeysuckle (White 1978, Gudlin 1984, Kalla and Dimmick 1987, Epperson 1988). Ruffed grouse monitored in this study heavily utilized both ericaceous thickets and regeneration cuts. Over 90% of the 690 independent grouse locations were in 1 of the 2 habitat types. A forest containing a diversity of age classes and an abundance of evergreen shrub vegetation should be considered high quality grouse habitat. The preservation of rhododendron and mountain laurel thickets is important when a forested area is managed with an emphasis on improving ruffed grouse habitat.

At the initiation of this study in 1984, clearcuts ranging in age from 2 to 9 years were available to grouse in the Big Cove-Queen Cove unit; a 19-year-old clearcut was adjacent to the Sugar Cove boundaries. In 1988, the Big Cove-Queen Cove clearcuts had grown into 6-to 13-year regeneration cuts; 6 new cuts had been made in the Sugar Cove unit. Of the 690 independent grouse locations gathered during this study, 121 locations were within regenerating clearcut areas; 104 of these were in 9- to 13-year-old clearcuts, 10 were in 4- to 8-year-old cuts, and 7 were in cuts 21- to 24-years-old. Consequently, it appears that clearcuts ranging in age from 9 to 13 years were most attractive to grouse. The age at which a clearcut becomes attractive to grouse varies among region and forest type,

but most researchers agree that clearcuts are initially utilized at 2 to 6 years, when they reach maximum stem density, and continue to attract grouse for 10 to 20 years, or until stem density decreases substantially (Gullion 1984, Gudlin and Dimmick 1984). Forests which are undisturbed for more than 30 years are generally unsuitable for grouse, unless they contain an abundance of shrubby vegetation.

The shape, size, and placement of a regeneration cut can also determine its value as grouse habitat. A linear or irregularly shaped cut is more beneficial than a square or rectangular cut; ericaceous thickets and desirable mast producers can be left "out" of the cutting boundary and the amount of edge is increased. The size of a clearcut, although important, is of less significance than might be expected. Forest Service standards and guidelines specify that clearcuts be no larger than 40 acres (16.2 ha) in this region; clearcuts in the Cherokee National Forest are an average of 10 ha in size. Grouse in this study readily utilized cuts ranging in size from 4 to 16 ha. Clearcuts in this size range are desirable when ruffed grouse and other early successional stage species are emphasized in a management scheme. Economics aside, however, a large number of cuts on the lower end of the size spectrum is more beneficial than a few large ones; more edge is produced and a variety of age classes can be interspersed throughout the forest. In addition to clearcutting, forest management

practices such as group selection, single-tree selection, and shelterwood cutting could potentially benefit ruffed grouse populations in this region. In management areas where early successional wildlife species are emphasized on the Cherokee National Forest, approximately 11% of each compartment is maintained in the 0-10 year age class; cuts are distributed evenly throughout the more mature age classes. Clearcuts are most beneficial to ruffed grouse and other wildlife species when they contact and lie between a large number and variety of cover types. Regeneration cuts made on north- or east-facing slopes are beneficial due to their sheltered position and tendency toward natural hardwood regeneration; south- and west-facing slopes tend to be more exposed, dry, and thus tend to regenerate into forests containing a higher percentage of coniferous species.

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APPENDIX

Table 15. Capture data from 35 grouse, Big Cove-Queen Cove and Sugar Cove Study Units, Tellico Ranger District, Cherokee National Forest, Monroe Co., Tennessee, 1985-1988.

AGE-SEX	WEIGHT (g)	CAPTURE DATE	STUDY UNIT	TRAP TYPE	FREQUENCY (Mhz)	TRANSMITTER TYPE	LEG BANDS	POST-RELEASE
Adult	670	8-20-85	Big	I	164.662	Solar	309-310	OK
Male	?	9-11-85	Sugar	I	164.455	Battery	394-395	OK
	635	9-17-85	Big	I	no trans.	-	363-371	*
	?	4-04-86	Big	I	164.154	Battery	311-312	OK
	730	4-05-86	Big	M	164.189	Battery	313-314	a
	600	4-05-86	Big	I	164.803	Solar	315-316	OK
	630	4-05-86	Big	I	164.455	Battery	390-391	OK
	690	4-05-86	Big	M	164.534	Battery	392-393	OK
	670	4-06-86	Big	M	no trans.	-	317-318	b
	580	5-29-86	Sugar	M	164.430	Battery	386-387	OK
	?	10-01-86	Big	I	no trans.	-	-	*
	580	4-02-87	Big	M	150.450	Battery	351-352	OK
	610	4-22-87	Big	M	150.786	Battery	329-330	OK
	620	4-24-87	Big	I	151.640	Battery	331-332	OK
	580	4-17-88	Sugar	M	150.056	Battery	368	OK
	600	4-27-88	Big	M	151.843	Battery	335	$
Total = 16		Mean weight = 630.4 g						

Table 15. Continued.

AGE-SEX	WEIGHT (g)	CAPTURE DATE	STUDY UNIT	TRAP TYPE	FREQUENCY (Mhz)	TRANSMITTER TYPE	LEG BANDS	POST-RELEASE
Adult	540	7-22-85	Sugar	I	164.383	Solar	301-302	OK
Female	490	8-15-86	Big	I	164.989	Battery	383-385	OK
Total = 2	Mean weight = 515.0 g							
Juvenile	320	7-21-85	Sugar	I	164.783	Solar	396-397	OK
Male	340	7-21-85	Sugar	I	164.883	Solar	398-399	OK
	315	7-22-85	Sugar	I	164.837	Solar	306-307	OK
	450	8-15-86	Big	I	164.759	Battery	379-380	OK
	715	10-08-86	Big	I	164.762	Battery	373-374	OK
	510	10-16-86	Big	I	164.430	Battery	341-342	OK
	380	7-23-87	Big	I	150.620	Battery	620	OK
	390	7-23-87	Big	I	150.299	Battery	337	OK
Total = 8	Mean weight = 427.5 g							
Juvenile	330	7-22-85	Sugar	I	164.662	Solar	304-305	*
Female	510	9-18-85	Big	I	164.131	Battery	370-384	c
	410	8-15-86	Big	I	164.844	Battery	281-282	OK
	?	8-15-86	Big	I	164.738	Battery	388-389	OK
	430	8-20-86	Big	I	164.189	Battery	377-378	OK
	350	7-23-87	Big	I	151.843	Battery	333-334	OK
	400	8-08-87	Big	I	150.346	Battery	367	OK
Total = 7	Mean weight = 405.0 g							

Table 15. Continued.

AGE-SEX	WEIGHT (g)	CAPTURE DATE	STUDY UNIT	TRAP TYPE	FREQUENCY (Mhz)	TRANSMITTER TYPE	LEG BANDS	POST-RELEASE
Unknown	?	4-10-87	Big	I	no trans.	-	-	@
	?	5-06-87	Sugar	M	no trans.	-	-	@
Grand Total = 35								

? - Grouse was not weighed.

@ - Grouse was removed from trap.

* - Grouse died during handling or immediately after release.

$ - Grouse was killed by a dog after release.

a - This grouse was recaptured on 10-5-86, in a mirror trap on the same drumming log it was captured on during spring. Its radiocollar was replaced and it was released.

b - This grouse was recaptured the following spring (4-9-87) on the same drumming log. It was fitted with a radiocollar and released.

c - The remains of this grouse were found in a trap on 4-15-87; it appeared to have been killed by a weasel. It was identified by leg bands.

VITA

Ruth A. Boyd was born in Johnson City, Tennessee, on April 20, 1963. She completed her elementary and high school education in Johnson City and graduated from Science Hill High School in June 1981. In 1985, she received her Bachelor of Arts degree in Zoology from the University of Tennessee, Knoxville. In February of 1987, she accepted a graduate research assistantship with the University of Tennessee's Department of Forestry, Wildlife, and Fisheries Science. She received her Master of Science degree in Wildlife and Fisheries Science in May 1990.

Ruth has worked for Tennesee Department of Conservation, Division of Parks, and has participated in a cooperative education program with the USDA Forest Service in Cleveland, Tennessee. She is currently employed by Cherokee National Forest as a Wildlife Biologist Trainee.