RUFFED GROUSE (*BONASA UMBELLUS*) USE OF STANDS HARVESTED VIA ALTERNATIVE REGENERATION METHODS IN THE SOUTHERN APPALACHIANS

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Abstract—Ruffed grouse (*Bonasa umbellus* L.) habitat use was studied in the mountains of western North Carolina. In 1997, 9 stands on the study site were harvested via alternative regeneration methods, including shelterwood, irregular shelterwood, and group selection. From 1999–2004, 276 grouse were radio tagged and monitored, resulting in over 7,000 location estimates. Habitat use differed from availability in all seasons. Preferred habitats included gated forest roads, 3–20-year old mixed-oak, late rotation mixed-oak, and mature mesic hardwoods. Shelterwood and two-aged stands created by irregular shelterwood were among habitats preferred in fall, winter, and spring. Group selections were among habitats preferred by broods in summer. Use of alternative regeneration stands began 3 years after harvest and continued through study completion (6 years post-harvest). Hardwood stem density in alternative regeneration stands was within the range recommended for ruffed grouse habitat. With proper implementation, alternative regeneration methods can create quality ruffed grouse habitat in the Appalachian region.

INTRODUCTION

Ruffed grouse (hereafter grouse) are forest-dwelling gamebirds distributed across southern Canada, the northern United States, and southward through the Appalachian Mountains. Although forest types vary across their range, a common characteristic of optimal grouse habitat is dense woody cover with >17000 woody stems/ha (Gullion 1984). Suitable conditions are often found in young (i.e., 5–20-year-old) forests created by timber harvest or natural disturbance; however, various age classes are used as biological activities and food availability change through the year (Gullion 1977, Kubisiak and others 1980).

Silvicultural prescriptions that intersperse age classes are a cornerstone of grouse habitat management. In the Great Lakes states, buds of mature aspen (*Populus tremuloides, P. grandidentata* Michaux) provide an important winter food source while regenerating stands afford cover (Svoboda and Gullion 1972). Over a typical 40-year aspen rotation, a patchwork of small clearcuts implemented at 10-year intervals meets both requirements in close proximity (Gullion 1977). In the central and southern Appalachians (CSA), interspersion of forest types and age classes is especially important as grouse use diverse food sources (i.e., hard and soft mast, and herbaceous plants) in the absence of aspen (Whitaker 2003). Although clearcutting is generally recommended as a grouse habitat management practice, public land managers in the CSA are interested in use of esthetic alternatives to clearcutting. In addition to esthetics, methods such as shelterwood, irregular shelterwood, and group selection may be used to influence species composition, hard mast production, and herbaceous communities (Beck 1986, Dale and others 1995, Loftis 1990, Miller and Schuler 1995, Stringer 2002, Wender and others 1999). Although alternative regeneration methods may have implications for habitat management, little information exists regarding grouse use of these stands. In the mid-1990s, the Southern Research Station began monitoring ecological impacts of alternative regeneration methods on Wine Spring Creek Ecosystem Management Area, (WSC). Initiated in 1999, this study represented the wildlife focus for Phase II of the overall WSC project. Ruffed grouse ecology data were collected through summer, 2004.

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STUDY SITE

Wine Spring Creek Ecosystem Management Area (WSC) is within Nantahala National Forest in Macon County, North Carolina. The area is in the Blue Ridge Physiographic Province and is part of the southern Nantahala Mountain Range. Elevation ranges from 915 m to 1644 m. Terrain is characterized by long, steep ridges with perpendicular secondary ridges that connect upper elevations to narrow valley floors (Whitaker 1956). Mean annual temperature is 10.4 ºC, and mean annual precipitation is 160 cm (National Oceanic and Atmospheric Administration). The area was predominantly forested with <1 percent coverage in permanent openings. The United States Department of Agriculture, Forest Service purchased WSC in 1912 after it was logged. Since then, forest management practices included salvage harvest of blight-killed American chestnut (*Castanea dentata* Marsh.), thinning, clearcutting, and diameter-limit cutting (McNab and Browning 1993).

PROCEDURES

Habitat Delineation

Habitats were classified by a combination of vegetative community type and stand age. Communities were stratified into 3 classes (xeric, subxeric, and mesic) defined by elevation, landform, soil moisture, and soil thickness (McNab and Browning 1993; table 1). Xeric communities were on high elevation, steep, south and west aspects characterized by thin, dry soils. Tree species included, scarlet oak (*Quercus coccinea* Muenchh.), black oak (*Q. velutina* Lam.), pitch pine (*Pinus rigida* Mill.) and chestnut oak (*Q. prinus* L.) in the overstory with ericaceous plants including huckleberry (*Gaylussacia baccata* Wangenh.), lowbush blueberry (*Vaccinium vacillans* L.), and mountain laurel (*Kalmia latifolia* L.) in the understory.

Subxeric communities were at middle elevations and upper elevations on less exposed aspects. Soil characteristics were between xeric and mesic, or subxeric and submesic (Whitaker 1956). Overstory was dominated by chestnut oak, white oak (*Q. alba* L.), hickory (*Carya* spp.), northern red oak (*Q. rubra* L.), red maple (*Acer rubrum* L.), and yellow-poplar (*Liriodendron tulipifera* L.). Ericaceous understory

Table 1—Forest stand associations, understory characteristics, and corresponding USDA Forest Service and Society of American Foresters codes for land classifications used to define ruffed grouse habitats on Wine Spring Creek Ecosystem Management Area, Macon County, NC 1999–2004

Land class	Moisture	Forest associations	Understory	USFS	SAF
Xeric	Xeric	Scarlet oak	> 75% ericaceous	59	NA
	Xeric	Pitch pine–oak	> 75% ericaceous	15	45
	Xeric	Chestnut oak–scarlet oak	50 – 75% ericaceous	60	NA
	Subxeric	Chestnut oak	50 – 75% ericaceous	52	44
Subxeric	Subxeric	Chestnut oak	25 – 50% ericaceous	52	44
	Subxeric	White oak–red oak–hickory	25 – 50% ericaceous	55	52
	Subxeric	Northern red oak	Herbaceous	53	55
	Submesic	Yellow-poplar–white, red oak	Herbaceous	56	59
Mesic	Submesic	Yellow-poplar	Herbaceous	50	57
	Submesic	Sugar maple–beech–yellow birch	Herbaceous	81	25
	Submesic	Basswood–yellow buckeye	Herbaceous	41	26
	Mesic	Hemlock	75 – 100% rhododendron	8	23

USFS = USDA Forest Service; SAF = Society of American Forests.
Adapted from McNab and Browning (1992).

occupied 25–50 percent groundcover on drier microsites whereas herbaceous plants occupied more mesic sites within this category.

Mesic communities occurred on north and east aspects, on lower slopes, and in sheltered coves. Stands were comprised of yellow poplar, eastern hemlock (*Tsuga Canadensis* L.), northern hardwoods, including sugar maple (*A. saccharum* L.), American beech (*Fagus grandifolia* Ehrh.), and yellow birch (*Betula alleghaniensis* Britton), and mixed mesophytic obligates, including American basswood (*Tilia Americana* L.) and yellow buckeye (*Aesculus octandra* Marsh.). Understory was herbaceous except where rhododendron (*Rhododendron maximum* L.) inhibited groundcover. Sites with 75–100 percent cover in rhododendron were placed in a separate habitat classification (RHODO).

An additional land class included gated forest roads (ROAD). Forest roads were defined by a width of 5m from road center on each side. The 10-m width included two gravel tracks separated by herbaceous vegetation and the adjacent berm maintained by mowing. Management of roads included an initial planting of orchardgrass (*Dactylis glomerata* L.), tall fescue (*Festuca arundinacea* Schreb.) and white-dutch clover (*Trifolium repens* L.) maintained by annual or biennial mowing.

Stand ages were determined by years since harvest or stand establishment in five categories deemed important to ruffed grouse (0–5, 6–20, 21–39, 40–80, >80 years). Forest roads and RHODO were not assigned age categories because their structural characteristics were similar across age classes.

Alternative regeneration stands were harvested 1996–1997. Target residual basal area for shelterwood stands was 9.0 m^2/ha. Mean size of shelterwoods was 5.56 ha ($\pm$ 0.42 SE, n = 3). Grouse habitat use data were collected prior to removal of residual overstory. Irregular shelterwood was used to create two-aged stands with target residual basal areas of 5.0 m^2/ha. Mean size of two-aged stands was 4.68 ha ($\pm$ 0.18 SE, n = 3). Group selection was implemented in 3 stands with 4–9 groups/stand. Mean stand size was 14.3 ha ($\pm$ 4.70 SE) and mean group size was 0.36 ha ($\pm$ 0.05 SE). On average, within-stand groups were 65.7 m apart ($\pm$ 7.83 SE). All shelterwood, two-aged, and group selection stands were on subxeric sites. Because these were the only harvests implemented after 1996, alternative regeneration exclusively represented the subxeric, 0–5-year habitat type (SUBXER1). Clearcuts on WSC (n = 44) were harvested in the late 1980s and early 1990s and represented the 6–20-year age class. Most clearcuts were on subxeric sites (SUBXER2) and ranged from 1.3 to 24.6 ha.

Subxeric oak and mixed oak-hickory in the >80 year age class (SUBXER5) made up the greatest proportion of the study area (31.7 percent; table 2). Early successional habitats in the 6–20-year age class (XERIC2 and SUBXER2) occupied 9.3 percent. The 6–20-year, and 21–39-year age classes were not represented on mesic sites. There were 52.6 km of gated forest roads (1.1 percent of total area).

Capture and Telemetry

Grouse were captured using intercept traps (Liscinsky and Bailey 1955, Gullion 1965) during two annual periods, late August–early November, and early March–early April, 1999–2003. Birds were weighed, leg-banded, fitted with 12-g necklace-style radiotransmitters (Advanced Telemetry Systems, Isanti, Minnesota) and released at capture sites after processing. Radiotagged birds (n = 276) were located $\geq$2 times per week from permanent telemetry stations. Telemetry accuracy was assessed by mean grouse location error ellipse (1.9 ha $\pm$ 0.06 SE) and bearing error on test beacons ($\pm$ 6.53^{o}).

Home Range and Habitat Use

The ArcView 3.2 Animal Movement Extension (Environmental Systems Research Institute Inc., Redlands, CA; Hooge and Eichenlaub 1997) was used to calculate fixed kernel home ranges (Worton 1989). Estimates were based on 75 percent kernel contours to define central portions of a home range and exclude "occasional sallies" (Burt 1943, Seaman and others 1999). Home ranges were overlain on a Geographic Information System (GIS) created for the area using color infrared aerial photographs, 1:24,000 U.S. Geologic Survey 7.5-minute quadrangles, U.S. Forest Service Continuous Inventory of

Table 2—Stand age, land class, resultant ruffed grouse habitat type and study area coverage on Wine Spring Creek Ecosystem Management Area, Macon County, NC, 1999–2004

Age	Land class	Habitat	Coverage
years			*percent*
0 – 5	Subxeric	SUBXER1	1
6 – 20	Subxeric	SUBXER2	8
21 – 39	Subxeric	SUBXER3	2
40 – 80	Subxeric	SUBXER4	3
> 80	Subxeric	SUBXER5	32
6 – 20	Xeric	XERIC2	1
40 – 80	Xeric	XERIC4	2
> 80	Xeric	XERIC5	12
40 – 80	Mesic	MESIC4	10
> 80	Mesic	MESIC5	9
NA	Mesic	RHODO	20
NA	Roads	ROAD	1

NA = not applicable.

Stand Condition (CISC), and ground truthing. The proportion of habitats within grouse home ranges represented habitat use. Home ranges were estimated for each of 4, 91-day seasons defined by plant phenology and grouse biology. Fall (17 September–14 December) was a period of food abundance and dispersal among juveniles. Winter (15 December–16 March) was defined by minimal food resources and physiological stress. Spring (17 March–15 June) coincided with vegetation green-up and breeding activity. In summer, telemetry efforts were focused on females with broods. Brood hens were located 2–3 times daily from hatch to 5 weeks post-hatch. Across seasons, mean locations/home range was 27 (3.1 SE).

Habitat use was compared to availability at the study area scale with compositional analysis (Aebischer and others 1993). Compositional analysis calculates pair-wise differences in use versus availability for corresponding habitat log-ratios. These differences are then used to rank habitats by relative preference and allow testing for between-rank significance ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Seasonal Habitat Use

Seasonal home ranges ($n = 172$) were estimated for 85 individuals. Habitat use differed from availability during all seasons ($P < 0.001$). Females tended to use greater diversity of forest types and ages compared to males. Top-ranked habitats for females included SUBXER1, SUBXER2, SUBXER5, and ROAD during brooding; SUBXER1, SUBXER2, SUBXER5, RHODO, ROAD, and XERIC5 in winter; and SUBXER1, SUBXER2, RHODO, ROAD, and MESIC4 during fall and spring. There were no between-type differences, indicating these habitats were interchangeable in their rank status. Top-ranked habitats for males included SUBXER2 and ROAD in fall and winter, and ROAD in spring.

Use of shelterwood and two-aged stands was indicated by inclusion of SUBXER1 among habitats preferred by females in fall, winter, and spring. Stands harvested via alternative regeneration techniques were restricted to the southern third of the study site; nonetheless, 22 grouse (7 juvenile female, 1 adult female, 7 juvenile male, 7 adult male) included shelterwood and two-aged stands in their home ranges. Use began 3 years after harvest and increased through the study's conclusion at 6 years post-harvest. Group selections were important brood habitats in summer, though they were not used extensively in fall, winter, and early spring.

Across seasons, female grouse used a diversity of early successional and mature stands and roads, while males centered activity in 6–20 year-old subxeric hardwoods and adjacent roads. Association of ruffed grouse with early seral stages is well documented (Dessecker and McAuley 2001); however, interspersion of forest types and age classes ultimately determines habitat quality (Bump and others 1947, Berner and Gysel 1969, Gullion 1972, Kubisiak 1985). In the Appalachians, interspersion is especially important, as grouse must optimize the balance between energy gain and predation risk. Nutritional constraints posed by reproduction may cause females to spend greater time in foraging habitats, while males opt for cover (Whitaker 2003). The use of diverse forest types by female grouse on WSC supports this contention.

Shelterwood and Two-Age

Grouse first utilize regenerating stands for cover after midstory stems are naturally thinned to approximately 37,000 total woody stems/ha (Gullion 1984). Grouse use on WSC indicated conditions were suitable at 3 years post-harvest when density of woody stems <5.0 cm dbh and >1 m tall was 38,269 stems/ha in shelterwood and 49,117 stems/ha in two-age (Elliott and Knoepp 2005). Stand age at first use was similar to oak-hickory clearcuts in Ohio (Stoll and others 1999), but sooner than 7 years post-clearcut in Pennsylvania mixed oak (Storm and others 2003) and Wisconsin aspen (McCaffery and others 1996).

Reports of regenerating stem densities following shelterwood, irregular shelterwood, and group selection in the Appalachians are within the optimal grouse habitat range of 17,000–37,000 woody stems/ha and similar to stem densities found in clearcuts (Beck 1986, Loftis 1983, Miller and Schuler 1995, Weigel and Parker 1995). An advantage of shelterwood and irregular shelterwood over clearcutting is retention of mature mast producers, especially oaks, for some time after harvest. Following clearcutting, there is a 25–40-year time lag in seed production, requiring grouse to forage and seek cover in different areas. With shelterwood and irregular shelterwood, hard mast and cover are available within the same stand creating optimal foraging conditions. Considering overwood retention time, benefits will be longer lasting in two-aged stands created by irregular shelterwood. Increased growing space also may result in greater acorn production by residuals (Stringer 2002). In a West Virginia two-aged stand, Miller and Schuler (1995) also noted regeneration of additional species important to wildlife, including American hornbeam (*Carpinus caroliniana* Walt.), flowering dogwood (*Cornus florida* L.), pin cherry (*Prunus pennsylvanica* L.), serviceberry (*Amalanchier arbororea* Michx.), and wild grape (*Vitis* spp). These species also were noted in WSC harvest units and grouse use of shelterwood and two-aged stands likely resulted from a combination of desirable midstory structure and food availability.

Group Selection

In summer, SUBXER1, SUBXER2, and SUBXER5 were among habitats used by broods, creating an apparent contradiction with use of both late rotation and early successional areas. Closer examination of stand conditions revealed why broods showed similar use of these habitat types. During the mid-1980's an extensive drought in the southeastern United States resulted in increased overstory tree mortality and canopy gap formation (Clinton and others 1993). These canopy openings promoted localized patches of early successional structure attractive to grouse broods (Jones 2005). Similar conditions were found in 0–5-year-old group selection, and brooding females were often associated with both types of forest openings.

Regarding forest management for grouse, a concern is that group selection creates isolated pockets of habitat. A potential solution may be to thin between groups within a stand. Thinning can soften edge effects and provide improved habitat conditions and connectivity between groups. Groups themselves also may serve as travel corridors. If positioned appropriately on the landscape, groups can provide patches of cover connecting otherwise disjunct habitats.

CONCLUSIONS

Various aspects of shelterwood, irregular shelterwood, and group selection have utility in creating grouse habitat in the Appalachians. Perhaps the greatest benefit is flexibility in management options with these methods. Depending on objectives, managers can influence conditions by adjusting percent canopy cover and species retention. For plans concentrating on grouse habitat (and other wildlife in general), retention of mature trees in both the white and red oak families will decrease probability of mast crop failure in a given year. Retention of other trees and shrubs including flowering dogwood, black gum (*Nyssa sylvatica* Marsh.), serviceberry, pin and black cherry (*Prunus serotina* Ehrh., *P. pensylvanica* L.), and witch hazel (*Hamamelis virginiana* L.) can prove beneficial without negatively impacting growth of commercial species (Miller and Schuler 1995). In addition, alternative regeneration methods can promote oak regeneration ensuring hard mast production in the future stand. As an esthetic alternative to clearcutting, shelterwood, irregular shelterwood, and group selection also may provide opportunities to regenerate mature stands that would not be possible via traditional clearcutting.

Topography of the Appalachians creates diverse vegetation communities defined by changes in soil type, thickness, and moisture (Whitaker 1956). With heterogeneity in soil characteristics, various communities and associated ecotones often occur in close proximity, presenting unique opportunities to intersperse forest types. The greatest diversity often occurs on midslope transition zones between xeric uplands and mesic lower slopes (Berner and Gysel 1969, McNab and Browning 1993). By placing timber harvests on midslope positions, managers can take advantage of diverse food sources while creating early successional cover in close proximity. Timber harvest on midslopes also can create corridors between upper and lower elevation habitats and connect disjunct patches. Management activities designed to intersperse forest types and age classes may prove most beneficial to ruffed grouse in the Appalachians.

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