C H A P T E R 7

Managing Forests for Wildlife

James G. Dickson[1]
US Forest Service
Southern Research Station, Nacogdoches, TX

T. Bently Wigley
National Council of the Paper Industry for Air and Stream Improvement, Inc.
Clemson University, Clemson, SC

Wildlife species and communities are molded and influenced by a variety of factors, including some abiotic conditions such as climate, topography, soils, and site. These conditions form the basis for productive and diverse southern forests and their wildlife communities.

These wildlife communities are affected by habitat conditions at different scales, such as the landscape level and the smaller, stand scale. Species are very different in the scale of habitat that individual animals use. For example. some amphibians have very restricted movements and ranges. Conversely, some larger vertebrates such as white-tailed deer have relatively large home ranges.

Some migratory species may use very distant and different habitats at different seasons. For example. wood ducks that winter extensively in southern bottoms, nest throughout much of forested North America.

And probably more importantly than use by individual animals, broad-scale landscape habitat conditions affect wildlife community composition and population function of species. For example, very small pockets of forest habitat may serve as sinks for forest interior birds, where mortality exceeds productivity.

In this chapter we present some information about habitat relationships and management options at a scale broader than the stand level, such as discussion of edge and streamside zones. But we treat wildlife habitat relationships primarily at the stand level, which is the basic management unit. We approach this by treating suitability of stand structure and composition for wildlife com-

[1]Current Address: School of Forestry, Louisiana Tech University, Ruston, LA

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Wide streamside zones (A. US Forest *Service)* in southern forests are beneficial for a number of game *(B. R. Griffin)* and nongame species such as the Acadian flycatcher *(C. B. Cottrille, Cornell Lab of Ornithology).*

munities, and present information about how common management practices affect that suitability as wildlife habitat for wildlife communities. Each species has different habitat requirements, so conditions or manipulations that favor some species likely will be negative for others.

Forest and stand suitability for wildlife should be considered in regard to alternative land uses and also how they fit into the broader landscape context. In recent years pine plantations have increased in extent in the South, there is much interest in pine plantations as wildlife habitat, and much of this chapter focuses on those relationships.

EDGE

As noted, landscape composition is important to southern wildlife communities. One factor which influences wildlife species is edge, or the juxtaposition of habitat types. The extent of edge is often determined by stand size or shape. Small stands or complex-shaped stands have large edge to area ratios. Edge has long been recognized as positive for many species (Leopold 1933). Most primary game species in the South thrive in forest edge habitat and in forest-field landscapes. For example, white-tailed deer and wild turkey thrive in forest-agriculture habitat mixes which are prime habitat for their year-round needs. Also, some other game birds, such as American woodcock and ruffed grouse, and some other species fare well in patchy habitat.

But there is concern for some forest interior birds, particularly neotropical migrants (Dickson et al. 1993). These species may be absent from small forest fragments, probably due to lower reproductive success or survival in edge-dominated forests (Faaborg 1992). While edge-related declines in reproductive success have been documented in fragmented forests in predominantly agriculture landscapes, the effects of edges created by timber harvest in predominately forested landscapes is unclear (Dickson et al. 1993). Many forest interior species remain abundant in managed forests but the status of their population viability is uncertain.

STREAMSIDE ZONES

Streamside zones (SZ) are strips of riparian and/or other mature stands maintained along intermittent or permanent streams (Wigley and Melchiors 1994). SZ usually are recommended in silvicultural Best Management Practices to protect streams from potential impacts from logging of adjacent stands, such as excessive sediment, nutrients, logging debris, chemicals, or water temperature alteration.

SZ also help maintain wildlife diversity in managed forest landscapes. Because riparian forests often predominate in SZ, they are very productive and often provide unique habitat in landscapes dominated by more xeric forest types. SZ also may provide important mature habitat attributes and may function as travel corridors and enhance connectivity within landscapes (Burk et al. 1990). SZ research in the South has documented habitat relationships for nongame birds, small mammals, herpetofauna, wild turkey, squirrels, and white-tailed deer.

Birds

Some habitat features that SZ offer birds include large trees and snags, multiple foliage layers, and open areas to forage along the land/water interface. Bird species present in SZ depend upon habitat conditions of the SZ and adjacent habitats. Thus SZ may support forest-interior species, riparian associates, early-successional species, and generalists (Murray and Stauffer 1995).

SZ width is a major consideration for many forest managers. Bird species richness usually increases with SZ or riparian zone width (Dickson et al. 1995a, Hodges and Krementz 1996). Different bird species, however, respond differently to increasing width. For example, Keller et al. (1993) found that the number of neotropical migrants increased with riparian forest width, but the number of short-distance migrants decreased. and resident species were not affected. Forest-dwelling and forest-interior species have been found to be more common in wider strips (Dickson et al. 1995a). However, data on reproductive success of forest interior species are lacking in these narrow habitats.

Game Species

SZ also can be important habitats for game species. In eastern Texas, Poteet et al. (1996) found that SZ traversing pine plantations were heavily used and an important part of deer home ranges during fall and winter. probably due to hard mast availability. Telemetry data show that SZ are heavily used by eastern wild turkeys, also primarily during fall and winter (Burk et al. 1990). Streamside zones at least 50 yards in total width appear to be necessary to provide adequate habitat for gray and fox squirrels (Dickson and Huntley 1987).

Small Mammals

Microhabitat features within SZ such as dense vegetation. fruits. seeds. down logs. and logging slash are important to small mammals (Dickson and Williamson 1988). Wider SZ may support small mammal communities associated with mature forests (Thurmond and Miller 1994). However, other studies have shown that characteristics of small mammal communities such as richness, diversity, and abundance can be similar across different SZ width-classes, or even higher in narrow strips (Dickson and Williamson 1988). Therefore, for small mammal communities, microhabitat features probably are more important than SZ width.

Herpetofauna

Obviously, SZ offer important habitat features for herpetofauna, such as pools of water, moist soils, down wood, and leaf litter. However, there are few data on these relationships, and results appear to vary. In eastern Texas, Rudolph and Dickson (1990) found the fewest amphibians and reptiles in narrow (less than 25 yards wide) strips and concluded that abundance of herpetofauna was positively related to closed-canopy conditions. But in Kentucky, Pais et al. (1988) found that herpetofaunal species richness was greatest in open, wildlife clearings while mature forest supported the fewest species. They concluded that herpetofauna richness was most affected by biomass of nonwoody vegetation and proximity to water.

Management

Retention of SZ in southern forests is positive for wildlife communities. Generally, streamside zones wider than about 50 yards total width appear beneficial for forest interior species, several important game species, and other species. Specific requirements of some species remain unknown.

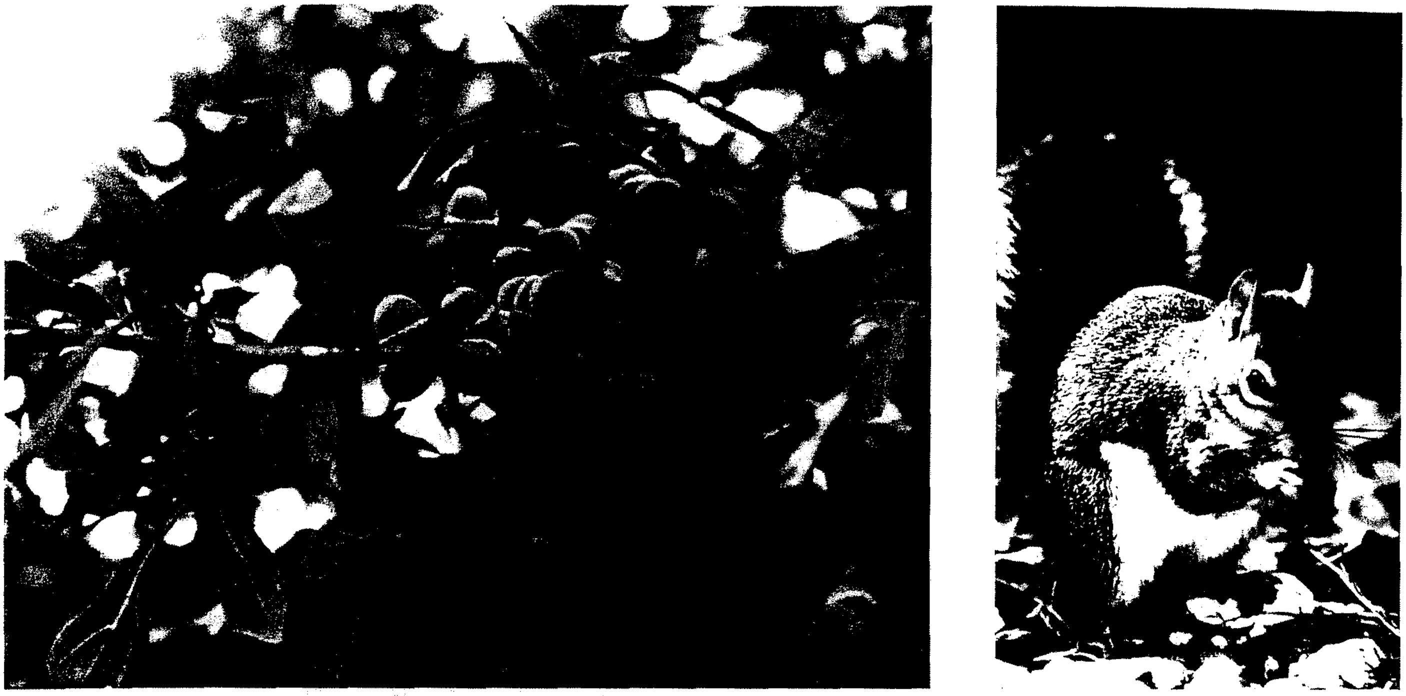
Extent and management of SZ should be considered in the context of economics and adjacent land use, as well as site-specific factors, such as topography, adjacent habitats, and stream width. Management of SZ, including silvicultural operations, could enhance habitat suitability for many wildlife species. For example, hard mast-producing oaks, soft mast-producing shrubs. or cavity trees could be featured. Or species regarded as pests, such as Chinese tallow tree, could be controlled.

STAND STRUCTURE AND COMPOSITION

Within-stand structure and composition are important factors in habitat suitability for many species. Structural features. such as stand overstory, understory, leaf litter. snags, and down wood, may be important to different species. In gross aspects, composition of stands affects suitability as habitat for species. In pine stands, a few species, such as red-cockaded woodpecker, pine warbler, and brown-headed nuthatch, are associated with pines. However, many other species are associated with herbaceous and hardwood vegetation (Johnston and Odum 1956, Dickson and Segelquist 1979). Thus, practices that promote hardwoods favor species, such as red-eyed and yellow-throated vireos in canopy-level foliage, and hooded and Kentucky warblers in understory foliage.

Oak mast is an important food for a number of species, such as white-tailed deer, wild turkey, black bears, gray squirrels, chipmunks, and wild pigs. But acorn production in oak-dominated forests can be quite variable from year to year (Greenberg in press), and can

Structure is important in determining habitat suitability of forest stands. This open stand is suitable for species associated with stand canopy as well as those associated with understory (US Fish & Wildlife Service).



Oak mast is an important food for a number of species, such as white-tailed deer, wild turkey, black bear, chipmunk and gray squirrel. But acorn production is quite variable from year to year *(H. Williamson, US Forest Service).*

range from several hundred pounds per acre to almost none in other years (Rogers et al. 1990). The white-oak group produces acorns in 1 growing season and red oaks in 2 growing seasons. Therefore, a variety of oaks and other hardwood species such as black gum provide diverse habitat and foods. But hardwood overstories and midstories intercept much sunlight, shading shrubs and limiting fruit production. Also, hardwood shading limits herbaceous ground vegetation (Blair and Feduccia 1977) and associated species.

HARVEST AND REGENERATION

Stand or tree harvesting can be a drastic habitat alteration (see Chapter 4, Defining the Forest). For example, bird species associated with forest canopy generally decreased and birds associated with patchy and early successional habitat increased following harvest (Webb et al. 1977). Of course, response of vegetation to harvesting depends on extent of tree. particularly overstory, removal. The more overstory removed the more profound the vegetative response. change in habitat suitability for wildlife. and change in wildlife community composition (Dickson 198 1). Single-tree selection harvesting affects stands and wildlife communities the least during each harvest. With this technique. stand structure remains mostly intact. However, uneven-aged management of southern pines requires more frequent harvest cycles and hardwood control. Clearcutting alters habitat and wildlife communities the most. With complete tree removal, forage and fruiting near the ground is increased many fold over that in shaded understories (Halls and Alcaniz 1968, Blair and Enghardt 1976). Group selection, shelterwood and seed tree cuts are intermediate in effects on habitat and wildlife communities, depending on the extent of stand removal.

SITE PREPARATION

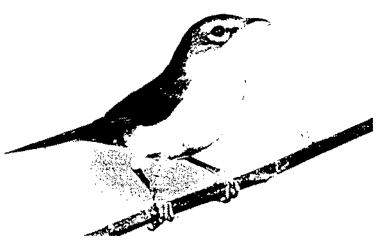
Site preparation includes measures conducted shortly before or after stand regeneration to reduce vegetation competing with pines. Moderate site treatment measures that delay development or modify non-pine vegetation can enhance vegetation diversity and wildlife habitat, particularly for early-successional species (White et al. 1975). For example, in East Texas after 3 growing seasons fruit production was lower on KG-bladed and chopped plots than on control or burned plots (Stransky and Halls 1980). But measures that severely reduce vegetation may be negative for many species of wildlife. Generally, the reduction of hardwoods in young stands favors herbaceous vegetation and species associated with that habitat type and disfavors the many species associated with the hardwood component of pine stands.

STAND DEVELOPMENT

Some species, such as white-tailed deer and northern cardinals, are tolerant of a wide range of habitat conditions Conversely, other species have more specific habitat requirements, and respond to changes in stand structure and composition as stands age (Buckner and Landers 1980, Dickson 1981). During the first year or two of development, stands usually are dominated by grass-forb vegetation. At this stage young pine stands are suitable habitat for some bird species, such as mourning doves (Lay and Taylor 1943), eastern meadowlarks (Johnston and Odum 1956), and prairie warblers (Dickson et al. 1995). Grass-forb vegetation also provides suitable brood habitat for newly-hatched chicks of primary game birds: northern bobwhites, wild turkeys and ruffed grouse, which depend on and feed extensively on arthropods. Also, populations of herbivorous and granivorous small mammals, such as cotton rats and *Peromyscus* spp., thrive in early successional habitat (Atkeson and Johnson 1979).

Normally within a couple of years, rapidly growing vegetation invades young stands. Timing and characteristics of this vegetation depend on site quality, prior land use, and source of revegetation, as well as herbicide and other site preparation treatments. In the South, young pine stands less than about 8 years old normally are characterized by diverse, lush herbaceous and woody vegetation. Forage production often exceeds 2,000 lbs per acre (Harlow et al. 1980), and fruit (soft mast) is abundant. For example, in eastern Texas Halls and Alcaniz (1968) found 7 common browse plants produced 32 times more fruit and 7 times more twig growth in the open than in the shade beneath a sawtimber stand.

Usually there is an abundance and variety of wildlife in young brushy stands. White-tailed deer fare well in this habitat with abundant browse and soft mast (Blymyer and Mosby 1977). In this dense habitat usually there is an abundance of herbivorous small mammals (Umber and Harris 1974, Atkeson and Johnson 1979). Also, there are abundant birds (Conner and Adkisson 1975, Dickson et al. 1995); typical breeding season species include field sparrows, yellow-breasted chats, white-eyed vireos, prairie warblers, and painted and indigo buntings (Johnston and Odum 1956, Dickson and Segelquist 1979, Dickson et al. 1995).



Usually there is an abundance and variety of wildlife in young brushy stands *(A. J. Dunning, Cornell Lab of Ornithology)*. Forage and soft mast production usually is high in these rapidly developing stands *(B. US Forest Service C. H. Williamson,)*.

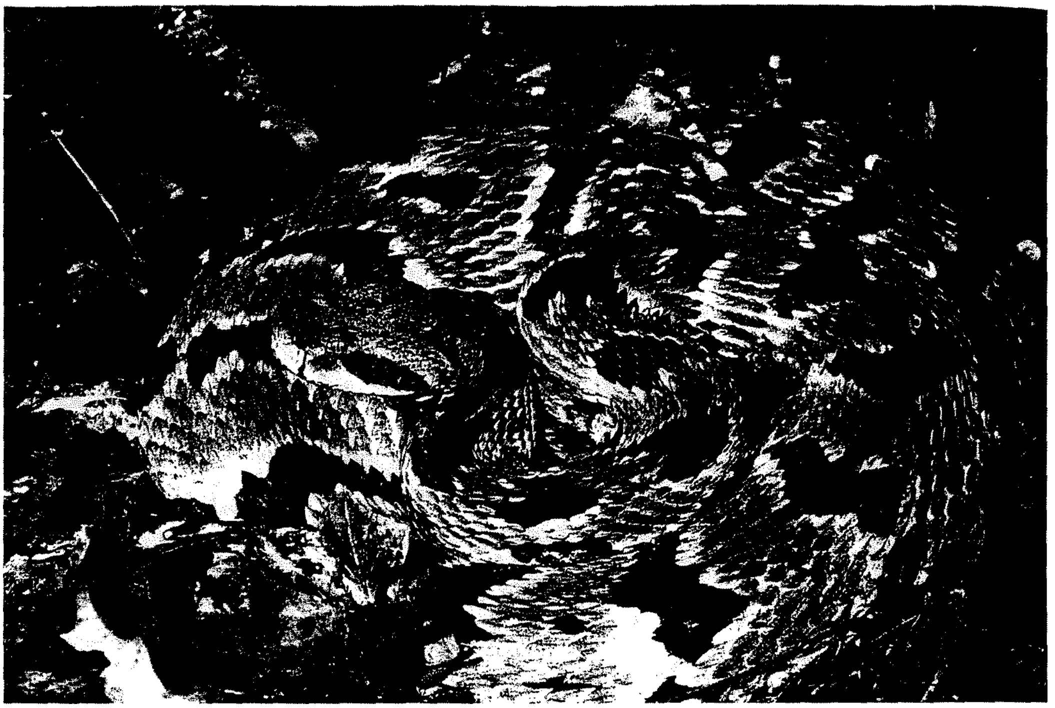
Young, dense, closed-canopy stands have little value for wildlife *(H. Williamson).*

As stands age and trees grow into the pole stage. suitability for wildlife changes. Some early successional species continue to use openings which have considerable hardwood or grass-forb vegetation. And some species associated with mature stands. such as yellow-billed cuckoos and red-eyed vireos in the canopies and hooded warblers in the understories. begin to inhabit stands with hardwood vegetation. In pine plantations about 7 to 10 years old or similar hardwood stands. pole-sized trees dominate the stand. canopies close. and shading by canopies drastically reduces vegetation beneath the canopies and fruit production of shrubs (Halls and Alcaniz 1968). Generally, habitat suitability for wildlife is reduced substantially. Usually there is little low vegetation, and bird (Dickson and Segelquist 1979) and small mammal populations (Atkeson and Johnson 1979) decline, and habitat suitability for deer and wild turkeys diminishes (e.g., Miller et al. 1999).

THINNING

Thinning is a silvicultural procedure typically conducted in stands with dense pole-sized trees. Up to ½ of the trees are removed to concentrate tree growth on the remaining crop trees. Tree removal opens up canopies and allows light into the understory. This promotes non-pine vegetation growth and fruiting, which is positive for many species.

As even-aged stands mature. some trees die and small openings develop. creating structural diversity. Also maturing trees produce mast. important to a number of species of wildlife. Generally suitability for wildlife is high in diverse mature stands, especially those with openings. For example. deer inhabit mature stands as well as stands of other ages. Gray and fox squirrels usually are abundant in mature hardwood stands. And there are high densities of breeding birds. such as yellow-billed cuckoo. tufted titmouse. red-eyed vireo. and summer tanager in mature hardwood stands, and brown-headed nuthatch. pine warbler. and red-cockaded woodpecker in mature pine stands (Dickson et al. 1995).



Logs and woody debris provide important habitat for a number of species of small mammals, amphibians, and reptiles, such as the timber rattlesnake, which hibernates in logs and also waits adjacent to logs for prey (C. Rudolph).

In stands designated for old growth, as stands approach old-growth condition habitat suitability changes. Tree fall creates openings and enhances stand diversity. Tree decay increases, which provides cavity and foraging substrate for cavity-using wildlife. And down material from trees provides structure on the ground inhabited by small mammals, and a variety of amphibians, and reptiles.

SNAGS AND DOWN WOOD

Snags, dead or partially dead trees, are used by and are important to a variety of wildlife species for nesting, roosting, foraging, perching, and other uses. Woodpeckers are primary cavity nesters that excavate cavities in snags. These cavities are used for nesting and roosting by primary cavity nesters and secondary cavity nesters, such as great crested flycatchers, wood ducks, and other species. including some mammals (Conner 1978).

Availability of cavities for nesting sites may limit some populations, and leaving or creating snags or artificial nest structures may accommodate some species. For example, in Arizona the number of cavity nesting birds declined by about half after conifer snags were removed during timber harvest (Scott 1979). In young pine plantations in the South. bird populations were increased by creating snags using herbicides (Dickson et al. 1993).

Snags may result from natural phenomena such as insects, disease, lightning, or other factors; or can be created through girdling, herbicides, or other means. Dead snags do not compete with crop trees for space, nutrients, moisture. or light. Recommendations for snag size and density for different species are presented by Evans and Conner (1979). But there may be some negative aspects of snags. They may be used as perches to search for prey by brown-headed cowbirds and raptors. Also, snags may pose a safety hazard for workers.

Artificial nest structures may accomodate cavity-nesting wildlife in local situations. For example, eastern bluebirds successfully nested in artificial nest boxes in a young pine plantation (Hurst et al. 1979). But widespread application is prohibitive for all cavity-using species.

Down wood, or woody material on the ground from dead limbs, snags. or logging debris, is an important structural feature. Wood on the forest floor in varying stages of decay may be instrumental in forest nutrient cycling, supports a wide variety of invertebrates, and is important to some species of vertebrates. Logs may harbor prey for some larger species, such as black bears. Small mammal populations may be closely associated with woody material on the forest floor (see Chapter 26. Terrestrial Small Mammals). Species of small mammals, such as *Peromyscus* spp. and eastern woodrats. use woody material for protection from prey and also as a source of food. Many species of reptiles and amphibians, including snakes, lizards, frogs, and salamanders, depend on woody material and some species are only found there. An important feature of down wood to these species is the moderate environment maintained by the physical protection from weather extremes. Logs are necessary for some species as a moist environment and to avoid dessication. Down wood also affords protection from predation, appropriate sites for reproduction, and suitable habitat to support prey populations (see Chapter 28, Reptiles and Amphibians). For example, timber rattlesnakes may hibernate in logs, use logs for protection, and often wait adjacent to logs for small mammal prey. Logs also are an important feature in small streams interspersing forests. They create structure in streams which benefits some fish species. And decaying logs provide stream nutrients and invertebrate prey for fish.

PRESCRIBED BURNING

Apparently fire has been a regular part of the southern landscape since the waning of the Pleistocene Period. Southern forests and the animals that inhabit them evolved with fire, and fire has had a major influence on communities of southern flora and fauna. Lightning-set fires have been a recurring force for thousands of years (Heyward 1939). Also, natives in the region used fire to manipulate vegetation and drive game for harvest, and European settlers used fire for the same purposes and to clear new ground for planting their crops. Prescribed burning continues to be used for a variety of purposes, including wildlife management. However, recent use has declined, mainly due to liability aspects and air pollution regulations.

Obviously, **fire** has the **potential to kill** animals. **However.** there **is little evidence of significant direct**

Prescribed burning has a long history in southern forests. It has been a major technique for the enhancement of wildlife habitat *(US Forest Service).*

mortality of vertebrates from prescribed burning (Landers 1987); and what does occur probably is insignificant on a landscape scale.

Some animals actually are attracted to the heat and smoke of fires, or to the burns shortly thereafter. Raptors, such as red-tailed hawks, kestrels, other hawks, and owls have been observed attracted to burns in search of prey (Landers 1987). Wild turkeys and mourning doves are attracted to new burns in search of exposed insects and seed. White-tailed deer are known to congregate on recent burns and lick the ash, apparently to obtain minerals.

Also, although our knowledge of fire effects is limited, arthropod populations and their interactions with vertebrates certainly are affected by fire (Landers 1987). It has been documented that parasites of wild turkey, northern bobwhite, and rabbits are reduced by burning.

Fire is commonly used to manage wildlife habitat in the South. Generally fire consumes the forest floor litter and sets back succession; usually reducing smaller hardwoods in favor of pines and herbaceous vegetation. Fire effects are quite variable because they involve condition of the area before burning and suitability for a wide variety of different communities or species; the intensity, periodicity, and seasonality of fires; landscape context and unburned areas, and numerous interactions. For example, areas burned annually for northern bobwhites are virtually devoid of hardwood shrubs, whereas areas burned occasionally with cool bums may be thick with hardwood sprouts. We approach this treatment by describing how fire may affect different forest stands or plants, and how that may affect different species of southern wildlife. Readers interested in fire effects on particular species are referred to appropriate chapters.

Prescribed burning normally is used in upland pine stands; mature pines are relatively fire resistant. Since fire causes wounds in hardwood trees it is not normally used in stands managed for quality hardwood timber. But fire affects hardwoods and their suitability for wildlife. Fire wounds on hardwood trees provide entrance for decay, that over time may become cavities used by animals such as tree squirrels. Severe fire may kill trees and create snags that are used by a variety of cavity-using wildlife. But conversely, dead snags used by cavity nesters may be consumed by fire. Fires severe enough to kill trees or cause snags to fall and produce woody debris on the ground would favor a variety of small mammals such as *Peromyscus* spp. Fires that consume woody debris on the ground, such as site preparation burns, would decrease area suitability for small mammals.

Prescribed fire is used for red-cockaded woodpeckers to reduce hardwoods and maintain a pine Savannah habitat. The birds peck cavity trees to produce a resin flow around the cavity and down the tree bole. Fire may ignite the resin up the tree bole of cavity trees and may even burn out and gut the nest cavity. So surface fuel around cavity trees may need to be raked away before burning.

Typically, frequent, intense, or growing season fire reduces small hardwoods and shrubs. Numbers of small mammals and rabbits probably are reduced with the cover reduction immediately after a fire. Birds associated with shrub-level vegetation and hardwood midstory, such as northern cardinal, Carolina wren, hooded warbler, and Kentucky warbler, probably would be reduced in response to shrub hardwood reduction (Dickson 1981).

This shrub-level reduction is accompanied by a growth flush of herbaceous vegetation which usually persists for a few years. This grass-forb growth with abundant seed production favors populations of early successional breeding bird species, herbivorous and granivorous small mammals, and provides important brood habitat for northern bobwhites, wild turkeys, and ruffed grouse. And the conditions maintained by burning should favor other species such as the gopher tortoise, which burrows in sunlit sites and forages on herbaceous vegetation resulting from fire (Landers 1987).

There is some evidence that the consumption of fuel can increase temporarily the nutrient content of post-fire vegetation, such as protein and phosphorus, which generally is limited in the South. This increase in nutrient content and palatability of plants could benefit a number of species, such as deer (Stransky and Harlow 1981) and rabbits, whose reproductive success may depend on forage nutrient quality (Hill 1972).

After a couple of years the post-fire herbaceous vegetation is gradually replaced by hardwood sprouts and shrubs. This transition affects vertebrate communities as detailed in the stand composition section of this chapter. Also, fruiting of shrubs recovering from fire and those benefitting from reduction of vegetative competition from fire increase. This fruit production benefits a number of fruit-consuming species, such as white-tailed deer, wild turkey, northern bobwhites, and some omnivorous furbearers, such as coyotes, foxes, opossums, and raccoons (Landers 1987).

HERBICIDES

Herbicides are used to control plants that are exotic. noxious, competitors with crop trees, or are otherwise undesirable. Growth of crop trees is enhanced through the reduction of competition (Autter and Miller 1998). Herbicides are applied at various times during a rotation such as during site preparation or thinning, and often are effective for vegetation control. For example, mechanical site preparation involves high equipment costs and may not be suitable for all landowners or sites. Vegetation control using herbicides is increasingly common because of: (1) increased availability of more selective and environmentally compatible chemicals; (2) rising costs and less available labor for alternative control methods; and (3) other considerations, such as liability, effects on productivity, and limited number of suitable days for burning (Miller and Witt 1991).

Although there have been concerns about possible environmental and human-health effects, forest chemicals generally are a minor source of water contamination (Ice et al., 1998), and are generally not associated with cancers or genetic abnormalities in wildlife (USDA Forest Service 1984, Miller and Witt 1991). Acute and chronic doses affecting wildlife are well above those of normal herbicide applications in forestry, and chronic levels are not reached because of the low persistence of forest herbicides (Morrison and Meslow 1983). Herbicides usually degrade within days or weeks, and they pose no significant toxic hazard when applied at recommended rates (Melchiors 1991).

But herbicides affect the structure and composition of plant communities, and subsequently, wildlife habitat and associated wildlife communities. For example, Dickson et al. (1983, 1995b) found that herbicide-created snags increased the diversity and abundance of birds in young forests in eastern Texas. Increased complexity and abundance of understory vegetation following herbicide application may result in increased abundance of small mammals (McComb and Rumsey 1982). Although few data are available, amphibians likely respond to herbicide-induced changes in microclimate such as humidity and temperature of the forest floor.

Herbicide effects on plant community structure and composition, and wildlife habitat differ with the herbicide used and a host of other factors. For example, phytotoxicity of tebuthiuron has been demonstrated to vary with soil texture, precipitation. and application rates (DeFazio et al. 1988). Application methods (banded, broadcast spray, pellets. injection) also can be important. Obviously, target-specific application, such as injection or banded spraying, will have less impact on plant communities than broadcast methods.

Usually, woody vegetation is reduced and herbaceous vegetation is increased following herbicide application (Hurst and Palmer 1988, DeFazio et al. 1988). McComb and Hurst (1987) report that some wildlife foods, such as fruiting from shrubs, can be adversely affected by herbicide application, and some, such as grass seed, can be enhanced by it.

Increasing pine growth through herbicide application can decrease the time until the overstory canopy closes and understory cover is reduced from shading. Dalla-Tea and Jokela (1991) observed that 6-year-old pine plantations receiving total vegetation control intercepted about 60% of photosynthetically active radiation compared to about 30% for plantations receiving no vegetation control.

In mid-rotation or mature forests, herbicides can be used to achieve specific structural or compositional objectives for wildlife. For example, herbicides can be used to reduce overstory cover, increase cover in the lower foliage levels, or alter the litter layer (McComb and Hurst 1987). Snags for wildlife can be created using herbicides, however herbicide-created snags usually deteriorate and fall in several years in the humid South (Dickson et al. 1995b, Cain 1996).

Even though herbicides alter plant communities, those effects often are apparent for only a few growing seasons (Hurst and Blake 1987, Copeland 1989). Miller and Chapman (1995) concluded that differences occurred in plant and associated animal communities following treatment with hexazinone, imazpyr, and picloram+triclopyr, but those differences were short-lived, and treatment-related differences generally were no longer evident at 5 years post-treatment.

FERTILIZATION

Forest fertilization with nitrogen or phosphorous is increasingly common for managers seeking to increase tree growth and yield in pine and hardwood forests (Jokela and Stearn-Smith 1993). Fertilizers are commonly applied at the time of stand establishment and at mid-rotation. Of course, productivity gains vary with soils, application timing and rates, and other factors.

Fertilization with nitrogen has been shown to improve first-year survival of pine seedlings by as much as 15% (Irwin et al. 1998). In pine stands, applications of nitrogen and phosphorous produce larger growth responses than applications of either element alone. With fertilization in young stands, rapid tree growth reduces the time until canopy closure and shortens the rotation.

Most investigations of how fertilization affects wildlife have focused on responses of deer forage. On many sites in the South, nutrient content and digestibility of wildlife forage are limited (Blair et al. 1977). Although understory vegetation is affected by factors such as overstory and other conditions (Conroy et al. 1982, Blair 1982), biomass and nutrient content of understory vegetation generally increase following fertilization (Dyess et al. 1994, Haywood and Thill 1995, Hurst et al. 1982, Wood 1986). Also, studies have shown that diversity and fruit production of selected plant species groups are highest on fertilized sites (Campo and Hurst 1980). Although plant community responses to fertilization generally are positive, they usually are temporary, lasting only 2-3 growing seasons (Wood 1986). Furthermore, gains in biomass and nutrient content may be mitigated by decreased time until canopy closure.

CONCLUSION

There are abundant and diverse wildlife communities inhabiting southern forests. These communities and the species comprising them are largely determined by habitat characteristics at the landscape level and the smaller, stand scale. Natural processes, such as plant succession, and the wide variety of human activities which affect landscape composition and stand structure, play a large role in determining the composition and status of vertebrate communities of southern forests. Broad measures, such as the retention of streamside zones, benefit a number of species, and specific measures, such as species restoration, can be employed to address particular conservation concerns.