To the Graduate Council:

I am submitting herewith a thesis written by Carrie L. Schumacher entitled "Ruffed Grouse Habitat Use in Western North Carolina." 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.

Craig A. Harper

____

Major Professor

We have read this thesis and recommend its acceptance:

David A. Buehler

____

Arnold Saxton

____

Acceptance for the Council:

Anne Mayhew

____

Vice Provost and Dean of Graduate Studies

(Originals are available in the Graduate Student Services office.)

RUFFED GROUSE HABITAT USE

IN WESTERN NORTH CAROLINA

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Carrie L. Schumacher

May 2002

ACKNOWLEDGMENTS

I want to thank my advisor, Dr. Craig Harper, for all of his patience and guidance throughout my time at Tennessee. Appreciation also goes out to my committee members, Dr. Dave Buehler, Dr. Arnold Saxton, and Gordon Warburton for their advice and constructive criticism. Thanks to Billy Minser for his assistance in the field and in the classroom. I want to thank Dr. Ray Wells for single-handedly getting me into graduate school.

I want to thank the Department of Forestry, Wildlife, and Fisheries for providing me the opportunity to conduct my research. The U. S. Forest Service, Coweeta Hydrologic Laboratory, the North Carolina Wildlife Resources Commission, and the Ruffed Grouse Society funded the project. Thanks to Jim Vose for allowing us to use Coweeta's facilities and equipment. A special thanks to Sharon Taylor for answering my endless GPS questions and to Ben Jones for his statistical help. Members of the Franklin, Andrews, and Waynesville crews of the North Carolina Wildlife Resouces Commission helped conduct drum surveys and set and check traps, and I thank them all for their help. I thank Bill Culpepper at the Wayah Ranger District for his assistance in providing silvicultural information and answering numerous questions. Holly Selig provided habitat coverages and GIS support. I appreciate the advice and camaraderie from my friends in the co-op, Pat Devers, George Bumann, Darroch Whitaker, and John Tirpak. I thank Jennifer Murrow and Dr. Frank van Manen for their help with GIS. A special thanks goes out to my technician, George Talyor. Without his dedication and hard work, this project would never have come to fruition. Thanks George!

To my fellow graduate students, Jennifer Murrow, Steve Dobey, Daniel Moss, Jennifer Fettinger , Laura Lake, Greg Bailey, Andy Edwards, Jaimie McNutt, Jun Yoshizaki, Jimmy Watkins, Brandon Wear, Allison Mains, and Jason Maxedon – thanks for the memories! I'll never forget you guys. A special thanks to Jeff Dobey for his love and support.

Finally, I want to acknowledge my family who supported me both emotionally and financially throughout this phase of my life. I couldn't have made it this far without you all. I love you.

ABSTRACT

Ruffed grouse (*Bonasa umbellus*) historically have been considered a bird of early successional habitats. Over the past 60 years, forests of the southern Appalachians have matured, as a result of reduced timber harvest. Because of pressure from special interest groups, the U. S. Forest Service no longer uses the clearcutting method of regeneration. Use of forest stands created by alternative silvicultural techniques by grouse is unknown. The primary objective of this study was to determine grouse use of various forest types and stand ages, including stands regenerated by shelterwood, 2-aged shelterwood, and group selection early after harvest.

Eighty-five grouse were captured in Fall 1999 and Spring 2000 with interception and mirror traps with a trap success rate of 1.2 birds/100 trap nights. Mesic pole stands (11– 39 years old) were preferred over mature stands (≥40 years old) and sapling stands (≤10 years old) for year-round habitat use. Males had an average annual home range of 43 ha (106 ac), a fall-winter range of 51 ha (126 ac), and a spring-summer range of 32 ha (79 ac). Females had an average annual home range 66 ha (163 ac), a fall-winter range of 64 ha (158 ac), and a spring-summer range of 46 ha (114 ac). Male grouse had an average day-use area of 1.5 ha (4 ac), while females typically stayed within 0.8 ha (2 ac).

A spring drumming census suggested there were 2 birds/100 ha in 1999 and 4 birds/100 ha in 2000. Drumming logs were most often located on ridge tops in mature stands with a dense mid-story of mountain laurel (*Kalmia latifolia*) or flame azalea (*Rhododendron calendulaceum*). Vegetation and topographic sampling suggested micro-

site selection did not affect trap success, however, traps located in edge habitat were more successful than traps in mature stands. The annual mortality rate was 62%. Ten mortalities were believed to be caused by avian predators, 18 by mammalian predators, 6 grouse were killed by hunters, and 9 by other causes.

Management recommendations should prescribe timber harvests in mesic forest stands to benefit ruffed grouse. Cuts should be separated both in time and space and be positioned near mature oak-hickory and/or northern hardwood stands when possible. Cuts should be located on mid- to lower slopes to provide early successional habitat, while leaving selected ridge tops uncut to provide suitable drumming log habitat. Logging roads and openings should be planted in a clover and annual grass mixture to establish quality herbaceous openings used by grouse for winter feeding and spring/summer brood rearing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

Ruffed grouse thrive in forested habitats throughout their range. In southern Canada and the Lake States region of the U.S., regenerating stands of quaking (*Populus tremuloides*) and bigtooth aspen (*P. grandidentata*) provide excellent habitat commonly used by grouse. South of the aspen's range, habitat quality tends to decline and grouse populations are smaller (Bump et al.1947; Fig. 1).

In the southern Appalachians, grouse thrive in forested habitats with high stem densities, such as those regenerated by clearcutting (Boyd 1990, Pelren 1991). Recently, however, negative public opinion regarding timber harvest and the clearcut method of regeneration has influenced the U. S. D. A. Forest Service (hereafter Forest Service) to reduce timber harvest substantially. Consequently, alternative regeneration methods, such as shelterwood and group selection, are being prescribed. There is concern that a reduction in timber harvest and the use of alternative harvest methods will lead to less favorable habitat for ruffed grouse and contribute further to population decline (Sauer et al. 2000). Specifically, it is not known whether grouse will use forest stands regenerated by alternative methods as readily as stands that have been clearcut.

No study concerning habitat use in North Carolina has been conducted. In 1996, the Appalachian Cooperative Grouse Research Project (ACGRP) was established to investigate population trends and factors influencing ruffed grouse survival in the central Appalachian region. Thus far, the Cooperative's research has focused on population

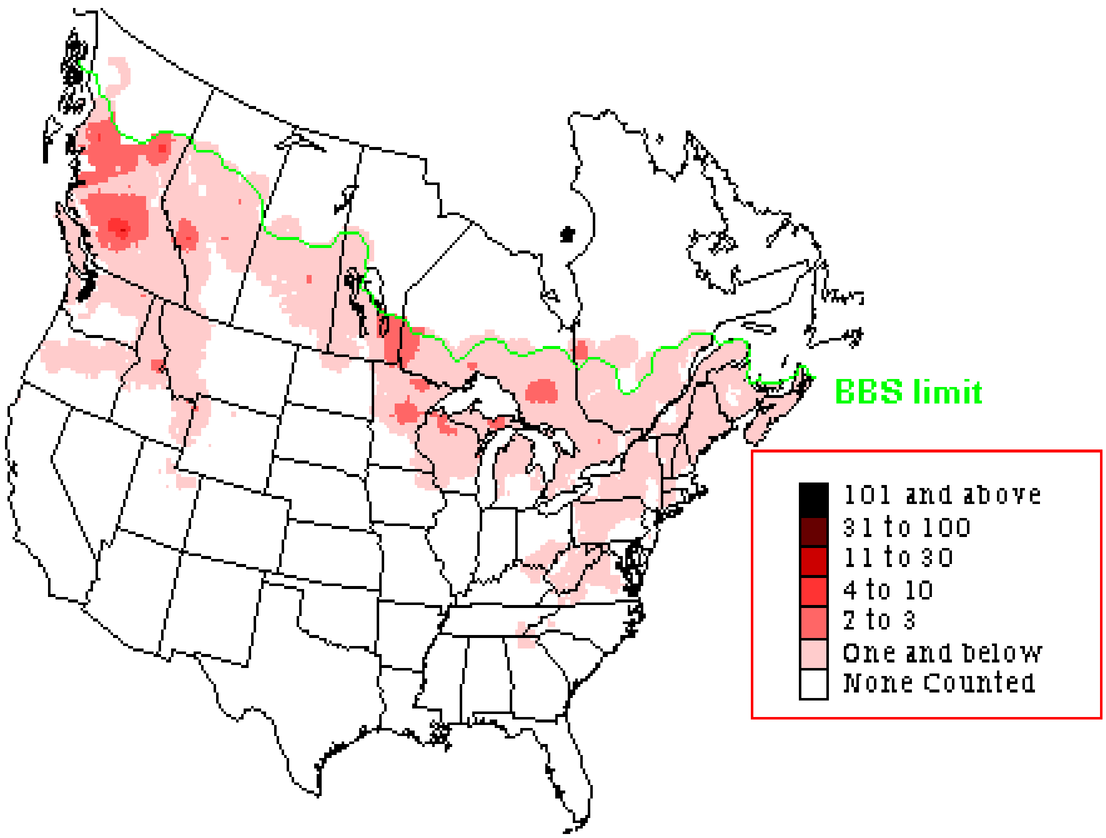

Fig. 1. The range of ruffed grouse is larger than any other non-migratory game bird in North America (Sauer et al. 2000).

ecology, brood survival, roost site selection, and home range. However, the effects of timber management on ruffed grouse movements and habitat use have not been investigated by the Cooperative. The results of this project should benefit forest and wildlife managers in the southern Appalachians by determining use of stands regenerated through alternative silvicultural methods, as well as drum log selection, trap success, and basic life-history information.

OBJECTIVES

1. Determine habitat use and home range of ruffed grouse within managed forests of western North Carolina

2. Obtain baseline census data provided through line-transect drumming surveys on the Wine Spring Creek study area.

3. Describe the vegetative, topographic, and physical parameters associated with drumming sites.

4. Determine vegetative and topographic parameters associated with successful and unsuccessful trap sites.

5. Determine causes of mortality.

CHAPTER II

STUDY SITE AND BACKGROUND INFORMATION

The study was conducted on the Wine Spring Creek Ecosystem Management Area and surrounding compartments located on the Wayah Ranger District of the Nantahala National Forest in western Macon County, North Carolina (Fig. 2). This area lies within the Blue Ridge Physiographic Province and is part of the Nantahala Mountains within the Unaka Range. The Wine Spring area is located approximately 110 km (68 mi) southwest of Asheville, North Carolina and 29 km (18 mi) south of the Great Smoky Mountains National Park. Encompassing approximately 4,579 ha (11,311 ac), elevation in this area ranges from 915 m (3,000 ft) to 1,644 m (5,392 ft). Mean annual temperature of the Wine Spring area is 10.4˚C (50.7˚F) and mean annual precipitation is 192 cm (76 in). Forest types within the study area included northern hardwood forests, mixed mesophytic hardwood forests, oak (*Quercus* spp.)-hickory (*Carya* spp.) forests, and mixed hardwood-pine (*Pinus* spp.) forests. Forest openings, primarily consisting of wildlife food plots and logging roads originally seeded in a white-dutch clover (*Trifolium repens*)/orchardgrass (*Dactylis glomerata*) mixture, comprised <1% of the land area. The Forest Service purchased the area in 1912 and timber has been harvested on the Wine Spring area on a regular rotation, making it representative of most Forest Service lands within the southern Appalachians of North Carolina and Tennessee.

In July 1992, the Forest Service took a new direction in its research and management programs in response to changing public views of natural resources. The new program was termed "New Perspectives for Managing the National Forest System,"

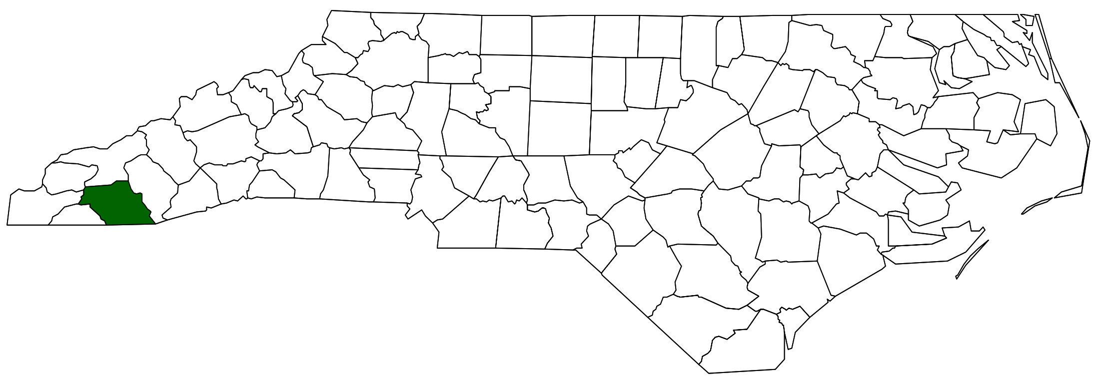

Fig. 2. Location of the Wine Spring Creek Ecosystem Management Area, Macon County, North Carolina.

and was intended to modify and broaden the multiple-use paradigm to one of ecosystem management. The intent of the new program was to implement beneficial wildlife and fisheries habitat manipulations in an area of the national forest not selected for timber production during the 1986–2000 planning period. With the implementation of New Perspectives, the project evolved into a demonstration of ecosystem management and was renamed the Wine Spring Creek Ecosystem Management Demonstration Project.

Since project inception, sites have been selected for various treatments and studied and described intensively. Furthermore, desired future conditions have been formulated (many of which have been met since origination), research opportunities have been realized and explored, and technology transfer has been completed for many of the research projects. During Phase I (1993–1997) of the Wine Spring Creek Project, personnel from 7 universities and different branches of the Forest Service conducted research exploring various aspects of natural resources management. This research included ecological classification of forest stands, stream chemistry and sedimentation, social values, nutrient cycling, and the impacts of forest management on fish, wildlife, and vegetation diversity.

In 1995–1997, the Forest Service selected 11 stands within the Wine Spring area for management prescriptions to study the effects of alternative silvicultural techniques. These management prescriptions included 3 stands harvested via shelterwood, 3 stands harvested via two-age shelterwood, 3 stands harvested via group selection, and 2 stands were identified as control sites. Foresters attempted to leave a residual basal area of

5.0–7.5 m^2/ha (20–30 ft^2/ac) in shelterwood cuts. The residual stems were retained in two-aged shelterwoods, while residual stems in the shelterwood cuts will be removed after the regeneration becomes established. Group selection harvests consisted of several small 0.4–0.8 ha (1–2 ac) cuts within the stand. All stands consisted of the high-elevation northern red oak (*Q. rubra*) type (forest type 53). These stands were chosen for study based on an ecosystem classification system (McNab and Browning 1993) that incorporates vegetation and environmental gradients in an effort to identify and group stands into similar ecological units. This study represents the wildlife focus for Phase II of the overall Wine Spring Creek project.

CHAPTER III

HABITAT USE AND HOME RANGE

INTRODUCTION

Throughout its range, ruffed grouse prefer forests with high stem densities for breeding, brood rearing, escape cover, and foraging (Bump et al. 1947). Stems per hectare in areas used by grouse ranged from 2,600 in winter to 11,000 in summer (Stauffer and Peterson 1985) but may be in excess of 20,000 stems/ha (Kubisiak 1989). Preferred cover during spring and summer is dominated by tall brush and young trees, especially for drumming and nesting activities (Gullion 1970); winter cover usually is comprised of coniferous shrubs and trees (Stauffer and Peterson 1985). Grouse select areas, whether deciduous or coniferous, with 80–85% canopy cover in all seasons (Stauffer and Peterson 1985).

Regeneration cuts in oak-hickory stands are important because of their potential to produce high woody stem densities (Thompson et al. 1987). Ground cover (e.g., slash or blown-down trees) is most beneficial when it occurs in small areas or clumps, rather than spread over a large area (Kubisiak 1989). Grouse populations are highest where young and old stands are distributed throughout an area (Barber et al. 1989).

Studies concerning habitat use have been conducted in eastern Tennessee (Boyd 1990, Pelren 1991), providing similar results as studies in northern states. However, studies in the southern Appalachians had extremely low sample sizes. Boyd (1990) had a sample of 35 radio-collared grouse over a four-year period and Pelren (1991) had a sample of 10 birds. Boyd (1990) and Pelren (1991) found grouse used regenerating clearcut areas more than expected (clearcuts were 5–10 years old).

The objective of this study was to determine grouse use of regenerating stands early after timber harvest using alternative silvicultural techniques. Use of other available habitats also was determined. Secondary objectives were to determine yearly and seasonal home ranges by sex and age and characterize daily activity patterns

METHODS

Trapping and Handling

Ruffed grouse were captured from April to May 1999 using mirror traps (Gullion 1965), August through October 1999 using interception traps (Liscinsky and Bailey 1955), and April through May 2000 using mirror traps and interception traps. Grouse were removed from traps, placed in mesh bags, and taken to a vehicle to prevent escapes. A small sock was placed over each bird's head to reduce stress induced by handling. Captured grouse were sexed, aged, weighed, and fitted with radio transmitters and numbered leg bands. The length of primary feathers 8, 9, and 10 were measured and extent of sheathing and the shape of the feathers were recorded to determine age. If the ninth and tenth primaries were fully-grown and the seventh and/or eighth primaries were growing, the bird was considered a juvenile. The tip of primaries were pointed on juveniles and rounded on adults (Gullion 1989b). A rump feather and central tail feather were removed and measured to determine sex. Male grouse had 2 or 3 spots on their rump feathers, while females had only 1 (Gullion 1989a). Central tail feathers were generally >144 mm (5.7 in) on males and <150 mm (5.9 in) on females (Gullion 1989a). Feathers 144 –150 mm were adult females or juvenile males. Radio transmitters weighed 12 grams (0.4 oz) with a battery life of 1 year.

Telemetry

An attempt was made to locate each grouse at least once per week during November through March. As the drumming and nesting season approached, grouse were located at least three times per week. Telemetry stations were selected as needed and coordinates determined by Global Positioning Systems (GPS). Radio-collared grouse were monitored using a portable, multi-channel receiver with a hand-held 3-element yagi antenna. Telemetry locations were determined from ≥3 compass bearings (Cochran and Lord 1963) of radio signals >30º apart taken within 30 minutes using the loudest signal method (Springer 1979). In addition, telemetry error was estimated by comparing bearings of 5 transmitters placed at randomly selected telemetry stations with known coordinates.

Habitat Use and Home Range

The study area was divided into 9 habitat categories based on Forest Service Continuous Inventory of Stand Condition (CISC) data – sapling (stands ≤10 years old), mixed mesophytic hardwood pole, mixed mesophytic hardwood mature, mixed hardwood-pine pole, mixed hardwood-pine mature, oak-hickory pole, oak-hickory mature, northern hardwood pole, and northern hardwood mature (Tables 1, 2, and 3). Pole stands were 11–39 years old, and mature stands were ≥40 years old. The small number of birds in the

Table 1. Forest type classification on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

Mixed hardwood/pine

- (03) White pine
- (10) White pine / upland hardwoods
- (15) Pitch pine / oak
- (42) Upland hardwoods / white pine
- (45) Chestnut oak / scarlet oak / yellow pine
- (59) Scarlet oak
- (60) Chestnut oak / scarlet oak

Mixed mesophytic hardwoods

- (08) Hemlock / upland hardwoods
- (41) Cove hardwoods / white pine / hemlock
- (50) Yellow-poplar
- (56) Yellow-poplar / white oak / northern red oak

Oak/hickory

- (52) Chestnut oak
- (53) White oak / northern red oak / hickory
- (55) Northern red oak

Northern hardwoods

- (81) Sugar maple / American beech / yellow birch

Table 2. Availability of habitat types on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

Class	Hectares	Acres	Percent
Sapling[1]	157	388	3.4
Mixed hardwood-pine pole[2]	134	330	2.9
Mixed hardwood-pine mature[3]	242	598	5.3
Mixed mesophytic hardwoods pole	16	40	0.4
Mixed mesophytic hardwoods mature	587	1,451	12.8
Oak-hickory pole	341	843	7.5
Oak-hickory mature	2,157	5,328	47.1
Northern hardwoods pole	27	66	0.6
Northern hardwoods mature	918	2,267	20.0
Total	4,579	11,311	100

[1] Sapling includes all stands ≤10 years old.
[2] Pole stands were 11–39 years old.
[3] Mature stands were ≥40 years old.

Table 3. Number and average stand size for regenerating stands ≤10 years old by harvesting treatment on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

Acres	No. of stands	Hectares	
Clearcutting	15	9.5	23.4
Shelterwood	3	5.7	14.0
Two-aged shelterwood	3	5.4	13.2
Group selection	3	6.8	16.9

analysis prohibited defining habitat categories on a finer scale (i.e., sapling stands by type, 100 year old mature forests versus 40 year old forests).

Telemetry station coordinates and bearings for all locations were entered into Locate II software (Pacer, Inc., Turo, Nova Scotia; Nams 1990), which estimated point locations using Lenth's maximum likelihood estimator (MLE; White and Garrott 1990). A 95% error ellipse (analogous to the 95% confidence interval for univariate statistics; Nams 1990) was calculated around each location based on an empirically derived (MLE procedures; Lenth 1981) standard deviation for each bearing. For locations in which the error ellipse encompassed more than 1 habitat type, each habitat type was assigned a percentage of the location in proportion to the amount of the error ellipse encompassed to further compensate for telemetry error (Harper 1998). Locations were entered into a Geographic Information System (GIS) and overlayed on forest type and age class coverages to determine habitat use. Habitat use was evaluated using compositional analysis (Aebischer et al. 1993) and by testing a habitat selection index with the Friedman test (Alldredge and Ratti 1986, Chapin et al. 1997). Habitat use was analyzed by all grouse and season as well as by sex and season. Compositional analysis was not conducted on the sex and season analysis if bird sample size was less than the number of habitat categories (9). In these cases, only the Friedman test was used. Only grouse with ≥30 locations were considered in habitat analyses. Seasons were delineated by calendar dates.

Use of all roads was determined by comparing known distances from bird locations to the nearest road with random points generated in ArcView using a pairwise t-test. Locations were analyzed by sex and season.

Day-use areas were determined by locating a bird once an hour from sunrise to sunset. Day-use areas were calculated using a 95% minimum convex polygon (Hayne 1949) and the longest distance moved between locations was calculated by measuring distances between each movement using ArcView. Annual and seasonal home ranges were estimated for birds with ≥30 locations using a 95% minimum convex polygon.

Randomly selected birds were flushed to determine telemetry accuracy. Forest type, stand age, overstory and understory vegetation, distance to nearest edge, and vegetation across edge were recorded at each flush site. Habitat at flush locations were compared to GIS habitat coverages to determine if telemetry placed the bird in the correct habitat.

RESULTS

Trapping

Spring 1999 trapping efforts were unsuccessful. Six veeries (*Catharus fuscescens*) were incidentally captured. Seventy-eight grouse were captured in interception traps August through October 1999. Of those, 9 were killed in the traps (8 by mammalian predators and 1 from capture myopathy) and 4 were released without transmitters because of poor physical condition or lack of transmitters on the last day of trapping. Transmitters were placed on 65 grouse – 15 adult females, 23 juvenile females, 20 adult males, and 7 juvenile males. Three birds were recaptured. One hundred fifty traps were used, resulting in 6,770 trap nights with a capture success rate of 1.2 birds per 100 trap nights. Two box turtles (*Terrapene carolina*) and a timber rattlesnake (*Crotalus horridus*) also were captured.

Four male grouse were captured during Spring 2000. Trapping resulted in 94 trap nights with a capture success rate of 4.3 males per 100 trap nights. There were no incidental captures.

Telemetry

The calculated telemetry error was 3.9°. A total of 1,847 radio locations were obtained from August 1999 to October 2000. Locations per bird ranged from 0 to 109.

Habitat Use and Home Range

One thousand, two hundred twenty-two locations were used in the habitat use analysis. Thirty-four percent of locations were obtained from females in spring-summer, 12% from females in fall-winter, 43% from males in spring-summer, and 11% from males in fall-winter. Fifteen birds (7 adult males, 1 juvenile males, 6 adult females, and 1 juvenile female) were considered for the analysis. Locations from 2 brooding hens were omitted from the analysis. One hen was killed shortly after hatching and the other lost her brood within 4 weeks. Locations post-brood loss were included in the analysis. Relatively few locations (n = 284) were obtained during the fall and winter seasons because of the lack of manpower and inclement weather. Therefore, seasons were combined into 2 categories – fall-winter and spring-summer.

Three percent of locations were found in sapling stands, 30% in pole-aged stands, and 67% in mature stands. The average error ellipse was 1.5 ha (3.7 ac) and the average stand size was 14.9 ha (36.7 ac). Fifty-three locations (4%) fell into the 9 stands harvested via alternative techniques, however, 36 of those were in group selection stands. Thirty-three locations fell into sapling stands that had been clearcut and only 1 location was in the control stands.

Based on availability, all grouse combined selected mixed mesophytic pole stands, oak-hickory pole stands, and northern hardwood pole stands during spring and summer (Table 4). During fall-winter, mixed mesophytic pole stands and northern hardwood pole stands were ranked highest (Table 5). Male grouse generally selected oak-hickory and mixed mesophytic pole stands in spring and summer (Table 6), while females selected these stands as well as pole and mature northern hardwood stands (Table 7). During fall and winter, little preference for habitats was exhibited by males (Table 8) and none by females (Table 9).

Bird locations were closer to roads than random locations ($P < 0.0001$). Distances between random points and roads averaged 175 m (574 ft) during fall-winter and 181 m (594 ft) during spring-summer (Table 10). Distances between female locations and roads averaged 120 m (394 ft) during fall-winter and 115 m (377 ft) during spring-summer. Distances between male locations and roads averaged 73 m (239 ft) during fall- winter and 102 m (335 ft) during spring-summer. Fifteen locations fell within wildlife openings.

Table 4. Habitat[1] use rankings for all grouse during spring and summer on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

	Preference Rank[3]								
	1	2	3	4	5	6	7	8	9
Compositional[2] Analysis	MMpole	NHpole	OHpole	NHmat	OHmat	sap	HPpole	HPmat	MMmat
Freidman Test	OHpole	MMpole	NHpole	NHmat	sap	HPpole	HPmat	OHmat	MMmat

[1] sap = sapling
MMpole = mixed mesophytic hardwood pole
MMmat = mixed mesophytic hardwood mature
HPpole = hardwood-pine pole
HPmat = hardwood-pine mature
OHpole = oak-hickory pole
OHmat = oak-hickory mature
NHpole = northern hardwood pole
NHmat = northern hardwood mature

[2] Relative preference of habitats sharing an underline was not significantly different (P > 0.05).

[3] Rank of 1 indicates most preferred, 9 least preferred.

Table 5. Habitat[1] use rankings for all grouse during fall and winter on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

	Preference Rank[3]								
	1	2	3	4	5	6	7	8	9
Compositional Analysis[2]	MMpole	NHpole	NHmat	OHmat	sap	OHpole	HPpole	HPmat	MMmat
Friedman Test	MMpole	NHpole	OHpole	sap	NHmat	OHmat	HPpole	HPmat	MMmat

[1] sap = sapling
MMpole = mixed mesophytic hardwood pole
MMmat = mixed mesophytic hardwood mature
HPpole = hardwood-pine pole
HPmat = hardwood-pine mature
OHpole = oak-hickory pole
OHmat = oak-hickory mature
NHpole = northern hardwood pole
NHmat = northern hardwood mature

[2] Relative preference of habitats sharing an underline was not significantly different ($P > 0.05$).

[3] Rank of 1 indicates most preferred, 9 least preferred.

Table 6. Habitat[1] use rankings for male grouse during spring and summer on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

	Preference Rank[3]								
	1	2	3	4	5	6	7	8	9
Friedman[2] Test	OHpole	MMpole	NHpole	OHmat	sap	HPpole	NHmat	HPmat	MMmat

[1] sap = sapling
MMpole = mixed mesophytic hardwood pole
MMmat = mixed mesophytic hardwood mature
HPpole = hardwood-pine pole
HPmat = hardwood-pine mature
OHpole = oak-hickory pole
OHmat = oak-hickory mature
NHpole = northern hardwood pole
NHmat = northern hardwood mature

[2] Relative preference of habitats sharing an underline was not significantly different ($P > 0.05$).

[3] Rank of 1 indicates most preferred, 9 least preferred.

Table 7. Habitat[1] use rankings for female grouse during spring and summer on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

	Preference Rank[3]								
	1	2	3	4	5	6	7	8	9
Friedman[2] Test	MMpole	OHpole	NHmat	NHpole	sap	HPpole	HPmat	OHmat	MMmat
Group (underline) A	MMpole	OHpole	NHmat	NHpole					
Group (underline) B	MMpole	OHpole	NHmat	NHpole	sap	HPpole	HPmat		
Group (underline) C						HPpole	HPmat	OHmat	MMmat

[1] sap = sapling
MMpole = mixed mesophytic hardwood pole
MMmat = mixed mesophytic hardwood mature
HPpole = hardwood-pine pole
HPmat = hardwood-pine mature
OHpole = oak-hickory pole
OHmat = oak-hickory mature
NHpole = northern hardwood pole
NHmat = northern hardwood mature

[2] Relative preference of habitats sharing an underline was not significantly different ($P > 0.05$).

[3] Rank of 1 indicates most preferred, 9 least preferred.

Table 8. Habitat[1] use rankings for male grouse during fall and winter on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

	Preference Rank[3]								
	1	2	3	4	5	6	7	8	9
Friedman[2] Test	MMpole	NHpole	OHpole	sap	OHmat	HPpole	NHmat	HPmat	MMmat

[1] sap = sapling
MMpole = mixed mesophytic hardwood pole   OHpole = oak-hickory pole
MMmat = mixed mesophytic hardwood mature   OHmat = oak-hickory mature
HPpole = hardwood-pine pole   NHpole = northern hardwood pole
HPmat = hardwood-pine mature   NHmat = northern hardwood mature

[2] Relative preference of habitats sharing an underline was not significantly different (P > 0.05).

[3] Rank of 1 indicates most preferred, 9 least preferred.

Table 9. Habitat[1] use rankings for female grouse during fall and winter on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

	Preference Rank[3]								
	1	2	3	4	5	6	7	8	9
Friedman[2] Test	MMpole	NHmat	NHpole	OHpole	sap	HPpole	HPmat	MMmat	OHmat

[1] sap = sapling
MMpole = mixed mesophytic hardwood pole
MMmat = mixed mesophytic hardwood mature
HPpole = hardwood-pine pole
HPmat = hardwood-pine mature
OHpole = oak-hickory pole
OHmat = oak-hickory mature
NHpole = northern hardwood pole
NHmat = northern hardwood mature

[2] Relative preference of habitats was not significantly different (P > 0.05).

[3] Rank of 1 indicates most preferred, 9 least preferred.

Table 10. Mean distances (±SE) to nearest road in meters on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

	Mean (±SE)
Random fall-winter	175 (9.1) A[1]
Female fall-winter	120 (10.6) B
Male fall-winter	73 (6.0) C
Random spring-summer	181 (5.5) A
Female spring-summer	115 (4.9) B
Male spring-summer	102 (3.8) B

[1] Same letter denotes no significant difference (P>0.05).

Day-use areas were calculated for 8 grouse (4 females and 4 males) during summer 2000. Females had an average day-use area of 0.8 ha (2 ac), ranging from 0.3 – 1.6 ha (0.7–4 ac). The greatest distance moved between locations averaged 42 m (138 ft), ranging from 31–58 m (102–190 ft). Males had an average day-use area of 1.5 ha (4 ac), ranging from 0.4 – 2.2 ha (1–5 ac). The greatest distance moved between locations averaged 34 m (112 ft), ranging from 14–51 m (45–ft).

Home ranges were determined for the same 15 grouse used in the habitat analysis (Fig. 3 and 4). Annual home ranges for adult males ranged from 27–71 ha (67–175 ac) and the juvenile male had a home range of 92 ha (227 ac). Annual home ranges for adult females ranged from 46–122 ha (114–301 ac) and the juvenile female had a home range of 74 ha (183 ac). Fall-winter home ranges for adult males ranged from 2–112 ha (5–277 ac) and the juvenile male had a fall-winter range of 162 ha (400 ac). Fall-winter home ranges for adult females ranged from 39–102 ha (96–252 ac) and the juvenile female had a fall-winter range of 109 ha (269 ac). Spring-summer home ranges for adult males ranged from 7–63 ha (17–156 ac) and the juvenile male had a spring-summer range of 23 ha (57 ac). Spring-summer home ranges for adult females ranged from 15–111 ha (37–274 ac) and the juvenile female had a spring-summer range of 10 ha (25 ac).

A total of 113 flushes were conducted. Thirty-five flushes were from birds not used in the habitat analysis and therefore were not considered. Eighty-five percent (n = 66) of flushes correctly corresponded to the GIS habitat coverage. The 12 flushes that did not correspond were within 23 m (77ft) of the correct habitat type.

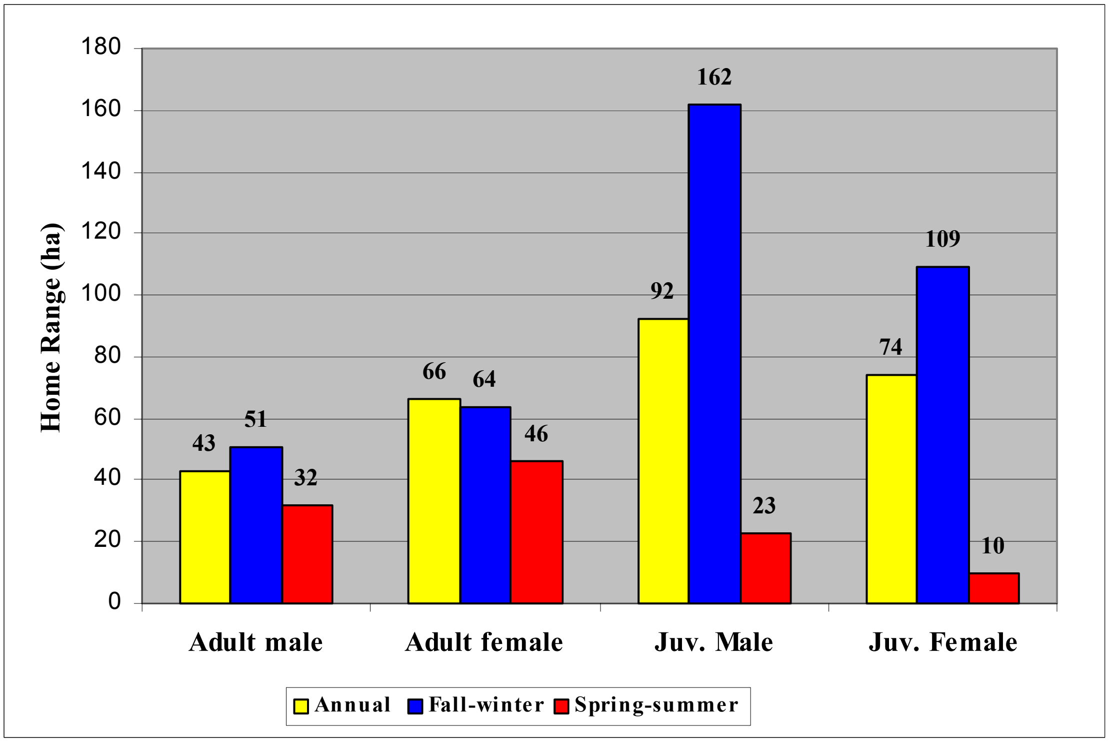

Fig. 3. Mean annual and seasonal home ranges of ruffed grouse on the Wine Spring Creek Study Area, North Carolina, August 1999–October 2000.

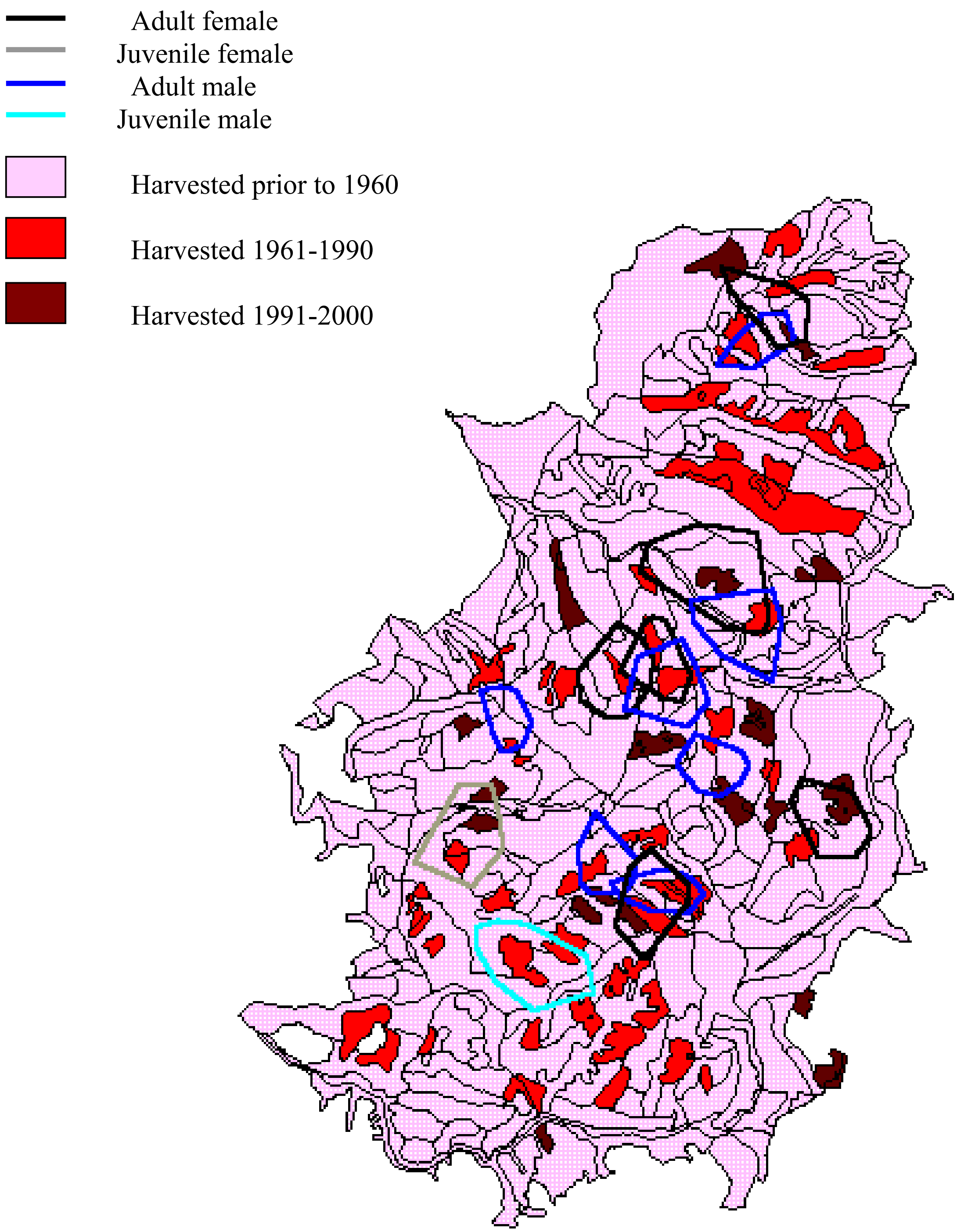

Fig. 4. Ruffed grouse home ranges in relation to stand age on the Wine Spring Creek Study Area, North Carolina, August 1999–October 2000.

DISCUSSION

Grouse appeared to use stands recently regenerated by alternative silvicultural techniques as expected, based on availability of these stands on the study site. Grouse usually do not begin using regenerating stands until they are 5–10 years of age (McCaffery et al. 1996). McCaffrey et al. (1996) went as far as eliminating aspen stands 0–4 of age from some analyses. Gullion (1982) stated grouse did not use aspen stands until they are 8–12 years old. McDonald (1993) found mixed oak forest clearcuts had grouse densities equal to or greater than densities in aspen clearcuts after 9 growing seasons. Dense slash remaining immediately after clearcutting impedes grouse movements. After 3–4 years, young hardwood stands are so dense they shade out important herbaceous food sources, contributing to decreased use (Sharp 1963). The stands regenerated by shelterwood and group selection at Wine Spring had similar stem densities and structure as similar-aged stands harvested by clearcutting (Elliott unpub. data).

Pole-aged stands (11–39 years old) of mixed mesophytic hardwoods, northern hardwoods, and oak-hickory were preferred most by grouse at Wine Spring. The preference for mesophytic hardwood stands, however, may be misleading. This result is based on 2 birds using a 13-ha (32-ha) mesophytic hardwood pole stand almost exclusively. There were only 2 stands of this type on the study area and only 1 was located in an area used by radio-collared grouse. Emphasis should be placed on the fact that mesic pole-aged stands were preferred over mature stands and recently regenerated stands regardless of stand type. Also, it is important to note that relatively dry stands located on south- and southwest-facing slopes (i.e., mixed hardwood / pine stands) received little use, regardless of stand age. Eleven percent of the study area was comprised of pole-aged stands while 85% of the area was mature forest.

Year round use of pole-aged stands has been documented throughout grouse research (Bump et al. 1947, Barber et al. 1989, Boyd 1990, Pelren 1991). Grouse use of pole-aged stands during spring and summer might be explained by food sources available as well as cover from avian predators. Food resources in pole-aged stands was probably less, however, than that found in younger or mature stands. After year 4 or 5, there is very little fruit produced on blackberries (*Rubus canadensis*) and other soft mast producers (e.g. huckleberry and blueberry [*Vaccinium* spp.]) did not fruit until late summer/early fall at the elevations encountered at Wine Spring. Grouse were most likely feeding on buds and leaves. Norman and Kirkpatrick (1984) found leaves of herbaceous plants were the primary food source in spring and summer in Virginia. They also found soft fruits were a dominant food source in summer. Norman and Kirkpatrick (1984) found soft fruit to be important in fall as well and pole-aged stands provided greenbriar fruit into fall. Leaves of woody plants made up only 2.8% of all foods consumed throughout the year. Dense cover found in pole size stands provides better overhead protection than mature stands from migrating avian predators (e.g., broad-winged hawks [*Buteo platypterus*]) found in the area only during spring and summer.

Grouse used mature oak-hickory and northern hardwood stands frequently in fall and winter, probably because of available food resources. Acorns, beech nuts, cherries, catkins, and grape (*Vitis* spp.) seeds were available in these stands. Long (unpubl. data) found the diet of 110 grouse collected along logging roads in North Carolina and Virginia consisted of buds, catkins, and twigs from birch (*Betula* spp.), azalea, and serviceberry (*Amelanchier arborea*), leaves of *Galax*, Christmas fern (*Polystichum acrostichoides*), and mountain laurel and soft mast (e.g., greenbriar (*Smilax* spp., grape, and *Viburnum*) during March 1999–2000. Norman and Kirkpatrick (1984) reported soft mast was preferred over hard mast, however, hard mast was the main food source in October and November. Mature oak-hickory stands were frequently used by male grouse during spring, as 75% of the drumming were logs located in mature stands at Wine Spring. Grouse also used evergreen shrubs, such as rhododendron (*Rhododendron* spp.) and mountain laurel, as roost sites during winter. "Thickets" of rhododendron and mountain laurel were available in many mature stands at Wine Spring.

Studies have looked at the importance of roads for grouse and wild turkeys (*Meleagris gallopavo*; Hurst and Owen 1980, Heally and Nenno 1983, Heally 1985, McDougal et al. 1990, Martin 1993, Howard 1994, Knox 1994, Hollifield and Dimmick 1995), primarily their importance as brood habitat. Distances from grouse locations to roads at Wine Spring were significantly less than random points. Grouse use roads for several reasons. Dusting, foraging for invertebrates by hens and broods, and male strutting displays all occur on logging roads. Roads also are an important source of grit used in digestion. The close proximity of grouse to roads is further rationalized by the fact that roads are generally associated with stands that have been cut recently and are therefore usually adjacent to habitats grouse frequent.

Wildlife openings composed <1% of the study area and 1% of locations were recorded in these areas. During 2 years of research at Wine Spring, grouse were flushed from within food plots dominated by orchardgrass only once, suggesting that these openings are largely unused by grouse. Most of the openings at Wine Spring had reverted to naturally occurring forbs and grasses germinating from the seed bank. Wildlife openings sown in an orchardgrass and clover mix become dominated by orchardgrass within a few years (Harper et al. 2001). This structure decreases the abundance of invertebrates and impedes travel of grouse chicks (Healy and Nenno 1983, Hollifield and Dimmick 1995).

The average home range for all grouse at Wine Spring (58 ha; 143 ac) was much greater than the home ranges found in Virginia (33 ha, 82 ac; Fearer 1999) and slightly greater than the average home ranges reported in Tennessee (45 ha, 111 ac; Pelren 1991). In Minnesota, Archibald (1975) reported an average female home range of 16.5 ha (40.8 ac). Home ranges in the southern Appalachians are generally larger than those in northern states, possibly because of lower habitat quality. Grouse that have mature and young stands in relatively close proximity have year-round food and cover requirements in a smaller area requiring less travel to find needed resources. Spring-summer home ranges were consistently smaller than fall-winter. This is a result of males staying close to their drumming logs and females staying close to their nesting sites. Fall-winter home ranges may not be reliable because of the low number of locations.

MANAGEMENT IMPLICATIONS

Mesic forest stands 11–39 years old were preferred by grouse in all seasons. For this reason, it seems obvious that this forest age class be present. Pole-aged stands should comprise a considerable percent of the management area where grouse are a focal species.

Mature stands seem to be used most in fall and winter for potential food resources and in spring for drumming sites (if structural requirements are met). Interspersion of regenerating stands with mature stands, within the area of a grouse home range (≈58 ha; 143 ac), provides cover and food during all seasons. Given the use mixed mesophytic pole stands received and the fact that only 2 stands exist on the study area, initial harvesting at Wine Spring should focus on mature mixed mesophytic stands. Currently, there is only 1 mixed mesophytic sapling stand (10 years old) 18 ha (44 ac) in size at Wine Spring. There are several stands of mature mixed mesophytic hardwoods encompassing 587 ha (1,451 ac). Mature mixed mesophytic hardwoods were not preferred by grouse.

Harvests should be positioned near mature oak-hickory and/or northern hardwood stands when possible. Size of the area harvested has been a topic of interest among wildlife and forest managers. McCaffery et al. (1996) reported 8-ha (20 ac) clearcuts produced higher grouse densities than larger cuts in Wisconsin. Several intensive experiments used ≤0.4-ha (1 ac) clearcuts to determine if clearcutting would increase grouse use (Sharp 1963, Gullion 1982, Yahner 1993). All studies reported clearcutting increased grouse numbers. Creating several small "clearcuts" may be best accomplished through group selection harvests, which structurally resemble small clearcuts. However, group selection cuts (as well as small clearcuts) may be too small to provide grouse with adequate cover (Dessecker and McAuley 2001). Harvest areas should be separated both in time and space to provide necessary food and cover. Harvests should be implemented approximately every 10 years to provide a continuous supply of pole-aged stands (Dessecker andMcAuley 2001). Residual basal areas greater than 4.9 m^2/ha (20 ft^2/ac) may result in decreased regeneration stem densities (Thompson and Dessecker 1997).

Thinning pole-aged stands would increase understory vegetation and enhance the structural component for grouse. The use of prescribed fire also may increase herbaceous cover especially in stands that have been thinned previously (Rogers 1985). Harvesting near first order creeks and seeps will provide grouse with an herbaceous food source as well as cover during winter.

Ruffed grouse use herbaceous openings (e.g., seeded logging roads) for several reasons. Given the fact that herbaceous openings comprise <1% of the Wine Spring area, it is obvious that existing roads and openings should be managed effectively. Roads and openings should be sown with perennial clovers along with an annual grass or cereal grain. Annual grasses and grains provide quick ground cover, however they are gone by the second growing season, leaving clover stands (Harper et al. 2001). Naturally occurring forbs and annual grasses found in the seed bank will begin to germinate and grow within 2–3 growing seasons. This type of cover harbors an abundance of insects and other invertebrates and does not inhibit chick travel.

CHAPTER IV

POPULATION INDEX

INTRODUCTION

Several census techniques have been used to determine grouse populations. Ammann and Ryel (1963) looked at many methods such as mail-carrier counts, brood counts, drumming counts, and hunting reports. Drumming surveys are often used because they are inexpensive and easily conducted, however, they may not provide an accurate estimate (Ammann and Ryel 1963). For example, the hearing ability of researchers is an important factor in obtaining accurate counts. Nevertheless, drumming surveys conducted in the same manner over several years can provide a good index of population growth or decline. To determine population trends and impacts of forest management on the ruffed grouse population at Wine Spring,, a drumming survey was initiated in accordance with ACGRP protocol.

METHODS

Two, 2-day drumming surveys were conducted in early- to mid-April. A series of logging roads and trails were walked beginning ½ hour before sunrise and ending 4 hours after sunrise. The starting points for each survey were alternated on the two consecutive mornings. A 0.4 km (0.25 mi) buffer was placed around each transect to determine the area covered by the survey. Depending upon environmental conditions, drumming grouse can be heard up to 0.4 km (0.25 mi; Bump et al. 1947). Time of detection, direction (via compass bearing), and an estimated distance to each bird were recorded. Locations between days were compared to eliminate replicate birds. Estimated log locations were placed on a map to allow researchers to return to the logs to conduct drumming site surveys. Drumming surveys were not conducted in heavy rain, snow, or high wind. Assuming a 1:1 sex ratio occurs in late winter and early spring (Bezdek 1944), the number of drummers heard was doubled to take females into account and give an approximate population estimate. It was also assumed that all juvenile grouse drummed.

RESULTS

The 1999 drumming survey was conducted 10–11 April and 24–25 April and covered approximately 1,060 ha. Eleven drumming males were heard, resulting in a population estimate of 2 birds/100 ha (0.8 birds/100 ac). The 2000 drumming survey covered the same area as the 1999 survey and was conducted 6–7 April and 17–18 April. Twenty-one drumming males were heard, resulting in 4 birds/100 ha (1.6 birds/100 ac).

DISCUSSION

Although the drumming counts doubled in 2000 from 1999, the results do not necessarily mean the population doubled, or even changed. The 1999 census might have been low because of increasing winds. Contrary to popular belief, wind does not discourage drumming (Gullion 1966), it just impedes the researcher’s ability to hear drumming. Wind speeds increased after the census began on 11 April, possibly precluding researchers from hearing some drumming males. Also, more birds might have been detected in 2000 because the survey was done earlier and better coincided with peak drumming season.

The census results from Wine Spring were similar to those found in eastern Tennessee, where Boyd (1990) reported an average of 2.9 birds/100 ha (1.2 birds/100 ac) from 1985 through 1988 (0.5–4.4 birds/100 ha; 0.2–1.8 birds/100 ac) and Pelren (1991) reported 2.7 birds/100 ha (1 bird/100 ac) and 5.2 birds/100 ha (2.1 birds/100 ac) in 1989 (2 sites). Drumming surveys in these studies were conducted 2–4 times a week from mid-March to mid-May.

Gullion (1967) claimed that some juvenile males are not associated with a drumming log their first spring because of a lack of suitable sites. Therefore, population estimates derived from drumming surveys tend to be conservative. This phenomenon, however, may be more pronounced in northern grouse ranges where large densities of established males may leave juveniles without a territory. Only 1 juvenile male survived to the drumming season in 2000 on Wine Spring, and he actively drummed. The smaller grouse populations in the southern Appalachians might well allow most, if not all, juveniles to establish a territory their first year. Therefore, a drumming census in the southern Appalachians might be able to be used as a population estimator.

A drumming census should be conducted for several years before any statements can be made concerning a population's status. Trends in the Wine Spring population will not be evident for some time.

CHAPTER V

DRUMMING LOG SELECTION

INTRODUCTION

Male ruffed grouse attract females during spring by drumming. Although males drum to attract females, the primary function of drumming is to define territories among neighboring males (Archibald 1975) and deter intruding males (Gullion 1970). Drumming is initiated during late March in the southern Appalachians and peaks during the first 2 weeks in April (Stafford 1972, Boyd 1990). Fall drumming by established males also may occur during October and November on sunny afternoons to deter dispersing juvenile males from settling in their territory (McBurney 1989).

Several studies have reported that males select drumming sites on upper slopes or ridge tops with varying aspects and slopes (Stoll et al. 1979, Hale et al. 1982, Thompson et al. 1987). Drumming sites are usually located in stands with a dense mid-story and open understory (Eng 1959, Gullion et al. 1962, Boag and Sumanik 1969). Physical characteristics of drumming logs are not thought to be significant in selection (Taylor 1976, Hale et al. 1982, Thompson et al. 1987).

The drumming log is the focal point for year-round movements of male grouse (Gullion et al. 1962). Males become sedentary once a territory is established (Palmer 1956) and rarely move more than 0.4 km (0.25 mi) from the drumming site (Johnsgard 1989). Thus, all habitat requirements for male grouse must be met within a relatively small area based on selection of a drumming site. Drumming site selection, therefore, becomes important in determining male grouse distribution. Hale et al. (1982) found most drumming logs in Georgia were located on ridge tops in mature forests; however, Boyd (1990) and Pelren (1991) reported that female grouse in Tennessee preferred regenerating stands in late winter and early spring. An interspersion of younger and older stands should facilitate interaction of males and females given their habitat preference during this time of year.

It is important to determine preferred drumming habitat in North Carolina. Land managers could use this information to ensure that quality grouse habitat is being provided in sufficient amounts. To determine criteria used by male grouse in selecting drumming sites in the mountains of North Carolina, vegetative and topographic parameters were measured surrounding drumming logs detected during drumming surveys.

METHODS

Drumming sites were located by approaching all drumming males heard during drumming surveys or other research activities in spring 1999, 2000, and 2001. A log was determined to be a drumming log by presence of accumulated fecal droppings and/or feathers. A random direction was chosen and the first log encountered at least 30 m (98 ft) from the drumming log (so plots would not overlap) was deemed the random log. Only random logs with a similar topographic position within the same forest stand were selected (Hale et al. 1982). Attempts were made to select random logs equal to or larger than the smallest drumming log – at least 23 cm (9 in) in height, 25 cm (10 in) in diameter, and 3 m (10 ft) in length. If habitat or physical condition criteria were not met, another log was chosen. Elevation at each site was determined using GPS remote unit. Topographic position of logs was recorded as ridge top, upper slope, mid-slope, or lower slope. Slope and aspect were determined using a clinometer and compass, and the direction each log was lying in relation to the contour (i.e., perpendicular or parallel) was recorded. The length of each log was measured from the butt end to the first major branching (when present), and height and diameter of each log. Moss coverage was estimated visually as percentage cover. The condition of each log was recorded as sound (bark still intact), worn (sound with no bark), or well worn (varying degrees of rotting). Distance to the nearest road, water source, and edge (considered a distinct change in forest type or stand age) ≤100 m (328 ft) was recorded. Basal area was measured using a 2.5 m^2/ha (10 ft^2/ac) factor prism, and vegetation surrounding drumming logs was identified and measured using nested, circular plots with drumming stage as plot center. Woody understory consisting of stems <1.4 m (5 ft) tall were counted within a 3.6-m (12-ft) radius plot. Mid-story vegetation, consisting of stems <11.4 cm (4.5 ft) diameter at breast height (dbh) and >1.4 m (5 ft) tall, was counted within a 5.7-m (18.7-ft) radius plot. Stems were tallied based on dbh categories of <2.5 cm (1 in), 2.6–5.0 cm (1.1–2 in), 5.1–7.5 cm (2.1–3 in), and >7.6 cm (3.1 in). Vertical vegetation density was estimated using a 2.0 × 0.4-m (6.5 × 1.3-ft) density board (Nudds 1977) placed 15 m (49 ft) up slope, down slope, and perpendicular to slope in both directions from plot center. Stand age and forest type were identified using Forest Service CISC data. We spatially referenced all sites with a GPS remote unit.

Data were analyzed using logistic regression because the dependent variable was categorical with only two possible values – drumming log or random log (coded as 1 and 0, respectively). Explanatory variables included drumming stage height and diameter, log length, slope, moss cover, vertical vegetation density, basal area, understory density, and mid-story density. The final model was chosen using backward elimination and the SCORE statistic. Significance of individual variables was tested at $\alpha = 0.05$. The Hosmer-Lemeshow goodness-of-fit test was used to assess the model fit ($P > 0.05$ was acceptable; SAS Institute, Inc. 2000). Discriminate analysis was used to develop discriminate criterion to classify each observation into the category drumming logs or random logs. Stand type, age, topographic position, and elevation were not analyzed for significance because random logs were located within the same parameters.

RESULTS

Thirty-three drumming logs and 1 drumming rock were identified (Fig. 5). Physical dimensions of the rock could not be compared with another rock; however, vegetation and topographic data surrounding the rock were collected. Log length, diameter, and height means were used to replace the rock dimensions in the analysis.

Drumming sites were found in stands varying from 10–137 years old; however, 28 sites were in stands >40 years old. Seventy-four percent ($n = 25$) of drumming sites were located in white oak (*Q. alba*) / northern red oak / hickory stands (Forest Service type 53) and 26%

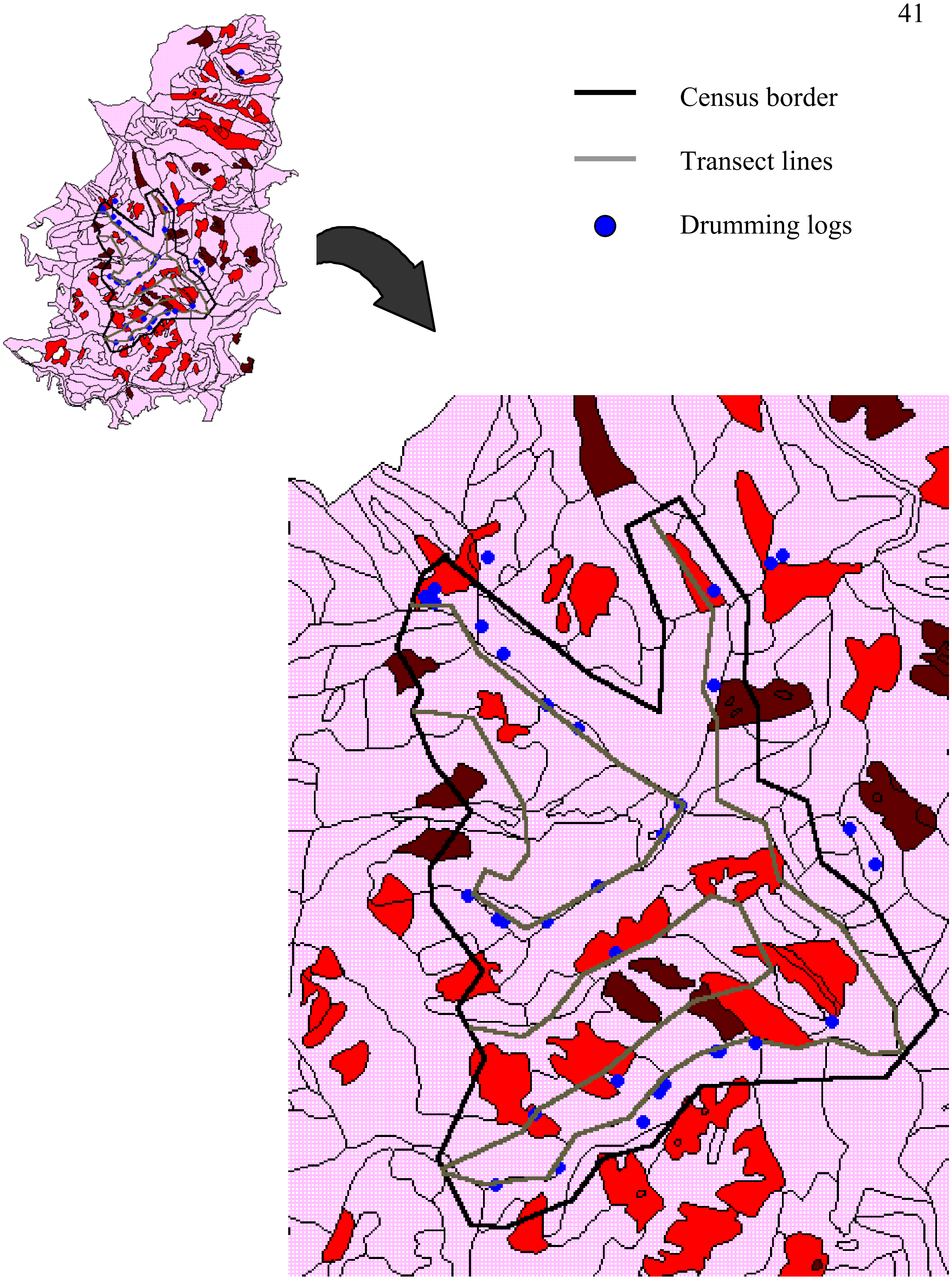

Fig. 5. Ruffed grouse drumming log locations in relation to survey transects on the Wine Spring Creek Study Area, North Carolina, August 1999–October 2000.

(*n* = 9) were located in northern hardwood stands (Forest Service type 81; Service Foresters Handbook 1986). These 2 forest types make up 73% of the study site.

Average height, diameter, and length (Table 10) of drumming logs did not differ ($P = 0.58$, $P = 0.53$, $P = 0.25$ respectively) from random logs. Height ranged from 23–75 cm (9–30 in), diameter ranged from 25–101 cm (10–40 in), and length ranged from 3–17 m (10–56 ft). Logs over 10 m (33 ft; $n = 8$) were used as often as logs only 3–6 m (10–20 ft; $n = 7$). Eighteen logs were 6–10 m (20–33 ft). One drumming log was sound, 22 were worn, and 10 were well worn. Moss cover on drumming logs was similar ($P = 0.26$) to random logs.

Drumming sites and random sites were located on all aspects. There was no difference ($P = 0.35$) in use of logs according to direction they were lying. Eighty-five percent ($n = 29$) of drumming sites were located on ridge tops or upper slopes. Drumming sites were located on a wide range of slopes and did not differ ($P = 0.66$) from random sites. Distances from drumming sites to nearest road, edge, and water varied from a few to >100 m (328 ft). Only 5 logs were located <100 m (328 ft) from the nearest water source.

There was no difference ($P = 0.16$) in basal area between drumming and random sites. Visibility was lower at drumming sites ($P < 0.01$; Table 11). Average woody understory density surrounding drumming sites did not differ ($P = 0.41$) from random sites; however, mid-story density was greater ($P < 0.01$) at drumming sites. Mid-story vegetation usually consisted of mountain laurel or flame azalea; however, rhododendron and highbush blueberry (*Vaccinium corymbosum*) were often present.

Table 11. Variable means (± SE) for drumming logs and random logs on the Wine Spring Creek Study Area, North Carolina, 1999–2001.

Variables	**Drumming logs**	**Random logs**
Height (cm)	50.0 (2.0) A[1]	51.9 (2.9) A
Diameter (cm)	50.5 (2.1) A	52.8 (3.0) A
Length (m)	8.3 (0.5) A	7.6 (0.4) A
Slope (%)	26.9 (2.5) A	28.3 (1.8) A
Moss Cover (%)	34.8 (5.8) A	44.6 (6.5) A
Vertical Vegetation Density (%)	41.4 (3.8) A	25.7 (3.1) B
Basal Area (m^2/ha)	15.4 (1.4) A	18.1 (1.2) A
Understory Density (stems/ha)	12,433 (1,858) A	10,302 (1,795) A
Mid-story Density (stems/ha)	6,805 (629) A	3,438 (429) B

[1] Same letter denotes no significant difference ($P > 0.05$) based on logistic regression analysis.

Backward elimination identified a model with only mid-story density remaining. The SCORE statistic supported the model. There was a positive relationship between mid-story density and drumming use. The model had a max-rescaled R^2 value of 0.28. The final model (Hosmer-Lemeshow goodness-of-fit statistic = 9.68, $P = 0.29$) indicated a difference between drumming and random logs. There was a 72.1% correct classification rate. Twenty-one percent ($n = 7$) of random logs were classified as drumming and 38% ($n = 13$) drumming logs were classified as random.

DISCUSSION

Male grouse primarily used mature stands located on an upper slope or ridge top with a dense mid-story for drumming. Preference for upper slopes and ridges may be associated with vegetative structure found at these sites. At Wine Spring, mountain laurel and flame azalea are abundant on ridges that receive full sun exposure and have shallow soils—stands with a relatively low site index. These shrubs provide excellent overhead protection from avian predators with a canopy of dense limbs. This structure, coupled with a drumming stage approximately 50 cm (20 in) above ground, affords males a better vantage to identify incoming females, as well as approaching mammalian predators. In addition, mountain laurel is used as a food source in winter months when little else is available (Stafford and Dimmick 1979). Hale et al. (1982) reported habitats containing mountain laurel and flame azalea were used by drumming grouse in north Georgia and Gullion (1977) reported 14,000–20,000 stems/ha (5,665–8,094 stems/ac) of aspen regeneration as optimal cover for drumming grouse. There were equivalent stem densities present at Wine Spring (Harper 1998); however, they existed only in stands 0–12 years old, not in stands >40 years old where most of our logs were located.

Although grouse tend to prefer upper slopes and ridge tops for drumming, the vegetation structure found there seems beneficial for protection from avian predators only. Gullion and Marshall (1968) reported avian predators killed male grouse in boreal forests only after leaving their logs. During spring 2000, 4 of 17 radio-collared males at Wine Spring were killed by mammalian predators near their drumming logs based on evidence found at the site (i.e., chewed calamus, broken bones, viscera remains).

Understory stem density did not appear to influence drumming site selection. During the drumming season (mid-March through mid-April), the deciduous understory (i.e., primarily blueberries [*Vaccinium* spp.] and huckleberries [*Gaylussacia* spp.]) at Wine Spring had not leafed-out. Without leaves, the understory vegetation provided little additional cover for drumming males. Studies in similar and dissimilar (e.g., aspen and spruce [*Picea* spp.]) habitat types also have reported understory density did not influence drumming site selection (Palmer 1963, Boag and Sumanik 1969, Hale et al. 1982, Thompson et al. 1987).

Physical characteristics (i.e., height, diameter, length) of drumming logs at Wine Spring were comparable to those found elsewhere (Table 12) and did not determine drumming site use. Although diameter was not significant, there must be a minimum log diameter for grouse to select a log (>25 cm in this study). The grouse using a rock as a platform had roughly 8 cm on which to balance. He remained at the site throughout the drumming season even though several

Table 12. Comparison of drumming log dimensions from North Carolina, Georgia, Tennessee, and Missouri studies.

Variable	NC (n=33)	GA[1] (n=14)	TN[2] (n=129)	MO[3] (n=34)
Height (cm)	50.0	43.0	30.0/44.0[4]	41.9
Diameter (cm)	50.5	—	37.0	46.5
Length (m)	8.3	10.6	9.3	8.6

[1] Hale et al. 1982
[2] Taylor. 1976
[3] Thompson et al. 1987
[4] Reported as height on the up-hill and down-hill side of log.

logs were found in the vicinity. The higher drumming stage (65 cm; 25 in) may have been more beneficial than a wider stage. Most drumming logs at Wine Spring were sound and without bark. Stoll et al. (1979) found 76% of logs in Ohio were sound and without bark and log condition varied from sound to rotten. They reported the lack of bark "probably reflects time required for vegetational succession to provide suitable habitat around a log rather than a preference for logs without bark." This suggests that habitat conditions (i.e., mid-story stem density) surrounding the log are more important in site selection than log condition.

Aspect, slope, and direction the log was lying did not influence drumming site selection at Wine Spring. Stoll et al. (1979), Hale et al. (1982) and Thompson et al. (1987) found similar results. Boag and Sumanik (1969) claimed male grouse rarely used logs parallel to the slope. One male at Wine Spring drummed on a log parallel to a 55% slope, but the log had a large curve in the trunk providing a flat drumming stage. As long as the drumming stage was relatively level, position of the log in relation to contour seemed irrelevant.

Wine Spring has been logged regularly over the last century and a network of logging roads (in various conditions and ages) existed on the study site. As a result, there were few places >100 m (328 ft) from some type of road. Therefore, the fact that 74% of drumming sites were located <100 m (328 ft) from a logging road or some type of edge is not surprising.

Proximity to a water source was not an important factor in drumming site selection at Wine Spring. Grouse obtain water primarily through dew and their food, not from permanent or temporary water sources (Bump et al. 1947). In addition, streams may actually deter males from selecting a log because of associated noise (Hale et al. 1982). For instance, the ability of a male to be heard by other grouse would be reduced by the rushing water and the potential for a male to detect approaching predators would be limited.

Bergerud and Gratson (1988) discussed a theory of Bradbury (1981) and Oring (1982) that male ruffed grouse spaced themselves to increase encounters with females and therefore "males should attempt to display near areas where females will later nest." This theory opposed Gullion's opinion (1967) that males select activity centers based on availability of cover. This study supports Gullion. According to Bergerud and Gratson, males should drum on ridge tops because females nest there. However, only 17% (n = 3) of females at Wine Spring nested on ridge tops in 2000-2001 (Fettinger, unpubl. data) while 65% (n = 22) of males drummed on ridge tops. Bergerud and Gratson also claimed southern grouse chose conspicuous sites on "exposed hilltops" and were able to do so because they were below the range of northern goshawks (*Accipiter gentilis*). The sites used for drumming at Wine Spring, however, were not exposed. In the southern Appalachians, northern goshawks are replaced by broad-winged, Cooper's (*A. cooperii*), and red-tailed (*B. jamaicensis*) hawks, and their presence may influence male grouse to use dense habitats for drumming sites.

MANAGEMENT IMPLICATIONS

Studies investigating sites used for drumming by male grouse have resulted in few management implications. In most areas, availability of potential drumming logs is not a problem and, at Wine Spring, there were usually several other “suitable” logs available within sight of drumming logs. However, it does appear that ridge tops within mature stands containing a dense mid-story offered preferable conditions for drumming sites. This does not mean mature stands, per se, offer the best conditions for drumming. In the southern Appalachians, stands located on relatively poor sites seemed to offer the best habitat for drumming because of the prevalence of a dense shrub mid-story. Male grouse may use harvested areas on mid-slopes if some trees are felled and left as they lay. Potential drumming sites were not limiting at Wine Spring because these stands were available throughout the area.

Retaining mature stands with a dense mid-story along ridge tops while implementing timber harvests on mid- and lower slopes seems warranted when making forest management decisions directed toward improving habitat conditions for ruffed grouse in the southern Appalachians. Increasing the interspersion of young and mature stands would enhance habitat conditions for both male and female grouse during the mating season and possibly reduce travel necessary for females when locating males.

CHAPTER VI

TRAP SUCCESS

INTRODUCTION

Considerable research has been conducted on ruffed grouse in the southern Appalachians (Stafford and Dimmick 1979, Hale et al. 1982, Norman and Kirkpatrick 1984, Servello and Kirkpatrick 1987, Cole and Dimmick 1991, Kalla et al. 1997), but the quality of research has been plagued by small sample sizes. Trapping ruffed grouse in the southern Appalachians can be frustrating and often fruitless. Relatively small grouse populations demand extreme trapping efforts to capture an adequate sample size for research purposes.

In eastern Tennessee, Boyd (1990) reported 0 grouse captured in 1984, 9 in 1985 using interception traps, 16 in 1986 using interception and mirror traps, 11 in 1987 using interception and mirror traps, and 2 in 1988 using mirror traps. Trap effort was not reported. In 1989, Pelren (1991) reported a spring trapping success rate of 2.9 birds/100 trap nights with 6 birds captured using interception and mirror traps. A summer rate of 5.5 birds/100 trap nights was reported with 4 birds captured using interception traps. Numbers of grouse captured were small when compared to many studies conducted in the northern regions of grouse range. For example, Hale and Dorney (1963) captured 1,125 grouse over an 8-year study in Wisconsin, while Rusch and Keith (1971) trapped 819 grouse (25 birds/100 trap nights) in a 3-year study in Alberta.

In 1999 and 2000, ruffed grouse were trapped and radio-collared in the mountains of North Carolina to determine use of forest stands harvested with alternative silvicultural methods. Vegetative and topographic parameters were measured at successful and unsuccessful trap sites to determine optimum placement of traps for increased capture success.

The results of this investigation should benefit ACGRP members and other grouse researchers by reporting trap site locations with the best chance of capturing grouse. Small increases (e.g., 10%) in trap success may save researchers considerable expense and increase sample sizes, thus increasing information learned.

METHODS

Based on the study's research goals and trap success in other regional studies, a goal of trapping 75 grouse per year was established and an estimated 7,500 trap nights would be needed to meet our goal. One hundred fifty interception traps were erected in fall 1999 and 147 in 2000. Traps were run 17 August through 7 October in 1999 and 21 August through 10 November in 2000. Traps consisted of 2 trap bodies connected by a 15-m (49 ft) chicken-wire drift fence (Liscinsky and Bailey 1955). No bait was used in trapping, therefore trap placement was very important. Because trap bodies were so bulky and cumbersome to transport by hand, and so many were used, traps were placed within

100 m (328 ft) of a Forest Service road to decrease time spent erecting, monitoring, and extracting traps. Trap sites were selected by past encounters with grouse or in areas thought to be used by grouse.

Stand age and forest type were identified for each trap site by overlaying trap sites onto Forest Service CISC stand maps. If the trap was located ≤30 m (98 ft) from an edge, it was considered to be edge habitat and was not assigned a specific stand age. Stand age was divided into 5 classes: edge, 0–10 years, 11–20 years, 21–40 years, and > 40 years of age. These classes were selected because they represent, respectively, areas ≤ 30m (98 ft) from a change in forest type or age, early successional habitat (as defined by Forest Service), sapling stands with high stem density, pole stands that have not reached mast production age, and stands that have reached mast production age. Forest types were grouped into 4 classes based on similarity of overstory composition and site quality (McNab and Browning 1993, Harper 1998): mixed hardwood/pine, mixed mesophytic hardwoods, upland oak/hickory, and northern hardwoods.

To determine the influence of vegetation and topography on trap success, data were collected at 25 successful and 25 unsuccessful traps selected at random from all traps in 1999 and again in 2000. A trap was considered successful if 1 bird was captured. An 11.3-m radius plot was established at each site using the mid-point of the drift fence as plot center. Slope and aspect were determined using a clinometer and compass. The direction of the drift fence in relation to the nearest road (parallel, perpendicular, or diagonal) was noted and distance to the road was measured.

Vegetation data were collected according to protocol for the ACGRP to ensure consistency among participating agencies. Woody understory vegetation <1m (3 ft) tall was visually estimated and recorded as percentage cover by the following categories: 0–20% woody and 0–30% herbaceous, 0–20% woody and 30–70% herbaceous, 0–20% woody and >70% herbaceous, 20–60% woody, and >60% woody. Shrub cover and canopy cover were visually estimated and recorded by the following categories: 0–25%, 25–50%, 50–75%, or 75–100%. Two, 2-m (6 ft) wide x 11.3-m (37 ft) long transects were established along north/south and east/west azimuths. The number of deciduous and coniferous trees >8cm (3 in) dbh and downed woody debris ≥15 cm (6 in) tall along the transects were recorded. All stems <8 cm (3 in) dbh encountered along the transects were recorded to determine stem density. Basal area of the overstory was measured using a 2.5-m^2/ha (10-ft^2/ac) factor prism.

Data were analyzed using logistic regression in SAS (SAS Institute, Inc. 2000) because the dependent variable was categorical with only two possible values – successful or unsuccessful traps. Significance of individual variables was tested at α = 0.05. The final model was chosen using backward elimination. The Hosmer-Lemeshow goodness-of-fit test was used to assess model fit. Stand type variables were included in the analysis individually as present/absent (i.e. 1/0), rather than by actual Forest Service code because the order and magnitude of code values had no biological basis.

RESULTS

During the 1999 and 2000 trapping seasons, 109 traps were successful and 188 traps were unsuccessful. In 1999, 6,770 trap nights resulted in 81 grouse (1.2 birds/100 trap nights) in 53 different traps. In 2000, 9,040 trap nights resulted in 87 grouse (0.96 birds/100 trap nights) in 56 different traps.

There were no differences between the 1999 and 2000 vegetative and topographic measurements; therefore, data for the 2 years were combined and reported results are for both years (n = 50 successful traps, 50 unsuccessful traps).

Forest type and stand age did not differ (P >0.05) between successful and unsuccessful trap sites. Understory and mid-story density, shrub and canopy cover, and basal area also did not differ (P > 0.05) between traps. There were no differences in number of deciduous trees, coniferous trees, or downed woody debris between successful and unsuccessful trap sites (Table 13).

The direction traps were arranged in relation to the road was not significant (P = 0.88). Twenty-two successful traps were arranged perpendicular to the nearest road, 25 parallel, and 3 diagonal. Twenty-six of the unsuccessful traps were perpendicular to the road, 16 parallel, and 8 diagonal. Distance to the nearest road was unrelated (P = 0.96) to trap success (Table 13). Traps were located on a wide range of aspects and slopes with no difference (P = 0.30 and 0.94 respectively) between successful and unsuccessful traps.

Table 13. Trap site variable means (± SE) on the Wine Spring Creek Study Area, North Carolina, 1999-2000.

Variable	**Successful traps** (*n* = 50)	**Unsuccessful traps** (*n* = 50)
Basal area (m^2/ha)	19.6 (7.1) A[1]	16.8 (5.9) A
Basal area (ft^2/ac)	78.4 (28.4)	67.2 (23.6)
Deciduous trees/ha	625 (0.5) A	671 (0.5) A
Deciduous trees/ac	253 (0.2)	272 (0.2)
Coniferous trees/ha	69 (0.2) A	46 (0.1) A
Coniferous trees/ac	28 (0.1)	19 (0.04)
Downed woody debris/ha	486 (0.4) A	532 (0.4) A
Downed woody debris/ac	197 (0.2)	215 (0.2)
Mid-story density (stems/ha)	8,393 (908) A	7,558 (1,110) A
Mid-story density (stems/ac)	3,396 (367)	3,059 (449)
Slope (%)	28.5 (1.7) A	28.3 (2.1) A
Distance to road (m)	22.7 (2.5) A	22.8 (2.4) A
Distance to road (ft)	74.5 (8.2)	74.8 (7.9)

[1] Same letter denotes no significant difference ($P > 0.05$)

Table 14. Placement of traps on the Wine Spring Creek Study Area, North Carolina, 1999–2000.

	Percent of Study Area	Stand Age edge		0-10		11-20		21-40		>40		Total
		S[a]	U	S	U	S	U	S	U	S	U	
Mixed hardwood/pine	8.7	2	5	0	0	0	0	0	0	0	0	S 2 U 5
Mixed mesophytic hardwoods	13.6	3	4	0	0	0	0	0	0	4	3	S 7 U 7
Upland oak/hickory	56.5	55	60	0	0	10	9	1	0	11	45	S 77 U 114
Northern hardwoods	21.3	10	19	0	2	0	0	0	2	14	38	S 24 U 61
Total	100	70	88	0	2	10	9	1	2	29	86	297

[a] S = successful trap
U = unsuccessful trap

When all 297 traps were analyzed, stand age was negatively related ($P < 0.01$) to trap success (Table 14); however, it explained only 5% of the variation between traps (max-rescaled $R^2 = 0.0470$). The Hosmer-Lemeshow goodness-of-fit test suggested the model fit the data reasonably well ($P = 0.22$).

DISCUSSION

Based on the analysis of a subset of traps, no differences were detected in the vegetation and topographic data collected at the successful and unsuccessful trap sites. This suggests successful and unsuccessful traps occurred across a wide variety of conditions and no specific patterns were present. Stand age did not differ between the randomly selected trap sites because similar numbers of successful and unsuccessful traps were in each age group. Interception traps are used to catch grouse at this time of year because of the frequency of movement during the fall shuffle and because grouse numbers are at an annual high. The fact that grouse are moving through different habitats and searching out new territories (especially juveniles) may explain the lack of vegetation or topographic pattern where they are captured.

When all traps were analyzed, however, stand age was related to trap success. Only 29 of 115 (25%) traps within stands >40 years old were successful capturing grouse. Traps in other stand age classes were more successful – 44% of traps along edge habitat, and 53% of traps within stands 11–20 years old.

The percentage of successful traps in edge habitat appears relatively low (44%), but the 70 successful traps in that class captured 66% of the grouse (n = 111). The success rate may have been reduced slightly because only 4 of the 28 traps along the edge 0–10 year-old stands were successful in 2000. Placement of traps along edge habitats was logical because grouse prefer areas where young and old stands are interspersed (Barber et al. 1989).

Traps were deliberately placed in areas thought to have the greatest likelihood of catching grouse (the primary goal), thus not all habitat types were sampled equally. Grouse in the southern Appalachians rarely frequent pine stands (Boyd 1990); therefore, only a few traps were placed there (7 in 1999 and 0 in 2000). Habitats located far from roads were not included because of time constraints in getting traps checked daily in a timely manner. Additionally, grouse left in traps for long time periods suffer increased mortality.

When looking at Table 14, it looks as though stands 0–10 and 21–40 years of age were not sampled in proportion to other aged stands. However, 57 traps were placed around the edges of 0–10 year-old stands and were considered to be in edge habitat. It was nearly impossible to place 15 m (49 ft) of chicken-wire in such young regeneration because of residual logging debris, therefore, traps were placed in edges adjacent to these stands. Pole-aged stands were also seldom trapped, because only 6 stands aged 21–40 were close enough to a road. Twenty-two traps were placed within the edge of the pole stands and were considered to be in edge habitat.

A frequently asked question by grouse researchers regarding trap placement is how the trap should be placed in relation to contour – whether interception lines should be parallel or perpendicular to a cove or road, should it cut off points created by a road, etc. Trap orientation did not appear to be an important factor. Furthermore, absence of woody debris and locating specific sites where drift fences could be erected were the determining factors in trap placement. Habitat selection seemed more important than orientation in determining trap success.

Ideally, traps should be monitored both in the morning and evening. However, given the project's resources, 2 daily checks were impossible when monitoring 150 traps while continuing regular telemetry duties. One trap line of 60–75 traps required 4–6 hours to run depending on the number of grouse caught. Monitoring traps only once per day may increase chances of trap mortality (there were 9 in 1999 and 8 in 2000). Reducing the number of traps may save time and decrease trap mortality; however, fewer grouse may be caught.

Trapping appreciable numbers of grouse is essential for acceptable sample sizes with regard to research-based objectives. To increase ruffed grouse trapping success, traps should be placed along edge habitats or within stands 11–20 years old. The orientation of the trap itself is not of importance. Woody debris and understory vegetation will most likely determine trap placement. Traps should be erected no earlier than the last week of August because a large proportion of juveniles will be too small and escape from traps and/or will be too small to carry a radio transmitter. The number of traps used depends on the sample size needed. If a sample of at least 60 birds is desired, then a minimum of 110–150 traps is recommended in the southern Appalachians, given a trap success rate of approximately 1 grouse caught per 100 trap nights.

CHAPTER VII

MORTALITY

INTRODUCTION

Predation is the primary cause of death for ruffed grouse. Lynx (*Lynx lynx*), great horned owls (*Bubo virginianus*), and goshawks are the primary predators in the northern range of grouse (Rusch 1989). Most grouse mortality occurs over winter when cover is scarce (Bump et al. 1947). In the southern Appalachians, other predators replace the lynx and goshawk. However, few studies have looked at this aspect of grouse ecology in its southern range.

METHODS

Radio collars placed on grouse during the trapping season contained a mortality switch, which emitted a faster pulse when the collar remained still for 8 hours. When the mortality signal was detected, researchers homed in on the signal and attempted to determine cause of mortality using ACGRP techniques. Avian predators are known to pluck feathers and pick bones clean, whereas mammals chew feathers and crush bones. Monthly mortality rates were determined using the Kaplan-Meier technique (Pollock et al. 1989).

RESULTS

Of the 65 collared grouse captured in Fall 1999, 8 were censored. Five for immediate loss of radio contact and 3 for dying within the first week after capture. Ten mortalities were believed to be caused by avian predators and 18 by mammalian predators. Six grouse were killed by hunters, 1 by blunt trauma, 1 by disease (*Aspergillosis*) and/or fractured jaw, 2 slipped their collars, 2 collars induced death by strangulation, 1 loss of radio contact after months of detection, and 2 unknown.

Of the 4 males captured in Spring 2000, 1 was censored after it died within the first week after release as a result of trap injuries. One was killed by a mammalian predator on 17 October 2000 and the other 2 remained alive when data collection ended in October.

Grouse experienced an annual mortality rate of 62% from September 1999 to August 2000 at Wine Spring. Mortalities were spread evenly over the year, excluding August 1999 and June and July 2000 when no deaths occurred (Table 15 and Fig. 6). Forty of 54 birds were killed from August 1999–August 2000. The 8 birds that were censored initially, the 2 slipped collars, and the 1 lost radio contact were not included in determining the mortality rate.

DISCUSSION

The annual survival rate (38%) of ruffed grouse in North Carolina is lower than the ACGRP average of 41% (Reynolds et al. 2000). However, the survival rate at Wine

Table 15. Number and causes of ruffed grouse mortalities by month, August 1999–October 2000.

	Mammalian	Avian	Hunter kill	Other[1]	Total
August	0	0	0	0	0
September	0	1	0	2	3
October	0	2	2	0	4
November	2	1	0	1	4
December	1	2	2	1	6
January	3	0	0	1	4
February	0	0	2	0	2
March	4	1	0	1	6
April	2	0	0	2	4
May	2	1	0	0	3
June	0	0	0	0	0
July	0	0	0	0	0
August	2	1	0	1	4
September	1	0	0	0	1
October	1	1	0	0	2
Total	18	10	6	9	43

[1] Other includes blunt trauma, fungus, collar induced death, and slipped collars.

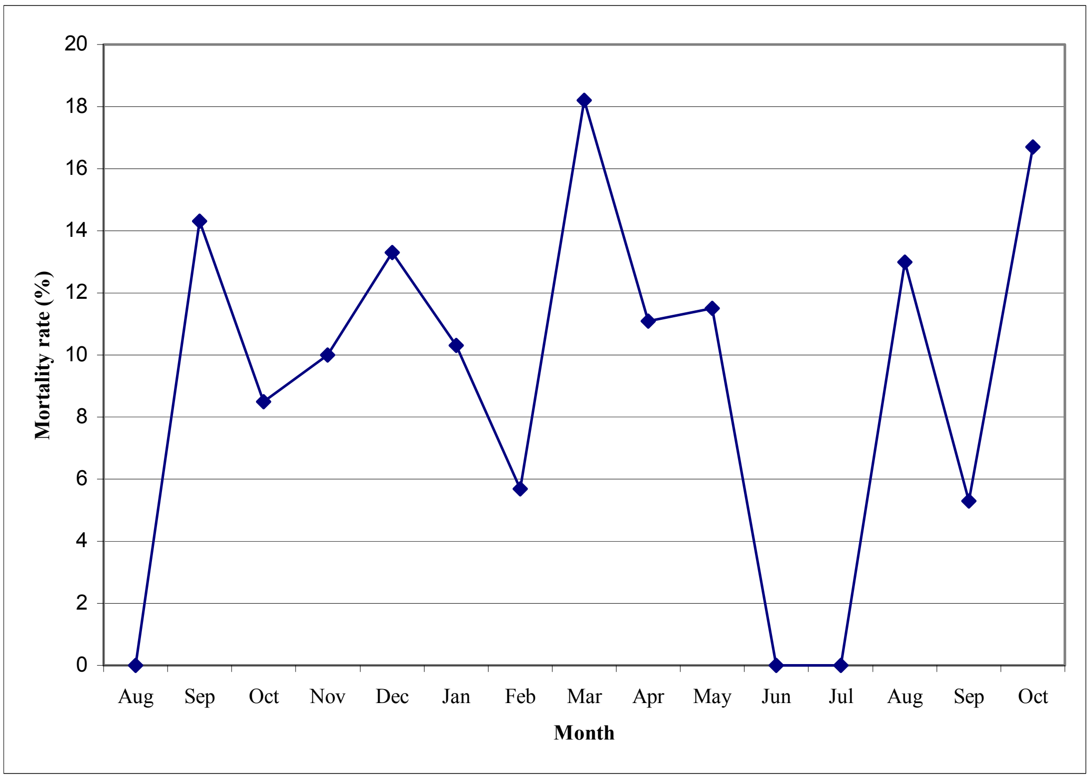

Fig. 6. Kaplan-Meier monthly mortality rates for ruffed grouse on the Wine Spring Creek Study Area, North Carolina, August 1999–October 2000.

Spring is within the 18–69% range of sites within the ACGRP. The 62% mortality rate was similar to overwinter rates in the north. Rusch (1989) reported overwinter mortality rates of 42–68 % in Wisconsin and Huemphner (1989) reported a predation rate of 92% in Minnesota.

Predators caused 68% of the mortalities at Wine Spring, which is almost identical to the 67% predation rate of the ACGRP (Reynolds et al. 2000). Bobcats (*Lynx rufus*) were the most likely mammalian predator at Wine Spring based on evidence found at mortality sites as well as numerous observations. Broad-winged hawks were the most numerous avian predator observed on the study area. While the results stated mammals killed more grouse than avian predators, this is based on personal observation of remains. It is virtually impossible to positively identify a predator based on a few remains. For example, an avian predator may kill a grouse, but a bobcat could displace the hawk or owl and continue eating the remains. The remaining evidence would suggest a mammalian kill, even though it was an avian kill.

Hunting accounted for 15% of mortality, which was similar to the ACGRP average of 16% (Reynolds et al. 2000). Hunter kills were spread out evenly during the hunting season – 2 in October, 2 in December, and 2 in February. Reynolds et al. (2000) determined late season hunting (January – February) had a negative impact on survival, suggesting that late season hunting is an additive source of grouse mortality. Early season hunting (October – December) was determined compensatory because of the high natural mortality associated with fall dispersal (McCaffery et al. 1996). The ACGRP is now conducting more in depth studies on the effect of hunting in an attempt to determine the full impact of late season hunting.

LITERATURE CITED

Aebischer, N. J., P. A. Robertson, and R. E. Kenward. 1993. Compositional analysis of habitat use from animal radio-tracking data. Ecology. 74:1313-1325.

Alldredge, J. R. and J. T. Ratti. 1986. Comparison of some statistical techniques for analysis of resource selection. J. Wildl. Manage. 50:157-165.

Ammann, G. A. and L. A. Ryel. 1963. Extensive methods of inventorying ruffed grouse in Michigan. J. Wildl. Manage. 27:617-633.

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

Barber, R. Kirkpatrick, J. Kubisiak, D. Rusch, F. A. Servello, S. K. Stafford, D. F. Stauffer, and F. R. Thompson. 1989. The ecological niche. Pages 15-20 *in* S.A. Atwater and J. Schnell, eds. The Wildlife Series: The Ruffed Grouse. Stackpole Books, Harrisburg, PA.

Bergerud, A. T. and M. W. Gratson. 1988. Survival and breeding strategies of grouse *in* A. T. Bergerud, and M. W. Gratson, eds. Adaptive strategies and population ecology of northern grouse, 1st ed. University of Minnesota Press, Minneapolis, MN. 809pp.

Bezdek, H. 1944. Sex ratios and color phases in two races of ruffed grouse. J. Wildl. Manage. 8:85-88.

Boag, D. A., and K. M. Sumanik. 1969. Characteristics of drumming sites selected by ruffed grouse in Alberta. J. Wildl. Manage. 33:621-628.

Boyd, R. A. 1990. Population density and habitat utilization of ruffed grouse in the Southern Appalachians. M. S. Thesis, Univ. Tenn., Knoxville, TN. 94pp.

Bradbury, J. W. 1981. The evolution of leks. Pages 138-169 *in* R. D. Alexander and D. W. Tinkle, eds. Natural selection and social behavior. Chiron Press, New York, NY.

Bump, G., R. W. Darrow, F. C. Edminster, and W. F. Crissey. 1947. The ruffed grouse: life history, propagation, management. The Holling Press Inc., Buffalo, N.Y. 915 pp.

Chapin. T. G., D. J. Harrison, and D. M. Phillips. 1997. Seasonal habitat selection by marten in an untrapped forest preserve. J. Wildl. Manage. 61:707-717.

Cochran, W. W. and R. D. Lord. 1963. A radio-tracking system for wild animals. J. Wildl. Manage. 61:9-24.

Cole, J. C. and R. W. Dimmick. 1991. Distribution of ruffed grouse southeast of the range of aspen. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 45:58-63.

Dessecker D. R. and D. G. McAuley. 2001. Importance of early succesional habitat to ruffed grouse and American woodcock. Wildl. Soc. Bull. 29:456-465.

Eng, R. L. 1959. A study of the ecology of male ruffed grouse in the Cloquet Forest Research Center, Minnesota. Ph. D. Diss. Univ. Minn., St. Paul, MN. 107pp.

Fearer, T. M. 1999. Relationship of ruffed grouse home range size and movements to landscape characteristics in southwestern Virginia. M. S. Thesis, Vir. Tech, Blacksburg, VA.

Gullion, G. W. 1965. Improvements in methods for trapping and marking ruffed grouse. J. Wildl. Manage. 29:109-116.

_____. 1966. The use of drumming behavior in ruffed grouse population studies. J. Wildl. Manage. 30:717-729.

_____. 1967. Selection and use of drumming sites by male ruffed grouse. Auk. 84:87-112.

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

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

_____. 1982. Rejuvenation and maintenance of forest habitats for the American ruffed grouse. Proc. 2nd Int. Symp. on Grouse. pp 11-25.

_____. 1989a. Determining sex. Pages 54-61 *in* S. A. Atwater and J. Schnell, eds. The Wildlife Series: The Ruffed Grouse. Stackpole Books, Harrisburg, PA.

_____. 1989b. Determining age. Pages 64-70 *in* S. A. Atwater and J. Schnell, eds. The Wildlife Series: The Ruffed Grouse. Stackpole Books, Harrisburg, PA.

_____, and W. H. Marshall. 1968. Survival of ruffed grouse in a boreal forest. The Living Bird. 7:117-167.

_____, R. T. King, and W. H. Marshall. 1962. Male ruffed grouse and thirty years of forest management on the Cloquet Forest Research Center, Minnesota. J. For. 33:617-622.

Hale, J. B. and R. S. Dorney. 1963. Seasonal movements of ruffed grouse in Wisconsin. J. Wildl. Manage. 27: 648-655.

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

Harper, C. A. 1998. Analysis of wild turkey brood habitat within the southern Appalachians. Ph. D. Diss., Clemson Univ., Clemson, SC. 166pp.

_____, J. K. Knox, D. C. Guynn, Jr., J. R. Davis, and J. G. Williams. 2001. Invertebrate availability for wild turkey poults in the southern Appalachians. Proc. 8th Nat. Wild Turkey Symp.

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

Healy, W. M. 1985. Turkey poult feeding activity, invertebrate abundance, and vegetation structure. J. Wildl. Manage. 49:466-472.

_____, and E. S. Nenno. 1983. Minimum maintenance versus intensive management of clearings for wild turkeys. Wild. Soc. Bull. 11:113-120.

Hollifield, B. K. and R. W. Dimmick. 1995. Arthropod abundance relative to forest management practices benefiting ruffed grouse in the southern Appalachians. Wildl. Soc. Bull. 23:756-764.

Howard, B. W. 1994. Utilization of linear wildlife strips by wild turkeys in western North Carolina. M. S. Thesis, Clemson Univ., Clemson, SC. 50pp.

Huemphner, R. 1989. The Grouse Cycle. Pages 210-226 *in* S. A. Atwater and J. Schnell, eds. The Wildlife Series: The Ruffed Grouse. Stackpole Books, Harrisburg, PA.

Hurst, G. A. and C. N. Owen. 1980. Effects of mowing on arthropod density and biomass as related to wild turkey brood habitat. Proc. Nat. Wild Turkey Symp. 4:225-232.

Johnsgard, P. A. 1989. Courtship and mating. Pages 112-117 *in* S. A. Atwater and J.

Schnell, eds. The Wildlife Series: The Ruffed Grouse. Stackpole Books, Harrisburg, PA.

Kalla, P. I., R. W. Dimmick, and S. Patton. 1997. Helminths in ruffed grouse at the host's southeastern range boundary. J. Wildl. Diseases. 33:503-510.

Knox, J. K. 1994. Forage and arthropod production on linear wildlife strips in the southern Appalachian Mountains. M. S. Thesis, Clemson Univ., Clemson, SC. 56 pp.

Kubisiak, J. F. 1989. Pages 320-321 *in* S. A. Atwater and J. Schnell, eds. The Wildlife Series: The Ruffed Grouse. Stackpole Books, Harrisburg, PA

Lenth, R. V. 1981. On finding the source of a signal. Technometrics. 23:149-154.

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

Martin, J. S. 1993. Logging roads as linear wildlife strips in the southern Appalachian Mountains. M. S. Thesis, Clemson Univ., Clemson, SC. 60 pp.

McBurney, R. S. 1989. Drumming. Pages 176-197 *in* S. A. Atwater and J. Schnell, eds. The Wildlife Series: The Ruffed Grouse. Stackpole Books, Harrisburg, PA.

McCaffery, K. R., J. A. Ashbrenner, W. A. Creed, and B. E. Kohn. 1996. Integrating forest and ruffed grouse management: A case study at the Stone Lake Area. Gen. Tech. Rep. 189. Wisconsin Dept. Nat. Res. 39pp.

McDonald, J. E. Jr. 1993. Characteristics of ruffed grouse drumming sites and habitat use by male ruffed grouse at State Game Lands 176, Pennsylvania. M. S. Thesis, Penn State Univ., University Park, PA.

McDougal, L. A., P. R. Vaughn, and P. T. Bromely. 1990. Wild turkey and road relationships on a Virginia National Forest. Proc. Natl. Wild Turkey Symp. 6:96-106.

McNab, W. H. and S. A. Browning. 1993. Preliminary ecological classification of arborescent communities on the Wine Spring Creek Watershed, Nantahala National Forest. Gen. Tech. Rep. SO-93. U.S. Dep. of Agric., For. Serv., Southern Forest Experiment Station.

Nams, V. O. 1990. Locate II: user's guide. Pacer. Truro, Nova Scotia. 84 pp.

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

Nudds, T. D. 1977. Quantifying the vegetative structure of wildlife cover. The Wildl. Soc. Bull. 5:113-117.

Oring, L. W. 1982. Avian mating systems. Pages 1-92 *in* D. S. Farner, J. R. King and K. C. Parks, eds. Avian Biology. Chiron Press, New York, NY.

Palmer, W. L. 1956. Ruffed grouse population studies on hunted and unhunted areas. Trans. North Am. Wildl. Conf. 21:338-344.

_____. 1963. Ruffed grouse drumming sites in northern Michigan. J. Wildl. Manage. 27:656-663.

Pelren, E. C. 1991. Daily movement and habitat utilization of ruffed grouse in the Cherokee National Forest. M. S. Thesis, Univ. Tenn., Knoxville, TN. 87pp.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. J. Wildl. Manage. 53:7-15.

Reynolds, M. C., D. F. Stauffer, R. L. Kirkpatrick, and G. W. Norman. 2000. Appalachian Cooperative Grouse Research Project report. 13 pp.

Rogers, R. E. 1985. Feeding activity of wild turkey poults in prescribed burned and thinned oak-hickory forests. Trans. Northeast Section, The Wildlife Society. 41:167-177.

Rusch, D. H. 1989. The Grouse Cycle. Pages 210-226 *in* S. A. Atwater and J. Schnell, eds. The Wildlife Series: The Ruffed Grouse. Stackpole Books, Harrisburg, PA.

_____, and L. B Keith. 1971. Seasonal and annual trends in numbers of Alberta ruffed grouse. J. Wildl. Manage. 35:803-822.

SAS Institute, Inc. 2000. SAS/STAT Version 8.1. SAS Inst. Inc., Cary, NC.

Sauer, J. R., J. E. Hines, I. Thomas, J. Fallon, and G. Gough. 2000. The North American Breeding Bird Survey, Results and Analysis 1966 - 1999. Version 98.1, USGS Patuxent Wildlife Research Center, Laurel, MD.

Servello, F. A. and R. L. Kirkpatrick. 1987. Regional variation in the nutritional ecology of ruffed grouse. J. Wildl. Manage. 51:749-770.

Service Foresters Handbook. 1986. USDA For. Serv. So. Reg. Misc. Rep. R8-MR11.

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

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

Stafford, S. K. 1972. Data on ruffed grouse drumming sites and activities in Haywood County, North Carolina. Unpubl. Rep.

_____, and R. W. Dimmick. 1979. Autumn and winter foods of ruffed grouse in the Southern Appalachians. J. Wildl. Manage. 43:121-127.

Stauffer, D. F. and S. R. Peterson. 1985. Ruffed and blue grouse habitat use in southeastern Idaho. J. Wild. Manage. 49:459-466.

Stoll, R. J., M. W. McClain, R. L. Boston, and G. P. Honchul. 1979. Ruffed grouse drumming site characteristics in Ohio. J. Wildl. Manage. 43:324-333.

Taylor, D. A. 1976. An analysis of some physical characteristics of ruffed grouse drumming sites and logs in middle and eastern Tennessee. M.S. Thesis, Univ. Tenn., Knoxville, TN. 72pp.

Thompson, F. R. III, D. A. Freieling, and E. K. Fritzell. 1987. Drumming, nesting, and brood habitats of ruffed grouse in an oak-hickory forest. J. Wildl. Manage. 51:568-575.

_____, and D. R. Dessecker. 1997. Management of early-successional communities in central hardwood forests. U. S. Dept. Agri. For. Ser. Gen Tech. Rep. NC-195, St.Paul, MN, USA.

White, G. C. and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Acad. Press, San Diego, CA. 383 pp.

Yahner, R. H. 1993. Effects of long-term forest clear-cutting on wintering and breeding birds. Wilson Bull. 105: 239-255.

VITA

Carrie Schumacher was born in Nürnberg, Germany on December 5th, 1974. She is the daughter of Major (Retired) Edward and Nancy Schumacher and has a brother, Matt, and a sister, Julie. She attended Brookwood High School in Snellville, Georgia and received her bachelor's degree in biology from North Georgia College in December 1996. She began her master's work at the University of Tennessee in August 1998 and completed her degree in May 2002. Carrie began working on the experimental elk reintroduction project in the Great Smoky Mountains National Park in May 2001.