Managing Habitats for Ruffed Grouse in the Central and Southern Appalachians

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Appalachian ruffed grouse require a variety of forested habitats as well as openings within the forest. Relative use of habitats by grouse depends on forest type, forest age, and season. Each season brings changes in biological activities of ruffed grouse and the environment in which they live. In the Appalachians, grouse adjust by using forest stands with seasonal foods in or near adequate cover. Optimal habitats afford these resources in close proximity, or better yet, within the same stand. Gardiner Bump and his crew of researchers in the Catskill Mountains recognized such *interspersion* of habitats as beneficial during the first in-depth investigation of ruffed grouse (Bump et al. 1947). Subsequent work by Gordon Gullion (1977, 1984) developed a silvicultural procedure for the Great Lakes States that diversified habitat through rotational harvest of aspen. Following Gullion's recommendation, a patchwork of small clearcuts implemented at 10-year intervals over a 40-year rotation has been shown to support high densities of grouse. In mixed oak forests where aspen is absent and timber rotations are longer (80 – 120 years), managers face a more daunting task of providing quality cover and diverse food resources over space and time. Although silvicultural practices differ, interspersion of forest age classes and other important habitat features is critical when managing habitat for ruffed grouse in the central and southern Appalachians.

Reproduction, recruitment, and survival determine year-to-year grouse abundance, and positive relationships have been shown between these parameters and habitat quality (Devers 2005). Lack of nutritious foods and suitable cover are often cited as limiting factors for Appalachian grouse populations (Norman and Kirkpatrick 1984, Servello and Kilpatrick 1987, Servello and Kilpatrick 1988, Long and Edwards 2004a). As a result, habitat manipulation that improves food availability and escape cover can promote population growth (Kubisiak et al. 1980, McCaffery et al. 1996, Stoll et al. 1999, Storm et al. 2003). The *location, proximity, and design* of management units with respect to seasonal habitat requirements in large part determine the success enjoyed by grouse management programs. This is the task for land managers who want to improve conditions for ruffed grouse: provide needed habitats in sufficient amount and in an arrangement that makes the area as favorable as possible for grouse.

Forest Management Practices to Improve Ruffed Grouse Habitat

Forests are managed through regeneration methods and various timber stand improvement (TSI) practices (Smith 1986). Sound forest management also involves managing forest roads and openings in an effective and efficient manner (Healy and Nenno 1983). Regeneration methods set back forest succession and allow a new stand to develop. TSI practices, such as thinning, are used to manipulate existing stands and provide additional resources (sunlight and nutrients) to favored tree species and individuals. To improve habitat conditions for ruffed grouse, the appropriate methods and practices used are determined by site, forest type, tree species composition, stand age, stand history, and the objectives of the landowner/manager. A review of the literature pertaining to habitat management for ruffed grouse reveals numerous recommendations for forest management, with clearcutting ubiquitous in most reports because of the propensity of ruffed grouse to use young forest stands (McCaffery et al. 1996, Stoll et al. 1999, Storm et al. 2003). There are several regeneration methods, but all are not suited for every forest type or situation (Sander et al. 1983, Smith et al. 1983, Tubbs et al. 1983). Careful consideration should be given to desired stand composition and structure (i.e., vertical and horizontal arrangement of vegetation) before silvicultural techniques are prescribed. Another important factor is the potential impacts of deer herbivory on desired regeneration. Deer population management is a prerequisite to successful forest management in many areas.

Regeneration Techniques

Clearcut

Clearcutting is a regeneration method that removes all trees from the site, creating an even-aged stand (Smith 1986). This is an efficient technique in terms of harvesting timber as loggers visit the site only once (over a period of a few weeks, or less, depending on the size of the stand). Clearcutting allows more sunlight to reach the forest floor than other regeneration methods, resulting in vigorous competition among shade-intolerant (e.g., yellow poplar, black locust, black cherry, pin cherry, and basswood) and other species that sprout and grow rapidly after cutting (e.g., red maple, white ash, and birches) (Beck and Hooper 1986, Lorimer 1992, Elliott and Swank 1994). Less aggressive species (including oaks) that are intermediate in shade-tolerance are often underrepresented in clearcut-regenerated stands, especially on higher-quality sites (Loftis 1990, Loftis 1993).

Despite shortcomings of clearcutting for regenerating oaks, clearcut stands provide excellent habitat for ruffed grouse, especially 5 – 20 years after harvest. Grouse may use clearcut stands for escape cover, foraging, nesting, drumming, and brood rearing during this period (Sharp 1963, Scott et al. 1998, Schumacher 2002, Whitaker 2003, Jones 2005). Beyond 20 years, habitat quality decreases as the canopy closes and grows taller, causing decreases in woody stem density, herbaceous ground cover, and soft mast production.

Following clearcutting, structural characteristics and species composition of the new stand are largely dependent upon site. Mesic sites, such as those found in coves and on north and east aspects, usually regenerate yellow poplar, sugar maple, yellow and black birch, black cherry, cucumbertree, basswood, serviceberry, and American beech, with scattered yellow buckeye and northern red oak. Several of these species (birch, cherry, serviceberry) produce buds that are an important winter food for grouse (Servello and Kirkpatrick 1987, Plaugher 1998, Long and Edwards 2004b). Other foods, such as blackberries and blueberries, as well as herbaceous forage, are often abundant following clearcutting.

In mixed-mesophytic and northern hardwood forests, clearcutting regenerates numerous desirable species for ruffed grouse. On drier sites, where oak-hickory forests are more prominent, hard mast (especially acorns) is an important winter food for grouse. Clearcutting oak-hickory stands creates high stem densities desirable for escape cover, however, mast production is eliminated for approximately 40 years (Guyette et al. 2004). Even then, mast production will not equal that of the previous stand if oaks are underrepresented in the regenerating stand. Where advance oak regeneration (regenerating seedlings or sprouts 1 – 3 feet tall) is present in the understory, clearcutting may be an effective system for regenerating oak-hickory forests; nonetheless, mast production is still eliminated for a number of years.

Despite sound forest management research and reasoning, forest management systems have come under extreme scrutiny in recent years by special-interest groups. Forest management options remain numerous on most private, industrial, and state-owned lands; however, forest managers on federal land (National Forests in the central and southern Appalachians) are limited in silvicultural options because of litigation surrounding timber management prescriptions. Many private landowners also feel clearcutting is too invasive and look for other regeneration methods as aesthetic alternatives to clearcutting. Some alternative methods (that may not be as likely to be appealed by special interest groups) have real value in promoting regeneration of some important hardwood species.

Shelterwood

The shelterwood method has been used more in recent years for increasing the development of advance oak regeneration (Loftis 1983, 1990, 1993). *This should be a major consideration for land managers in the central and southern Appalachians who are interested in ruffed grouse* (as well as many other wildlife species). Shelterwood harvests occur in two or more stages and produce an even-aged stand (Smith 1986). The initial shelterwood harvest removes a pre-determined amount of the forest canopy, enabling partial sunlight into the forest floor. This enables existing seedlings of moderate shade tolerance (especially oaks) to better compete with shade-intolerant species and produce advance regeneration. Advance regeneration then is released by subsequent harvest(s) that removes residual overstory (usually 6 – 8 years post initial harvest).

The amount of overstory retained in the initial harvest depends on desired species composition, the amount of oak regeneration present, site productivity, and regeneration mechanism (seed, sprout, advance reproduction) of both oaks and competing species. There is a fine line in deciding how much overstory to leave to benefit oaks. Too much shade will benefit shade tolerant species, such as sugar maple, dogwood, and beech, while too little shade will benefit yellow poplar, red maple, and black cherry.

Where oak dominated forests are desired and site index for oak is relatively low (60 – 65), the overstory retained may be only 20 – 40 square feet of basal area per acre. On these sites, advance reproduction is usually not a problem as oaks are often the dominant overstory species. Where site index for oak is high (75 – 80), more overstory must be retained in the initial shelterwood harvest to suppress shade intolerant species. In some cases, only overtopped and intermediate trees or just the midstory are removed (or killed with herbicides) to allow relatively little additional light in to the forest floor (this is termed a *thinning from below*; no dominant or co-dominant trees are removed from the overstory) (Loftis 1990). Where existing oak regeneration is sparse or nearly absent, a thinning from below may be conducted after a good acorn crop to help stimulate germination and seedling establishment. Once advance oak regeneration becomes established (3 – 5 feet tall), the overstory may be harvested.

On sub-mesic sites (transition sites between mesic and xeric) where yellow poplar, red maple, and others are serious competitors, a shelterwood cut followed by prescribed fire has shown promise (Brose and Van Lear 1998, Brose et al. 1999a, Brose et al. 1999b). Three to five years after the initial shelterwood harvest, a growing-season fire is used to top-kill all trees in the stand. Young oaks arising from an existing root system are then able to send up a vigorous stem the year following fire and compete with other species. On more xeric sites, especially south- and west-facing slopes and ridgetops, establishment of oak regeneration is less difficult. Several species of oaks (including white, chestnut, black, and scarlet) reproduce vigorously on drier sites following harvest.

Initial shelterwood harvests may leave as little as 10 – 30 percent of the original canopy cover. This results in regenerating stem densities and species composition similar to that following a clearcut. Regardless of the amount of residual overstory left standing, **it is critical that quality mast producing trees (especially oaks) are retained instead of other species**

with less value to ruffed grouse. A good mixture of oaks (species from both white and red oak groups) should be retained to offset interspecific variation in mast production.

Shelterwood harvests can benefit grouse in several ways. Depending on site, opening the forest canopy increases groundcover and enhances foraging and brooding opportunities. A greater herbaceous response can be expected on mesic sites, while a greater woody response can be expected on xeric sites. Soft mast production (e.g., blackberry, raspberry, blueberry, huckleberry, pokeberry) also can be expected to increase 2 – 5 years post harvest, increasing both food availability and quality brood cover (Greenberg et al. in press). Escape cover is enhanced as midstory stem density increases following harvest. The benefits of shelterwood harvests over clearcutting are the retention of mature, mast-producing oak while advance regeneration is developing, provision for oak in the future stand, and retention of mature trees for aesthetic purposes. Acorns are a nutritious food that can influence survival and recruitment of Appalachian ruffed grouse. Therefore, stands that intersperse mature oaks with woody sapling cover will benefit grouse in the region. In North Carolina, our radio-tagged grouse began using stands harvested by the shelterwood method 3 years after initial harvest, prior to removal of residual canopy trees (Jones and Harper 2006; Fig. 1).

Another advantage of the shelterwood method is that loggers have to come back into the stand one or more times over several years after the initial harvest and remove the residual overstory. Although this is less efficient in terms of harvesting timber, it is beneficial to grouse because another flush of herbaceous cover and soft mast production can be expected after each harvest. This benefit is reduced, however, if invasive non-native plants (such as japangrass (*Microstegium vimineum*)) are allowed to pioneer into those disturbed areas.

Two-aged system

A 2-aged system represents a planned sequence of treatments designed to regenerate and maintain a stand with two age classes where select “reserve” trees are retained after the initial harvest to attain goals other than regeneration. Reserve trees not only increase the future value of the stand, but also can provide wildlife benefit and make the stand more aesthetically pleasing after harvest (Smith et al. 1989).

A shelterwood with reserves (or irregular shelterwood) produces a stand of two distinct age classes—a residual mature overstory with developing regeneration below. The difference between a shelterwood and irregular shelterwood is the regeneration period is extended with an irregular shelterwood, resulting in a new stand that is not really even-aged, but 2-aged. The stand will include 2 age classes for at least 20 – 30 percent of the rotation and often for the entire rotation, depending upon objectives. Normally, 15 – 25 square feet per acre in dominant, co-dominant, and good intermediate crown-class trees are retained; however, a higher residual basal area may be retained if desired. As with a shelterwood, regenerating stem density is greater when less overstory is retained. Trees retained in an irregular shelterwood are chosen based on their capacity to produce seed and increase in value until the regenerating stand is harvested. When few oak seedlings are present, a thinning from below following a good mast crop can be used to help stimulate and increase oak regeneration before harvest.

Another 2-aged regeneration method is a clearcut with reserves. This method is similar to an irregular shelterwood except a clearcut with reserves retains no more than 5 – 10 square feet of basal area post harvest and there is no plan to harvest the overstory until the end of the rotation of the regenerating stand.

Regeneration methods that produce 2-aged stands show great promise in creating optimal habitat for Appalachian grouse; however, *it is imperative that oaks with good growth form and mast production potential are retained as residuals*. When quality oaks are selected, **an irregular shelterwood that retains the residual overstory for at least 30 – 40 years (until the regenerating stand begins to produce mast) is the best regeneration method to improve habitat for ruffed grouse when harvesting oak-hickory stands in the central and southern Appalachians**. Our research indicated a strong inverse relationship between grouse home range size and mast crops in oak-hickory stands (Whitaker 2003). When stands are clearcut, there is a time lag in hard mast production while trees mature (at least 30 – 40 years). During that period, grouse must balance time spent in early successional cover and time spent foraging among mature oaks. Two-age stands provide both food and cover, allowing grouse to forage on acorns and other foods without increasing risk of predation. In West Virginia, flowering dogwood, serviceberry, and pin cherry were present in 2-aged stands, and grapevines occurred in 58 percent of the co-dominant reproduction stems (Miller and Schuler 1995). Similar to shelterwoods, grouse also began using irregular shelterwoods in North Carolina at 3 years post-harvest (Jones and Harper 2006).

Group Selection

The group selection method mimics small-scale canopy gaps created by low-intensity natural disturbance events. Group selection harvests small groups of trees within a stand over time, creating a mosaic of even-aged patches within an uneven-aged stand (Smith 1986). By using group selection harvests, a percentage of early successional habitat can be maintained across the stand while avoiding visual impacts of larger even-aged harvests. The size of group selection harvests ranges from a small area occupied by a few trees (0.10 acres) to nearly 2 acres.

Size of group selection cuts may influence stand composition and structure (Dale et al. 1995). Although site quality, moisture regime, and previous stand composition are the primary influences on future stand composition, larger group harvest units (>1 acre) are more likely to result in shade intolerant species, such as yellow poplar and basswood. Shade tolerant (sugar maple, beech) and intermediate species (oaks, birches) may be more prevalent in smaller group harvests. In North Carolina, yellow poplar, sweet birch, and red maple sprouts dominated regeneration within small group openings (<0.2 acres) on mesic sites, while oak regeneration was plentiful as a result of diffuse sunlight on the forest floor around the periphery of each patch. As with even-aged methods, the presence of advance oak regeneration is an important consideration before implementing group selection harvests in oak-hickory stands.

Density of group selection harvests in a given stand is debatable. If the character of a mature stand is desired, the density of cuts should be low. If visual impact is not as important, the density of group cuts can be increased. Positioning one patch cut per 10 acres would place patches approximately 800 feet apart, harvesting 2.5 – 6.25 percent of the stand. Thus, grouse would be able to remain within about 400 feet of escape cover when foraging in an adjacent mature stand.

Although not documented or demonstrated, concern has been expressed that the group selection method creates isolated pockets of habitat. To relieve this concern, thinning between groups would soften edge effects, increase understory stem density, and improve groundcover conditions and connectivity between groups. Regardless, group cuts should be well interspersed to increase cover and foraging opportunities for ruffed grouse in mature stands. Groups themselves also may serve as stepping stones and thus act as travel corridors. The group selection method should not be viewed as a substitute for even-aged management, but rather as a complement, serving to connect young forest stands and improve conditions for grouse over a broader area.

Grouse broods often use small canopy gaps and edge habitats within otherwise mature forest cover (Stewart 1956, Thompson et al. 1987). In North Carolina, brooding hens used edges of group cuts 4 years after harvest (Jones and Harper 2006; Fig 2). These cut units contained abundant groundcover and were located within 80+-year-old mixed oak stands – an important forest type for broods on the study area. Providing further evidence that group selection harvest units enhanced brood habitat was that broods using mixed oak stands lacking group cuts were often associated with canopy gaps, which were similar in composition and structure to the group selection harvest units.

Timber Stand Improvement Practices

Thinning and Wildlife Retention Cuts

Hardwood stands can be thinned prior to maturity to influence stand composition and increase sunlight and nutrients to promote growth and development of selected residual trees. Growth and yield are increased most if the stand is first thinned at about age 20 and continued at about 10-year intervals until age 60 – 70, though timing will depend on species composition and site quality (Smith 1986). Thinning has real implications in ruffed grouse management if those species that do not produce preferred food resources (e.g., maples, yellow poplar, ashes, and sourwood) are targeted for removal, while more desirable species (e.g., oaks, black cherry, serviceberry, birches, American beech) are retained. Thinning undesirable trees also allows increased sunlight into the stand, stimulating understory development. As with regeneration methods, understory composition following treatment will depend on the site. Typically, mesic sites will produce more herbaceous vegetation, while xeric sites will produce more woody cover (Jackson et al. 2006). Regardless of site, soft-mast production by species such as blueberry, huckleberry, blackberry, and raspberry can be expected to increase 2 – 5 years post treatment. In subxeric and xeric mixed hardwoods, soft- and hard-mast producing species favored by grouse (e.g., oaks, serviceberry, blackgum) are retained in the overstory, while others are targeted for removal. In mesic stands where oaks are less prominent, retention of black and pin cherry, birch, American beech, and serviceberry and release of herbaceous understory for foraging opportunities and quality brood habitat are the primary objectives of thinning to improve grouse habitat.

By definition, thinning is conducted in immature stands only. Thinning past age 60 – 70 does little to increase the growth of residual trees; thus, thinning operations are not warranted economically to increase timber production in mature stands. Mature stands can be enhanced for grouse and other wildlife through a *wildlife retention cut* (Jackson 2002, Basinger 2003, Gordon 2005). The objective of a wildlife retention cut as a TSI practice is to reduce percent canopy closure to 60 – 80 percent (or less, if desired, for increased stem density) by killing selected trees with herbicide injection or girdling and spraying the wound with herbicide (mixture of 3 quarts water with 1 quart Garlon® 4 and 6 ounces Arsenal® AC). Targeted trees are treated and left standing as snags; they are not felled or removed from the site, but allowed to fall apart over time providing coarse woody debris. Trees are selected based on mast-producing capability and overall form. Non-mast producers and trees with poor growth form are targeted first to reduce canopy closure to the desired level. Mid-story soft mast producers (e.g., dogwoods) are normally retained unless they are so abundant they cast an inordinate amount of shade.

Wildlife retention cuts not only stimulate understory development, but also enable crowns of residual trees to develop more fully when adjacent trees are killed. Mast is produced near the ends of twigs within a tree's crown. As a crown increases in diameter, more twig ends are present to produce additional mast. By default, the larger the crown, the more potential the tree has to produce fruit. Thus, it is possible for a stand to produce *more* mast with *fewer* trees *while* supporting enhanced understory cover. A wildlife retention cut is not the same as *crop tree release*. Crop tree release is conducted only in immature stands and a stand-wide reduction in canopy closure is not an objective. In addition, a wildlife retention cut is not similar to a *diameter-limit cut*, which removes all trees with a given diameter-at-breast height and above and gives no consideration to species composition. Diameter-limit cuts normally amount to "high-grading" and are not recommended with regard to forest ecology or ruffed grouse management.

Salvage operations

Forest succession in the central and southern Appalachians is commonly driven by wind, ice, insects/disease, and fire. Salvage harvest operations are often feasible after stand disturbance, particularly wind, ice, and insect/disease. This offers opportunity to make good use of merchantable timber that might not be harvested otherwise and improve habitat conditions for ruffed grouse at the same time. Depending on the source and level of damage, salvage cuts often resemble shelterwood or 2-age harvests as there are usually residual trees remaining after the operation. In 1995, Hurricane Opal caused extensive blowdown of forest stands in the southern Appalachians. Following salvage operations, researchers at Coweeta Long-Term Ecological

Research Station measured greater understory plant diversity in salvage areas compared to undamaged stands and recent clearcuts. The greater understory diversity was due in part to shading provided by residual trees and slash, as well as pit-and-mound topography (soil disturbance) created by uprooted trees (Elliott et al. 2002).

The opportunity for salvage operations to improve ruffed grouse habitat in the central and southern Appalachians should not be overlooked. A major consideration when implementing a salvage operation should be to address the composition and quality of residual trees. Poor-quality, previously suppressed stems should be felled during salvage operations to help ensure future stand quality. Likewise, non-favored species for ruffed grouse also should be killed or felled to positively influence future stand composition.

Prescribed fire

Although once commonly used, fire has been suppressed in the Appalachian region for nearly 100 years, altering many of the associated forest types and wildlife communities (Van Lear and Waldrop 1989, Johnson and Hale 2002, Van Lear and Harlow 2002). Fortunately, forest and wildlife managers are realizing the positive benefits of fire and using it more often in the central and southern Appalachians, especially to reduce fuels and foster oak regeneration. This has proven most beneficial for ruffed grouse and wild turkeys, especially in oak-hickory forests where controlled burning can enhance understory structure important for winter foraging and brooding habitat (Rogers and Samuel 1984, Pack et al. 1988, Jackson et al. 2006).

In North Carolina, fire was prescribed in an upland oak forest druing March 2002. By 2004, the treated area (approximately 700 acres) supported a diverse herbaceous community, which was used almost exclusively by several grouse broods. Midstory conditions also were improved by sprouting flame azalea, buffalo-nut, and mountain holly. In western Virginia, we documented positive results in young hardwood clearcuts following prescribed fire, including increases in invertebrate abundance and soft mast-producing plants (Whitaker et al. 2004). Grouse broods in the central and southern Appalachians select areas with abundant herbaceous vegetation, especially forb and fern cover, but also low-growing woody cover, such as blueberries and huckleberries (Scott et al. 1998, Haulton 1999, Fettinger 2002, Jones 2005).

Prescribed fire in the Appalachians is restricted primarily to oak-hickory forests and other forest types associated with southern and western exposures and ridgetops (Van Lear and Waldrop 1989). This offers numerous opportunities for habitat enhancement, especially where oak-hickory forests comprise 50 percent or more of the available forest cover. When burning oak-hickory stands, fire often feathers into coves and more mesic forests types, but intensity is much less and these areas rarely burn. In fact, when burning relatively large areas (200 – 500 acres; which is usually necessary on national forests where there is a lack of roads or firebreaks), coves, creeks, and northern/eastern exposures are commonly used as natural firebreaks. This provides an exceptional mosaic of conditions across the burned area, which is most favorable for ruffed grouse.

Fire intensity is determined by fuel load and moisture content, wind, humidity, temperature, and atmospheric conditions (Wright and Bailey 1982). Land managers must balance fire intensity with existing site conditions to create the desired habitat structure and composition. For example, a relatively cool fire may be used to consume the litter layer and promote a herbaceous understory, while a hot fire is necessary to reduce extensive coverage of mountain laurel and allow adequate light to the forest floor to stimulate the seedbank. Depending on stand age, stocking, and percent canopy cover, thinning or a wildlife retention cut is sometimes desirable prior to burning. Basal area will fluctuate among sites, but reducing canopy closure to 60 – 80 percent normally allows sufficient sunlight into the forest floor to develop the desired understory structure for brood habitat and will also promote additional soft mast production (Jackson et al. 2006).

The historical occurrence of fire in the Appalachian region has been debated, but historical dendrochronological evidence shows lightning- and native American-ignited fires occurred every 3 – 25 years in those stands that would burn, depending on the site and climatic conditions (Frost 1998). As related to habitat management for grouse, understory composition and structure, midstory characteristics, fuel load, and site determine fire rotation. On drier sites, it is common for woody species to dominate the understory, while more mesic sites have greater herbaceous cover. This can influence fire rotation. More frequent fire (annually to every 2 – 3 years) on drier sites can be used to stimulate increased herbaceous cover.

Special considerations

In addition to forest regeneration and TSI practices, there are other activities that can improve ruffed grouse habitat, often dramatically, albeit on a smaller scale. Spring seeps occur where relatively warm groundwater percolates to the surface and forms a saturated area. Even during periods of deep snow, these areas are often snow-free (Healy 1977, Healy and Pack 1983, Wunz et al. 1983). Reducing canopy cover to approximately 50 percent around spring seeps allows increased light into the site and can promote herbaceous groundcover and shrub growth, which produces many fruit and seeds that are eaten by grouse in mid-winter. Hard and soft mast producers should be retained. Where soft-mast producing trees and shrubs do not exist, they can be planted around seeps when adequate sunlight is available through thinning. Shrub species such as hawthorn and crabapple have been successfully established around spring seeps after thinning. When stands containing seeps are regenerated, trees surrounding the seep (1/4 – 1 acre, depending on the site) should be left uncut to provide mast and perches for grouse.

On many areas, old homeplaces are present. These sites usually support relatively high stem densities and often hold grouse, especially if old fruit trees remain. Thinning around existing fruit trees to allow adequate light, pruning excess limbs, and fertilizing stimulates increased growth and fruit production. Planting additional soft mast-producers on these sites and maintaining them as wildlife orchards benefit ruffed grouse and many other species. Species that should be considered include apples, crabapples, pears, plums, hawthorn, persimmon, mulberry, serviceberry, elderberry, and Carolina buckthorn.

Grapes are an important food of grouse in the central and southern Appalachians. Grapevines not only should be retained, but promoted when possible. Grapevines are often found on mesic sites, often in a narrow cove just above or below a logging road. These sites can be improved by thinning non-desirable trees and allowing sunlight into the site to stimulate additional groundcover and stem density and improve conditions for foraging grouse. Teepee style grape arbors can be created by felling adjacent, undesirable trees against the tree supporting the main vine. Grapevine growth is not necessarily desirable to foresters and loggers as they can suppress valuable trees and make timber harvest more difficult. Where habitat management for ruffed grouse is an objective and grapevine growth is so excessive it poses a danger, then the tree(s) should be left standing. If the tree(s) supporting grapevines is not desirable for grouse, then it can be killed and left standing as in a wildlife retention cut.

Although grouse may roost in pines, there is not a strong selection for roosting in pines in the central and southern Appalachians (Whitaker 2003). As a result, we do not feel there is a need for planting pines as a means to improve roosting cover in this region. In fact, isolated evergreens (e.g., large hemlocks) can serve as predator traps for grouse as hawks and owls easily develop a search image and concentrate on these trees, especially when individuals are retained in regenerated stands. Gullion (1990) felt any advantage grouse gained by using coniferous cover was offset by a higher risk of predation and shorter survival (Gullion and Marshall 1968, Gullion 1981). If suitable roosting cover is limited on a particular area, a more sound recommendation is to simulate blowdowns by felling small groups of trees (similar to group selection harvests) because grouse roosting in mature stands selected microsites having locally high stem densities (Whitaker 2003).

Forest Roads and Openings

Forest roads, such as old logging roads, and managed openings provide critical habitat for ruffed grouse in the central and southern Appalachians (Whitaker 2003, Jones 2005). Grouse (male and female, adult and juvenile) select forest roads as preferred habitats during various seasons throughout the region. Forest roads and openings can be an important foraging habitat, especially within oak-hickory-dominated forests during years with little mast. In most areas where grouse are found in the Appalachians (especially national forest land), forest roads and openings comprise less than 1 percent of the land cover. Because they are such a critical habitat, managing roads and openings in an effective and efficient manner is paramount to ruffed grouse management.

The Importance of Forest Roads for Ruffed Grouse

When seeded and managed properly, forest roads can be turned into "linear openings" for wildlife, providing increased habitat interspersion, much-needed quality forage, and attractive brood habitat. Forest roads are an important grouse habitat in the central and southern Appalachians and may be an important alternate foraging habitat during winters following poor hard mast crops (Schumacher 2002, Whitaker 2003). More than 90 percent of the 326 grouse crops collected from forest roads as part of the ACGRP during March of 2000 – 2002 contained herbaceous leaves and flowers (Long and Edwards 2004b). These foods represented 25 percent of all material in the crops over the 3-year period. The vast majority of the herbaceous leaves eaten by grouse were those of clover, cinquefoil, wild strawberry, avens, hawkweed, and birdsfoot trefoil. Coltsfoot was the most frequently eaten flower. Interestingly, though orchardgrass was the predominant cover type on most of the forest roads where grouse were collected, no orchardgrass was found in any of the grouse crops. In fact, of 326 crops examined from 6 states, **no grass of any kind was found in measurable amounts**. From this research, it is apparent forest roads dominated by legumes and other forbs are most beneficial to grouse.

Considerations with Sedimentation, Road Construction, and Road Closure

The primary consideration in managing forest roads is preventing erosion and sediment run-off. Openings are not as prone to wash and are not typically located on steep slopes. Proper road construction is the best deterrent to prevent erosion and siltation into streams (Swift 1984, 1985). Long-term research at the Coweeta Hydrologic Lab showed improper road construction leads to **more than 95 percent** of the siltation into streams following logging operations, not the logging operation itself (Swift 1988). Logging roads should be constructed (or repaired) following Best Management Practices set by state forestry agencies. Steep slopes should be avoided. Water bars and broad-based dips should be created where water flow and drainage may be a problem. Roads must be seeded to establish vegetation as quickly as possible after the logging operation is finished to prevent erosion. Finally, all logging roads should be gated to reduce vehicular travel, which damages established vegetation and may lead to undue pressure on the grouse population during the hunting season. Roads (whether gated or not) that receive considerable traffic should be graveled. It is unrealistic to expect vegetated roads to sustain regular vehicular traffic. This inevitably creates “2-tracks”—tire lanes worn down to mineral soil that channel water flow during heavy rain events and lead to increased siltation.

“Daylighting” Roads

The foremost consideration when seeding forest roads is available sunlight. To achieve adequate germination and growth after seeding, the road should receive at least 4 – 5 hours of direct sunlight per day. This may not be a problem for roads recently created, but the canopy of adjacent trees will slowly shade the road over time. Unless the adjacent stand has been thinned or regenerated recently, roads require “daylighting”—that is, removing select trees along at least one side of the road (≥30 feet on one or both sides of the road) to allow sufficient sunlight for herbaceous cover to establish and grow in the road. This practice alone improves conditions for grouse as herbaceous groundcover and woody stem density is increased along one or both sides of the road, providing a soft edge into the adjacent forest. Not all trees have to be removed. Again, species that provide little benefit for grouse can be removed, while scattered beneficial trees are retained.

Liming and Fertilizing Roads

Most of the soils in the central and southern Appalachian region are acidic (pH <5.8). Most plantings on forest roads require a pH closer to neutral (6.0 – 7.0) to release nutrients bound to clay particles and organic material in the soil (Donahue et al. 1983, Ball et al. 2002). Liming is required to increase pH. Depending on soil characteristics, 2 tons (or more) of lime per acre are often required to increase pH for optimum plant growth. Only by collecting soil samples and having them tested is it possible to know how much lime (or fertilizers) is actually needed. It is important to realize the full effect of liming on soil pH is not realized until approximately 6 months after application. Soil pH will slowly decline to original levels 5 – 10 years after liming unless the site is top-dressed with additional lime as recommended from a soil test. Phosphorus (P) and potassium (K) levels often test low (≤18 pounds P per acre; ≤ 90 pounds K per acre). To expect most planted materials to produce at least 75 percent of their potential, 19 – 30 pounds of P and 91 – 160 pounds of K should be available per acre. Although commonly applied, balanced fertilizers (e.g., 15-15-15) are rarely needed, especially if legumes (e.g., clovers) are planted. Symbiotic bacteria produce nitrogen within nodules attached to the roots of legumes. As a result, other fertilizers, such as triple super phosphate (0-46-0) and muriate of potash (0-0-60), can be used to increase P and K levels without unnecessarily increasing nitrogen levels.

Considerations for Planting Forest Roads

If roads are to provide nutritional benefit for grouse, plants that are nutritious and *actually eaten* by grouse must be established. To provide attractive brood habitat for grouse, plants that restrict travel and feeding by chicks should *not* be planted. At the same time, consideration must be given to preventing erosion and sediment flow. Plants that germinate and establish root systems quickly are needed to hold the soil together and prevent washing.

Plants that best meet these requirements are annual cool-season grains (wheat, rye, and oats), clovers, and birdsfoot trefoil (Harper 2006). One mixture that has worked well in the Appalachian region includes (per acre) 50 pounds of wheat, 4 pounds of ladino white clover, 2 pounds of white-dutch clover, and 2 pounds of birdsfoot trefoil. For best results (if seed are top-sown), wheat should be sown and lightly disked prior to sowing the small clover and trefoil seed. After planting, the seedbed should be firmed using a cultipacker (Note: Cultipacking after seeding greatly improves germination rates and initial growth). If drilled, the wheat and clover/trefoil seed must be planted in separate seed boxes. All legume seed should be inoculated with species-specific inoculant unless pre-inoculated seed are sown. Ladino and white-dutch clover require *Rhizobium leguminosarum* biovar *viceae* and birdsfoot trefoil requires *Mesorhizobium loti* (Harper 2006).

Perennial cool-season grasses (e.g., tall fescue, orchardgrass, bromegrasses, bluegrass, and timothy) are not recommended in seeding mixtures because they are slow to establish (as opposed to annual grasses), do not produce forage or seed that are eaten by grouse, produce a dense structure at ground level (precluding travel by chicks), do not support high invertebrate populations (as compared to forbs), and out-compete favored plants (such as clovers) within 2 growing seasons, leaving a strip of rank grass that provides little, if any, benefit to ruffed grouse (Harper et al. 2001, Fettinger et al. 2002, Harper 2006, Jones 2005). Many land managers have been led to the false assumption that it is necessary to include perennial cool-season grasses (especially orchardgrass or tall fescue) in a mixture sown on forest roads. **This is not true and certainly counterproductive for wildlife!**

The Value of Annual Grains Over Perennial Grasses

Annual cool-season grains can be planted in spring or fall, germinate within 4 days of a rain event and establish a root system capable of preventing erosion within a few weeks, depending on local conditions. Perennial grasses (cool- or warm-season) require much longer to germinate and grow as there is not nearly as much energy stored in the seed. In fact, when planted in the fall, perennial cool-season grasses rarely produce sufficient growth to prevent soil movement in a heavy downpour until the following spring. Annual cool-season grains (especially wheat) also produce seed that may be eaten by grouse and other birds and serve as a nurse crop while clovers become established underneath. By the time the annual grain completes its life cycle, clovers and other forbs have become established and cover the site.

Renovating Species Composition Along Forest Roads

Plant composition along forest roads can be improved with herbicides and (if desired or needed) top-sowing or drilling seed. Roads dominated with perennial cool-season grasses can be renovated by spraying a glyphosate herbicide (such as Roundup® at 2 quarts per acre) over actively growing grass in September. Approximately 1 month prior to spraying, the road should be mowed to reduce senescent stems and encourage fresh grass growth. Also at that time, lime and fertilizer should be applied as recommended by a soil test. When the grass is approximately 6 – 10 inches high, it should be sprayed. Herbicide label recommendations should be followed. Approximately 2 weeks after spraying, clovers and trefoil can be top-sown over the dying/dead grass. As the thatch begins to decay, the planted seed will germinate. Instead of top-sowing, seed can be drilled. The existing root systems hold the topsoil intact through winter and, by March, the road will be lush and green with quality forage for ruffed grouse and other wildlife. If unwanted residual grass begins to re-appear, it can be selectively removed using a grass-selective herbicide, such as clethodim (Select® at 10 ounces per acre with 0.3 ounces of non-ionic surfactant added per gallon of total spray solution).

Japangrass (*Microstegium vimineum*) is a non-native annual warm-season grass that has become problematic in many areas, especially along roadsides. Japangrass often dominates these sites, inhibiting growth of native plants and suppressing the seedbank, similar to tall fescue and other non-native perennial cool-season grasses. Japangrass can create poor structure for grouse with broods and decrease food availability. Fortunately, this invasive grass can be removed fairly easily by spraying selective herbicides in mid- to late summer (before producing seed). Imazapic (4 ounces Plateau® or 11 ounces Journey®) and clethodim (10 ounces Select®) are both very effective in killing japangrass and leaving various forbs that may provide attractive brood cover and/or food. Repeat applications are necessary to eradicate residual seed from the seedbank.

Site Considerations

Clovers and birdsfoot trefoil are cool-season plants that do best on moist or well-drained sites that are not too dry (Ball et al. 2002). These plants typically do not persist long on south- and west-facing slopes, especially during hot, dry summers. Under harsh, dry conditions, these plants wilt down and the stand generally thins. This is not a problem for grouse (fortunately for land managers) because many forbs are available in the seedbank (that collection of seed occurring naturally in the top few inches of soil) waiting to germinate. Many of these forbs are readily eaten by ruffed grouse—wild strawberry, cinquefoil, avens, hawkweeds, ragwort. Naturally occurring forbs also harbor higher invertebrate populations than grasses and provide attractive brood habitat that allows travel under the protection of forb cover (Harper et al. 2001). These are the very reasons female grouse with broods use forest roads so often during the early brood-rearing season!

Land managers should use these site limitations to their advantage. Roads on exposed south- and west-facing slopes should be managed for brood habitat—that is, allowed to re-vegetate to naturally occurring forbs and grasses. Liming and fertilization are not needed on these sites. Native forbs germinating from the seedbank are adapted to local soils and soil amendment is not needed to improve brood habitat. In addition, these roads do not need to be mowed every year. Mowing every other year is sufficient. Once the cool-season grasses have been eradicated, a deep thatch and dense structure at ground level no longer persist. Travel conditions for chicks remain open.

Those roads located on north- and east-facing slopes and those in riparian areas and toe-slopes should be planted to quality forages that will provide needed nutrition fall through spring. These roads should be top-dressed with lime and fertilizer as appropriate. Mowing is needed only to reduce weed competition. For best results, weeds should be suppressed using selective herbicides. Pursuit® (4 ounces per acre) or Butyrac® 200 (2 quarts per acre) will selectively remove the majority of broadleaf (and some grass) weed problems coming into clover/birdsfoot trefoil plantings. A non-ionic surfactant should be added (0.3 ounces surfactant per gallon of spray solution). If grasses become problematic in clover/trefoil plantings, 10 ounces of Select® per acre (with 0.3 ounces of non-ionic surfactant per gallon of spray solution) will selectively kill the grass and not harm the legumes. Pursuit® or Butyrac® 200 and Select® can be tank-mixed for combined broadleaf and grass control (Note: applicators should read and follow herbicide label instructions).

The Importance of Forest Openings (Old-field Habitats)

Forest openings are used by many wildlife species. As with grouse, a major limitation for white-tailed deer in the Appalachians is nutrition, especially during fall/winter months when there is a poor mast crop. Bears frequent forest openings to forage on clovers and soft mast (e.g., blackberries, blueberries). Forest openings provide critical habitat for wild turkeys, raptors (e.g., red-tailed hawks, red-shouldered hawks, great-horned owls, and saw-whet owls), and songbirds (e.g., indigo buntings, common yellowthroats, eastern towhees, dark-eyed juncos, brown thrashers, gray catbirds, and chestnut-sided warblers). Several species of small mammals (e.g., rabbits, groundhogs, meadow voles, white-footed mice, big brown bats, hoary bats, and red bats) are strongly associated with forest openings. Openings can be managed in a way that is compatible for all of these species, including ruffed grouse, if attention is given to the site and the specific habitat needs of those species.

The Importance of Openings for Ruffed Grouse

The ruffed grouse is a bird of the forest. Appalachian grouse use forest openings, but not to the extent they use forest roads. In North Carolina, adult grouse (without broods) did not use openings (Jones 2005). Brooding females used openings, but only around the periphery. Reasons for this are not entirely clear. Most openings contained considerable orchardgrass cover—an obvious deterrent to brood travel. Along the edge of openings, however, was bramble growth, scattered slash, and various forbs—structure quite similar to that found within group selection cuts and natural canopy gaps, which were preferred brood habitats. Distance to edge may be the key. Regardless of the structure within field interiors, grouse with broods simply may not feel comfortable venturing far from the protective cover of the wood's edge. For these reasons, we believe smaller (<2 acres) and irregularly shaped openings are best for ruffed grouse in the central and southern Appalachians.

Managing Openings for Ruffed Grouse

The first step in making forest openings attractive to ruffed grouse and many other species that use forest openings is to eradicate the non-native, perennial cool-season grasses (e.g., orchardgrass, tall fescue, bromegrasses, timothy, and bluegrass). This can be accomplished only with the use of herbicides, as outlined under *Renovating Species Composition Along Forest Roads* on page X. Plowing and/or disking will not eradicate these grasses. They **will** return in later months. Burning, without the use of herbicides, may only increase their vigor.

Openings must be evaluated for site limitations to determine appropriate management options. Attention should be given to the native (or naturalized) plant community that will arise from the seedbank. Once the competing sod-forming grasses are removed from the site, the seedbank is able to respond, often resulting in an amazing diversity of forbs, grasses, and ferns, which creates optimal brood habitat for grouse and turkeys, nutritious summer forage for deer rabbits and groundhogs, and usable nesting cover for indigo buntings and common yellowthroats.

"Natural" openings are best managed with prescribed fire or disking, **not** with a bushhog (mower)! Fire and disking recycles nutrients into the topsoil, stimulates germination from the seedbank, creates optimum structure at the ground level for foraging and movement, and increases seed and invertebrate availability. Mowing should be avoided, especially during the nesting/brooding season (May – August), because it destroys critical brood (for grouse and turkeys) and nest (for songbirds) cover during the time it is needed most. And, as anyone who has ever bushhogged an opening in the summer knows, mowing also kills wildlife directly. Fawns, bird nests with hatchlings, and young rabbits are commonly killed by rotary mowers during the summer months. Mowing also creates less-than-desirable conditions on the ground for grouse and turkey broods as mowed debris accumulates on the surface, making it much more difficult for chicks to move through the field and limiting the ability of broods and other birds to glean seed from the ground because seeds are buried under a deep thatch layer. In addition, accumulating debris from mowing inhibits the seedbank from germinating, which leads to decreased plant diversity. If prescribed fire and disking are absolutely not possible, mowing should be delayed until late winter, providing winter cover within the opening as long as possible.

Quality fall/winter forage can be provided by planting the wheat/clover/birdsfoot trefoil mixture recommended for forest roads on page X. Other forages that might be considered in openings include chicory (a forage variety, such as *Puna* or *Oasis*; not the naturalized “roadside weed”) and alfalfa. The following mixture (per acre rate) produces outstanding forage quality and also creates favorable bugging sites for grouse and turkeys: 40 pounds wheat, 10 pounds alfalfa, 4 pounds ladino white clover, and 2 pounds birdsfoot trefoil. Planting recommendations are the same as those listed on page X. Additional consideration, however, should be given to incorporating lime and fertilizer into what will become the root zone. Ideally, when planting openings, lime (and fertilizers) should be incorporated 6 – 10 inches by plowing or disking for optimum growth (Ball et al. 2002, Harper 2006).

Perhaps the best strategy to provide quality grouse forage and optimum brood habitat is to plant the firebreak around openings in quality forages, while the interior of the opening is managed for naturally occurring vegetation, using fire and/or disking. Firebreaks should be approximately 2 tractor-widths wide and approximately 30 – 50 feet from the edge of the woods to allow a soft edge to develop where the forest meets the field. This is especially attractive for grouse using the periphery of an opening, providing easy access to both quality brood cover, invertebrates, and quality forages. Another management alternative (if enough openings are present) is to manage some openings in natural vegetation and some in quality forages, or half of an opening in natural vegetation and the other half in quality forages.

Openings should be well distributed throughout management areas to provide/enhance brood habitat and increase interspersion of habitats, which is a critical factor in reducing home range sizes and possibly leading to increased survival (Fearer 1999, Whitaker 2003, Jones 2005). More, smaller openings will benefit grouse to a much larger extent than fewer larger openings. Realizing other wildlife species are included in most wildlife management plans, larger fields (>2 acres) can be made more attractive to grouse by breaking the opening into smaller sections using hedgerows comprised of soft mast producers (e.g., crabapple, apple, plum, hawthorn, pear, persimmon, serviceberry, mulberry, dogwood, viburnums, spicebush, elderberry, devil's walkingstick, and Carolina buckthorn). Hedgerows should be relatively wide (30 – 50 feet), not just a single line of trees/shrubs across the field. Hedgerows should be irregularly shaped, not a straight line. Instead of merely dividing an opening in two (e.g., two 1-acre sections) with a hedgerow, it may be better to create 2 or 3 smaller sections (e.g., three ¼-acre sections) to create more useable space for grouse with broods.

All forest openings can be made more attractive to grouse by thinning into the forest approximately 100 feet from the edge. As with a wildlife retention cut, percent canopy closure should be reduced to 60 – 80 percent (or less) and mast-producing species should be retained, giving emphasis to soft mast producers.

What about Native Warm-Season Grasses?

Native warm-season grasses (nwsg) have been promoted in recent years to improve habitat for small game (namely bobwhite quail and rabbits) and grassland songbirds (e.g., grasshopper and Henslow's sparrows, eastern meadowlarks, and dickcissels) (Heard et al. 2000, Washburn et al. 2000, Dimmick et al. 2002, Giuliano and Daves 2002, Dykes 2005). Nwsg (especially big, little, and broomsedge bluestem, indiangrass, switchgrass, and sideoats grama) are recommended for these species because of the cover and structure they provide (Harper et al. 2006). Nwsg are bunchgrasses and, when sown and managed correctly, contain open ground between bunches, which allows small wildlife to travel through the field and allows forbs to germinate and grow amongst the grasses. Nwsg are rarely, however, used as forage by wildlife. Their value for wildlife is in the cover they provide.

Nwsg have been recommended by some forest managers in the Appalachians for planting forest openings and along forest roads, particularly within national forests. Strong consideration should be given to the existing seedbank before attempting to establish nwsg (Dickerson et al. no date). On most sites, the seedbank in forest openings contain several native warm-season and native cool-season grasses (ncsg). Broomsedge bluestem, little bluestem, purpletop, poverty oatgrass, beaked panicum, deertongue, and Canada wildrye already exist on many sites. More importantly, the seedbank almost always contains a rich diversity of native forbs (e.g., black-eyed susans, firepinks, bluets, fleabanes, mints, lyre-leaved sage, robin's plantain, goldenrods, etc.), which is the primary consideration for early brood-rearing cover and invertebrate availability.

The main problem with establishing nwsg is they do not compete well with non-native perennial cool-season grasses, which commonly carpet these openings and grow with vigor in the relatively cool, moist climate of the central and southern Appalachians. In order to establish nwsg (or ncsg), it is absolutely necessary to eradicate the competitive non-native cool-season grasses before planting (Packard and Mutel 1997, Harper et al. 2006). This can be accomplished only with the use of herbicides as outlined on page X.

If native grasses are sown in wildlife openings, a low seeding rate (mixtures should not exceed 4 pounds Pure Live Seed) should be used to retain the integrity of an open structure at ground level, allowing travel and foraging by grouse broods and promoting germination and growth of forb cover. Native grasses that might be considered for planting in forest openings within the central and southern Appalachians include (varieties in parentheses) little bluestem (*Aldous*), big bluestem (*Niagra*), sideoats grama (*El Reno*), deertongue (*Tioga*), Canada wildrye (*Mandan*), and Virginia wildrye. A wide variety of forbs may (and should) be added to the grass mixture, including New England aster, butterfly milkweed, partridge pea, lanceleaved coreopsis, purple coneflower, *Heliopsis* sunflowers, roundhead lespedeza, wild bergamot, evening primrose, mint, and others. Species planted should be determined by site conditions.

Nwsg are not recommended for planting on forest roads, for a couple of reasons. The biggest limitation for Appalachian ruffed grouse is nutrition, particularly during fall/winter. Not only are nwsg dormant during the fall/winter, our research showed grouse do not eat grasses during the pre-breeding period. Secondly, escape cover is not needed *in* the road, it is already available *alongside* the road, as slash, brambles, and brush are plentiful. Quality forage (e.g., clovers/birdsfoot trefoil, and various naturally occurring forbs) and associated invertebrate populations are the most important considerations.

Arrangement of Habitat Management Units

Managing habitats for ruffed grouse involves both art and science. Science identifies the reproductive ecology, daily/seasonal movements, home range sizes, survival, and habitat use patterns of grouse. Improving overall habitat quality by arranging habitat types in such a way that movements, home range, survival, and reproduction are influenced in a positive manner is an art, guided by a body of scientific knowledge. The creative and skilled manager selects from a variety of methods and techniques to improve habitat quality. Because of variability in forest ownership, management history, management goals, dominant forest types, and other factors, various management approaches must be considered.

Appalachian grouse rely heavily on young forests, along with a mix of other habitats, to meet specific seasonal needs. Developing a management design for the array of forest types used by grouse – from early successional to late rotation and dry uplands to mesic bottoms – may seem impracticable; however, the region's physiography presents unique opportunities to create habitat mosaics preferred by grouse and other wildlife. The topography of the central and southern Appalachians creates diverse vegetation communities and associated ecotones, which often occur in close proximity. Vegetation response differs according to elevation and slope position. Grouse managers should use this intermixing of cover types to their advantage. By planning forest management activities according to topography and associated vegetation, habitats can easily be interspersed across a management area or landscape. The full benefits of silviculture are realized only when the appropriate methods and techniques are matched with site-specific conditions and habitat objectives. Figure 3 shows excellent interspersion of regenerating forest with adjacent thinned and uncut mature forest. Female grouse used this area on the North Carolina study site extensively during fall and winter.

Placement of Habitat Units

Habitats used by ruffed grouse throughout the central and southern Appalachians include a variety of forest types and age classes. Young hardwoods 6 – 20 years old, gated forest roads, mesic stands with a herbaceous understory, and mature mast-producing stands are important habitats for grouse across the region. To benefit grouse, a concerted effort must be made to use the appropriate silvicultural techniques and provide these habitats in a mosaic across the management area.

Food should be located adjacent to cover. Forest management planning should ensure mature stands are interspersed with regenerated stands to increase food availability, especially acorns, beechnuts, and cherries. For example, regenerated oak-hickory stands should be adjacent to a mature hard mast-producing (acorns, in particular) stand not scheduled for harvest in the next 40 years. This is especially important if the clearcut method is used because there will be no hard mast available in the harvested unit (as opposed to a shelterwood or shelterwood with reserves harvest that retains some quality oak trees). Regenerated mesic stands are best located adjacent to a mature stand of desirable mixed mesophytic or northern hardwood species, such as yellow or black birch and black cherry, which provide buds and soft mast. Group selection harvests might be positioned within mature mesic stands containing black cherry, serviceberry, and grape with a well-developed understory. Close proximity of brood cover (group selection cuts) with soft mast and herbaceous groundcover would be beneficial for broods through late summer and early fall. In oak-hickory stands, group selection cuts should be placed adjacent to 2 or 3 quality oaks to help ensure food is available adjacent to cover, while the canopies of those trees are released.

Several quality brood sites should be within a relatively small area, or at least connected by corridors of suitable habitat. Hens with broods often use logging roads and riparian zones with a lush herbaceous understory. These linear habitats can link otherwise disjunct habitats. Group selection cuts placed near riparian areas can offer several brood sites within a relatively small area. If positioned appropriately on the landscape, group cuts can provide patches of cover connecting other important habitats and make adjacent mature stands more accessible. Logging roads also can connect brood sites and sources of cover across more xeric stands where cover may be less attractive. Given the average distance traveled during a day by broods, the distance between identified brooding areas should not be further than 800 meters (Jones 2005).

Elevation and slope position are important considerations when planning forest management for Appalachian grouse. Upper elevation sites generally have thin soils and are prone to disturbance by wind, ice, and fire. Male grouse in the central and southern Appalachians typically select drumming sites on ridgetops having a dense midstory (Schumacher et al. 2001). Drumming sites are often above logging roads, which are frequently used by females (Jones et al. 2005). Lower slopes are often used for brood rearing in summer and foraging sites in winter (Schumacher 2002, Fettinger 2002, Jones 2005). Also in winter, Appalachian grouse tend to make short-distance, upslope movements to avoid lowland cold air pockets caused by temperature inversion after sundown (Geiger 1950, Whitaker and Stauffer 2003). Middle slopes are “transition zones” between ridge tops and lower slopes, sharing soil, moisture, and vegetation characteristics with both upper and lower sites (Berner and Gysel 1969). Positioning timber harvests along the mid-slope can increase food and cover resources *and* create corridors for grouse between roosting cover on upper slopes and foraging habitat on lower slopes. When developing prescriptions for mid-slope sites, managers should concentrate on connecting disjunct habitats and providing food, roosting habitat, and cover in close proximity.

Strong consideration should be given to regenerating (or at least thinning) stands on lower slopes, bottomlands, *and along riparian zones*, which are preferred habitats for ruffed grouse during winter and summer if a relatively dense stem density and/or well-developed understory is present. Grouse broods will use bottomland clearcuts and other dense stands (Thompson et al. 1987, Scott et al. 1998, Rusch et al. 2000, Fettinger 2002), as well as mature stands with well-developed understories (Haulton et al. 2003, Jones 2005). Realizing most Best Management Practices are ecologically sound, we believe *excluding forest management from all riparian zones is not sensible* when and where logs can be removed without increasing siltation into the stream. This is especially true along ephemeral and first order drainages. In some areas, forest management has been entirely excluded far into the uplands because of designated Streamside Management Zone widths, precluding habitat management in areas that may be selected by grouse and other wildlife if the correct structure was present. This policy, where it exists, should be changed to better meet the needs of ruffed grouse, as well as American woodcock.

Logging Road Placement

Placing logging roads adjacent to harvested stands increases interspersion by juxtaposing a food source (forbs and insects on roads) with cover and additional foods (within regenerating stands).

However, greatest interspersion is achieved when forest roads *intersect* (go through the middle of) harvest units and effectively reduce contiguous stand area, as opposed to traversing only one side. In North Carolina, we documented significantly smaller ruffed grouse home ranges in watersheds where logging roads dissected regenerated stands as opposed to those watersheds where roads adjoined only one side or end (Jones 2005; Figure 3). New logging roads should be planned with this in mind. Likewise, along existing logging roads, stands delineated for harvest should be planned accordingly (above and below the road). Not only does this technique improve grouse habitat, but skid lanes used to remove logs are shorter because the haul road is in the middle of the stand, not on one end or side. *Increasing interspersion of preferred habitats and positioning cover and food in close proximity across a management area is certainly the most important consideration when managing habitats for ruffed grouse*. Positioning harvest units and logging roads correctly makes this possible.

Size and Shape of Harvest Units

There is a confusing abundance of literature concerning the optimal size of timber harvest units for ruffed grouse (Gullion 1977, Kubisiak et al. 1980, McCaffery et al. 1996, Storm et al. 2003). Recommendations of 1 – 25 acres in mixed oak forests allow good interspersion of early successional habitats with other important features. Considering harvesting economics, some managers recommend larger cuts, up to 40 acres or more. Research has shown grouse will use any size stand (at least some portion of it) large enough to allow regeneration (Sharp 1963, Macdonald et al. 1994, Fearer and Stauffer 2003). However, *because interspersion of quality habitats within a relatively small area* is the most important consideration when managing for ruffed grouse, harvest units should be relatively small (less than 25 acres with even-aged and two-aged regeneration methods) and well distributed across the management area. This has been demonstrated in Pennsylvania (Storm et al. 2003) where mixed oak forests managed with 5-acre patches in a checkerboard arrangement (to maximize interspersion) sustained grouse populations at levels similar to those found in the Lake States.

In the Appalachians, topography and associated moisture gradients strongly influence forest composition. Forest types weave around the mountains in a mosaic according to aspect, elevation, and landform. Of course, operational factors must be considered, but following the natural mosaic of topography when harvesting stands is most sensible in terms of matching regeneration methods with the appropriate forest type. Therefore, harvest units may not be uniform or straight in size or shape, but fluctuate naturally on a given site. Following natural patterns in forest structure and composition creates more edge habitat across a management area and helps increase interspersion.

Rotation

Rotation length varies with site, forest type, past intermediate cuttings, and landowner objectives. In terms of financial maturity, rotation length is determined by the growth rate of the stand and local timber markets. When dominant trees cease to respond much to thinning, and height, shoot elongation, and crown expansion have slowed, the stand is normally harvested. For Appalachian hardwoods, this might be as early as 60 years (on better sites) or as long as 120 years on poor sites. Rotation length might be even longer when landowners desire to allow trees to continue to grow very slowly to large diameters. Naturally, this increases the risk of disease and damage by natural factors, and overall timber quality usually declines.

Pressure from special interest groups has caused rotation lengths on national forests to increase to the point that, on a landscape scale, the forest is maturing out of desired age classes for ruffed grouse. Excessive rotation lengths coupled with newly created "zero-cut zones" have decreased land available for improving ruffed grouse habitat significantly on national forest lands. Where the potential to create valuable early successional forests is limited or eliminated, even greater emphasis must be placed on improving habitat suitability through timber stand improvement practices (e.g., thinning) and, if possible, group selection harvests.

To benefit ruffed grouse in the central and southern Appalachians, a management area should be comprised, as much as possible, of those habitats needed for various life requirements. That means as much forest area as possible should be comprised of stands 6 – 20 years old, well interspersed within mature (>40 years) mast-producing hardwoods or mixed mesophytic hardwoods, as determined by site. If ruffed grouse were the only consideration, the proportion of various age classes would be determined by that needed to meet the requirements of a grouse population through the year. This is rarely the case. Many other factors, in actuality, dictate the percentage of a forest in various age classes, including aesthetics, timber management considerations, finances, other wildlife species, etc.

Appalachian ruffed grouse are often under severe nutritional stress during winter, prior to breeding. Acorns, buds, and quality forage are important foods during this period and, when found in abundance, lead to higher nesting success (Devers 2005). Thus, quality winter foods can be a primary limiting factor in Appalachian grouse populations, especially in landscapes dominated by oak-hickory forests (Whitaker 2003, Devers 2005). Increased forest area of mast-producing age over the past 20 years, however, has **not** led to increased grouse populations in the central and southern Appalachians. Providing quality winter foods *within a stand that also* *provides quality cover* will help ruffed grouse populations increase. This is possible through the shelterwood, irregular shelterwood, and clearcut with reserves methods.

Table 1 shows how the distribution of age classes across a forest changes with various rotation lengths. In reality, a number of rotation lengths would be used on a large forest with various forest types and site conditions. Nonetheless, Table X shows how desirable cover for ruffed grouse represented in the 6 – 20-year age class is reduced with increasing rotation lengths.

Table 1. Percent forest cover within various age classes using 3 different rotation lengths.

Age class	60-year rotation	80-year rotation	100-year rotation
1 – 5	8	6	5
6 – 20	25	19	15
21 – 40	33	25	20
>40	33	50	60

In the central and southern Appalachians, the mixed mesophytic and northern hardwood forest types are found within coves and eastern/northern exposures. These sites allow rapid growth of yellow poplar, black cherry, sugar maple, black and yellow birch, American basswood, yellow buckeye, white ash, American beech, and northern red oak. Where additional cover is needed for ruffed grouse, a shorter rotation length (60 –70 years) would be prudent for stands in these forest types (Whitaker 2003, Devers 2005). Also, the presence of cherry, birch, and beech reduce the need for acorns in these forests. There was little evidence of nutritional constraint in mesophytic forests of the central and southern Appalachians. Although there is mast potential in mixed mesophytic and northern hardwood forests, the majority of mast in the

Appalachians is produced within the oak-hickory forest type. Longer rotation lengths (80 – 90 years) within oak-hickory stands allow more time for mast production and may be desirable with regard to variable acorn production across years. All things considered, we believe rotation lengths averaging 80 years would be desirable for ruffed grouse in most areas of the central and southern Appalachians.

Perhaps more important than the exact rotation length to providing continued quality habitat for ruffed grouse is implementation of intermediate treatments (i.e., thinnings), prescribed burning, and habitat arrangement. A proactive prescription for intermediate thinnings and burning will enhance the structure and composition of mature and developing stands (20 – 40 years) for grouse and extend those desirable characteristics of the 6 – 20-year age class preferred by ruffed grouse in the central and southern Appalachians.

Conclusions

Ruffed grouse populations can be increased by addressing their habitat needs. Correct habitat management for ruffed grouse in the central and southern Appalachians is relatively straightforward: 1) provide adequate early successional forest habitat by incorporating a sensible timber harvest rotation; 2) use regeneration methods that match the site and forest type being regenerated; 3) retain and enhance hard mast production; 4) manage forest roads and openings in an effective and efficient manner; and 5) address special habitat features, such as soft mast plantings, seep management, and old homesites, as necessary. Most importantly, however, habitats must be managed in an arrangement that facilitates grouse movements and needs throughout the year.

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Figure 1. Kernel home range and locations of a ruffed grouse hen that used a 6-year-old shelterwood from October 2002 through February 2003, Macon County, North Carolina.

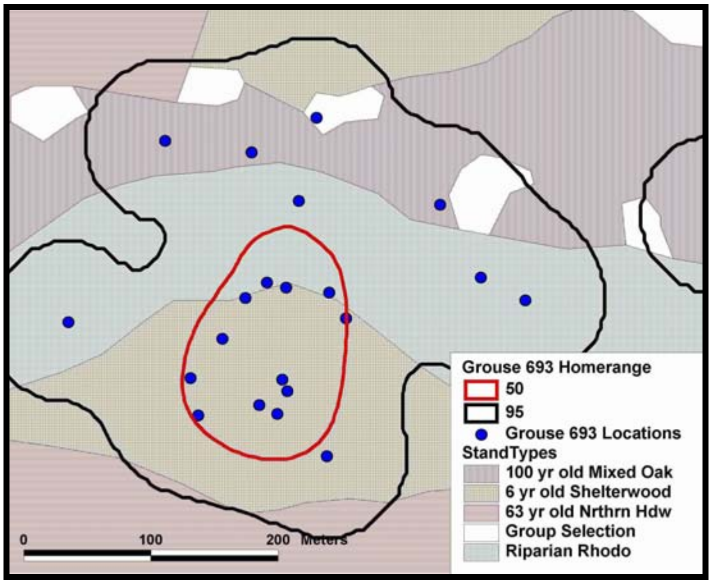

Figure 2. Kernel home range and locations of a grouse brood that used group selection cuts during the first 2 weeks post-hatch, Macon County, North Carolina.

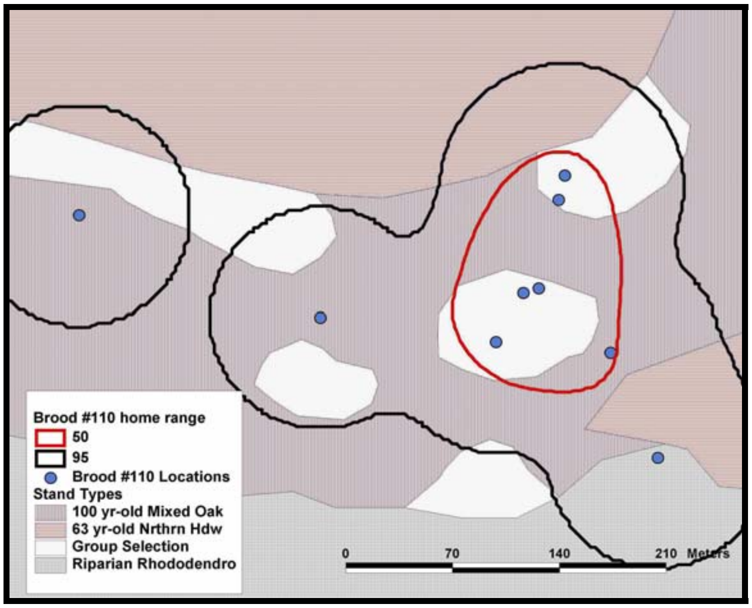

Figure 3. Thinning this mesic stand on a north aspect adjacent to mature xeric and 6 – 20-year-old midslope harvests created interspersion resulting in extensive use by female grouse in fall and winter. Also note that forest roads bisect cuts, providing food juxtaposed to cover and further increasing interspersion.