FOREST MANAGEMENT AND WILDLIFE IN FORESTED WETLANDS OF THE SOUTHERN APPALACHIANS

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Abstract. The southern Appalachian region contains a variety of forested wetland types. Among the more prevalent types are riparian and bottomland hardwood forests. In this paper we discuss the temporal and spatial changes in wildlife diversity and abundance often associated with forest management practices within bottomland and riparian forests. Common silvicultural practices within the southern Appalachians are diameter-limit cutting, clearcutting, single-tree selection, and group selection. These practices alter forest composition, structure, and spatial hetereogeneity, thereby changing the composition, abundance, and diversity of wildlife communities. They also can impact special habitat features such as snags, den trees, and dead and down woody material. The value of wetland forests as habitat also is affected by characteristics of adjacent habitats. More research is needed to fully understand the impacts of forest management in wetlands of the southern Appalachians.

1. Introduction

Recent estimates indicate that there are about 7.4 million ha of forested wetlands in the southeastern states of Alabama, Florida, Georgia, Kentucky, North Carolina, South Carolina,Tennessee, Virginia, and West Virginia (Cubbage and Flather, 1993). The more mountainous states of Kentucky, North Carolina, Tennessee, Virginia, and West Virginia contain an estimated 1.6 million ha of forested wetlands (Cubbage and Flather, 1993). Precise estimates are not available for area in forested wetlands within the southern Appalachian ecoregion. However, most of the forested wetlands in the southern Appalachians probably are associated with streams.

The area of wet forest in a river reach varies with stream gradient and surrounding topography. Generally, however, the gradient of first- and second-order streams results in only a area that meets the jurisdictional definition of wetlands. In more mountainous portions of the southern Appalachians, watersheds are relatively intact and wetland forests are continuous with upland forests. In coves and valleys, and near the periphery of the southern Appalachian region, many of the forested

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wetlands and adjacent uplands have been converted to other non-forest land uses. Where wetland forests do occur, they frequently are only narrow fringes immediately adjacent to the stream or river. In managed forest landscapes, these narrow fringes usually are incorporated in streamside management zones (SMZs) (Wigley and Melchiors, 1993). Bottomland hardwoods (BLHs) occur in the region, but expansive floodplains such as those associated with lower gradient streams in the Gulf Coastal Plain and Mississippi Alluvial Valley are uncommon.

The relatively narrow configuration of forested wetlands in the southern Appalachians has important implications for their management. Actions that occur beyond the boundaries of the jurisdictional area can have significant effects on the quality of the riparian systems as habitat for terrestrial, semi-aquatic, and aquatic organisms. Therefore, when examining effects of management on wildlife, it is important to consider not only the management of wetland forests, but the management of adjacent upland forests as well.

Southern wetland forests provide habitats that generally support a rich wildlife community (Howard and Allen, 1989), including endangered or threatened species, and species that are candidates for listing (Ernst and Brown, 1989). For some species, the sometimes linear nature of forested wetlands in the southern Appalachians is important. Some species such as beavers (*Castor canadensis*), minks (*Mustella vison*), and prothonotary warblers (*Prothonotaria citrea*) are strongly associated with streamside habitats (Brinson *et al.*, 1981), and often use the streams and wetland forests as travel corridors. Sometimes, however, relatively few species from the total community show an distinct affinity for riparian areas. For example, Murray and Stauffer (1992) found that in Virginia, total bird density and species richness showed no riparian influence. Only two species, acadian flycatchers (*Empidonax virescens*) and Louisiana waterthrushes (*Seiurus motacilla*), were closely associated with habitats near streams.

Forested wetlands in the South have significant potential for timber production. Separate data are not available for the southern Appalachian region. However, between the years 1984 and 2030, hardwood timber removals from BLH forests across the South are predicted to increase by approximately 64% (USDA For. Serv., 1988). Concurrently, between 1990 and 2030, area of BLHs in the South is projected to decrease by about 13% (USDA For. Serv., 1988). Thus, management of forested wetlands across the South may intensify. Future trends for the southern Appalachians, however, are unclear.

For these reasons, we must understand the consequences of managing forested wetlands for multiple products, including timber and wildlife. It is increasingly difficult and impractical to exclusively rely upon public land acquisition and set-asides as a key conservation strategy. This is particularly true in the eastern states which encompass the southern Appalachians; there, about 91% of forests are privately held (Waddell *et al.*, 1989). Thus, it is evident that meaningful conservation strategies must consider and be compatible with the economic needs and goals of private landowners. Often those goals include the harvest of timber for economic or other benefits. In this paper we review and summarize key results from extant literature pertaining to timber harvesting in forested wetlands and its effects on wildlife communities. Unfortunately, data specific to the southern Appalachian ecoregion are limited. Therefore, the bulk of information in this paper is based on studies from related systems.

2. Forest Management Practices in Forested Wetlands

Management of forested wetlands in the southern Appalachians is highly varied with both even-aged and uneven-aged techniques employed. Toliver and Jackson (1989) provide an excellent overview of silvicultural practices appropriate for use in forested wetlands. One practice not discussed in their paper, however, is diameter-limit cutting. Diameter-limit cutting, while not usually recommended by foresters, is common within the southern Appalachians, particularly in forests held by non-industrial, private owners (D. H. Van Lear, personal commun.). Diameter-limit cutting removes all merchantable trees above a specified minimum diameter, commonly 30.5 cm. Early successional tree species often regenerate in the gaps created when large trees are harvested. This practice results in a highly variable stand structure, but usually in an uneven-aged stand with three or more canopy layers. Because diameter-limit cutting usually removes the largest and best quality trees, it can result in high-grading.

In parts of the southern Appalachians where forests are managed, many riparian forests are incorporated within SMZs. SMZs are strips of forest vegtetation maintained along waterways, and may include both wetland and upland habitats. SMZs commonly are recommended within state voluntary Best Management Practices (BMP) programs or required in states with forestry practices acts. BMP recommendations for SMZs vary among states. Over time, recommended widths have increased; thus, long-established SMZs usually are narrower than SMZs created more recently. Similarly, SMZ width generally increases with slope and width of the associated stream. This is particularly important in areas where slopes may be severe. For example, recommended SMZ width in Tennessee increases from about 14 to 20 m as slope increases from 10 to 20% (Tennessee Department of Conservation, 1985).

BMP programs commonly recommend SMZs with one or more zones. In the southern Appalachians, some timber harvesting activities usually are deemed most appropriate in the outer portions of the SMZ; this area sometimes is called the secondary SMZ. For example, in South Carolina, recommended SMZ width is 24.4 m on each side of a high-gradient stream capable of supporting trout. The inner half of the buffer is the primary SMZ and the outer half is the secondary SMZ. To minimize potential damage to the stream banks or channel, BMPs often recommend no site preparation or heavy equipment within the primary SMZ. Within the secondary SMZ, BMPs commonly specify minimum amounts of residual canopy cover or basal area. Thus, uneven-aged management such as single-tree or group selection is common within secondary SMZs.

3. General Effects on Wildlife Habitat

By altering existing habitat conditions, forest management affects wildlife at several temporal and spatial scales. At the stand level, species respond differently to the immediate consequences of management; populations of some species may be relatively unaffected, some may decrease, and some may increase. The response varies according to the forest community; the type, extent, and intensity of management; and the sensitivity of the wildlife species to habitat alteration. Other variables such as aspect, topographic position, and site quality can affect wildlife response to forest management.

Wildlife species associated with mature forests are likely to decline in abundance locally following intensive management such as clearcutting or seed-tree harvests which remove all or most of the overstory. Other types of forest management such as single-tree selection and group selection have less dramatic stand-level effects, and may not appreciably affect local species richness. However, more subtle effects can occur even with single-tree selection. For example, first-year data from an ongoing study in Arkansas suggest that parasitism of bird nests is higher in stands managed using single-tree selection than by other methods. Other treatments such as thinnings and improvement cuts also impact wildlife habitat. The degree to which the wildlife community is affected varies with the intensity of these operations. Generally, intermediate treatments have less impact on wildlife than regeneration operations.

Following is an overview of how the wildlife community is likely to be affected by forest management activities. We will discuss both even-aged (clearcutting, shelterwood, seed tree) and uneven-aged (single tree and group selection) harvest and regeneration methods. The consequences of diameter- limit cutting are not well understood, but likely are similar to those of uneven-aged management. Effects also vary based on the landscape-level context in which the management is occurring. These potential effects will be more fully addressed in a separate section.

3.1. CLEARCUT METHOD

Clearcutting is an intensive form of management in which all trees in an area are removed. Normally, clearcuts are a minimum of 1.2 ha to ensure that adequate light is available for establishment and growth of the new stand (Toliver and Jackson, 1989). In forested wetlands, clearcutting is a common management practice because it favors regeneration of commercially desirable tree species and minimizes the number of times a stand must be entered. The immediate stand-level effects of clearcutting is the reduction of habitat for some species, particularly those associated with mature forest. However, favorable conditions are created for species dependent on early successional stages (e.g., herbaceous or shrub stages). The degree to which clearcutting affects wildlife is related partially to size of the harvest unit. Clearly, smaller cuts have less immediate stand-level impact to species associated with mature forests. However, larger clearcuts are necessary if the management goal is to eventually develop extensive areas of mature, even-aged forest.

The loss of habitat features associated with clearcutting mature, deciduous stands may locally decrease habitat suitability for species such as the gray squirrel (*Sciurus carolinensis*), southern flying squirrel (*Glaucomys volans*), and raccoon (*Procyon lotor*) that rely to varying degrees on hard mast production and the availability of cavities in mature trees for dens. Similarly, abundance of species such as the ovenbird (*Seiurus aurocapillus*), red-eyed vireo (*Vireo olivaceous*), yellow-throated vireo (*Vireo flavifrons*), and white- breasted nuthatch (*Sitta carolinensis*) may decline locally when a mature overstory is removed (Thompson and Fritzell, 1990). Mitchell (1989) found that eleven species of birds were more abundant in a 127-year-old baldcypress-tupelo (*Taxodium distichum-Nyssa aquatica*) stand than in younger stands. In general, birds that glean insects from overstory foliage and limbs such as the red-eyed vireo, northern parula warbler (*Parula americana*), and American redstart (*Setophaga ruticilla*) will be negatively affected immediately following a clearcut. Richness and abundance of amphibians also can be reduced after clearcutting (Petranka *et al.*, 1993). However, even amphibian communities apparently return to pre-harvest structure and composition within 50-70 years (Petranka *et al.*, 1993). Thus, Enge and Marion (1986) concluded that amphibian and reptile communities would be most diverse in a landscape dominated by a variety of stand types and structures.

Populations of some species not usually associated with mature forests often benefit from clearcutting. Increased forage in the form of green foliage and soft mast, and cover from ground-level vegetation and logging slash will improve habitat conditions for species associated with brushy areas and early successional habitats. Capture rates for many small mammal species may be higher in harvested tracts than in uncut stands. As an example, Kirkland (1977) found that clearcutting deciduous forests in the northern Appalachians altered the density and relative abundance of small mammals. Some species that were substantially more abundant following harvest included the masked shrew (*Sorex cinereus*), smoky shrew (*S. fumeus*), woodland jumping mouse (*Napeozapus insignis*), red-backed vole (*Clethrionomys gapperi*), meadow vole (*Microtus pennsylvanicus*), and bog lemming (*Synaptomys cooperi*). Although species richness initially decreased following cutting, it increased during the sapling and young-pole stage. Several species attained their highest densities during the five-year period following cutting. Buckner and Shure (1985) reported that densities of both the deer mouse (*Peromyscus maniculatus*) and white-footed mouse (*P. leucopus*) were higher in openings than in control forests. The two species showed different responses to opening size; the former reached highest levels in 10-ha openings, while the latter was most abundant in smaller ones (<2.0 ha).

Richness and diversity of forest birds has been found to be higher where clearcutting creates a variety of stand conditions and edge habitat (Mitchell and

Lancia, 1990). Welsh and Healy (1993) found that bird species diversity was greater on areas under even-aged management than on unmanaged areas. Managed areas contained all species present on unmanaged areas plus 20 additional species. Because their study was conducted in New Hampshire, however, it is not known if its results apply to the southern Appalachians. Generally, species that prefer dense thickets of saplings, shrubs, or vines such as white-eyed vireo (*Vireo griseus*), hooded warbler (*Wilsonia citrina*), golden-winged warbler (*Vermivora chrysoptera*), and northern cardinal (*Cardinalis cardinalis*) will benefit from activities that open the canopy. Larger openings created through timber harvesting may support some species such as the common yellowthroat (*Geothlypis trichas*), yellow-breasted chats (*Icteria virens*), prairie warblers (*Dendroica discolor*), and indigo bunting (*Passerina cyanea*) not normally associated with mature forests. Some species associated with these openings, e.g., prairie warblers, golden-winged warblers, are relatively uncommon and may be declining.

3.2. SEED-TREE AND SHELTERWOOD METHOD

The seed-tree and shelterwood regeneration methods affect wildlife much as clearcutting does. The primary difference is the maintenance of some overstory trees for a period of years allowing some species that use the bole and canopy of mature trees to continue using the site. These methods currently are not employed extensively in southern Appalachian wetlands, but may be soon on national forests.

3.3. GROUP SELECTION METHOD

Group selection normally involves harvesting small groups of trees (typically from 0.4 to 2.0 ha), resulting in an uneven-aged stand. In the harvested area, the effects are similar to that of a clearcut operation; however, habitat within the entire stand is less dramatically affected. The effects of group selection on wildlife communities have not been well studied. Thus, the following discussion of group selection is based partially on studies of small clearcut operations.

Because the groups selected for harvest or intermediate treatment are small and scattered throughout the forest, populations of many species found in the original stand may be largely unaffected by group selection. For example, few if any, negative effects would be expected to occur to populations of gray squirrels, eastern wild turkeys (*Meleagris gallopavo*), or pileated woodpeckers (*Dryocopus pileatus*), all species associated with mature forest conditions. However, the effects of small scattered openings on other forest-dwelling species, particularly "interior" neotropical migrant songbirds, is unknown.

Species associated with early successional habitat such as eastern cottontail (*Sylvilagus floridanus*), white-tailed deer (*Odocoileus virginianus*), ruffed grouse (*Bonasa umbellus*), prairie warbler, common yellowthroat, golden-winged warbler, and yellow-breasted chat use regeneration areas due to the abundant food and cover resources created (U.S. Forest Service, 1980). Openings created by group selection in an otherwise forested landscape may be extremely important to some game species. For example, wild turkeys often nest in or near such areas (Speake *et al.*, 1975; Wesley *et al.*, 1981), and broods require insects associated with herbaceous vegetation (Hurst and Stringer, 1975; Healy and Nenno, 1983). Ruffed grouse also use openings as brood habitat (Cade and Sousa, 1985). The American woodcock (*Scolopax minor*), a game species of minor importance in the southern Appalachians, is known to make extensive use of regenerating bottomland hardwoods in other portions of the South (Roberts *et al.*, 1984).

3.4. SINGLE-TREE SELECTION

Single-tree selection results in the removal of individual trees. As with group selection, foresters usually determine the desired structure and composition of the residual stand using systems such as BDq regulation (Marquis, 1978). With BDq regulation, the desired residual basal area (B), maximum retained diameter class (D), and q-factor (q) are determined. The q-factor is the negative exponential constant between diameter classes. It is used as a multiplier to yield the target number of trees in each diameter class. Trees are removed from the stand within the constraints of those 3 variables. Guldin (1991) provides an excellent overview of the technical application of this regulation method.

This system of harvest and regeneration is sometimes compared to the natural, gap-phase processes by which small gaps are created in the canopy, and subdominant trees are released. Most wildlife species associated with the existing stand will continue using the site, and the small regeneration areas may temporarily provide habitat for early successional species. For example, hooded warblers which often are associated with canopy gaps in mature forests (James, 1971). Other species that likely would respond similarly include the northern cardinal, carolina wren (*Thryothorus ludovicianus*), and white-eyed vireo.

Species associated with mature forests such as the gray squirrel and eastern wild turkey likely will be unaffected by single-tree selection, and in fact, may benefit from increased soft mast production associated with gaps. For example, Nixon *et al.* (1980) found that while food and cover resources for gray squirrels were reduced immediately following harvest, population levels one year later were the same as pre-cut levels. Squirrels frequently foraged in logged areas, presumably feeding on abundant fungi and insect populations.

Of the regeneration methods, single-tree selection alters stand structure and existing habitat conditions least. Thus, it is viewed by some as the most desirable method for use. In spite of this, research has documented that shade-intolerant tree species that often are the target of management (e.g., oaks [*Quercus* spp.]) do not reproduce well under this system. Long-term management by single-tree selection can, in fact, result in significant and sometimes unwanted changes in the makeup of the forest community, i.e., toward more shade tolerant species. This undesirable side-effect, along with other factors such as the necessity for repeated entry into the stand, extensive road construction, and potential damage to residual trees caused by harvest negates many of its positive features.

4. Landscape Considerations

Harvesting and regeneration also affect wildlife at a larger, landscape scale. The habitat quality of any particular forest stand sometimes is more affected by its context than its within-stand characteristics. For example, the wildlife community in a 20-ha, sawtimber-size, floodplain stand will vary depending upon whether it is located within a larger, similar landscape or within a landscape dominated by early successional habitats. Wildlife response to forest management activities in such a stand also will vary depending upon the landscape context.

Often, wildlife species richness increases with area of a habitat; this phenomenon also has been observed in riparian forests (Stauffer and Best, 1980; Keller *et al.*, 1993). Species gained as forest area increases are sometimes referred to as "area-sensitive" or "interior" species. Large blocks of mature BLH forest often contain large numbers of habitat specialists, including forest-interior, neotropical migrants (Hamel, 1989; Mitchell *et al.*, 1990). Fragmentation, resulting in small, isolated forest patches has been found to be related to declines of some forest-interior species and local extinctions of others (Finch, 1991).

Most of the studies related to fragmentation, however, have been conducted in regions of the country lacking extensive forest cover. The authors of a recent study in heavily forested areas of Missouri (Thompson *et al.*, 1992) concluded that, at the landscape-scale, clearcutting was compatible with maintaining populations of forest-interior, neotropical migrants although some species would likely become less abundant. Likewise, research in northern hardwoods of New Hampshire (Welsh and Healy, 1993) suggests that even-aged management actually increases forest songbird diversity without the loss of any species. It is unknown whether these conclusions are applicable to BLH and riparian forests in the southern Appalacians.

The relationship between wildlife species richness and forest area has not been well studied, but there is some indication that it is not linear. In the study by Stauffer and Best (1980), most of the gains in bird species richness occurred in the narrower riparian width classes. In fact, 70-78% of the breeding bird species occurred in riparian strips that were 17% of the maximum width sampled of approximately 250 m. Some species occurring only in the widest riparian strips are considered by many to be interior species, e.g., American redstart, scarlet tanager (*Piranga olivacea*). Others, however, such as the rufous-sided towhee (*Pipilo erythrophthalmus*) are not. Moderate-width riparian forests may provide for the habitat needs of many species. For example, Keller *et al.* (1993) recommended that riparian forests be at least 100 m wide to provide nesting habitat for interior species.

It cannot be inferred that increased species abundance always is related to increased habitat area. Many other habitat variables such as forest species composition and richness, average dbh, snag availability, and understory density are all important in avian communities. One recent study showed that the character of adjacent habitats can have a major influence on wildlife communities (Tappe *et al.*, 1993). Unfortunately, few studies have critically evaluated how stand characteristics within riparian and other wetland forests interact with other forest characteristics and those of adjacent habitats.

SMZs generally are considered to contribute to the maintenance of diverse wildlife communities in managed forest landscapes. They offer an opportunity to provide habitat features such as den trees and snags that are less abundant in intensively managed stands (Wigley and Melchoirs, 1993). Triquet *et al.* (1990) concluded that SMZs provide habitat for some species of mature-forest and edge-dwelling songbirds that otherwise would be absent. Burk *et al.* (1990) found that eastern wild turkeys used SMZs more than expected in a managed forest landscape. Likewise, studies have demonstrated the value of SMZs to squirrels (Warren and Hurst, 1980; McElfresh *et al.*, 1980; Dickson and Huntly 1987; Fischer and Holler, 1991).

SMZs also are thought to function as travel corridors (Harris, 1989), connecting habitats dissected by other forest types, non-forest land uses, or other barriers. Simberloff *et al.* (1992), however, note that a "remarkable publicity campaign, much of it outside the bounds of mainstream science, has promoted corridors for conservation." In truth, there are few data regarding the efficacy of forested corridors or whether SMZs function as such. Simberloff *et al.* (1992), however, observed that the utility of riparian forests, such as those contained within SMZs, often is important independent of their value for movement.

5. Conclusions

Timber harvesting and other forest management activities can be compatible with the goal of maintaining a diversity of wildlife species and communities in BLH and riparian forests. At the stand level, forest management influences wildlife diversity and abundance in these forests by affecting a multitude of habitat features. Any perturbation, such as timber harvesting, likely will reduce habitat suitability for some species but improve suitability for others. However, it is important to consider the spatial and temporal aspects of stand-level changes. Negative impacts to populations of many species are frequently short-lived and a diversity of seral stages created by harvesting, including some of all age and structural classes, are needed to provide for the full spectrum of biota.

Harris and Gosselink (1990) suggested that an ideal approach to the maintenance of biotic diversity would consider all types of species such as interior, edge, and wide-ranging species. Thus, mature stands are needed for interior or area-sensitive species. Similarly, early successional stages are needed for specialists dependent upon those habitats. The necessity of having a diverse forest ecosystem is highlighted by trends in the Breeding Bird Survey which show that neotropical migrant songbird species asssociated with both early- and late-successional habitats may be experiencing long-term population declines. And, managed forests can accomodate a suprisingly large array of species. Even those species sometimes considered "old-growth" dependent, can sometimes be accomodated in managed forests through use of creative silvicultural practices (Lennartz and Lancia, 1987). For most wildlife species, reversing the decline in BLH and riparian area is probably a more important concern than the spatial or temporal arrangement of a forested mosaic.

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