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Management of Early-Successional Communities in Central Hardwood Forests

With Special Emphasis on the Ecology and Management of Oaks, Ruffed Grouse, and Forest Songbirds

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CHAPTER 1—INTRODUCTION

In this paper we describe the ecology and management of young forest communities in the Central Hardwood Region. We refer to these young forest communities as early-successional forest because they are in the early stages of forest regeneration or growth following a disturbance. We focus on early-successional species here for several reasons. In general there is concern about the status of forest wildlife in eastern forests because of the loss, fragmentation, or change in forest habitats as a result of land-use practices such as land development, agriculture, and forest management. Some of the forest-dwelling species that are declining specialize in early-successional forest habitats. These include the ruffed grouse (chapter 3), several neotropical migratory songbirds (chapter 4), and the American woodcock (Bruggink and Kendall 1995).

A second reason to be concerned about these species is that their habitats are dependent on disturbance, and humans have altered historic disturbance patterns and created new ones. Early-successional forest habitats are transitory or ephemeral because they change over time as a result of forest growth and succession. This means the community is dependent on repeated disturbances (a disturbance regime) to create or maintain habitat. Disturbance from fire, wind, insects and disease, timber harvest, and other land-use practices have been an important part of the history of central hardwood forests and to a large extent have determined the composition and structure of present-day forests. Within the last 200 years, there have been significant changes in the disturbance patterns of these forests due to changes in land-use and forest management.

Additionally, an understanding of the ecology and management of these species is needed because of significant public interest in both consumptive and non-consumptive uses. There is also significant public and private interest in timber harvest, one of the primary disturbance factors that creates early-successional forest. In addition, forest resource management and the harvest of forest products receive a great deal of public interest, particularly on public lands. Our focus on management for early-successional forest communities should not detract from the need for other habitats or communities. For example, there is great concern for some species that live in mature forest as well as great concern for the extent and distribution of old-growth forest in this region. We offer some approaches to integrating conflicting habitat needs such as early- and late-successional forest in landscapes and regions.

We focus on oak-dominated forests within the area defined as the central hardwood forest (Clark 1989) (fig. 1). This area is within the area of the oak-hickory forest type as defined by the Society of American Foresters (Eyre 1980) and the eastern-broadleaf forest province of the National Hierarchical Framework of Ecological Units (McNab and Avers 1994). Although, our specific focus is on oak-hickory forest, much of the information presented applies to other forests in the Eastern U.S. in which oaks are an important component.

A focus on management for oaks in central hardwood forests is important from both a

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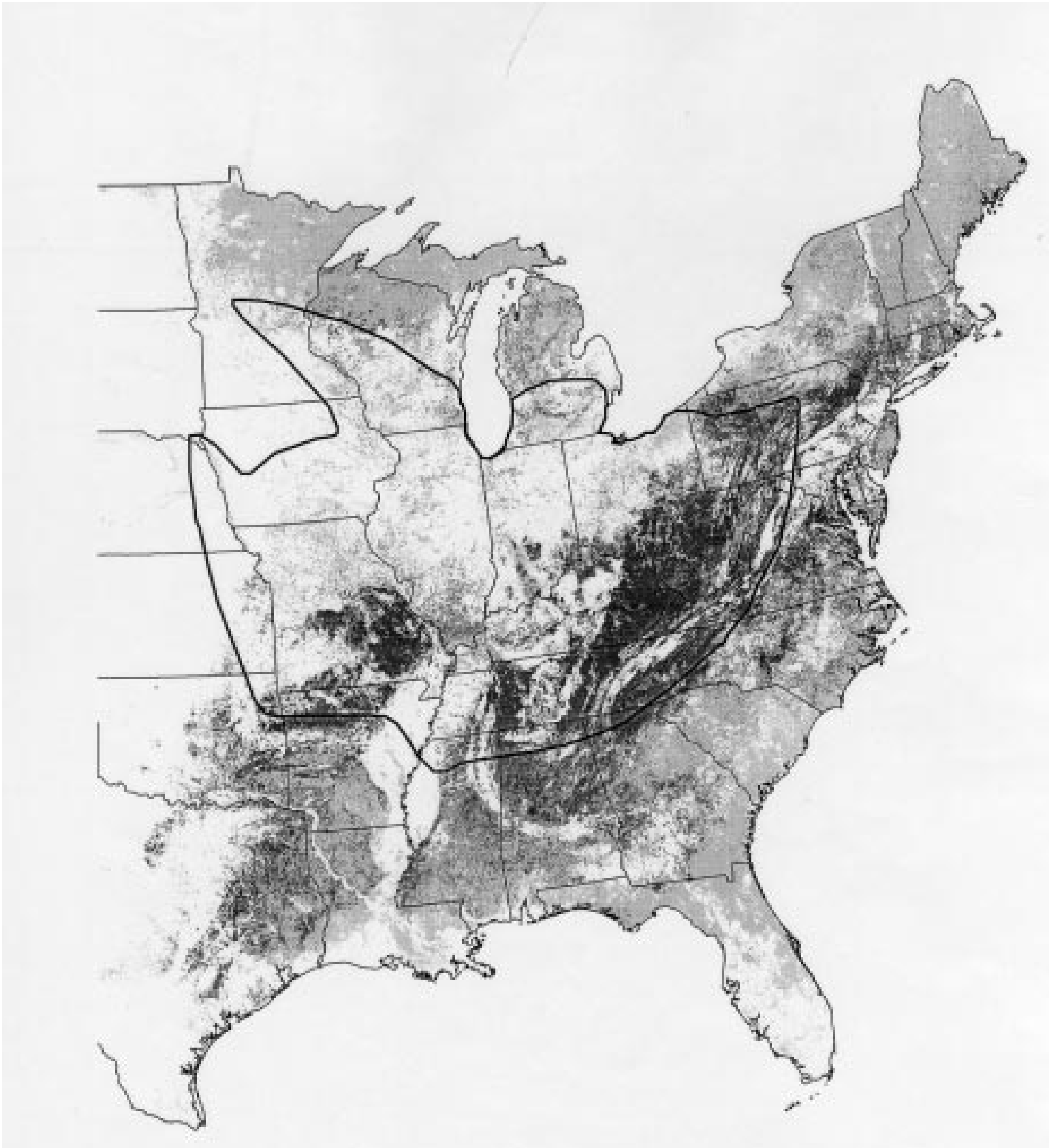


Figure 1.—*Distribution of forest in the Eastern United States. Oak-dominated upland forest is shown as dark gray, all other forest as light gray. The extent of the Central Hardwood Region (as defined by Clark 1989) is outlined in black.*

wildlife and silvicultural perspective. Oaks have a fundamental role in central hardwood wildlife communities. Acorns are at the base of a complex ecological web that affects the regeneration and abundance of oaks, the abundance of mast-consuming wildlife, the predators and parasites of mast-consuming species, and the abundance of defoliators and decomposers of oaks (Healy *et al*., in press). Acorns and other seeds represent the most valuable and energy-rich plant food available to eastern wildlife in the dormant season (Robbins 1993). Acorn production is often 3 to 10 times greater than browse production in oak forests (Rogers *et al*. 1990, Segelquist and Green 1968). Oak has increased in importance as a food for eastern wildlife because of the elimination of American chestnut and decline in American beech. A focus on oak management is important not only because of its value to wildlife but also because of its dependence on disturbance for regeneration. Some form of active forest management will be required to maintain oak as an important component of future forests (Healy *et al*., in press).

In chapter 2 we review the distribution, history, ecology, and silviculture of the central hardwood forest. In chapters 3 and 4 we describe important aspects of the ecology and management of the ruffed grouse and early-successional songbirds. In chapter 5 we suggest forest management strategies for early-successional communities within the context of maintaining the native biological diversity of the Central Hardwood Region. In the remainder of the introduction, we review relevant principles and terms of landscape ecology and forest management that are applicable to management of early-successional communities.

Basic Principles and Terms

Because of the ephemeral nature of early-successional habitats, their distribution in time and space is important. Natural and human-induced disturbances and succession change the availability and location of habitat for early-successional wildlife. This means that wildlife requirements need to be planned for over long time periods and large areas. The distribution of regenerating oak stands is important from a silvicultural perspective as well. Sustained yield of timber products and early-successional habitat is dependent on the frequency of timber harvest and its spatial distribution.

A **habitat** is an area with the appropriate combination of resources (food, cover, water) and environmental conditions for the survival and reproduction of a species. We refer to several spatial scales when discussing habitats and land management planning. A **habitat patch** is a contiguous block of habitat. Its size is relative based on the definition of habitat, which can be specific to a particular animal or plant. So, a habitat patch can be a group of shrubs and saplings in a gap created by a blowdown or a 1,000-acre island of forest surrounded by cropland. Habitat patches are often considered analogous to **stands**. Stands are commonly defined as a contiguous group of trees sufficiently uniform in species composition, age structure, and condition to be distinguished as a unit (Smith 1986). A **landscape** consists of a group or mosaic of habitat patches and usually is a large area. Often landscapes are considered to be areas ranging from thousands to tens of thousands of acres. Forest management is often regulated at scales referred to as compartments, districts, or forests, which can often be considered landscapes. And, finally at a larger scale, we will discuss regions. **Regions** are often defined geographically, such as the Midwestern or Southeastern U.S., or they are defined ecologically, such as the Central Hardwood Region. A regional scale is often important when talking about the geographic distribution of a species or when comparing patterns among landscapes.

For reasons already stated, landscapes are an important scale at which to consider habitat for early-successional forest wildlife. Habitat quality is affected by two general factors at a landscape scale, **landscape composition** and **landscape pattern**.

Landscape composition is the amounts of habitats present in a landscape and can be thought of as **habitat availability** within a landscape. Forest managers often evaluate landscape composition based on the distribution of forest age classes. Landscape pattern is a result of the **arrangement of habitats** or spatial distribution in the landscape. The spatial distribution of habitat patches in a landscape can affect the habitat quality of those patches or of the landscape as a whole. Landscape pattern is determined by the amount, size, shape, and location of habitat patches. Another important component of landscape composition or habitat availability is **temporal availability**. Ecological succession and disturbances will cause landscape composition to change through time so temporal availability must be considered in habitat management.

Early-successional forest habitats are created by natural or human-related disturbances. These disturbances, and the resulting habitat, create diversity or variety in a landscape. A diverse landscape provides habitat for many different species as well for species that require more than one type of habitat. Too much habitat diversity, however, can reduce the quality of some habitats for some wildlife species as habitat patches become small and fragmented. **Habitat fragmentation** is a process that results in increased habitat discontinuity by breaking up blocks of habitat. It ranges from the creation of small disturbance patches within a large block of habitat to widespread habitat loss resulting in small, isolated patches of habitat. Habitat fragmentation can have positive or negative effects on wildlife, depending on the wildlife species of interest, the overall landscape composition and structure, and the level or scale of fragmentation. Populations in small isolated habitat patches or in fragmented landscapes can be less viable than those in larger patches or more contiguous habitat. Reasons for this include large area requirements (home range), effects of small population size, and competition or predation from animals in adjoining habitats. Some species are considered area sensitive because they are not present in small patches of habitat due to the effects of habitat fragmentation or because they avoid small habitat patches (Faaborg *et al.* 1995, Robinson and Wilcove 1994).

Habitat fragmentation results in an increase in the amount of **edge**. Edge is the border or ecotone between adjacent habitats. Several patterns or processes, often referred to as **edge effects**, may occur at edges. Edge effects can include changes in animal and plant diversity or abundance, increased interactions among species from adjoining habitats, (predators, competitors, parasites, and humans), and changes in the micro-climate.

Forest fragmentation is a general term that refers to the fragmentation of forest habitats by non-forest habitats. High levels of forest fragmentation have negative consequences for many forest wildlife species. Forest songbirds are often absent from highly fragmented forests, and some species, while present in fragmented landscapes, have lower reproductive success there. Although no studies have directly investigated the effects of forest fragmentation on ruffed grouse, these birds also presumably suffer from the effects of fragmentation. Small forest patches are not large enough to sustain populations of grouse, and grouse eggs and chicks are prey for many of the same predators that depredate forest songbird nests in fragmented landscapes. Also, grouse dispersing in fragmented landscapes are likely to move through insecure cover and may be susceptible to predation.

Forest habitat can be defined more finely based on species requirements and can reflect differences between successional stages, age classes, or forest types. Forest management activities, including the regeneration of forest stands, fragment forest **habitats**. Previously we discussed fragmentation of forest by non-forest habitats. Forest management practices maintain forest habitat in general, but fragment forest age classes, forest types, or habitats. For example, the use of regulated clearcutting will create patches of young forest mixed with mature forest, and forest habitats will be more fragmented than if the entire landscape were the same age. Similarly, silvicultural practices can change tree-species composition and forest type, again fragmenting forest habitats. It is this issue of habitat fragmentation resulting from the creation of early-successional forest habitats that is often controversial with the public and land managers.

This type of habitat fragmentation creates forest habitat diversity and can have positive and negative consequences for forest wildlife. It has positive effects for early-successional wildlife or species that require habitat diversity because it creates patches of early-successional forest amidst older forest habitats. It has negative effects on late-successional wildlife because it results in a loss of late-successional forest habitat. Scientists have debated whether this level of habitat fragmentation results in some of the other negative consequences of forest fragmentation, such as edge effects. Most evidence suggests the primary effect of this type of habitat fragmentation is changes in the availability of early- and late-successional forest (Thompson 1993, Thompson *et al.* 1996). Forest habitat fragmentation is generally ephemeral because of forest succession; forest fragmentation resulting from the conversion of forest to non-forest land uses is usually more permanent.

CHAPTER 2—CENTRAL HARDWOOD FORESTS

Oak-hickory forests cover approximately 127 million acres (51 million ha) in the Eastern U.S. and make up 34 percent of eastern forests (fig. 1). Approximately 82 percent of this forest land is owned by non-industrial private landowners, 6 percent is in National Forests, 6 percent is held by other public owners, and 6 percent is owned by the forest products industry (fig. 2) (Powell *et al.* 1993).

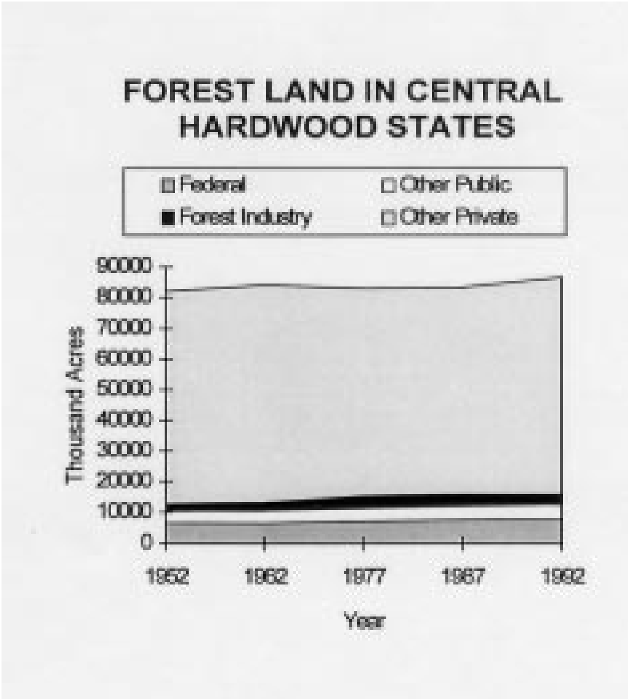


Figure 2.—*Trends in area of forestland by ownership classes in eight states that make up most of the Central Hardwood Region (IA, IL, IN, MO, OH, PA, TN, WV).*

Oak-hickory forests dominate the Central Hardwood Region but give way to mixed hardwoods in the north and in the Appalachian Mountains, and to oak-pine forest to the south (Eyre 1980, Sander and Fischer 1989). Bottomland hardwood forests extend into the region as well. Dominant tree species in oak-hickory forests are white, black, scarlet, and northern red oak. Other overstory trees are southern red, post, blackjack, chinkapin, bur, and northern pin oak; bitternut, mockernut, pignut, and shagbark hickory; black gum; yellow poplar; red and sugar maple; white ash; elms; American beech; black walnut; and black cherry. The most common understory trees or shrubs are flowering dogwood, sassafras, redbud, serviceberries, eastern hornbeam, American hornbeam, Witch-hazel, blueberries, mountain-laurel, rhododendron, and beaked hazel (Braun 1950, Eyre 1980, Sander and Fischer 1989).

The oak-pine forest type is very similar to the oak-hickory type except shortleaf, loblolly, pitch, and Virginia pine make up 25 to 50 percent of the forest. Mixed hardwoods are typically found on moist, relatively productive sites primarily east of the Mississippi River. Principal species are yellow poplar, white and northern red oak, and sugar maple. Many other species are usually present including white ash, black and chestnut oak, red maple, black gum, basswood, buckeyes, black walnut, black cherry, and hickories. Common understory species include flowering dogwood, eastern redbud, rhododendron, serviceberries, sourwood, and sassafras (Braun 1950, Eyre 1980, Sander and Fischer 1989).

History and Ecology

The central hardwood forest has been changing since the end of the last glaciation. Oaks, however, have dominated the region for the last 6,000 years (Lorimer 1993). The rate of ecological change has accelerated since European settlement. Deforestation and conversion of lands to agricultural land uses over the last 200 years, the exclusion of fire during the 20th century, and the introduction of exotic diseases and insects have greatly affected forest communities (see review by Hicks 1997). The chestnut blight fungus eliminated American chestnut from eastern forests during the first half of this century. American elm and American beech have also been greatly reduced in abundance by insects and pathogens (Healy *et al.*, in press). Oaks have maintained their dominance over the last 6,000 to 9,000 years, but they are now losing dominance in the overstory of many mesic (moist) sites whose understories are usually dominated by shade-tolerant species (Fralish *et al*. 1991).

Frequent and uncontrolled burning of oak forests ended less than a century ago in the Missouri Ozarks to several hundred years ago in the Eastern U.S. There is some debate about the extent fire has affected oak forests (Beilmann and Brenner 1951, Steyermark 1959). Some evidence suggests that historic disturbance by Native Americans in the southeast was substantial (DeVivo 1991). Forest disturbance by Native Americans throughout Eastern North America was greatly reduced after their populations declined precipitously during the 16th and 17th centuries (Hicks 1997). In the Missouri Ozarks, fires occurred frequently between 1785 and 1810 during a period of influx of Native Americans and European explorers. This period was followed by a period of decreased fire frequency beginning with an exodus of Native Americans around 1815 (Guyette and Cutter 1991). Frequency and extent of fires in Missouri forests are further substantiated by evidence of vast oak savannas, which historically covered an estimated one-third of the State (Nelson 1985). Repeated burning of oak forests in the more humid regions to the east was also common (Day 1953, Komarek 1974, Little 1974, Lorimer 1989). From an ecological perspective, the current control of fire is likely the single most significant human-induced alteration to the central hardwood forest landscape.

Logging had substantial impacts on the central hardwood forests throughout the 1800's. For instance, with the influx of settlers into the Ozarks from 1850 to 1874 came the railroad and a period of accelerating logging during the 1880's (Smith and Petit 1988). The lumber boom came to an end in the Ozarks in the early 1900's and much of the land was sold by lumber companies sight unseen through the mail as farmland. During the period 1860-1899, more than 42 million acres of central hardwood forest were converted to agricultural land use (Williams 1989). Widespread burning and open range grazing of the forest occurred up until the 1930's in parts of the region.

The presettlement and early settlement history indicate the Central and Eastern States were heavily impacted by humans, and the widespread abundance of oak today is largely a result of this disturbance history. Many of today's oak-dominated stands are successional in nature and will likely convert to other forest communities in the absence of continued disturbance (Johnson 1993, Parker and Weaver 1989).

Since the early 1900's the amount of forest land in the United States has remained fairly constant. Within the Central Hardwood Region, forest land area has remained fairly stable since the 1950's and has more recently shown a slight increase (fig. 2). To the south and east there are small declines in forest land (Powell *et al*. 1993). The increase in forest land is primarily the result of farmland and pasture reverting to forest. There are also trends in forest composition indicating central hardwood forests are becoming older and shifting to shade-tolerant species such as maple and beech (Raile and Leatherberry 1988, Smith and Golitz 1988).

The Regeneration Ecology of Oaks

Oaks are generally intolerant to moderately tolerant of shade. Many of their associates such as maples, blackgum, elms, beech, dogwood, and redbud are much more shade tolerant. The dominance of oaks in many forests is therefore dependent on canopy disturbances that allow light to reach the forest floor as well as on the ability of young oaks to quickly gain a competitive position in the canopy.

In most years nearly all oak flowers and oak acorns are destroyed by insects, fungi, or animals. Occasionally, usually following a bumper acorn crop, enough seed survives to produce seedlings. Oak seedlings grow very slowly and, unless released by a canopy disturbance, cannot compete with other species. In xeric (dry) ecosystems, oak reproduction tends to accumulate in the understory of the parent stand. The repeated dieback and sprouting of oak seedlings appears to be important to oaks because it allows seedlings to survive and develop a large root mass. Accumulation of young oaks may occur over several decades, resulting in populations of seedlings and seedling sprouts that originated from several sporadic acorn crops. These seedling sprouts are capable of rapid and competitive growth when there is a significant reduction in the density of the canopy (Johnson 1979, Johnston 1941). Such events can result from fire, windthrow, insect- and disease-related mortality and defoliation, drought, and timber harvesting.

Accumulation of oak reproduction under the parent stand is one of the most important aspects of the regeneration ecology of oaks. This accumulation of small oak trees is called "oak advance reproduction" because it is present in advance of a regeneration harvest. Oak advance reproduction largely determines the composition of the next stand and the combination of advance reproduction, seedlings, and stump sprouts represent the oak "regeneration potential" of a stand (Sander *et al*. 1984). Sustaining oak-dominated forests thus depends on perpetuating preestablished reproduction from one generation to the next. Oak reproduction does not need to be present at all times in a stand but should be present when the stand is regenerated.

Recurrent fire promotes the accumulation of oak reproduction by eliminating or reducing the number of fire-sensitive understory competitors, including shrubs and shade-tolerant trees, and by killing overstory trees with thin, fire-sensitive bark. In addition, fire kills stems of oak reproduction, which increases the root:shoot ratio of those that survive by resprouting. Oak reproduction is well adapted to surviving fire because of the concentration of dormant buds near the root collar. These buds often remain an inch or more below the soil surface where they are protected from potentially lethal temperatures (Korstian 1927).

Not all oak-dominated ecosystems require fire or disturbance to be sustained. Many xeric oak forests appear to be relatively stable communities that show little evidence of succession to more shade-tolerant or mesophytic species. Probably the largest North American ecosystem of this type occurs in the Ozark Plateau in Missouri where oak reproduction may accumulate in the understory for 50 years or longer. However, even in this ecosystem, the capacity of oak reproduction to accumulate varies with topographic features such as slope position and aspect, which collectively control light, heat, and soil moisture (Sander *et al*. 1984).

There is a general relation between site quality and regeneration success: ironically, the better the site the more difficult it is to regenerate oaks (Arend and Scholz 1969, Loftis 1990b, Lorimer 1989, Trimble 1973). Obtaining the accumulation of oak reproduction necessary for successful regeneration on highly productive sites requires recurrent disturbance. Historically, fire created the necessary conditions. Thus, one potential solution to sustaining oak-dominated forests on productive sites is prescribed burning. Based on a review of research results on prescribed burning in eastern hardwoods and southern mixed pine-hardwood stands, Van Lear and Waldrop (1988) concluded that fire, if correctly employed, has the potential to create the necessary conditions for sustaining oak-dominated forests on productive sites.

Oak Silviculture

Many forests in the Central Hardwood Region will likely succeed from oak-dominated forests to forests comprised primarily of shade-tolerant species. Most silvicultural systems when applied to oak-dominated forests will maintain a hardwood forest of which oak is a component. The cutting or regeneration method used, however, will determine to what degree oaks are replaced by other species. Generally, where the objective is to perpetuate oaks, even-aged management has been accepted as the most appropriate regeneration method. Group-selection cutting, however, is increasingly being used where smaller canopy disturbances and partial cutting methods are desired.

Even- versus uneven-aged management

Regeneration methods can be classified as those that produce either even-aged forests or those that produce uneven-aged forests. Even-aged stands typically have one dominant age-class of trees (which may vary in diameter) and generally a level, closed canopy. An uneven-aged stand contains three or more age classes and trees of various diameters and height (fig. 3). The canopy of an uneven-aged stand is distinctly irregular in height. The clearcutting, seed-tree, and shelterwood methods are used to regenerate even-aged stands, and the single tree or group selection methods are used to regenerate uneven-aged stands (Smith 1986). Recently there has been increased interest in the management of two-aged stands, and silvicultural methods for two-aged stands are under development.

Clearcut method

Where adequate advance oak reproduction exists, clearcutting will produce rapidly growing fully stocked stands containing oaks, hickories, and other shade-intolerant species as well as some tolerant species. The better the site quality, the more difficult it will be to regenerate oaks. Clearcutting is most successfully used on relatively dry sites where oak reproduction naturally accumulates in the understory. It is often unsuccessful in regenerating oaks on mesic sites (Beck and Hooper 1986, Gammon *et al*. 1960, Johnson 1976, Loftis 1983b). Failures are largely because oak advance reproduction does not accumulate under the heavy shade of the parent stand. Where clearcutting fails to regenerate oaks, other commercially valuable species often become established. In many mesic ecosystems where adequate advance oak reproduction is not present, clearcutting will accelerate the succession of oak-dominated forests to mixed-mesophytic forests (Johnson 1993).

The shelterwood method

The shelterwood method may be useful on sites where advance oak reproduction is not present. The shelterwood method involves the removal of a stand in a series of partial cuttings. It is useful in regenerating oaks on mesic sites because it controls stand density near the end

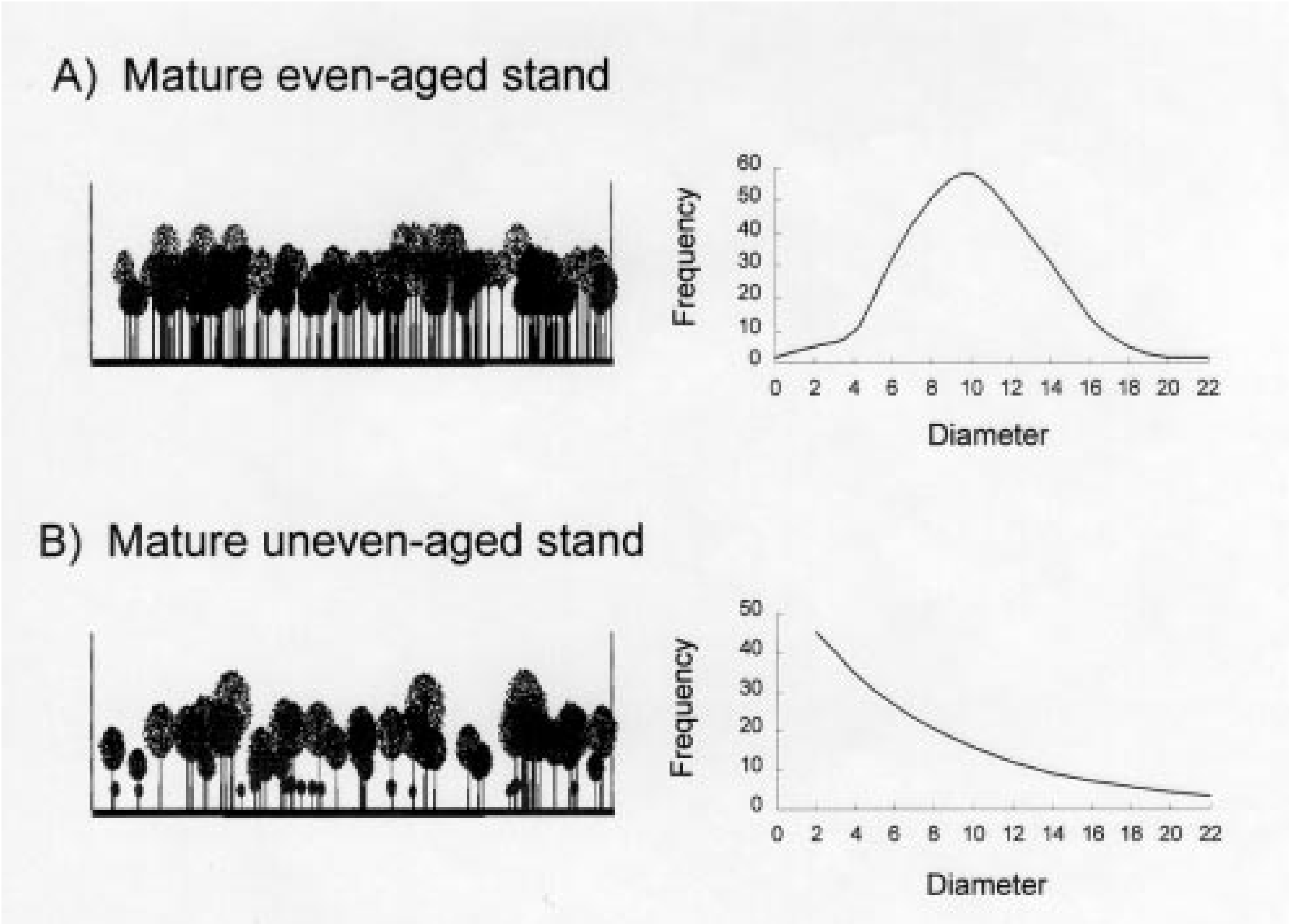


Figure 3.—*Cross-sections of A) a mature even-aged stand, and B) an uneven-aged stand and their respective tree-diameter distributions.*

of the rotation when oak reproduction needs to accumulate. Natural reproduction or planted-oak seedlings maintain their viability under the partial canopy of the parent stand and are released by the final harvest.

The shelterwood method has been moderately successful in regenerating oaks. The initial shelterwood cut reduces the basal area by about 70 percent. Herbicides or prescribed burning may be needed to reduce competition from shade-tolerant trees in the understory and to increase survival of oak reproduction (Loftis 1990b). When adequate oak advance reproduction is present, a final cut removes the remaining overstory. The accumulation of adequate oak advance reproduction may take anywhere from 1 or 2 years on dry sites to 10 or more years in mesic forests (Johnson 1993, Loftis 1990a, Sander 1989). Planting of oak nursery stock can also be used in conjunction with the shelterwood method to make up for a deficit in natural oak reproduction (Johnson 1989).

The seed tree method

The seed tree method is an even-aged method that usually leaves 10 or fewer seed-producing trees on every acre (Smith 1986). The seed tree method is not appropriate for regenerating oaks because successful regeneration is dependent on the amount of advance reproduction and not seed production after the harvest. Seed trees left after the tree harvest would contribute very little to the regeneration of oaks but may be desirable if sustaining acorn production (for wildlife) on harvested areas is important. The regeneration method in this case is the clearcut method with trees retained for values other than regeneration.

Selection methods

Selection methods maintain a range of tree-age classes and diameters in a stand. Selection cutting is regulated by a diameter distribution curve. The target diameter distribution is determined by the largest diameter tree to be retained in the stand, the q-value, and the desired residual basal area or stocking level. The q-value represents the average quotient between the number of trees in consecutive diameter classes and essentially determines the steepness of the curve. A stand with a q-value of 1.3 will have more large trees than a stand with a q-value of 1.7. Generalized guides exist if an inventory cannot be conducted and a diameter distribution curve constructed (Law and Lorimer 1989). Stands can be harvested whenever stocking exceeds 80 percent. On most average to good sites, this should be every 15 to 20 years. Stands regenerated by selection methods retain many more large trees than stands managed with even-aged regeneration methods, and maintain some of the attributes of mature forest. Because they retain significant amounts of canopy, however, they do not provide many of the attributes of early-successional communities.

The group-selection method—The group selection method can be used to regenerate oaks. Trees are marked for harvest with a target diameter distribution in mind for the stand. Some trees are harvested in small groups to create small regeneration openings. Just as with clearcuts, openings should be located where there is sufficient advanced oak reproduction. The openings provide the necessary light for intolerant species like the oaks to gain a competitive advantage over more shade-tolerant species. Recommended opening size ranges from 1/10 acre to 1/2 acre (Law and Lorimer 1989, Marquis 1989, Roach 1963). Larger openings should be referred to as patch cuts or clearcuts if the objective is to perpetuate these as even-aged units through successive rotations (Marquis 1989). As with clearcut or shelterwood treatments, the reproduction that develops in the openings depends on the advance reproduction present at the time the opening is created (Sander and Clark 1971).

The single-tree selection method— Trees are harvested across all diameters to maintain a desired diameter distribution, but there is no intentional effort to create regeneration openings as in group selection. The single tree selection method generally has been considered inappropriate for managing oak forests (Sander and Clark 1971). Canopy openings the size of individual trees presumably provide inadequate light for the accumulation of oak reproduction. The method also encourages the development of a shade-tolerant understory. The ecological and silvicultural literature generally substantiates these assertions, although virtually all the related studies were in mesic ecosystems where oak reproduction apparently did not accumulate (Della-Bianca and Beck 1985; Schlesinger 1976; Trimble 1970, 1973).

The method has nonetheless been used successfully for 50 years on a large industrial forest in the Missouri Ozarks (Loewenstein *et al.* 1995), and the diameter distribution of this forest approximates the classical reverse J-shaped distribution characteristic of an all-aged forest (Loewenstein 1996). The key to the success of this method may lie in the large number of small diameter oaks typically found in xeric ecosystems such as the Ozark Highlands (Johnson 1993). In contrast, the smaller diameter trees in mesophytic oak forests are likely to be shade-tolerant non-oaks; small diameter oaks are typically absent (Loftis 1983a). Guidelines are currently being developed for use of the selection method in the Ozark Highlands (E. Loewenstein, personal communication), but it is not recommended for more mesic, eastern parts of the Central Hardwood Region.

Alternative methods

A number of alternative silvicultural systems and revised practices are currently under development in response to increased public concern over the ecological effects (whether real or presumed) of traditional forestry practices. This includes the use of shelterwoods without final removal cuts as well as management of two-aged stands, which retain more residual structure than clearcutting, but usually fewer residual stems than the traditional shelterwood method.

Diameter-limit cuts are frequently used on private non-industrial forest lands. Individual trees of marketable species that exceed a certain diameter are harvested. This method retains forest cover on a site while removing marketable trees. Unlike the previous silvicultural methods, however, the focus is on the harvest and not on the regeneration or structure of the future stand. Because the largest trees of desirable species are removed, the slower growing trees and undesirable species make up the residual stand. This may have serious negative impacts on forest composition and structure. Diameter limit cuts may exacerbate oak regeneration problems and typically do not provide habitat for most early-successional species.

CHAPTER 3—HABITAT AND ECOLOGY OF THE RUFFED GROUSE

Distribution

The ruffed grouse (fig. 4) is North America's most widely distributed gallinaceous bird (Johnsgard 1973). Ruffed grouse can be found throughout a significant portion of the Central Hardwood Region, yet are common only where extensive tracts of forest dominate the landscape (fig. 5). The predominately agricultural landscapes in the Farm Belt that extends from central Ohio westward through Indiana, Illinois, Missouri, and Iowa are largely inhospitable to ruffed grouse. Here, scattered populations exist only along wooded river drainages or other areas where sufficiently large tracts of forest exist. Ruffed grouse are found in central hardwood forests throughout the southern parts of these States as well as Kentucky, Tennessee, parts of Arkansas, and the central and southern Appalachian Mountains. The southern extreme of the range of ruffed grouse is consistent with the southernmost edge of the Appalachians in northern Georgia. Ruffed grouse are generally uncommon below 1,500 feet (460 m) in the extreme southeastern part of their range even though habitats that appear suitable exist in the Piedmont from Louisiana east to Georgia and north through Virginia. In Kentucky, central Virginia, and further north, the impact of elevation on ruffed grouse distribution becomes less pronounced than in more southerly latitudes. This may indicate that warm southern climates are inhospitable to ruffed grouse.

Figure 5.—*Distribution of the ruffed grouse in the Eastern United States. Modified from Johnsgard (1973) with input from State wildlife management agencies.*

Status in Central Hardwood Region

The ruffed grouse has a fragmented distribution throughout the Central Hardwood Region except in the largely contiguous forests of the Appalachian Mountains. This distribution is

Paul Carson, The Ruffed Grouse Society

Figure 4.—*The ruffed grouse, perhaps more than any other resident wildlife, is an early-successional habitat specialist. While often thought of as a bird of northern forests, its range extends throughout the Central Hardwood Region and southern Appalachian Mountains.*

largely the result of land-use patterns and active efforts to restore ruffed grouse populations. Efforts to restore grouse populations began in the late 1940's and have occurred throughout the Central Hardwood Region. These efforts have successfully restored some populations, however, local extirpations of ruffed grouse populations are likely to occur periodically throughout this region because of the fragmented habitat, its location near the edge of the grouse range, generally low grouse densities, and the successional nature of required habitats.

There is no range-wide population survey of ruffed grouse, but many States monitor populations or harvest rates. Surveys of drumming male grouse show some distinct patterns in grouse numbers. Densities of drumming male grouse are lower in the Central Hardwood Region, and the Southeast in general than in the northern portion of the grouse range (figs. 6, 7). Approximately 4 to 6 birds can be expected in the fall population for each drumming male identified in the spring. Central hardwood populations do not show the strong cyclic fluctuations exhibited by northern populations

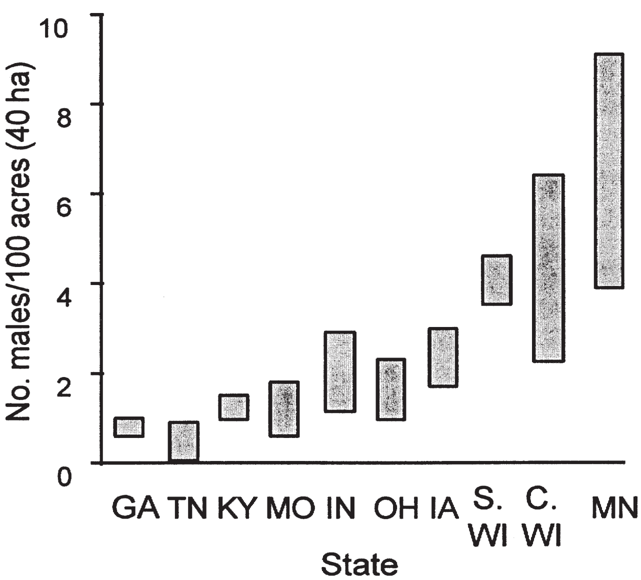


Figure 6.—*Densities of drumming male ruffed grouse in nine Eastern States. Data sources: Georgia, Hale* et al. *(1982); Tennessee, Boyd (1990); Kentucky, J. Sole (unpubl. data); Missouri, Hunyadi (1984) and F. Thompson (unpubl. data); Indiana, Backs (1984); Ohio, Stoll and Culbertson (1995); Iowa, Porath and Vohs (1972); southern Wisconsin, Rodgers (1981); central Wisconsin, Kubisiak (1985); northern Minnesota, Gullion (1984).*

(fig. 7). Central hardwood populations in Indiana and Ohio may have declined over several decades (fig. 7). Hunter flush-rate data from Ohio, Tennessee, and Virginia also indicate long-term declines in these States' ruffed grouse populations, while West Virginia and North Carolina show periodic fluctuations but no consistent long-term trends.

Ruffed grouse population densities in the central hardwood forests seldom reach levels attained in the aspen forests of the Great Lakes region (fig. 6). The reasons for this pattern of abundance are likely related to differences in the forest composition and climate. Aspen, an important component of northern forests, provides a unique combination of food and cover that is not provided by central hardwood species. Note that, in general, population densities are greater in the northern portion of the Central Hardwood Region than in the south. Ruffed grouse can, however, be locally abundant in this region where quality habitats exist.

Habitat Use and Annual Cycle

Ruffed grouse are habitat specialists. Although they can survive in various forest communities, they are common only on extensively forested landscapes that include numerous young (< 15 years old), even-age hardwood stands. Optimum ruffed grouse habitat is most often created through the drastic disturbance of mature forest stands by processes such as timber harvest, fire, blowdown, or by succession of open lands back to forest. The high stem densities characteristic of these stands (5,000 to 8,000 or more stems/acre) protect ruffed grouse from predators and enable local populations to attain levels substantially higher than on landscapes dominated by mature forest (Gullion 1984a, Kubisiak 1985, Stoll *et al.* 1979). Perhaps more than any other year-round resident wildlife, ruffed grouse are early-successional forest specialists.

Early-successional forest provides several important habitat components. Most important is the low-dense overhead cover provided by high densities of saplings and tall shrubs. Overhead cover protects grouse from their most important source of mortality—avian predators. The shade cast by dense overhead cover precludes the growth of a dense herbaceous understory, providing grouse with both unobstructed movement and the visibility needed to detect approaching predators.

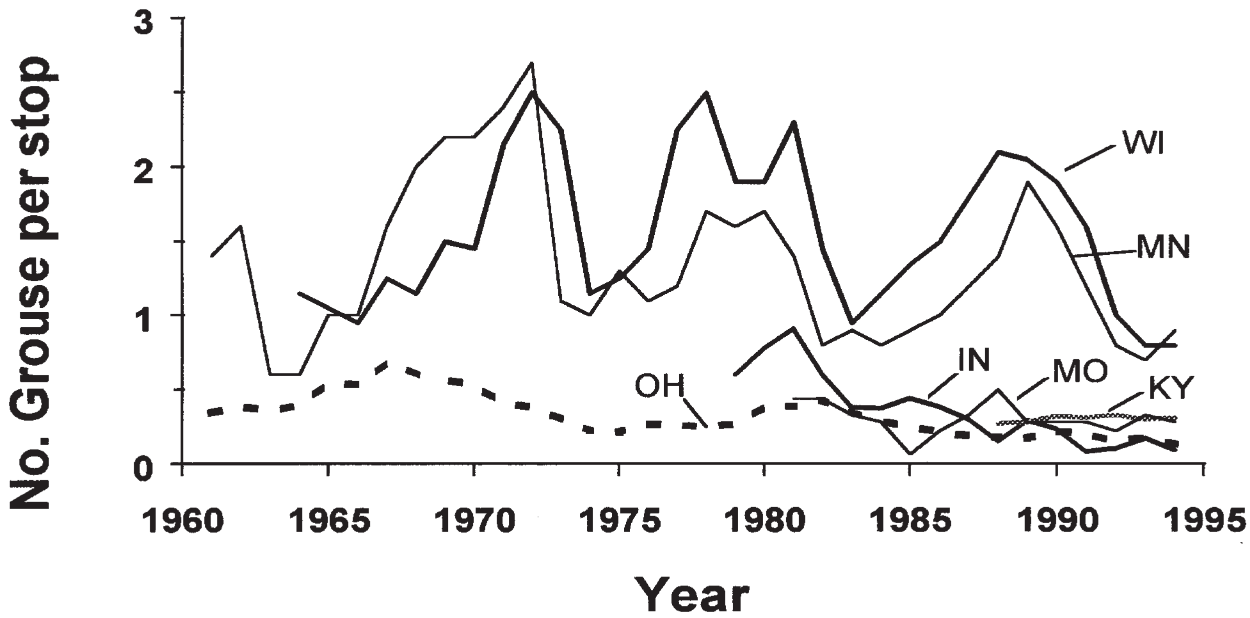


Figure 7.—*Trends in ruffed grouse abundance determined by surveys of drumming males. Data provided by State wildlife management agencies. Data may not be comparable between States due to differences in survey methods.*

Ruffed grouse habitat needs vary during the year and between males and females and young and adults. It is easiest to understand these differences by following the birds through their annual cycle. The breeding season occurs in the spring. Male grouse drum to advertise their presence to females and male competitors. In the Central Hardwood Region, drumming is usually at its peak during March and April. Hens visit males during this period and initiate nesting in early or mid-April. Broods hatch throughout May and into early June. Hens spend the summer with their broods, and juvenile birds disperse in the early fall. Grouse are primarily solitary during the winter, although they will sometimes concentrate in good habitat to take advantage of locally abundant food sources.

Subtle differences sometimes exist between quality brood habitat and habitats frequented by adults throughout much of the year. In general, habitat requirements for nesting appear to be imprecise; nesting hens can be found in a wide variety of habitats.

Year-round adult cover

Optimum adult cover usually consists of young regenerating forest or shrub cover. This dense, almost impenetrable cover protects grouse from the host of predators with which they must contend. The dense overhead cover provides protection from hawks and owls and shades out ground cover, enabling grouse to detect mammalian predators. Dense, young forest stands are especially important to drumming males advertising their presence to nearby females. The visual and auditory displays of a performing male are designed to draw attention to the bird. Drumming habitat must provide dense overhead cover for protection from avian predators while providing good visibility at ground level so a displaying male can detect approaching mammalian predators or other grouse. A male's activity center, the area that encompasses his drumming platform or platforms, is typically the most structurally dense and, therefore, the most secure site available.

Grouse are sometimes observed in more open cover, usually because they are traveling between habitat patches or feeding on a particularly attractive food. Grouse are more susceptible to predation in open cover, and on average, grouse densities will be higher where all habitat components are provided in close proximity to dense protective cover.

In the Central Hardwood Region, adult cover is provided by habitats such as regenerating oak or mixed hardwood forests, advanced stages of old-field succession with sapling and pole-size hardwoods and eastern redcedar, and older oak or mixed hardwood stands with dense understories of shade-tolerant shrubs or tree reproduction (Atwater and Schnell 1989; Dimmick *et al.*, in press; Stoll *et al.* 1979; Thompson *et al.* 1987; Triquet *et al.* 1988).

Regenerating hardwood stands provide the highest stem densities and most secure cover. Six- to 15-year-old stands generally provide excellent adult cover (fig. 8). A 10-year-old upland-oak stand on average will have from 2,400 to 6,800 tree stems/acre, 1 to 2 inches d.b.h. (diameter at breast height), and 7 to 21 feet tall (Schnur 1937). The variation is largely due to site quality (site index); poor sites will have higher densities of smaller stems than better quality sites. Total stem densities, including all shrubs and trees >1m tall, often range from 6,000 to 25,000 stems/acre (Kurzejeski *et al.* 1987, Laubhan 1987, Stoll *et al.* 1979). Resource Managers are often interested in regenerating a high density of oaks because of their commercial and wildlife value. From the perspective of grouse cover, tree species composition is less important than a fully stocked sapling stand of hardwoods. Oaks, however, also provide an important food (acorns) in the Central Hardwood Region. In the Great Lakes Region, adult cover is usually provided by dense stands of aspen saplings 6 to 15 years old, or older stands with dense understories of alder or hazel.

Old-field habitats are the result of land abandonment. These habitats are composed of invading hardwood trees such as oaks, sassafras, persimmon, yellow poplar, hickory, ash and maple; shrubs such as dogwoods, multiflora rose, blackberry, hawthorn, and honeysuckle, as well as conifers such as eastern redcedar. Old fields usually do not have the uniformly distributed high stem density that regenerating forest does, but this may be partially compensated for by the low dense evergreen growth of eastern redcedar or low canopies of trees such as hawthorn and dogwood. Redcedar has unique value as winter cover in portions of this region and is found almost exclusively in this habitat. Old-field habitats also have a diversity of fruit-producing shrubs and trees that provide important foods for grouse and other wildlife.

Ruffed grouse populations in the Central Hardwood Region seldom are confronted by prolonged, severe winter weather conditions characteristic of northern latitudes. However, brief periods of ice, snow, and extreme cold can be expected during most winters. Contrary to what might be expected, it is the lack of deep snow during most winters throughout the Central Hardwood Region that can stress ruffed grouse. As temperatures drop below freezing in the north, ruffed grouse escape the cold and potential predators by burrowing into the snow until they are completely covered. Snow conditions are rarely suitable for snow-roosting in the Central Hardwood Region. Conifers with a dense canopy such as spruce, fir, or redcedar can provide thermal protection for ruffed

Figure 8.—*An example of good year-round adult cover and a drumming log in a 10-year-old oak-hickory stand in central Missouri.*

grouse, as can evergreen shrubs - rhododendron and mountain laurel. In Missouri ruffed grouse strongly prefer redcedar trees as a winter roost, and birds roosting in redcedar loss less heat and save more energy than those in hardwood cover (Thompson and Fritzell 1988).

Another component of adult cover is the presence of suitable drumming platforms. Preferred drumming platforms are typically large-diameter (>10 inches [25 cm]), partially decayed fallen logs > 10 feet (3 m) in length. Rocks, stone fences, upturned roots, and other elevated perches are also used as drumming platforms. In hilly terrain, logs oriented along the contour provide a relatively level platform and are most likely to be used by displaying males. Although ruffed grouse activity centers can be located anywhere on a hillside, quite often males select upper slopes or benches near the top or the base of the ridge where the slope is < 25 degrees (Boag and Sumanik 1969, Porath and Vohs 1972, Rodgers 1981, Stoll *et al*. 1979, Thompson *et al*. 1987, Triquet *et al*. 1988).

Nesting cover

A hen grouse sitting on a nest is well camouflaged and predators are likely to pass by without detecting her. As a result, a key habitat feature is visibility. This allows hens to watch predators and determine when or if she needs to flush and potentially expose her nest. Nests are usually next to a tree or log, perhaps to provide cover in the one direction the hen can't see. Other than visibility and proximity to brood and adult cover, there are no other apparent requirements of nesting cover. Nesting cover is frequently located in pole-size, or larger, hardwood stands. These older stands generally have good ground-level visibility because their closed canopies shade out understory and ground vegetation. In most forested areas nesting cover is readily available but it is important that it be close to secure adult cover and brood habitat.

Brood cover

Broods, like adults, need suitable cover for protection from predators. They also need an abundant high protein food source to support rapid growth. Grouse chicks, like the young of many other birds, feed heavily on insects during the first few weeks of life. Throughout much of the grouse range, broods are seldom found far from dense protective cover characteristic of regenerating forest stands or shrub-dominated old-field habitats. Broods are often found in 3- to 7-year-old regenerating stands that still have a significant herbaceous component. These habitats are often more "patchy" and support more herbaceous ground cover than adult cover. Brood habitat is often more mesic than adult cover, often along creek bottoms, alder swales, or lower north or east slopes (Thompson *et al*. 1987). Small herbaceous openings with a significant shrub component provide an important source of insects for developing chicks.

Grouse Foods

Grouse eat a wide variety of buds, catkins, fruits, and leaves. Their diet varies from region to region. Grouse populations in the Central Hardwood Region are more likely to be limited by a lack of quality winter forage than northern populations (Servello and Kirkpatrick 1987). Catkins and buds of yellow and paper birch, hazel, and especially quaking and bigtooth aspen are important winter foods throughout the northern part of the grouse range. Central hardwood forests contain few species of trees or shrubs that support catkins that are readily available to feeding grouse. Aspen is an important winter food because grouse can quickly fill their crops foraging in trees and then return to secure cover or snow burrows.

Grouse depend more on soft and hard mast and leaves for their fall and winter diet in central hardwood forests than in northern forests (Korschgen 1966, Norman and Kirkpatrick 1984, Thompson and Fritzell 1986). Grouse may spend considerable time and energy feeding on these foods because of the greater difficulty of foraging in fruiting shrubs or searching for succulent vegetation and other food on the forest floor. Also, important foods such as hard mast (acorns, hickory, and beech nuts) are not often found in dense, young forest stands. Therefore, to take advantage of these foods, grouse must forage in relatively open, mature stands and increase their exposure to potential predators. Soft mast, the fleshy fruits from dogwoods, grapes, greenbrier, hawthorn, serviceberry and many other fruiting plants, is readily consumed by ruffed grouse.

Insects make up the majority of the diet of ruffed grouse chicks during their first 4 to 6 weeks of life. Insect abundance is greater in open habitats dominated by herbaceous vegetation than on the forest floor beneath a closed canopy (Bump *et al*. 1947, Hollifield 1992). These herbaceous openings can provide an abundant source of insects for young chicks. Unfortunately, foraging in an opening is unsafe for ruffed grouse, and the potential benefits of herbaceous openings must be weighed against the likelihood of increased predation. Young forest regeneration cuts or old fields that contain patches of herbaceous ground cover as well as dense shrub and sapling cover are ideal brood habitat because they provide both food and cover.

CHAPTER 4—EARLY-SUCCESSIONAL FOREST SONGBIRDS

Early-successional forest habitats provide food, cover, and nest sites for a variety of songbirds. Some of these species are specialists that depend on dense shrub-sapling cover, while others are generalists that use a wide range of habitats. Some are abundant, while others are declining and there is a high level of concern for their conservation.

Birds that nest in shrubland or young-forest habitats make up an important component of the midwestern avifauna. Probst and Thompson (1996) compiled information on midwestern neotropical migratory birds. They identified species for which there was a high degree of management concern and species that were declining in numbers. Of 187 species that breed in Midwestern North America, 95 use shrub-sapling or young-forest habitats to some degree during the breeding season (fig. 9).

Population trends of some common early-successional forest birds are shown in figure 10. Of the 12 species depicted in figure 10, the brown thrasher, prairie warbler, yellow-breasted chat, indigo bunting, and rufous-sided towhee show significant long-term declines.

Habitat Associations of Early-successional Forest Songbirds

Midwestern, early-successional birds use a wide variety of shrubland or young-forest habitats ranging from semi-forested grasslands, such as glades, barrens or savannas; old fields; and young forest resulting from silvicultural treatments. General habitat requirements of some common birds in central hardwood forested and semi-forested habitats are shown in figure 11.

Several distinct habitat components of early-successional forest are used by songbirds.

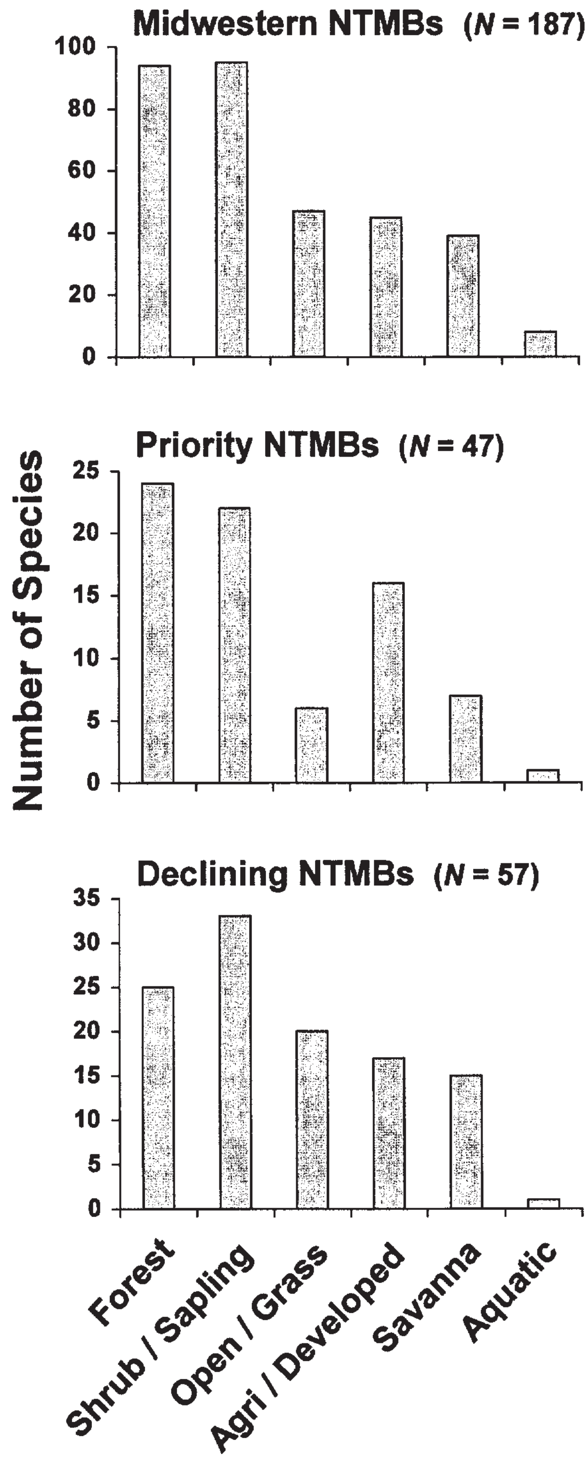


Figure 9.—*Number of neotropical migratory birds, priority neotropical migratory birds, and declining neotropical migratory birds in the Midwestern United States grouped by major breeding habitats. Priority species are species considered a high management concern based on abundance, distribution, population trend, and known threats. Declining species had a significant (P<0.1) negative population trend based on the Breeding Bird Survey. Adapted from Probst and Thompson (1996).*

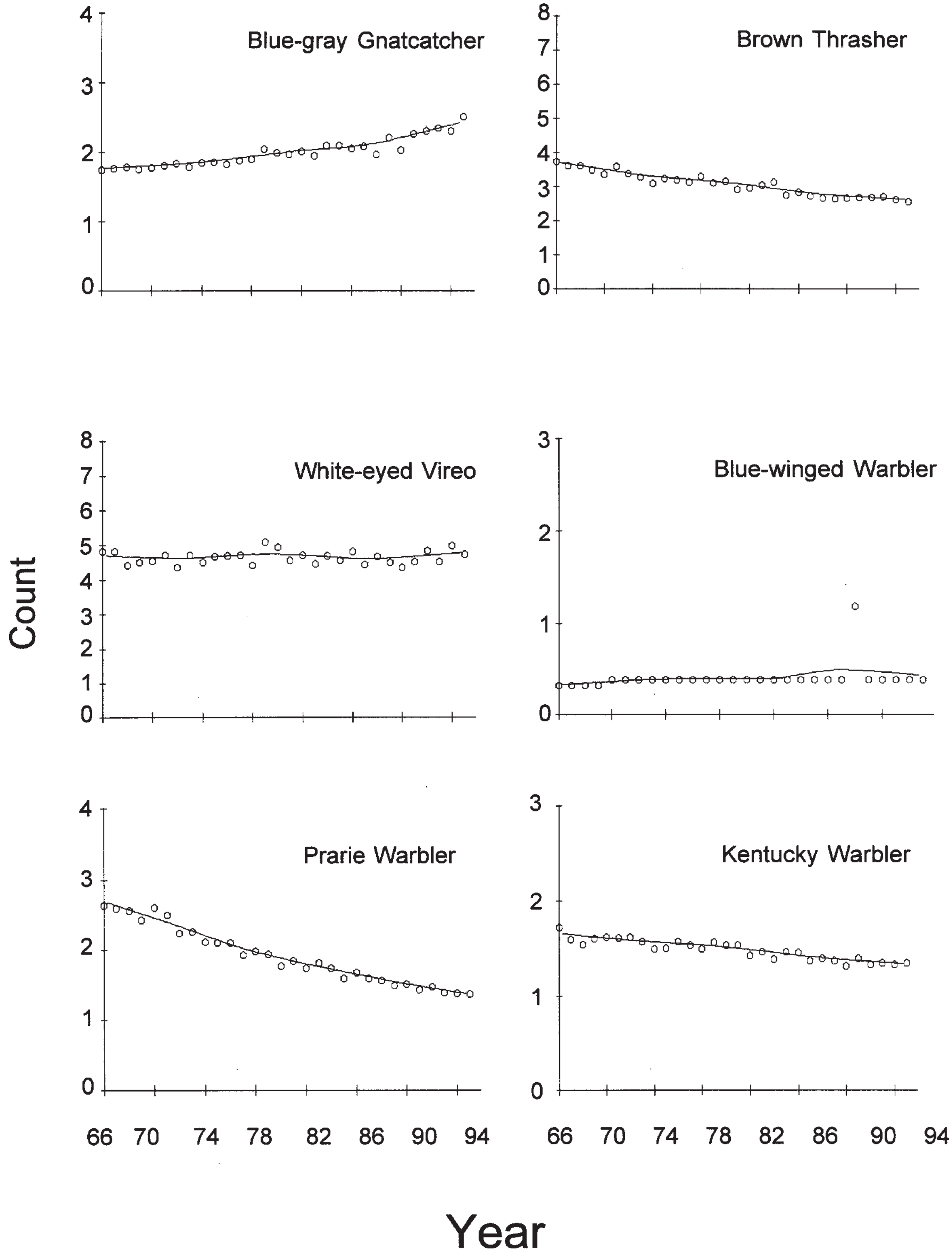
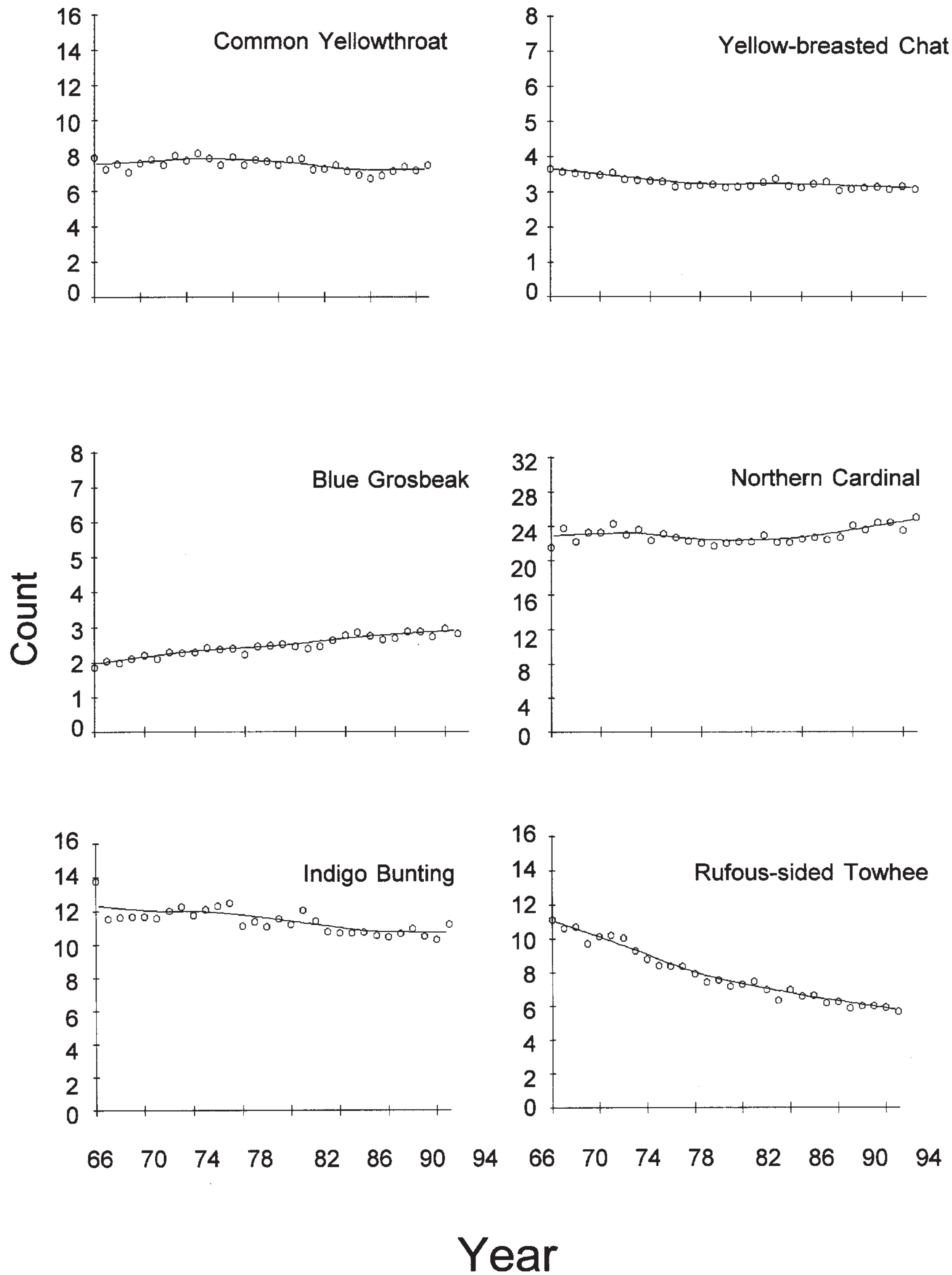


Figure 10.—*Population trends of common breeding songbirds in early-successional forest habitats in North America. Data are from the North American Breeding Bird Survey (Bruce G. Peterjohn, National Biological Service, Patuxent Environmental Center, Laurel, Maryland).*


Common Yellowthroat
Yellow-breasted Chat
Blue Grosbeak
Northern Cardinal
Indigo Bunting
Rufous-sided Towhee
Count
66 70 74 78 82 86 90 94
Year

During the early stages of forest regeneration (1 to 3 years after canopy removal), these habitats have dense clumps of grasses and herbaceous vegetation that are used for nesting and foraging by species such as the prairie warbler and field sparrow. As seedling-sapling-size trees and shrubs grow, they begin to shade out ground cover. Regenerating stands support a very diverse and abundant bird community during this stage because there is a mix of grasses, forbs, shrubs, and tree reproduction. Species such as the yellow-breasted chat and blue-winged warbler are common in such stands. This stage of stand development, however, lasts only a few years (approximately 3 to 9 years after regeneration) before the canopy closes and much of the groundcover succumbs to shade. Species such as the wood thrush, ovenbird, and worm-eating warbler begin to use these stands within 10 to 20 years after they are regenerated.

Residual Structure in Regenerating Stands

Snags, slash, and residual live trees that were not removed during timber harvests are also important habitat components in early-successional forests. Snags, woody debris, and some large live trees from the previous stand provide habitat features needed by certain species and increase within-stand diversity in deciduous and coniferous stands (Balda 1975, Dickson *et al*. 1983, Niemi and Hanowski 1984, Scott 1979). Snags are used for nesting and feeding. Primary cavity nesters such as woodpeckers excavate their own nest cavities. Secondary cavity nesters such as bluebirds and great-crested flycatchers use existing natural cavities or cavities excavated by primary cavity nesters. A wide variety of species feed on snags or use them as perch sites. Residual live trees in regeneration cuts provide structure for open canopy species such as blue-gray gnatcatchers, northern orioles, and yellow-billed cuckoos, or species from surrounding forests such as red-eyed vireos and some flycatcher species (Probst *et al*. 1992). However, tree regeneration and shrub stem densities can be reduced if too many live residual trees are left standing, thereby reducing habitat quality for species dependent upon structurally dense habitats.

There has been some speculation that snags or residual trees might provide perches for brown-headed cowbirds (a brood parasite) and nest depredators (such as blue jays and crows). Nest predation and parasitism can be high for some birds nesting in early-successional forest (Annand and Thompson 1997), so this could be a real concern. Clustering residual trees or leaving them near the periphery of the stand could reduce the effective use of these by cowbirds and predators. Large stands with a higher area to perimeter ratio will also have less forest edge and fewer potential perch sites for cowbirds and predators.

Habitat Patch Size

In addition to habitat structure, the size of a patch of early-successional forest influences the bird community. Some species of songbirds that breed in early-successional central hardwood forest have strong preferences for specific patch sizes. Patch-size preferences generally fall into two categories: species that prefer small patches created by small disturbances that remove one to several trees, or species that prefer large contiguous patches of at least 3 to 5 acres. Small gaps can be created by windthrow, single tree deaths due to insects or disease, or by selection cutting. Hooded and Kentucky warblers prefer small gaps created by single-tree or group selection methods, and many other late-successional forest species are also abundant in these stands. Large patches of at least several acres are created by large-scale windthrow, high intensity fires, insects and disease, and even-aged regeneration methods. Yellow-breasted chats, prairie warblers, blue-winged warblers, and white-eyed vireos are typically found in stands regenerated by the clearcut or shelterwood method but not in those regenerated by selection methods (fig. 11, Annand and Thompson 1997).

Importance of Landscape Context

In addition to habitat structure and patch size, landscape context may also be an important factor affecting the quality of early-successional forest habitat for songbirds. Landscape context refers to the overall landscape composition and pattern within which a specific habitat is located or being considered. Forest songbirds, including those that nest in mature or young forests, have higher reproductive success in landscapes that are predominately forested. Patches of early-successional forest habitat located within heavily forested landscapes may be of more value to these species than habitats in agricultural landscapes. This may seem contrary to many managers' ideas of habitat for these species because they are often associated with forest edges bordering agricultural fields, and are sometimes referred to as "edge species." Species nesting in agricultural landscapes, however, have a greater risk of brood parasitism by brown-headed cowbirds or nest depredation by predators (Donovan *et al.* 1995a, 1997; Robinson *et al.* 1995; Thompson *et al.*, in press).

CHAPTER 5—FOREST MANAGEMENT PRACTICES FOR EARLY-SUCCESSIONAL WILDLIFE

Resident and migratory birds use a wide range of forested and semi-forested habitats in central hardwood landscapes. Even when management activities are focused on a reduced set of high priority or featured species, these species still span a wide range of habitats. Conservation planning is further complicated when lands are managed for multiple use, including recreation and forest products. Land managers and the public should recognize that management of any particular landscape will benefit some species and harm others, but that across landscapes the needs of all species can be met. Thompson *et al.* (1996) suggest that a mix of even- and uneven-aged silvicultural practices, designated reserve areas, and use of prescribed fire will be required within the Central Hardwood Region to meet bird conservation objectives and other objectives for forest lands. Even if we narrow our focus to species found in early- successional forest created by silvicultural practices, a mix of regeneration methods will be needed to meet species habitat needs (Annand and Thompson 1997). Thompson *et al.* (1996) used a simple landscape model to demonstrate how most regulated, sustainable forest management practices likely will sustain most species across a landscape. Species abundances, however, differ greatly among alternatives.

Depending on forest ownership, legal mandates, historical landscape composition, and management objectives, practices that create early-successional habitats or produce forest products will be appropriate. Regulated forest management with standards and guidelines for wildlife, practiced within an adequate forest landbase, can accommodate the needs of central hardwood forest songbirds.

Importance of Extensively Forested Landscapes

Fragmentation of forest by non-forest land-uses, such as urban and agricultural uses, has negative consequences for many species of forest wildlife. While the total amount of forest area in the Central Hardwood Region has in recent years been relatively stable, few areas are extensively forested or minimally fragmented. We believe an important conservation need is to maintain landscapes in these regions in an extensively forested condition. Active reforestation, or encouraging succession of non-forest lands to old fields and forest, could minimize fragmentation in some landscapes and benefit forest wildlife (though at the expense of farmland wildlife).

Availability of Habitats Through Time

Early-successional forest-wildlife will be most abundant through time in landscapes managed for the greatest amount of early-successional forest habitat that is sustainable. The appropriate amount of early-successional forest habitat in the landscape will depend on wildlife objectives (particularly the balance between early- and late-successional wildlife), silvicultural practices and objectives, and ecological land type or suitability of the site for these communities (particularly glades, barrens, and savannas).

Because early-successional forest habitat is ephemeral, its availability varies by location (space) and through time. This means that land managers must carefully plan management activities over long time periods and large areas to ensure the availability of these habitats. For instance, if even-aged forest management is the primary method being used to create early-successional forest, regulating harvest activities to provide sustained yield over the commercial rotation will result in a balanced forest age-class distribution and consistent levels of early-successional habitat through time. This provides a consistent level of habitat availability for late-successional forest wildlife as well. For example, in central hardwoods, generally 10 or 12 percent of forest land can be regenerated per decade under regulated forest management with a 100- or 80-year rotation, respectively, and would sustain 10 to 12 percent of the landscape in 1- to 10-year-old forests. More forest can be regenerated in any one decade, but a higher level of regeneration cannot be sustained throughout the rotation and would eventually result in widely fluctuating amounts of habitat and population levels.

Shorter rotations will result in more young forest in a landscape than longer rotations.

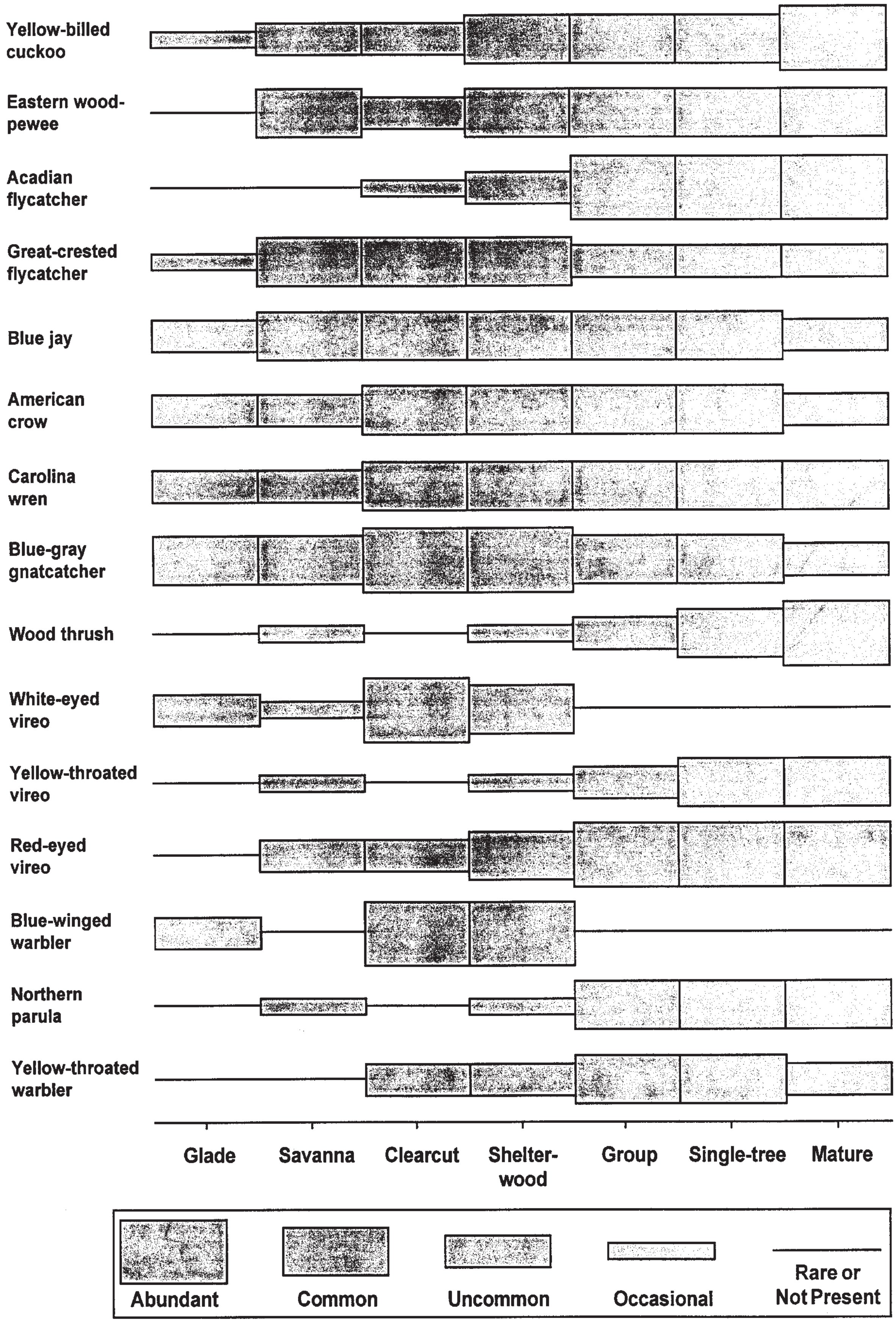
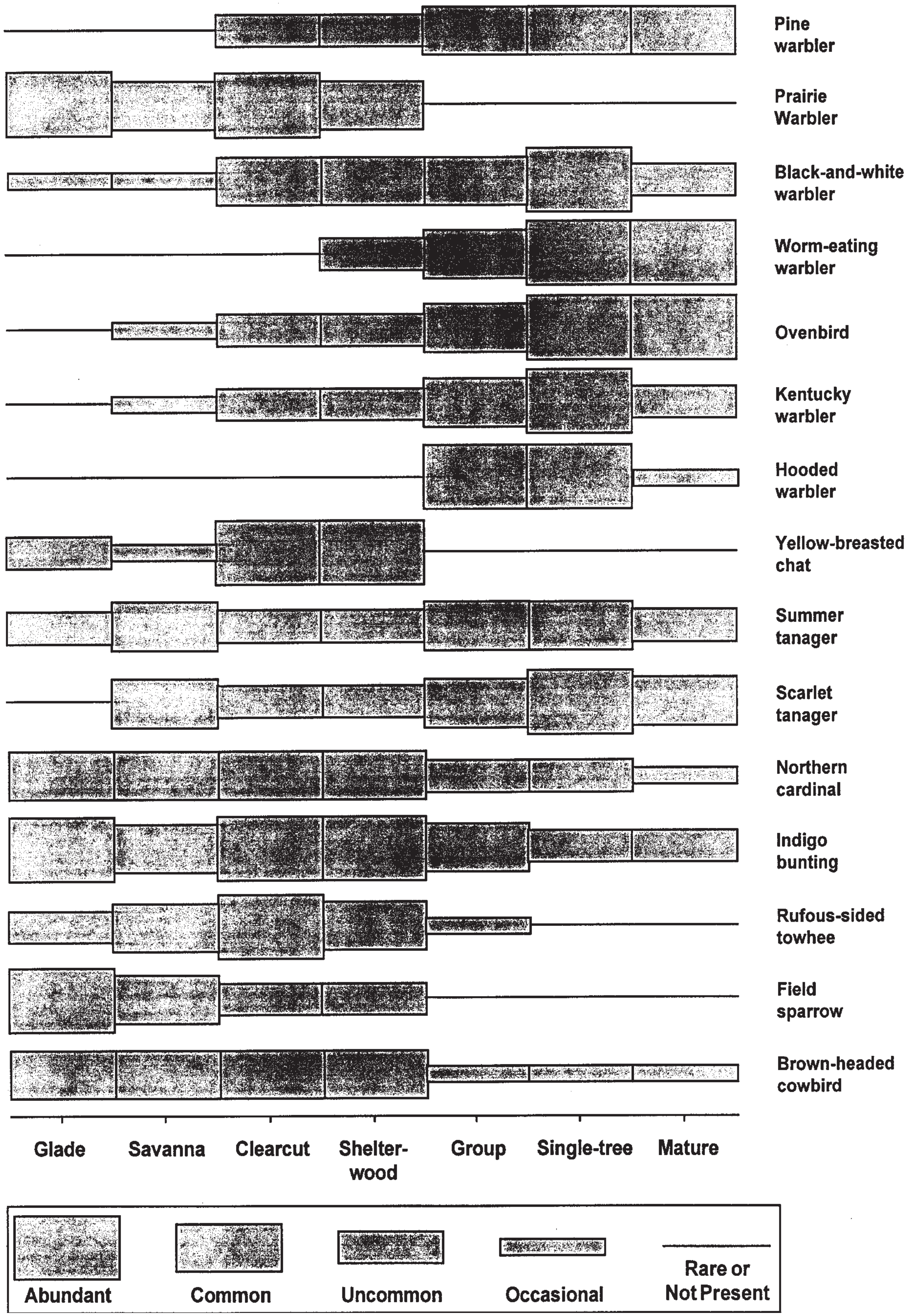


Figure 11.—*Habitat associations of some common breeding songbirds in the Central Hardwood Region. Glades and savannas are semi-forested habitats managed by prescribed fire. Clearcut, shelterwood, group selection, and single tree selection refer to stands treated within 10 years by these silvicultural methods. Mature forest was even-aged forest 60 to 100 years old. Adapted from Thompson* et al. *(1996) and Annand and Thompson (1997).*



Pine warbler
Prairie Warbler
Black-and-white warbler
Worm-eating warbler
Ovenbird
Kentucky warbler
Hooded warbler
Yellow-breasted chat
Summer tanager
Scarlet tanager
Northern cardinal
Indigo bunting
Rufous-sided towhee
Field sparrow
Brown-headed cowbird
Glade
Savanna
Clearcut
Shelter-wood
Group
Single-tree
Mature
Abundant
Common
Uncommon
Occasional
Rare or Not Present

Because most oak forests are regenerated by commercial harvest for saw logs, minimum rotation ages are usually dependent on the age at which oaks reach saw log size and are typically around 80 years old. Conceivably, if markets existed for smaller diameter trees, shorter rotations could be used as long as the combined regeneration potential of stump sprouts and advanced reproduction was adequate to regenerate the stand. Other management objectives should also be considered when setting rotation ages. For instance, extending rotation ages beyond a typical commercial rotation will result in more habitat for late-successional forest wildlife, more old-growth characteristics, but less early-succession forest habitat.

Regulating harvest activities to maintain a balanced age-class distribution with a 80-year rotation will ensure relatively consistent amounts of habitat for all forest wildlife through time. Regulated harvest on a 80-year rotation would maintain about 15 percent of the forest in ruffed grouse brood or adult cover (forest 3 to 15 years old). Other direct management of habitats such as old fields or riparian forest (discussed below) could increase this area to more than 15 percent of the landscape. The amount of the landscape that can be maintained in prime grouse habitat by regulated-commercial timber harvest is notably smaller in central hardwood forests than in aspen forests. Twenty-five percent or more of northern aspen forests can be maintained in brood and adult cover, largely because of younger rotation ages.

Habitat Patch Size

Songbirds that breed in early-successional forest and ruffed grouse will benefit most from patches of regenerating forest greater than 5 acres and preferably 10 to 40 acres. Larger patches have less edge per unit area and are more efficient to manage. Forest wildlife in general, however, may benefit more from a range of patch sizes. Some species, such as the hooded warbler, are primarily found in habitat patches <1 acre. For example, a mix of even-aged and uneven-aged regeneration methods applied at different intensities across the landscape will maintain diversity at a large scale better than one method uniformly applied across the region (Thompson *et al*. 1996). Also, the variation in habitat-patch size created by a mix of even- and uneven-aged management more closely mimics historic disturbance patterns. Fire and wind tend to create many small habitat patches (<1 acre) and fewer large patches (>10 acres), resulting in a reverse J-shaped distribution in the frequency of different size gaps. This distribution can be approximated using even-aged and uneven-aged methods on approximately equal areas of the forest. In even-aged management, the size of stands and the rotation lengths can be varied.

Research in aspen forests of the Great Lakes Region shows that small harvest units (3 to 5 acres) are of greater benefit to ruffed grouse than larger harvest units (Gullion 1984a). The small harvest units are designed to provide ruffed grouse with patches of protective cover (6- to 15-year-old stands) interspersed with mature stands where grouse find their principal winter food, the flower buds from male aspen trees. The small harvest unit size ensures that stands of varying ages are close to one another, thereby promoting maximum ruffed grouse densities.

Grouse in central hardwood forests will also benefit from interspersion of habitats, but they may not benefit from a pattern of small-block timber harvests to the same degree as in aspen forests. We recommend regenerating stands 10 acres or larger because the level of forest age-class interspersion required in aspen forests may not be required in central hardwood forests. Throughout much of the Central Hardwood Region, there is no universally available or dominant food comparable to mature aspen in northern forests. Many foods are abundant in recently regenerated stands and mature stands. However, ruffed grouse that are forced to feed in the relatively open understory of mature forest stands are susceptible to predation. Interestingly, small-block cutting units (2.5 acres) in mixed oak stands in central Pennsylvania support surprisingly high ruffed grouse densities (Storm, unpubl. data). Precise density estimates for these mixed oak stands are difficult to determine due to the presence of adjacent small-block cutting units in aspen and scrub oak (*Quercus ilicifolia*) communities. Scattered small-block harvest units in landscapes dominated by mature forest stands can provide quality habitat for ruffed grouse, but these isolated islands likely provide only limited security from predators. Although there is no conclusive research, we believe cutting units > 10 acres, and perhaps 20 to 40 acres, may provide better security for ruffed grouse in central hardwoods. Most of the resources they need will be within or immediately adjacent to the cutting unit.

Arrangement of Habitat Patches

Just as habitat use varies among wildlife species, so do the benefits derived from different spatial arrangements of habitats. Some species, such as songbirds, generally restrict their breeding activities to a single habitat patch. Generally the larger the habitat patch, the larger and more secure the local population will be. For early-successional songbirds in managed-forest habitats, this means the larger, regenerating stands are better than smaller. Regenerating adjacent stands will also create a larger expanse of contiguous habitat. Regenerating large stands or regenerating groups of stands will also minimize any potential negative edge effects for early-successional and late-successional species. Migrant songbirds may use several different habitats during the year but because of their great mobility they readily travel between them. In fact, neotropical migratory birds travel among several countries and temperate and tropical zones to meet their annual habitat needs.

By contrast species such as ruffed grouse that use several habitats during a day, season, or year; and that are less mobile, will benefit from the proper interspersion or local diversity of habitats. The optimum habitat arrangement for ruffed grouse should provide all their annual habitat requirements adjacent to 10 acres or more of dense protective adult cover. For instance, a good arrangement of habitats for ruffed grouse is a 10-acre or larger 5- to 15-year-old regeneration cut on a northeast slope, an old field on the adjacent ridgetop, and riparian forest along the stream at the base of the slope managed by group selection method (fig. 12).

Regeneration Methods

Even-aged methods (clearcut, seed-tree, and shelterwood) are the most appropriate methods for creating habitat for early-successional forest specialists like ruffed grouse, prairie warblers, and blue-winged warblers. These methods remove sufficient canopy from the parent stand to result in enough understory development to provide protective cover for ruffed grouse and foraging and nesting cover for songbirds. Selection methods seldom remove sufficient overstory to allow the development of a sufficiently dense understory, or create large enough openings for many early-successional forest species. Group selection methods can produce stem densities comparable to clearcuts in central hardwood forests (Weigel and Parker 1995), but regeneration patches are generally too small to provide large enough patches of contiguous habitat. Uneven-aged management should not be prescribed where early-successional forest species are the primary management objective. In areas where regeneration methods are limited to selection cutting because of other objectives or regulations, group selection should be used, groups should be made as large as possible, and group openings should be clustered. Selection methods do provide habitat for gap species such as the hooded warbler and indigo bunting, and they provide other habitat values that may warrant their inclusion in forest landscapes. Selection methods may be used in riparian zones where clearcutting may be inappropriate and understory and groundcover development is desired for ruffed grouse and other species.

Although not a regeneration method, crop tree release deserves some mention as a management consideration. Throughout the Central Hardwood Region, likely crop trees exhibit dominance and can be identified as early as 5 years after the parent stand has been regenerated (Marquis and Jacobs 1989). The growth of these crop trees can be enhanced by felling all adjacent stems. Initial crop tree release typically is conducted in stands < 15 years old. This 10-year window from age 5 to age 15 is precisely that period in stand development when habitat quality for ruffed grouse is optimum. The release of crop trees in 5- to 15-year-old stands can significantly reduce stem densities and greatly diminish the protection afforded ruffed grouse by these stands. Such treatments are inconsistent with ruffed grouse management and should not be prescribed where the development of quality habitat for ruffed grouse is an objective.

Retaining Trees and Snags in Regeneration Cuts

Retention of mature live trees in regeneration cuts provides potential cavity and den trees, mast production for grouse and other wildlife in the regenerating stand, song perches for songbirds, structural diversity in even-aged stands,

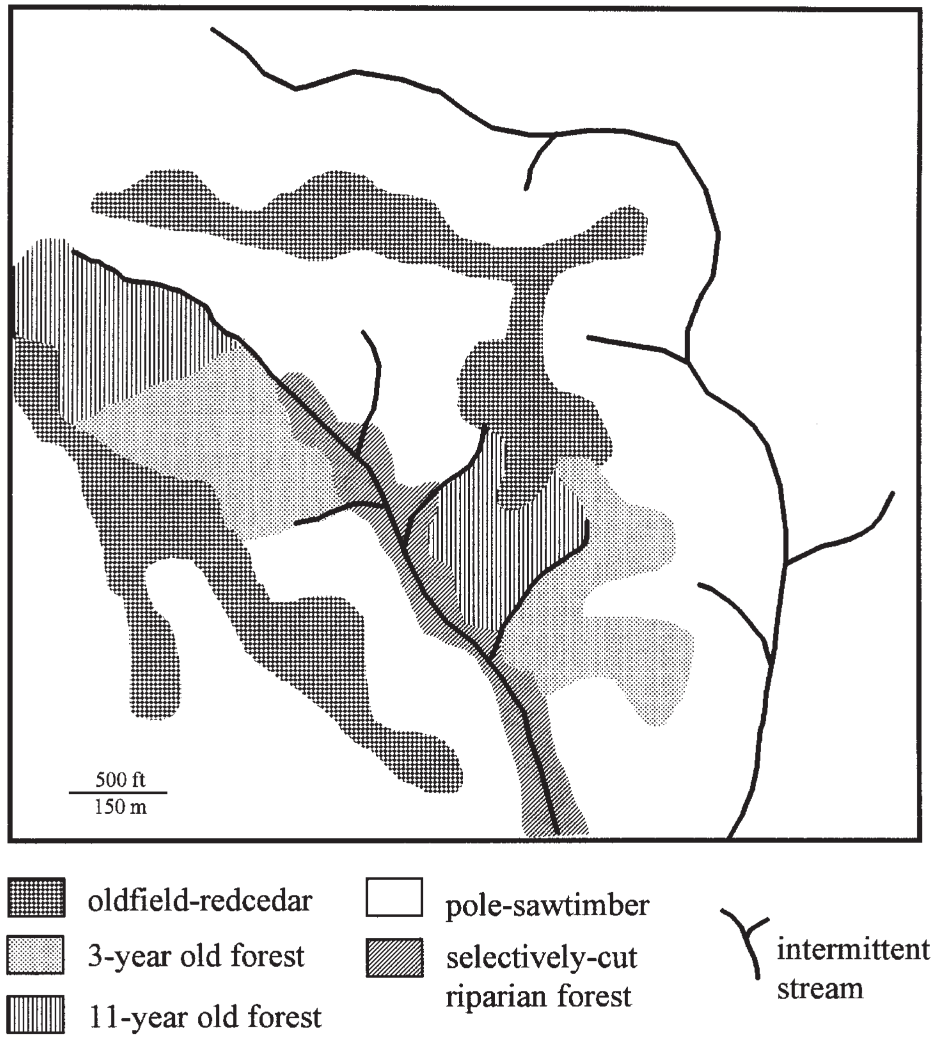


Figure 12.—*An example of forest management for early-successional wildlife. The habitat composition of this landscape represents a balanced age-class distribution for regulated timber harvest on a 80-year rotation. Young forest stands on side-slopes, adjacent to old fields on ridgetops and selectively cut riparian forest, provide a good arrangement of habitats for ruffed grouse. A diversity of early-successional habitats provides habitat for many songbirds. Grouping harvest activities in one portion of the landscape maximizes habitat quality for early successional wildlife in that portion of the landscape while providing a large block of late-successional forest for other wildlife.*

potential large den trees and snags in developing stands, and the potential for some large trees that might not develop under intensive even-aged management. Many of these characteristics are not of direct value to early-successional songbirds but are easily accommodated in management plans and benefit other wildlife species.

To accommodate cavity and snag-using wildlife in young even-aged stands, four or more live cavity trees and three or more snags should be maintained across a range of tree diameters from 6 to >19 inches d.b.h. (Titus 1983). Retaining individual trees throughout a stand would result in a uniform distribution, but clustering retained trees may increase their survival because they may be less susceptible to wind, lightning, or dieback after cutting. There is also concern that large trees or snags in early-successional habitats create perches for predators and cowbirds (a brood parasite); clustering retained trees will reduce the dispersion of potential perches. When clustering retained trees and snags in stands regenerated with even-aged methods, consider retaining two 1/6-acre clumps or one 1/3-acre clump per 5 acres. A range of tree sizes exists in uneven-aged stands but a conscious effort may be needed to be sure that a minimum number of suitable cavity trees and snags is present.

Retaining some mature oaks in regeneration cuts can provide for substantial acorn production in the regenerating stand. Substantial gains in acorn production can be obtained by selecting good acorn producers in a stand and considering the d.b.h. at which acorn production peaks for different species (see Johnson 1993 for guidelines). Identifying the seed producers, however, requires long-term records on seed production, which few forest managers are likely to have at their disposal. Sharp (1958) observed that fewer than 30 percent of white oaks produced acorns and many of those were poor producers. If this is typical of most oak species, leaving 10 good acorn producers per acre would retain 40 percent or more of the acorn-producing capacity of the original stand. This assumes that about 75 oaks are in the overstory at the end of the rotation. Moreover, under the open-grown conditions created by the seed tree method, seed tree crowns can expand to their maximum, thus increasing acorn production per tree. The crowns of some seed trees may degenerate from crown dieback resulting from their sudden exposure (Smith 1986). However, the snags that ultimately develop may provide valuable habitat for cavity nesting birds and the standing dead wood essential to preserving components of biological diversity. Moreover, seed trees can be quickly converted to dead snags by girdling once it is determined they have little value for acorn production or other purposes.

In general, the greatest amount of overstory removal will yield the greatest degree of understory development and cover for ruffed grouse and other early-successional wildlife. Retention of a limited number of mature trees may have little impact on stem densities in the developing stand. Smith *et al*. (1989) found similar stem densities 5 years post treatment in clearcut stands and stands with < 20 ft^2/acre of residual basal area. Regeneration treatments with low levels of basal area retained have been called deferment cuts or modified shelterwood harvests and can lead to a stand dominated by two distinct age classes. If many trees are retained, however, stem densities in the developing stand will be significantly reduced. The diameter distribution of residual trees can also have a significant impact on regeneration stem densities. For example, 20 ft^2 of residual basal area per acre is provided by retaining approximately 16, 15-inch diameter trees or approximately 150 5-inch diameter trees. Although the crowns of the larger diameter trees are far more expansive than those of the 5-inch trees, the latter would quickly respond to release, and the shade cast by the combined crowns of these small-diameter trees would likely have a greater effect on the developing regeneration than would the shade cast by the larger trees.

The spatial distribution of residual trees within a harvest unit can also have a significant impact on regeneration stem densities. If we use the above example, 150 5-inch diameter trees equally spaced across 1 acre would require that the trees be only 17 feet apart. This spacing would lead to substantial crown closure over the developing regeneration and would have a significant negative impact on regeneration stem densities. Residual basal area maintained in discrete patches will minimize shading of regenerating hardwoods and, therefore, the effects of this shade on regeneration stem densities. Residual basal areas > 20 ft^2/acre can significantly reduce regeneration stem densities and should not be maintained within harvest units designed to provide quality habitat for ruffed grouse and other early-successional species. In addition, residual basal area levels < 20 ft^2/acre can under some circumstances reduce stem densities and habitat quality for ruffed grouse.

Soft and Hard Mast Production

Acorns are an important resource in oak-dominated ecosystems because of their role in tree reproduction and as a key component in complex food webs. They are one of the most important fall and winter foods of grouse in the Central Hardwood Region (Korschegen 1966, Thompson and Fritzell 1986). Acorn production varies greatly among trees, but in general large-diameter trees produce more acorns than small-diameter trees (Johnson 1994). Acorn production can potentially be increased in adult grouse cover by retaining some large-diameter, high-producing trees in regeneration cuts, as previously discussed. This ensures acorn production within the secure grouse cover of the developing stand. An important general guideline for ensuring mast production is to use silvicultural methods that will regenerate stands with a large percentage of oaks. The importance of mast as a grouse food is the predominant reason for interspersing regenerating and mature oak stands in areas managed for grouse. Regulating even-aged management on a 80-year or greater rotation should meet the needs of mast-consuming wildlife at a landscape scale.

Soft mast is another important wildlife food in central hardwoods. Fruits of shrubs and trees are important summer, fall, and winter foods of birds. Regeneration cuts can increase production of these foods because they remove the overstory. Mast-producing species are sometimes controlled by felling or herbicide treatments when stands are regenerated. Where wildlife habitat is an objective, control of mast producing species should be minimized.

Direct planting of soft-mast producing trees and shrubs can benefit ruffed grouse, but it is expensive and usually not cost-effective at a large scale. Deciduous plantings are often eaten by deer unless protected by fencing or tree shelters, which can add significantly to planting costs. Species selected for planting should be well suited to local soil and climatic conditions. Examples of trees and shrubs that provide fruits eaten by ruffed grouse include hawthorns (*Crataegus* spp.), *Viburnum* spp., dogwoods (*Cornus* spp.), and cherry (*Prunus* spp.).

Existing sources of soft mast can also be maintained and enhanced in established stands. Fruiting trees and shrubs and grape arbors can be released from the competition of surrounding overstory trees. These food sources are most beneficial to ruffed grouse when they are located in close proximity to dense protective cover.

Consideration of Site Characteristics

Microclimate is an important parameter to consider when identifying specific sites for ruffed grouse habitat development efforts. Typically, relatively moist sites produce a greater abundance of soft mast and succulent herbaceous vegetation than do droughty sites. In hilly or mountainous terrain, clearcut regeneration harvests on north- and east-facing slopes are more likely to provide quality forage for ruffed grouse than are similarly treated stands on south or west exposures. However, the availability of dense woody vegetation on relatively warm south and west exposures can benefit ruffed grouse during inclement winter weather. Habitats positioned at or near the base of a slope often provide a more cool, moist microclimate than those near the top of a ridge and are typically preferred by ruffed grouse. Severely restricting silvicultural treatments within varying distances from small streams exacerbates efforts to establish early-successional communities on these inherently productive sites. Clearly, riparian corridors warrant special consideration before any timber harvest operation is implemented, but here too disturbance must be allowed to play a role. Sufficient overstory must periodically be removed from sites where conditions allow to promote a response from understory vegetation and at least marginal habitats for ruffed grouse.

Management of Early-successional Habitats Other Than Regenerating Forest

Diversity of early-successional communities

Management for early-successional forest communities should provide a range of habitats including regenerating forest, glades, barrens, savannas, and old fields. Glades, barrens, savannas, and old fields generally have lower woody-stem densities and a greater grass and forb component than regenerating forests. Bird species abundances vary greatly among these habitats, so a mix of these habitats is most likely to meet the needs of all early-successional forest birds.

Old-field habitats

Ruffed grouse habitat can develop as agricultural cropland or pasture is retired from production and allowed to revegetate naturally. Succession on recently abandoned agricultural lands can be a slow process. Decades may pass before woody vegetation of sufficient height exists in sufficient densities to support ruffed grouse. The rate of establishment of woody vegetation is dependent upon many site factors. A dense sod layer can limit seed germination and seedling development. The thick humus layer and the interwoven root systems of densely matted herbaceous vegetation can physically preclude seeds from shrubs or trees from making contact with moist mineral soils, a requirement of many species for successful seed germination. The natural regeneration of woody trees and shrubs can be accelerated by mechanical treatments. Mineral soil can be exposed by physically disrupting the humus and the established root systems. A shallow-running plow or disk can provide the physical disturbance required, but mechanical treatments can be expensive and they are impractical on steep terrain. Mechanical treatments to expose mineral soil should be timed to provide an appropriate seedbed in the spring when soil moisture is high. This means site preparation should occur in spring or the previous fall after herbaceous plant growth and seed dispersal have largely ended for the growing season.

Existing old fields will require periodic treatments to set back succession. Management practices could include felling of pole-size or larger trees, prescribed burning, and mowing or brush cutting. The objective is to maintain secure woody cover (including redcedar), a diversity of fruit-producing shrubs and vines, and patches of herbaceous cover. If the site is opened up too much, grasses and forbs will dominate and make the site less valuable to ruffed grouse.

Herbaceous openings

Maintained herbaceous openings can provide ruffed grouse with a readily available source of quality forage. These openings also support greater arthropod densities than do habitats dominated by woody vegetation (Bump *et al*. 1947, Hollifield 1992). These openings are often planted with several grasses and a legume such as clover. Annual mowing helps to maintain the legume component of these openings. Legumes remain relatively succulent throughout much of the year and provide ruffed grouse with a nutritious source of forage during winter when little other herbaceous vegetation is available. The abundant arthropods supported in maintained openings can be an important source of protein-rich food for developing chicks (Hollifield and Dimmick 1995). The high-contrast edge formed by the maintenance of herbaceous openings adjacent to forested habitats, however, might lead to increased predation. Increased predation can be minimized by locating herbaceous openings adjacent to dense, young forest habitats. Dimmick *et al*. (in press) recommend seeding landings and logging roads with a mixture of clover and orchard grass to accomplish this objective.

Conifers

Snow depths sufficient to allow snow roosting are uncommon in the Central Hardwood Region. Establishing small patches of conifers can provide ruffed grouse with protection from inclement winter weather. Conifer cover for ruffed grouse should be dense and low to the ground. Eastern redcedar is perhaps the best native conifer for grouse cover in the region, while species such as short-leaf pine are not suitable. Species exotic to the region, such as white spruce (*Picea glauca*) or Norway spruce (*Picea abies*), also provide good cover. Norway spruce is relatively unpalatable to white-tailed deer and, therefore, is the easiest to establish in areas that support high deer densities. Plantings should be > 0.5 acres in size to provide an effective refuge from inclement weather. This refuge effect can be enhanced by using a relatively tight spacing (6 ft X 6 ft) during planting.

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Describes the history, ecology, and silviculture of central hardwood forests and the status and ecology of early-successional forest songbirds and ruffed grouse. Concludes with management guidelines for early-successional communities in central hardwood forests.

Key Words: Early-successional forest, ruffed grouse, songbirds, wildlife habitat, central hardwoods, silviculture, oaks.