OAK FOREST BIRD COMMUNITIES

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Abstract.--Oak forests represent the largest forest type in the United States. The density and diversity of avian species in oak forests are dependent on habitat factors such as vegetation structure and successional stage. Therefore, they are greatly affected by management considerations such as cutting, thinning, rotation age, stand size, and tree species composition. The species number and population sizes of breeding birds and winter birds are contrasted.

The Appalachian Oak and/or Oak-Hickory types form the largest forest type in the United States, representing about 125 million acres. Eastern hardwoods compose more than half the commerical timber land in the United States, and the Oak and Oak-Pine types combined total about 147 million acres, or 60 percent of the eastern commercial forest. This acreage exceeds the total commercial timber area of all western forest types combined (U.S. Department of Agriculture, Forest Service 1977). Because this forest type spans a wide range of altitudes, latitudes, and longitudes, a number of bird species are associated with it as breeding, migrant, or wintering birds. In the nesting season, from 90 to 100 different bird species can be found in northeast or north-central oak forests, clearcuts, and edges. The avifauna of southern Oak-Hickory and Oak-Pine forests has been covered by Evans (1978).

DESCRIPTION AND EXTENT OF THE TYPE

The oak forests of the northeast and north-central United States are more concentrated in the northern Appalachian region, extending north to New York and southeastern New England, and west to Ohio and the Cumberland Plateau. Oak forests are common in the Piedmont of the Mid-Atlantic States, and the oak-hickory type forms a mosaic with other vegetation types in much of Ohio, Indiana, Illinois, and southern Michigan. In addition, oak stands are found at the border of the northern hardwoods region in Minnesota, Wisconsin, and Michigan, and oaks can be the major seral species in both the mixed mesophytic area and the northern hardwoods type. Last, oaks are the major tree species in the prairie borders (Minnesota, Wisconsin, Illinois, and Iowa) in oak savannas or in fairly closed stands that expand and contract with temporary climatic conditions and fire.

Oak Forest Acreages for Selected States
(U.S. Department of Agriculture, Forest Service 1977)

		(millions of acres)
1.	Missouri	11.46
2.	Virginia	10.33
3.	Tennessee	9.71
4.	Kentucky	9.27
5.	Pennsylvania	7.98
6.	West Virginia	7.50
7.	North Carolina	6.36
8.	Ohio	3.00
9.	Wisconsin	2.76
10.	Indiana	2.42
11.	Illinois	2.26
12.	Michigan	2.12
13.	Maryland	1.45
14.	Connecticut	1.39
15.	New York	1.36
16.	Minnesota	1.33
17.	Massachusetts	1.26
18.	Iowa	1.25
19.	New Jersey	.81
20.	New Hampshire	.62
21.	Maine	.29
22.	Vermont	.11
23.	Delaware	.08

The most common oak species are northern red *(Quercus rubra)*, white *(Q. alba)*, black *(Q. velutina)*, scarlet *(Q. coccinea)*, and chestnut *(Q. prinus)*. On medium sites hickories, such as pignut *(Carya glabra)* or mockernut *(C. tomentosa)*, may form a minor part of the canopy, and on moist sites yellow-poplar *(Liriodendron tulipifera)*, shagbark hickory *(C. ovata)*, and various northern hardwood species may be present. On steep slopes and ridge tops, pitch pine *(Pinus rigida)* may occur regularly as a minor component. Red maple *(Acer rubrum)* and white ash *(Fraxinus*

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americana) usually fill in openings in the canopy and can often be major constituents of the canopy or understory. Such openings can result from natural causes, or be caused by selective cuttings, or thinning.

In southern Michigan, northern pin oak *(Q. ellipsoidalis)* can be important, and bur oak *(Q. macrocarpa)* can be dominant in southern Minnesota and the prairie borders. Oak forests in southern New England may be heavily mixed with white pine *(P. strobus)* as well as beech *(Fagus grandifolia)* and maple.

Tree species of oak forests that are usually of subordinate status include flowering dogwood *(Cornus florida)*, sassafras *(Sassafras albidum)*, black birch *(Betula lenta)*, and black gum *(Nyssa sylvatica)*. Choke cherry *(Prunus virginiana)*, hop hornbeam *(Ostrya virginiana)*, black cherry *(P. serotina)*, and redbud *(Circis canadensis)* are less common on the poorer sites. The shrub layer of the drier sites is usually dominated by ericaceous shrubs such as laurel, blueberries, huckleberries, and sweet fern *(Myrica asplenifolia)*. Fair sites may have witch hazel *(Hamamelis virginiana)*, azaleas, various ferns, club mosses, and striped maple *(Acer pensylvanicum)*. The better oak stands may contain such plants as green briars, viburnums, poison ivy *(Rhus radicans)*, and spicebush *(Lindera benzoin)*.

The most distinguishing characteristic about the herb layer in oak forests is its poor development. Tree seedlings and blueberries often form the predominant forest floor cover, but common herbs are wild sarsaparilla *(Aralia nudicaulis)*, may apple *(Podophyllum peltatum)*, teaberry *(Gaultheria procumbens)*, asters, bloodroot *(Sanguinaria canadensis)*, and trilliums.

Major tree species in old-field succession in the oak forest region include hawthorne, aspens, black locust *(Robinia pseudo-acacia)*, red maple, black cherry, and choke cherry. In oak barrens that result from fire, scrub oak *(Q. ilicifolia)* may form nearly pure, almost impenetrable stands. In more mesic situations, shrubs such as dogwood may be the earliest woody pioneers and may be associated with American elm *(Ulmus americana)* and black walnut *(Juglans nigra)* along with the more mesic oak species. On dry sites such as slopes or abandoned upland pastures, conifers such as red cedar *(Juniperus virginiana)*, pitch pine, and scrub pine *(Pinus virginiana)* are well represented. The oaks themselves tend to seed in from the edges and are rarely pioneers in abandoned fields because the acorns need to be spread by animals for longer dispersal distances.

The oak type grades into the oak-pine type in drier situations and into mixed hardwoods (mixed mesophytic) in moister areas. Intermediate stands on mesic sites contain greater proportions of red oak, yellow poplar, American basswood *(Tilia americana)*, beech, sugar maple *(Acer saccharum)*, white ash, and hickories. Compared with other hardwood forest types, oak woodlands typically have simple vegetation structure and often contain few plant species.

BREEDING BIRD COMMUNITIES

Species Composition

Blue Jays and Brown-headed Cowbirds are species of generalized habitat requirements that are found in almost every stand, regardless of age or structure. However, most birds require a specific type of habitat. The breeding bird species of oak forests can be conveniently grouped into five categories, each of which responds to a different habitat (table 1).

(1) The bark foragers nest in cavities of dead or dying trees, and drill, chip, or glean for their food on the tree trunks or large branches. Many other secondary cavity-nesting birds are ultimately dependent on those bark foragers that excavate cavities. Some examples of birds in this group are Flicker, White-breasted Nuthatch, Downy Woodpecker, and Hairy Woodpecker.

(2) The active gleaners that feed in the tree canopy. Some examples of birds in this group are Chickadee, Tufted Titmouse, and Red-eyed Vireo.

(3) The pursuers also feed in the tree canopy but follow a sit-and-wait strategy. Flycatchers and tanagers are the common pursuers in oak forests.

(4) The ground species are associated with the shrub and sapling layers, but not all members of this group use the understory for their feeding activities--Thrushes, Rufous-sided Towhees and Ovenbirds forage on the ground and use the shrubs for cover and nest sites.

(5) Warblers are the main species associated with a dense growth of saplings and small trees beneath the canopy. Other birds, such as Parids, can become more abundant under these conditions than they would be in forests with a tree layer of simple structure. Because most Appalachian Oak forests are too dry and open for a dense, continuous column of foliage to develop, woodland warblers are less common than they are in more mesic forest types, such as

Table 1.--*Consuming biomass of the forest feeding groups (adapted from Probst 1976)*

(In grams per 40 hectares)

Plot No.	Bark	Gleaners	Pursuers	Ground	Warblers	Misc.	Total
Young-1	--	219	178	1,321	44	459	1,762
Young-2	--	553	100	602	--	403	1,255
Intermed.-1		432	583	10	--	403	1,600
Intermed.-2	556	273	618	360	--	457	1,807
Intermed.-3	771	910	452	--	--	476	2,133
Mature-1	940	320	450	--	--	403	1,710
Mature-2	637	160	716	--	--	678	1,513
Mature-3	1,124	384	446	--	--	364	1,954
Mature-4	956	264	864	66	--	663	2,150
Complex Can.	340	569	883	2,702	--	221	4,494
Complex Can.	454	770	375	939	--	559	2,538
Forest-32	1,150	224	713	1,446	--	301	3,533
Forest-33	839	629	963	1,387	--	325	3,818
Forest-34	673	751	342	361	--	476	2,128
Forest-35	521	164	676	1,354	--	831	2,715
Forest-36	388	236	545	1,453	95	442	2,717
Forest-37	41	634	473	1,304	216	--	2,668
Forest-38	621	251	700	1,407	161	658	3,140
Forest-39	418	568	308	2,143	470	400	3,907
Average	579	437	547	887	52	448	2,502

Mixed Hardwoods. When present, Black-throated Green Warbler, Black and White Warbler, and Chestnut-sided Warbler are the most regular species, but in the southern parts of the oak forest region, Hooded Warbler, Kentucky Warbler, and Yellow-throated Warbler can be important in stands of suitable vegetation structure.

There is a group of species that favors open, mature stands with large, spreading tree crowns. Such conditions are most common in floodplain forests, but can also occur in other forests with incomplete timber harvesting or heavy natural tree mortality. In forests of this structure Yellow-throated Vireos, Blue-gray Gnatcatchers, and rarely, Cerulean Warblers may be found.

As a young oak forest matures, the relative importance of the avian groups discussed above changes. Shrub cover diminishes with canopy closure and eliminates some ground feeders and foliage gleaners that require dense growth. The maturation of the tree layer makes possible the availability of the bark-foraging niches, and the openings in the canopy can be used by pursuers. If management or historical factors such as fire or disease allow for an understory and complex canopy to develop, ground feeders will be common and warblers and other foliage gleaners should also be present. However, the lower age distribution of trees in such stands are less favorable for bark-foragers than forests with more large trees.

Breeding bird censuses conducted in 16 upland oak forests with widely different structures showed that the following bird species occur in most types of forests (adapted from Probst 1976):

Species	*Frequency* (percent)
Red-eyed Vireo	100
Downy Woodpecker	93
Scarlet Tanager	93
Cowbird	93
Wood Pewee	87
Crested Flycatcher	87
Blue Jay	80
Flicker	80
White-breasted Nuthatch	80
Parid	67
Additional Bark Feeder	40

The first nine species occurred in at least 80 percent of the stands examined. The most frequent additions or substitutions to the basic census were Parids and additional bark feeders. This indicates that forest bird communities are formed by an accumulation of rarer species combined with this more constant group.

The bird species of open habitats in the oak forest region are similar to those in many other forest types. Species of young seres tend to be widespread, and many are found in several biomes. Such wide distributions are rare among climax bird species (Pitelka 1941) This pattern may be a result of the scarcity of secondary habitats. As succession progresses, the loss of grasses and forbs decreases the opportunities for seed- and plant-eating birds, while the addition of shrubs and trees provides new niches for primarily insectivorous species.

The red-winged Blackbird and Field Sparrow are overwhelming dominants in the open fields and shrublands, respectively. These two species typically have densities exceeding those for all other species in the community combined. Other important open-field species are Eastern Meadowlarks and Grasshopper Sparrows. In the shrublands, subdominant species include the Yellowthroat, Rufous-sided Towhee, Indigo Bunting, Goldfinch, Song Sparrow, Chipping Sparrow, and Golden-winged Warbler.

Avian Diversity and Density

At the level of the forest stand, avian diversity is strongly influenced by the vertical complexity of the vegetation (Karr and Roth 1971, MacArthur and MacArthur 1961, Probst 1976, Willson 1974) and the amount of patchiness or horizontal heterogeneity (Balda 1975, Roth 1976). The number of species increases with the size of the area sampled, but levels off rapidly in uniform stands. The number of bird species clearly increases with the number of habitat types, a factor strongly affected by climate and topography. The turnover in species per unit of habitat change is also an important factor. All of the above are determinants of the avian diversity of a region or large group of management units.

The following discussion of avian density and diversity is based on census data published in *AMERICAN BIRDS* and on data from a study I conducted in Central Pennsylvania (Probst 1976). The Pennsylvania information was obtained at 39 study plots--7 fields or grasslands, 6 shrublands or old fields, 1 open shrub thicket, 6 clearcut or regeneration stands, and 19 forest stands.

The number of breeding birds in oak forest census plots ranges from 9 to 29 species. The estimated number of territorial males per 40 ha ranges from 65 to 390. The average values for 36 oak census plots are 21.2 species and 222 males/40 ha. Mesic stands can have higher populations; mixed hardwood stands range as high as 413/40 ha (average = 247) with a maximum of 66 species (average = 26.3). Density and diversity of breeding birds generally increases with plant succession (Johnston and Odum 1956, Shugart and James 1973, Shugart *et al.* 1975). Consequently, it is often possible to predict avian density and diversity from estimates of total plant cover (Karr and Roth 1971, Willson 1974, Probst 1976). However, at least in the oak forest region, young seres may overlap with forest stands in their values for avian density and diversity (tables 2 and 3). For example, the densities of birds in shrublands and clearcuts are usually higher than those of dry upland forests.

Table 2.--*Avian diversity of oak forest seres*

Habitat-group	Plots	Equally common species[1]	Species	Equat-ability[2]
		Number		
Field	7	3.7-4.5	5-8	0.46-0.75
Shrub				
Open	1	6.3	9	.70
Woods	2	2.6-2.9	3	.87-.92
Simple canopy (narrow age range)				
Young	2	5.6	7	.80
Intermediate	3	6.5-8.8	8-11	.72-.81
Mature	4	7.6-9.1	9-11	.73-.85
Complex canopy (wide age range)	2	7.4-9.3	13	.57-.71
Complex forest (multi-layered)	8	7.7-15.0	11-20	.59-.92
Shrubland	6	5.2-11.6	9-18	.48-.81
Clearcut	4	8.7-11.2	14-16	.60-.75

[1]Calculated as $2^{-\Sigma p_i \log_2 p_i}$, where p_i is the proportion of each species.
[2]Number of equally common species divided by the actual number of species.

Table 3.--*Avian abundance of oak forest seres*

Habitat-group	Plots	Birds per 40 ha	Mean abundance per species
		Number	
Field	7	54-80	9.1-14.3
Shrub			
Open	1	181	20.1
Woods	2	59-66	20-22
Simple canopy (narrow age range)			
Young	2	37-52	5.3-7.4
Intermediate	3	65-106	5.9-11.8
Mature	4	72-89	6.5-8.9
Complex canopy (wide age range)	2	131-156	10.1-12.0
Complex forest (multi-layered)	8	102-188	7.8-12.9
Shrubland	6	132-270	8.9-15.9
Clearcut	4	296-349	20.8-23.3

Predictions of bird species diversity by total coverage show a leveling off somewhere in the high range of values characteristic of forested habitats, so estimators that account for the distribution of foliage are often used. MacArthur and MacArthur (1961) found that Bird Species Diversity (BSD) for a broad range of habitats could be predicted from a measure called Foliage Height Diversity (FHD), an average of the logarithms of the *proportions* of foliage in three height intervals. Although this method underlines the importance of habitat complexity to avian diversity, it has a number of faults (Probst 1976). In addition to being an unnecessary abstraction, the FHD predictor does not allow for differential contributions by the natural layers (structural forms) to the vegetation, especially in plots with a single layer or life form. It also does not account for the absolute amount of foliage in a layer or the total of all layers, and does not register site variations in productivity. As a result, this predictor lacks generality and often cannot be used to compare habitat types as broad as all forest stands within a locality (Probst 1976, Willson 1974). It is more informative to examine the differential contribution of the herb, shrub, and tree layers to avian diversity (tables 2 and 3). When this is done, it can be seen that fields (grasslands) have from 5 to 8 species, but the mature tree layer (simple canopy) in oak forests has from 9 to 11 species. An open scrub oak barren with little herb cover approximates a shrub monolayer and has an intermediate number (9) of species. Thus, the fields show the lowest bird diversity of all habitat groups and simple forests have diversities in the range of more complex open habitats. Complex forests have a higher average diversity than simple canopies, and clearcuts have a slightly higher average than shrublands.

Each layer or structural form of the forest adds to avian diversity, and the amount of cover of each layer also adds to the number of species up to a certain plateau after which the number of bird species remains constant. However, differences in bird diversity are best predicted using only shrub and sapling cover, because in most practical field situations the herb and tree layers are already in the plateau region.

Ground-feeders, shrub-foragers, and bark-foragers can be estimated by shrub-sapling cover. However, it is difficult to predict the density or biomass of the canopy birds by either plant coverage, volume, or conic surface estimates (Probst 1976, Willson 1974). Tree conic surface is linearly related to bark surface area and leaf surface area (Whittaker and Woodwell 1967) and has the potential for simultaneously predicting both bark-feeders and canopy insectivores.

Much of the constancy in the avian density and diversity of the forest canopy can be explained by compensatory changes in the composition of the forest avifauna with changes in age or structure of woodlands. Substantial changes in composition usually do not significantly alter the total species count (fig. 1). Major changes in composition occur when a forest matures (loss of ground species, addition of bark-feeders), when shrubs are added (addition of ground birds), and when a simple forest is contrasted with a complex forest (addition of warblers and thrushes, and the eventual loss of a pursuer and some bark species). In forest stands, great changes in structure cause predictable alternations in avian composition but surprisingly small differences in bird diversity.

Winter Birds of Oak Forests

A large portion of the summer avifauna of the oak forest region migrates to the southern United States or Central and South America in winter. Christmas Bird Counts conducted on a standard 458 km^2 area commonly show land bird counts of from 8 to 14 species (Tramer 1974).

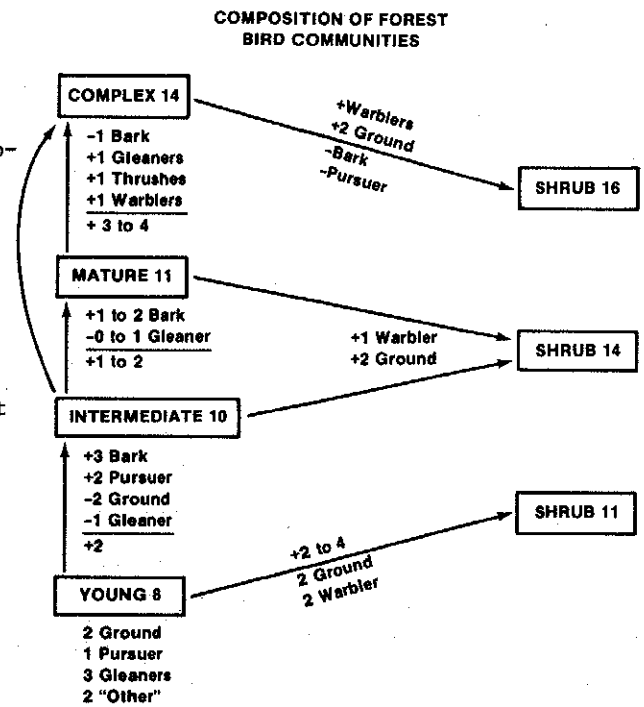

Figure 1.--*Vegetation changes alter the importance of various bird feeding groups, but these changes are often offsetting. The presence of shrubs has a significant positive effect on total species number. The same may be true to a lesser extent for added canopy complexity. The third net increase involves the maturation of the canopy.*

The average number of bird species found in oak forests in the winter is 9 (Winter Bird Population Studies, *AMERICAN BIRDS*). The number of species ranges from 3 or 4 to 16 (Probst and Pearson, unpublished). The average number of species from these winter counts represents less than half of those for oak breeding bird censuses. The number of individuals per 40 ha for the winter counts ranges from 8 (Minnesota) to 140 (Virginia) with an average of 69.4. This is less than a third of the density for breeding bird censuses in the same forest type. By contrast, bottomland hardwoods in Louisiana may have twice as many birds in winter as are present in the summer (Dickson 1978).

Obviously, the oak forest winter avifauna is limited directly or indirectly by climate. Severe temperatures place heavy energy demands on birds at a time when food and cover is minimal. Continuous snow cover eliminates most ground-feeding species such as Common Grackles, Carolina Wrens, and many finches, which are numerous in the southeastern United States during the winter. Insectivores, such as vireos and warblers, also winter south of most of the oak forests. The Yellow-rumped Warbler is usually the only winter warbler to be found in the regions where oak forests are the dominant forest type.

The insectivores that are year-round residents such as Parids or Woodpeckers specialize on arthropods that have over-wintering forms in the crevices of bark or branches. It has been suggested that mixed hardwood-conifer forests may provide better winter habitat for birds (Evans 1978). Few tree species in oak forests retain usable seeds in the winter, as do the birches and conifers of the Northern Hardwood forests. Consequently, stands that contain pine or hardwoods such as yellow poplar or white ash may have higher winter bird populations than pure oak stands.

Bird species that forage in shrubs or on the ground are often found in edges, old fields, or forest openings during the winter because these habitats provide more cover and food (seed-bearing grasses and herbs and fruit-bearing shrubs). In old fields where conifers are important seral species, bird populations might be higher but data are scarce. Winter bird populations may be augmented by irregular invasions of northern finches (crossbills, grosbeaks, and redpolls) in some years. Because most of these species are normally found in boreal or mixed coniferous forests, when found in oak forests they are usually in stands with some mix of conifers or seed-bearing hardwoods.

For almost all bird species, populations are generally higher in valleys or lowlands than on ridges and mountains. This is even true for high elevation stands with a good conifer component. The low density of winter bird populations in highlands is probably related to the short growing season, low productivity, and rigorous winter climate of the highlands.

The most regular or abundant winter bird species of oak forests are the Black-capped Chickadee, White-breasted Nuthatch, Dark-eyed Junco, Golden-crowned Kinglet, Downy and Hairy Woodpeckers, Common Crow, Blue Jay, and Brown Creeper. In the southern part of the region, Carolina Chickadees, Tufted Titmice, Red-bellied Woodpeckers, and Carolina Wrens can be an important part of the winter avifauna.

TIMBER MANAGEMENT

Although timber management practices in oak forests vary with geography, site, and species composition, some common strategies apply (Sander 1977, Trimble 1973, Watt *et al.* 1973). Even-aged management through clearcut harvesting is the usual practice. However, because planting oaks is rarely practical, a shelterwood is often used if advance regeneration or anticipated sprout growth is insufficient. Uneven management by group selection can regenerate oaks but is less economical and is difficult to administer and manage.

Species composition and desired products of oak forests vary with site quality. The best sites (site index > 75) are usually managed for saw logs or veneer logs, and fair sites (site index 55-75) are managed for saw logs or pulpwood. If poor sites (site index < 55) have commercial potential, they are managed for pulp. Because the mix of species in oak stands depends on ecological conditions, and regenerated stands come from sprout growth and advance regeneration, species composition goals usually closely follow the natural tendencies. The associated species on the better sites in the northern part of the oak range include sugar maple, white ash, basswood, and black cherry. In the south-central States, yellow-poplar and black walnut can be important, and hickories are common in the southwest part of the oak region. On average sites in the north, white and red pine are found with the hardwoods, and farther south hickories and shortleaf pine are characteristic. On poor sites, jack pine and aspen are common in the north-central States. These marginal stands are managed for pulpwood, wildlife, or converted to conifers such as jack pine or shortleaf pine. If conversion is not prescribed, management is usually minimal. Fair sites are ideal for oaks and are managed for oaks or an oak-hardwood mixture. The lower part of this range of sites is often managed for oak-pine. In stands of intermediate quality, commercial thinning becomes possible. If there is to be only one thinning, it should be done at about 30-40 years because after that time the released trees will not respond well.

On better sites oak forests are managed for oak-hardwoods or converted to pure hardwoods

through natural succession of the advance reproduction. This process may be accelerated by spraying oak sprout-growth. Oak-hardwood stands may be thinned to 60 percent of stocking as often as every 10 years up until 3/4 of rotation age. Best results are obtained by thinning intermediate trees from below to release the more vigorous, dominant trees.

Rotation age varies with site and desired product. Forests managed for sawtimber have rotation ages of 60 to 120 years, and forests managed for pulp have rotation ages of 40-60 years. But rotation age can be shortened by appropriate thinnings.

The stand size of oak forests may vary according to physical, economical, or silvicultural considerations. The lower limit to stand size is fixed by efficiency of harvesting and the need for the intolerant oaks to be released from the influence of nearby mature trees. In addition, animal browse activity can be more severe in small plots. As a result, stands are usually not less than 2-5 acres. The upper limit is about 100 acres and is often determined by topography and the age distribution of the management unit. Concerns about soil erosion, water quality and quantity, and nutrient losses and factors such as wildlife habitat diversity and aesthetics all tend to keep stand size down. Also, very large stands are difficult to work into an acceptable rotation schedule.

MANAGEMENT IMPACTS ON AVIAN COMMUNITIES AND SUGGESTED GUIDELINES

The effects of timber harvesting on avian populations varies during the life of the regenerating stand. Clearcutting and shelterwood regeneration usually cause a drastic reduction in the avian community population size and an almost complete turnover in species composition the first growing season after harvest. However, vigorous sprout growth often results in second-year populations higher than those of mature stands. Peak density and diversity of birds probably occurs 5 or 6 years after cutting on most sites, though peaks might be reached later in understocked stands. When regenerating stands shade out the shrub layer, the density and diversity of birds is reduced. Open, less productive woodlands may be more favorable to a wider range of species at this stage due to greater foliage stratification. Avian communities similar to those of mature forests generally develop when the dominant and codominant trees reach 40 to 50 feet in height. At that point, bark foragers are well-established and ground-feeding birds have reappeared. If the loss of undergrowth in regenerating stands is marked, species such as Wood Thrushes and Rufous-sided Towhees can show a bimodal distribution, with peaks in the mature forest and late clearcuts.

The principal difference between clearcut and shelterwood harvests is in the reduced populations of bird species in the residual trees of the latter. Other species found in shelterwoods, such as Northern Orioles or Blue-gray Gnatcatchers, may be absent from any other stage of oak forest development. If small residual trees are left during harvesting operations, they may provide sufficient habitat diversity to allow some foraging by birds from surrounding forest areas, or to allow earlier invasion by species with a preference for elevated song perches (Alder Flycatcher, Golden-winged Warbler, etc.). Another habitat factor that can operate under the shelterwood system is a higher probability of associated shrub species gaining temporary dominance over oak sprouts and seedlings during the younger years of the stand. This tends to favor ground-feeders over the smaller finches and warblers.

Thinning Practices

Thinnings open the canopy and make it less useful for insectivores but create better opportunities for flycatchers and other pursuers. As thinned stands mature, the dominants may develop fuller crowns, which are favorable to several bird species that are scarce or uncommon in oak forests. If the thinning substantially releases the undergrowth, bird species using those layers will be enhanced. Conversely, those species will be eliminated if the underbrush is removed to stimulate tree growth or as part of a "whole tree" chipping operation. This results in a larger proportional decrease in avian biomass in oak forests than in other forest types where species of the upper strata are usually more dominant (table 1). In addition, understory removal may not even be justified by its contribution to tree growth (Dale 1975).

Rotation Age

The major impact of adjusting rotation age will be on the bark foragers, and primary and secondary cavity nesters. Rotation age should be long enough to allow a sufficient number of trees to die for the cavity excavators to utilize and to optimize the foraging substrates for birds that search for prey on tree bark surfaces. In addition, dead trees of all sizes are used as song perches by many birds, and some species also favor snags as perches from which to hawk or sally after prey. When forests are harvested, enough snags should be saved to accommodate the projected number of cavity nesters at the different stages of regeneration, while allowing for the expected attrition of snags during the rotation period. The species, size, and condition of trees preferred by each species of woodpecker needs further research (Conner 1978).

Another benefit to nongame birds from long rotations is the increased populations of birds--chiefly warblers--that select forests with more stratified foliage. Consequently, some portion of the stands in a management unit should be left as old growth. In stands of shorter rotation, it may be necessary to create artificial snags (Conner 1978).

Single Species Management

Bird species requiring young growth are accommodated by normal timber harvesting. This leaves a small number of species with more specialized or unusual requirements that may require specific management prescriptions. However, the land manager can do little to enhance species that are rare in an area because their distributions are centered in another forest type or geographical region, nor can he manage for species that have population size depressed by factors that are not habitat related. The problem of maximizing the populations of the more common species is a second-order concern, and is complicated not only by our lack of specific knowledge of each species but also by the virtual certainty that such prescriptions would contradict or conflict with one another. Although optimization of a group of individual species populations among all stands is easily handled by modern methods, it will always be difficult to assign relative values to the more common bird species.

Stand Size

A very general account of species number and area relations was given above. When avian census results are broken down into subplots, the species count is usually complete after about 5 ha (fig. 2). However, this includes some partial territories in census plots that are a portion of a larger, forested area. While most of the smaller songbirds have home ranges of less than 5 acres, very few species use all of the suitable habitat available to them. Most bird species show very patchy distributions so rare species usually result more from fragmentation than dilution. The density of a particular avian population is rarely related simply to the census area divided by the average home range size.

The ideal stand size is probably about 10 to 20 acres and would accommodate several individuals of the both common and uncommon species. Stands that are too large tend to decrease overall habitat diversification. Birds with large home ranges can almost always use several proximate large patches of habitat, or a variety of habitat types.

Tree Species Composition

Tree species composition of eastern deciduous forests has little effect on bird communities because most birds select habitats by vegetation structure rather than by the tree species or genera that compose the forest. Any avifaunal differences between oak stands and mixed hardwood stands with greater plant variety are almost certainly due to differences in productivity and/or vegetation structure. However, forests containing appreciable densities of trees bearing usable seeds could receive more winter use by birds in some years, but there is no conclusive data to support this idea. Another question that needs further research is the possibility that trees with smooth bark surfaces such as aspen may contain fewer arthropods than those with rough bark. If so, bark foragers could be less prevalent in forests stocked with smooth-textured tree surfaces.

The management practice with the most potential to severely affect bird communities is conversion of hardwood stands to conifer plantations. Oak stands on poorer sites are often converted to red, jack, or shortleaf pine. Although such plantations may have higher winter bird densities, they would support a much lower density and diversity of breeding birds due to their extreme structural simplicity and scarcity of dead trees. In addition, undergrowth may be virtually eliminated for most stages of the rotation by site preparation, release, and shading.

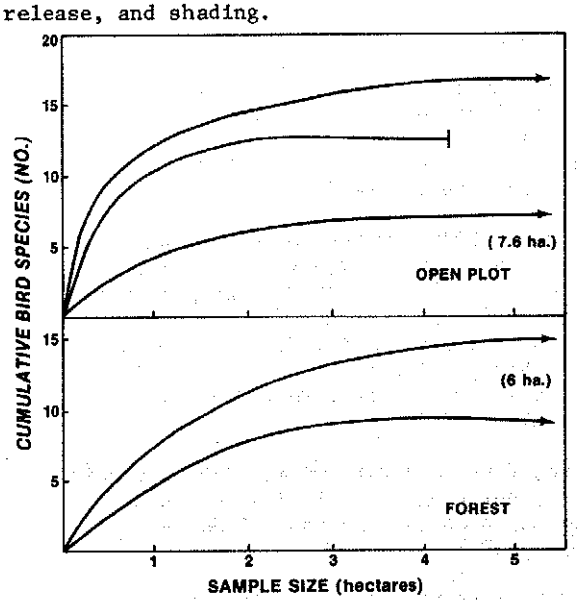

Figure 2.--*Species-area curves for open and forest study areas, which plot cumulative bird species vs. size of plot subset for selected plots of contrasting diversity. All plots show a plateau before 4 ha size. The minimum plot size was 4 ha and most were 6 ha or more. This would indicate that sampling sufficiency for species number has been achieved. The three truncated curves (indicated by arrows) show no increase in cumulative species through their full areas of 6 ha for the forest and 7.6 ha for the open plot.*

In summary, the density and diversity of breeding birds in oak forests can be enhanced by practices that increase the rotation age, structural complexity, and the variety of stands. Some mixture of conifers in some forests benefits both the breeding and winter avifauna, but conversion to pine plantations is detrimental to many breeding populations.

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