Partners in Flight
Bird Conservation Plan
for
The Ozark/Ouachitas
(Physiographic Area 19)

AMERICAN
BIRD
CONSERVANCY

Partners in Flight

Bird Conservation Plan

for

The Ozark/Ouachitas
(Physiographic Area 19)

Version 1.0

25 August 2000

by

Jane A. Fitzgerald and David N. Pashley

Please address comments to:

Jane Fitzgerald
PIF Midwest Regional Coordinator
8816 Manchester, suite 135
Brentwood, MO 63144

314-918-8505
e-mail: fitzgj@mail.conservation.state.mo.us

Table of Contents:

Executive Summary: 1

Preface 3

Section 1: The planning unit

Background 4

Conservation issues 7

General conservation opportunities 9

Section 2: Avifaunal analysis

General characteristics 11

Priority species 12

Section 3: Habitats and objectives

Forests 18

Factors affecting densities, community structure and reproductive success 18

Forest birds and silviculture 20

Pine plantations 23

Fire, savannas and birds 24

Bottomland hardwoods 26

Population objectives and habitat strategies 27

Research needs 32

Outreach 33

Literature cited 35

Appendix 1. Percentage of forest coverage and forest type by county in the Ozark/Ouachita physiographic area 44

Appendix 2. Percentage of forest ownership by county in the Ozark/Ouachita physiographic area 49

Appendix 3. The Partners in Flight prioritization scheme and criteria for the development of species priority lists 54

Appendix 4. Percentage of forest by county in the Ozark/Ouachita physiographic area in shrub/sapling, poletimber, and sawtimber stages 57

Appendix 5. Density and acreage estimates for declining species in the mature and early successional forest suites 62

Appendix 6. Recommendations for implementation strategies in subregions of the Ozark/Ouachita physiographic area 69

Appendix 7. Species suites by habitat type and seral stage 74

Partners in Flight

Ozark/Ouachita Bird Conservation Plan

(Physiographic Area 19)

Executive Summary:

The Ozark/Ouachita physiographic area is largely blanketed by oak-hickory, oak-pine and pine forest ecosystems (See mapset attached at end of document or at: <http://www.cast.uark.edu/edu/pif/main/maincont.htm>). Many bird species of Partners in Flight (PIF) conservation priority have centers of abundance in this region. For example, relative abundance data from the Breeding Bird Survey (BBS) indicate that the physiographic area supports over 30% of the world's breeding population of Whip-poor-wills, over 15% of the world's Kentucky Warblers and Summer Tanagers, and over 10 % of the Worm-eating Warblers, Yellow-billed Cuckoos, and Acadian Flycatchers. Conservation efforts in the physiographic area have a proportionately greater ability to impact such species as declines or increases in areas with large percentages of a species global population have a greater effect on their global abundance than if similar rates of increase or decline occur where there are fewer individuals. Further, the reproductive success of forest-breeding birds in the Ozark/Ouachitas appears to be above that needed to sustain local populations, and offspring from birds breeding in the physiographic area may be the sources of individuals that colonize other geographic areas where reproductive rates of forest birds are extremely low. Research in the Midwest has shown that such "source-sink" dynamics result primarily from the effects of high levels of brood parasitism and nest predation in areas where forest fragments fall below a size of approximately 4,000 hectares (10,000 acres) or where forest coverage across broad landscapes falls below 70%. Therefore, maintaining the forested landscapes needed to support source populations of forest birds is probably the single most important contribution that the physiographic area can make to the conservation of non-game birds.

Several species on the Partners in Flight Watch List breed in the physiographic area. Although the Ozark/Ouachitas are not necessarily the center of abundance for most of these species, all were once much more abundant and widely distributed in the region than they are today. Three of these are species associated with pine savannas (Red-cockaded Woodpecker, Brown-headed Nuthatch, and Bachman's Sparrow) and three with bottomland hardwood forests (Prothonotary Warbler, Cerulean Warbler, and Swainson's Warbler). Because these species have undergone drastic rangewide declines, PIF feels that active restoration and management of those habitats across their range is warranted.

A number of species of concern that have declined significantly in the physiographic area are associated with grass-shrub or early successional forest (e.g. Northern Bobwhite, Brown Thrasher, Prairie Warbler, Field Sparrow, and Orchard Oriole). These species can be provided for by idling agricultural lands, even-aged timber management, or restoration of glade and savanna habitats. However, decisions about fire intervals and other management techniques for glades and savannas should take into account the need of these birds for scattered trees or shrubs. Acreage needs of early successional species must be balanced with the needs of mature forest species also in need of conservation attention.

Urbanization is increasing rapidly in parts of the physiographic area. Efforts must be made to work with planners and policy makers to insure important bird areas are protected wherever possible. Developers should be encouraged to leave areas of native vegetation intact within and around development sites. Outreach programs should promote "landscaping for wildlife", with special emphasis on fruiting shrubs and trees to provide food for birds during migration.

Habitat conservation strategies suggested in this plan vary among subdivisions of the physiographic area, and are based upon present day or projected patterns of bird

distribution, land use, land cover, ownership, etc. Suggested conservation strategies for each subdivision of the physiographic area are given at the end of the habitat objectives section. In general, recommendations focus on maintaining the region's largely forested landscapes and large blocks of forest to keep source populations intact, restoring landscapes or blocks where potential currently exists, and balancing forest age classes within those areas so that the needs of species requiring a variety of successional stages all can be met.

PREFACE:

Partners in Flight (PIF) is a voluntary, international coalition of government agencies, conservation groups, academic institutions, private businesses, and everyday citizens dedicated to "keeping common birds common." PIF's goal is to direct resources toward the conservation of birds and their habitats through cooperative efforts in North America and the Neotropics. While PIF's focus generally is limited to the conservation of landbirds, it is intended to complement similar efforts for waterfowl, shorebirds, and other taxa. PIF now joins the North American Waterfowl Management Plan, United States Shorebird Conservation Plan, and North American Colonial Waterbird Conservation Plan in undertaking the kind of long-range planning necessary to help insure that viable populations of all native bird species continue to exist and that all our native ecosystems have full and functional avifaunal communities.

The foundation of PIF's bird conservation strategy is a series of Bird Conservation Plans, of which this document is one. These plans identify species and habitats most in need of conservation, and establish objectives for bird populations and habitats in physiographic areas (ecoregions) and states. The plans not only identify the general habitat requirements of priority species at the site level, but also seek to identify the quantity and quality of habitat required by birds at the landscape scale. Needed conservation actions are recommended and opportunities to accomplish them are suggested. Information and recommendations in the plans are based upon sound science and consensus among interested groups and knowledgeable individuals.

Many of the species that are part of the avifauna of the United States migrate through or winter in other countries in the Western Hemisphere. Most species have suffered loss in non-breeding areas, and some are exposed directly to toxicants and persecution (Basili and Temple 1995; Bird Conservation Fall 1996). While it is beyond the scope or desire of Bird Conservation Plans to recommend conservation objectives for other countries, PIF is working in concert with like-minded counterparts throughout the hemisphere to deliver integrated bird conservation at the necessary geographic scale. For more information about Partners in Flight, see the following web site: <http://www.partnersinflight.org/>.

Section 1: The planning unit

Background:

The Ozark/Ouachita physiographic area (also known as the “Interior Highlands”) encompasses two distinct mountain ranges, the Ozarks and the Ouachitas. The Ozark region is comprised of three dissected “plateaus” that resulted from erosion of a geologic dome uplifted during the Paleozoic era. It occupies most of southern Missouri and extends into northwestern and north-central Arkansas. The Ouachita region, extending from central Arkansas west into eastern Oklahoma, was extensively folded and faulted, resulting in the distinct east-west ridges that are evident in the landscape today. Soils throughout the planning unit typically are shallow, stoney, and acidic except on broad ridges and bottomland. The physiographic area is roughly coincident with sections 222A, M222A, M231A and 231G of McNab and Avers (1994).

The Ozark/Ouachita physiographic area grades into the Osage Plains to the west and north and into the West Gulf Coastal Plain to the south and east. Oak-hickory forests predominate throughout much of the Ozarks, with mixed pine-hardwood or pine forests more common in the Ouachitas (see mapset attached at end of document or at: <http://www.cast.uark.edu/edu/pif/main/maincont.htm>). Prairie grasses, such as big-

bluestem (*Andropogon gerardi*), are found in the understory of forests and savanna habitats that were subject to recurrent fire. Glades and barrens occur throughout the physiographic area where thin soils and dry exposures limit woody growth. Although the glades are characterized by warm-season grasses and a diversity of forbs, Eastern Red Cedar (*Juniperus virginiana*) and Ashe's Juniper (*Juniperus ashei*) invade glades during fire-free intervals. Their presence gave rise to the term "cedar glades," which often is used colloquially.

The Missouri Ozark Natural Division is comprised of six subdivisions (Upper Ozark, Lower Ozark, St. Francis Mountains, White River and Elk River drainages and the Springfield Plateau) that are differentiated by geologic history, drainage, geography, soils, and presettlement biota. Elevations range from 144-650 m (400-1800 ft) above sea level, with local relief of 100 or more meters (300 ft) typical of the region (Thom and Wilson 1983). The potential natural vegetation is pine, mixed pine-hardwood, oak-hickory forests, and glades. The Missouri range of short-leaf pine (*Pinus echinata*) and scarlet oak (*Quercus coccinea*) is centered in the Lower Ozarks of south-central Missouri. The White River section has extensive limestone and dolomite glades on south- and southwest-facing slopes. The glade-associated Ashe's juniper, a relict species in Missouri, is found only in this part of the state. Further west, in the Elk River section, glades are less common, although approximately 7% of the land was prairie prior to settlement. The Springfield Plateau is less highly dissected than other sections of the Ozarks and represents a transition between the tallgrass prairie of the Osage Plains and Ozark forests. Prairie occupied about 29% of the area (Thom and Wilson 1980).

Pell (1983) describes three Natural Divisions in the Ozark-Ouachita region of Arkansas with subdivisions as follows: Ozark Natural Division (Salem Plateau, Springfield Plateau, and Boston Mountains), the Arkansas Valley Natural Division, and the Ouachita Mountains Natural Division (Fourche Mountains, Central Ouachita Mountains, and the Athens Plateau). The Springfield Plateau extends into Oklahoma and Missouri, and the Salem Plateau into Missouri. Most of the land is rolling; glade and savanna

habitats are more common here than in other parts of the physiographic area. Gently undulating tallgrass prairie formerly occupied the flat tops of plateau in the southwestern Missouri and Northwestern Arkansas, but little remains today. The northern border is highly dissected and remains forested.

The Boston Mountains, extending from northern Arkansas into eastern Oklahoma, are the highest and most dissected area of the Ozark Natural Division. Gorges and ravines up to 385 m (1250 ft) in depth are common. Forest types are determined largely by topography; south-to-west facing slopes often are shortleaf pine mixed with drought tolerant hardwoods such as blackjack oak (*Quercus marilandica*), post oak (*Quercus stellata*), and black hickory (*Carya texana*). White oak (*Quercus alba*), northern red oak (*Quercus rubra),* and black oak (*Quercus velutina)* are dominant on other slopes, although American beech (*Fagus grandifolia*), basswood (*Tilia sp.*), and umbrella magnolia (*Magnolia tripetala*) can be found in deep hollows, ravines, and other mesic sites in the eastern portion of the sub-region. The Boston Mountains of Oklahoma, however, are more oak-dominated and pine, beech, basswood and magnolia are much less common than they are to the east (Oklahoma Biodiversity Plan and Mark Howery, pers. comm.).

The Arkansas Valley occupies a transitional zone between the Ozarks and Ouachitas, and extends into eastern Oklahoma. While a large part of the valley is undulating lowland, flat-topped synclinal mountains, and long, forested ridges also are present. Bottomland hardwood forests and swamps can be found along the Poteau, Arkansas, Petit Jean, and Fourche rivers.

The Ouachitas are a ridge and valley system of east-west trending mountains lying to the south of the Arkansas Valley. All of the ranges extend westward into Oklahoma. The Fourche mountains, the most northern of the ranges, occupy more than half of the Natural Division. Local relief can be as much as 540 m (1800 ft). Oak-hickory and oak-pine forests are the dominant vegetation, although pure stands of short-leaf pine occur on dry, rocky sites. Prairies appear never to have been common, although bluestem

grasses are associated with glades, savannas, and woodlands. Mesic vegetation is restricted to steep, north-facing or otherwise protected slopes. Plant communities in the Central Ouachita Division are similar, although extensive beech forests are present in the western portion. The Athens Plateau is less rugged than the subdivisions to its north, and the natural communities typically are less diverse.

Conservation issues:

Euro-American settlement of the Ozark/Ouachita region began in the early 1800s, although the population grew more rapidly in the latter part of the century after railroads reached the region (Stroud and Hanson 1981, Smith 1986, Stone County Historical Society 1989). Shortly thereafter, a logging boom ensued, and by 1909, Arkansas ranked 5th in the nation for lumber production (Smith 1986). The bulk of the state's production consisted of short-leaf pine harvested in the Ouachitas. Large volumes of oak were cut in areas where deciduous forests predominated; 500,000 white-oak railroad ties, for example, were shipped via rail from a small town in the White River subdivision of Missouri in 1912 alone (Stone County Historical Society, 1989).

The virgin timber supply was exhausted by the 1920s. Natural regeneration occurred, although the stands were characteristically even-aged and/or the original species composition altered. Vast acreages also were planted with pine seedlings. Fire suppression was encouraged throughout the region to protect tree seedlings and saplings (Smith 1986, Palmer 1991). Some cut over areas were converted to agricultural uses, primarily for livestock production in the uplands and to cropland in the bottoms.

The amount of land in the Ozark/Ouachita physiographic area that is currently forested varies greatly by county and subdivision (Appendix 1). Coverage is greatest (often more than 70%) in the Lower Ozarks and St. Francois Mountains of Missouri, in the Boston Mountains of Northern Arkansas, and in many counties of the Ouachitas. Other subdivisions, such as the Springfield Plateau, Upper Ozarks, Elk River, and White River

have a much lower percentage (roughly 40 - 55%) of forest cover. With the exception of the Lower Ozarks and Boston Mountains subdivisions, less than 20% of forest land in the Ozarks is in public ownership, but averages 20-30% in the Ouachitas (Appendix 2). Although the forest products industry owns relatively little land in the Ozarks, a much greater percentage of the Ouachitas is in corporate ownership (Appendix 2).

Glade habitats can be relatively small patches (less than a hectare or 2.5 acres) interspersed within a largely forested matrix, or may themselves predominate across 10s - 100s of hectares on drier exposures. Many glades have been invaded by eastern red cedar as a result of widespread fire suppression and have grown into cedar "forests," rendering them unattractive to the priority bird species typically associated with glade habitats. However, species such as Prairie Warblers and Field Sparrows require a shrubby or woody component interspersed within the grass/forb matrix and are not likely to occur if scattered cedars or other small trees are not present. This may present a conflict in areas where glades are managed exclusively for native herbaceous flora, as frequent burns and mechanical methods often are utilized to remove cedars and promote grass and forb growth.

Dams have been constructed on most major rivers in the physiographic area, and areas that were formerly floodplain forests have been lost to inundation. Most affected are the White River drainage of southwestern Missouri and northwestern Arkansas, and the Ouachita River Valley. An additional six dams are planned for major rivers in the Ouachitas (The Nature Conservancy 1994). In addition to the loss of floodplain habitats, tourism facilities and retirement communities often follow the creation of reservoirs, yet planning and zoning regulations that protect native habitats and mitigate environmental degradation typically are non-existent in rural areas.

While much of the physiographic area is still sparsely populated, some areas are experiencing tremendous population growth primarily as a result of immigration from nearby cities or other parts of the country. For example, a three-county area in the White River subdivision of Missouri was the fastest growing region of the state between

1990 and 1996, with population increases of 38, 36 and 30% in Christian, Stone and Taney counties, respectively. Similarly, three nearby counties in northwestern Arkansas (Carroll, Benton, and Washington) increased 20, 29 and 19%, respectively, in the same period. Most other counties in the Ozark/Ouachitas are showing positive, if not so dramatic growth rates, while relatively few have decreased in population (statistics from the Missouri Department of Economic Development and Arkansas Institute for Economic Advancement, University of Arkansas, Little Rock, 1997).

Associated with population growth are construction of new roads, houses, schools, and other infrastructure that permanently displace habitat in a given area and fragment what remains. Barriers to dispersal among fragments also increase in importance in an urban setting as organisms have to negotiate traffic, fences, buildings, parking lots, etc. Although some counties have planning and zoning ordinances, many counties do not. Of those that do, some require “green space” in planned developments, but most of these areas are not left in native vegetation, or preserve only some of the largest trees. Further, the acreage of green space required by ordinance at any given site is typically well below the territory sizes or minimum area requirements of many species of forest birds. Fortunately, some of the larger development corporations in the fastest growing areas do set aside considerable acreages and blocks of native habitat for aesthetic considerations or because of engineering and building constraints, which can help to maintain habitat for wildlife as well.

General conservation opportunities:

Several of the PIF priority species in the Ozark/Ouachita physiographic area are of extremely high conservation concern throughout their breeding range (e.g. Red-cockaded Woodpecker, Swainson’s Warbler, Cerulean Warbler, Bachman’s Sparrow, and Bell’s Vireo). A number of other priority species, such as Worm-eating Warbler, Kentucky Warbler, and Whip-poor-will, have relatively large percentages of their global populations in the planning unit (from BBS data, Ken Rosenberg, pers. comm.). As a result, conservation efforts in the Ozark/Ouachitas have a great opportunity to affect

the long-term survival of a number of priority bird species.

The physiographic area also is blessed with an active community of avian ecologists. Researchers employed by the U.S. Forest Service; University of Missouri, Columbia; University of Arkansas, Fayetteville; University of Arkansas, Monticello; Arkansas Technical University; Missouri Department of Conservation; the corporate timber industry; and others within the region have provided much needed information about the effects of forest management practices, fragmentation, and landscape ecology on the habitat use and demographics of forest songbirds. The Missouri Ozark Forest Ecosystem Project (MOFEP) is a cooperative effort among agency and academic researchers to provide a long-term assessment of forest management practices on the overall forest ecology in the Lower Ozarks subdivision. Similarly, the Ouachita Forest Ecosystem Research Program is a cooperative among agencies, academic and industry researchers to evaluate response to forest management in the Ouachitas. Agencies responsible for forest management on public lands, as well as those in the private sector, seem recognize a need for the information such research provides in order to implement sound, sustainable management objectives.

A number of non-governmental organizations have projects underway to foster protection and habitat restoration within the physiographic area. The Nature Conservancy recently designated 5250 square kilometers (3200 square miles) of the Missouri/Arkansas Ozarks as “One of the World’s Last Great Places” and plans to raise 3.5 million dollars over the next three years to fund scientific studies, management of its preserves, and community-based projects. The Ozark Center for Wildlife Research (OCWR) has been monitoring forest bird communities in the White River subdivision of Missouri annually since 1992 at a large residential development site and at undeveloped sites to gain more understanding of bird-habitat relationships in the area and how bird communities are affected by development pressures. OCWR also works with developers, planners, and community groups to educate them about issues associated with habitat fragmentation and to promote more “habitat-friendly” development patterns.

Tourism has been and continues to be an important economic force in the Ozark/Ouachitas, with many people attracted to the area for its natural beauty and outdoor recreation values. Because the opportunity to view scenic vistas of forests, glades, and other natural features is an integral part of the tourism experience, there is an economic incentive to maintain large expanses of native habitat in the landscape.

Perhaps one of the greatest barriers to effective conservation in the physiographic area is a misperception among some rural people that the United Nations, state and federal agencies, and conservation organizations are involved in a conspiracy to take property away from private citizens and place it under the control of a “one-world government.” Landowners must be assured that this is untrue, and that private property rights always will be respected by the Partners in Flight community. Participation at any or all levels of the PIF conservation effort always has been voluntary and will remain so in the future.

Section 2: Avifaunal analysis

General characteristics:

Approximately 115 species of birds breed in the Ozark/Ouachita physiographic area (Sauer 1996). Of those, roughly 13% are associated with wetland or riparian habitats, 17% with grassland or glade habitats, 43% with forests in various successional stages, and 27% with a variety of habitat types. Seventy percent of species did not exhibit a significant population trend during a thirty-year period of the Breeding Bird Survey (1966-1996), indicating that populations are stable or are undersampled by that methodology. Approximately 7% of wetland/riparian species have declined and 27% have increased; 40% of grassland associated species have declined and 20% have increased; 20% of forest species have declined and 2% have increased; and 20% of habitat generalists have declined and 10% have increased.

Priority Species:

Species are considered of conservation priority for PIF physiographic area Bird Conservation Plans if they meet one of six criteria (see Appendix 3). These criteria variously emphasize the species' vulnerability to extinction across its range, its population trend in the physiographic area, and the degree to which the planning unit in question is a center of abundance for that species. Population increases or declines in areas with large percentages of a species' global population have a greater impact on global abundance than if similar rates of increase or decline occur where there are fewer individuals. Therefore, conservation efforts for species in areas where they are relatively abundant can be more efficient than those directed toward areas where the species is relatively rare. Species that have a large proportion of their population breeding in the planning unit but that are not declining do not warrant immediate conservation action, but their needs should be considered in long-range planning.

The thirty-three species designated as species of conservation priority for the Ozark/Ouachitas are given in Table 1. Fifteen have greater than 5% of their global population breeding in the planning unit. Populations of five of those (Pileated Woodpecker, Acadian Flycatcher, Prairie Warbler, Field Sparrow, and Orchard Oriole) declined significantly in the physiographic area between 1966 and 1996, and three (Eastern Wood-Pewee, Great Crested Flycatcher, and Carolina Chickadee) show strong evidence of decline.

Thirteen priority species are on the PIF National Watch List, indicating that they warrant conservation attention in each physiographic area where they occur in manageable numbers. Population trends of most of these species either are unknown due to rare appearances on Breeding Bird Survey routes, or at least appear to have declined.

The Ozark/Ouachita priority species are grouped by habitat type in Table 2. Several of the Watch List species and the priority species that have exhibited population declines are associated with bottomland forests (Pileated Woodpecker, Acadian Flycatcher,

Prothonotary Warbler, Cerulean Warbler, and Swainson's Warbler), early successional habitats (Brown Thrasher, Prairie Warbler, and Field Sparrow), mature forest (Acadian Flycatcher, Wood Thrush, Eastern Wood-Pewee, and Ovenbird) and pine savanna (Red-cockaded Woodpecker, Brown-headed Nuthatch and Bachman's Sparrow). As a result, conservation attention must be focused on a variety of habitat types in the physiographic area if declines of these species are to be halted or reversed.

Table 1. Partners in Flight Priority Species for Physiographic Area 19: The Ozark-Ouachitas.

Species	Criteria	Total Score	RS	AI	PT local	PT global	BBS Trend	% Pop-B
Red-cockaded Woodpecker*	1a	30	b	2	5	5	na	na
Swainson's Warbler*	1b	26	b	2	3	3	na	na
Cerulean Warbler*	1b	25	b	2	4	5	-12.8	2.3
Kentucky Warbler	1b	25	b	5	4	3	-1.5	18.8
Worm-eating Warbler*	1b	25	b	4	3	3	-2.0	14.5
Bachman's Sparrow*	1b	25	b	2	3	4	na	1.2
Bell's Vireo*	1b	24	b	2	4	5	-9.4	1.3
Prairie Warbler*	1b	24	b	4	5	5	-4.2	6.2
Whip-poor-will	1b	22	b	5	2	3	0.1	31.0
Acadian Flycatcher	1b	22	b	3	4	3	-1.6	5.2
Brown-headed Nuthatch*	1b	22	b	2	3	4	na	na
Prothonotary Warbler*	1b	22	b	2	4	5	-4.4	1.8
Louisiana Waterthrush	1b	22	b	4	2	3	0.9	13.0
Field Sparrow	1b	22	b	5	5	5	-2.7	10.7
Orchard Oriole	1b	22	b	5	5	5	-3.4	5.4
Northern Bobwhite	2a	21	b	4	5	5	-3.0	4.3
Brown Thrasher	2a	21	b	3	5	5	-3.1	2.9
Great Crested Flycatcher	2a	20	b	4	5	3	-1.8	5.7
Ovenbird	2a	20	b	3	5	1	-3.4	0.7
Pileated Woodpecker	2a	19	b	5	5	1	-2.1	6.6
Carolina Chickadee	2a	19	b	4	4	3	-1.1	7.8
Chuck-will's-widow*	2b	21	b	5	2	5	0.0	14.1
Blue-winged Warbler	2b	21	b	3	2	3	1.8	11.8
Yellow-billed Cuckoo	2b	20	b	5	2	5	0.1	10.9
Yellow-throated Warbler	2b	19	b	3	2	3	1.13	8.3
Summer Tanager	2b	19	b	5	2	3	0	15.6
Painted Bunting*	3a	21	b	2	3	5	-0.6	4.2
Wood Thrush*	3a	20	b	3	2	5	-0.6	2.3

Species	Criteria	Total Score	RS	AI	PT local	PT global	BBS Trend	% Pop-B
Red-cockaded Woodpecker	1a	30	w	2		5		
Bachman's Sparrow	1b	26	w	2		4		
Smith's Longspur	1b	25	w	2		3		
Sprague's Pipit	1b	24	w	2		5		
Red-headed Woodpecker*	1b	23	w	5		5		
Brown-headed Nuthatch	1b	23	w	2		4		
Short-eared Owl*	1b	22	w	3		5		
Northern Bobwhite	2a	21	w	4		5		
Brown Thrasher	2a	21	w	4		5		
Loggerhead Shrike	2a	20	w	3		5		
Field Sparrow	2a	20	w	3		5		
Carolina Chickadee	2a	19	w	5		3		
Purple Finch	2a	19	w	5		3		
Rusty Blackbird	2a	19	w	3		5		
Bewick's Wren (T. Bewickii bewickii)**					4		-3.8	

* Indicates the species is on the Partners in Flight Watchlist.

** Although subspecies have not been subjected to prioritization by PIF in any formal sense, populations of *Thryomanes bewickii bewickii* have declined drastically during the 30 year period of the breeding bird survey. The Ozark/Ouachitas physiographic area appears to be one of the last remaining strongholds for the subspecies, and it therefore is included as a priority species for the planning unit.

Criteria: the criteria by which the species qualified for inclusion as a priority species in Table 1. (see appendix 1).

Total score: the sum of the seven variables that are used to rank species in the Partners in Flight species prioritization process. (see appendix 1).

RS: residency status. b = species breeds in the physiographic area; w = species winters in the physiographic area.

AI: area of importance score, a measure of intraspecific relative abundance among physiographic areas. (see appendix 1).

PT local: the species' population trend score for the physiographic area (see appendix 1).

PT global: the species' population trend score rangewide (see appendix 1).

BBS trend: population trend as measured by the North American Breeding Bird Survey (Sauer et al. 1997). * = PT significant at 0.10; ** = PT significant at 0.05; na = not available.

%pop - B: percentage of the species' breeding population that occurs in the planning unit during breeding season. (See appendix 2).

Table 2: Priority species by habitat type in the Ozark-Ouachitas physiographic area.

Species	PS	PF	MPH	OH	OS	BH	GL	GR
Red-cockaded Woodpecker*	x	4						
Swainson's Warbler*						3		
Cerulean Warbler*				3		3		
Kentucky Warbler			3	3		3		
Worm-eating Warbler*				3				
Bachman's Sparrow*	x	1	1	1				
Bell's Vireo*			1	1				
Prairie Warbler*	x	1	1	1	x	1		
Whip-poor-will		2, 3	2, 3	2, 3	x			
Acadian Flycatcher				3		2, 3		
Brown-headed Nuthatch*	x	2, 3	2, 3					
Prothonotary Warbler*						3		
Louisiana Waterthrush				3		3		
Field Sparrow		1	1	1	x		x	
Orchard Oriole*				1, 2, 3	x			
Northern Bobwhite	x	1	1		x			
Brown Thrasher		1	1	1	x		x	
Great Crested Flycatcher		3	3	3	x	3		
Ovenbird			2, 3	2, 3				
Pileated Woodpecker			3	3		3		
Carolina Chickadee		2, 3	2, 3	3		3		
Chuck-will's-widow		2, 3	2, 3					
Blue-winged Warbler				1				
Yellow-billed Cuckoo				2, 3	x	2, 3		
Yellow-throated Warbler		3	3			3		
Summer Tanager		3	3	3	x			
Painted Bunting							x	
Wood Thrush*		3	3	2, 3		2, 3		

Species	PS	PF	MPH	OH	OS	BH	GL	GR
Smith's Longspur								x
Sprague's Pipit*		1	1	1		1		
Red-headed Woodpecker*	x			3	x	2, 3		
Short-eared Owl*	x	1	1	1		1		
Loggerhead Shrike	x				x			x
Purple Finch			2, 3	3		2, 3		
Rusty Blackbird						2, 3		
Bewick's Wren (T. Bewickii bewickii)**		1	1	1	x			

Habitat codes: PS = Pine savanna; P = Pine; MPH = Mixed Pine-Hardwood; OH = Oak-Hickory; BH = Bottomland hardwood; GL = glade; SG = Short, sparse grassland, especially with a three-awn grass (Aristida sp.) component. PS information is from Wilson et al. 1995, OS info from Brawn 1998, glade info from Jacobs and Wilson (1997), James and Shugart 1973.

1 = seral stage shrub-sapling (combines stages 1 and 2 of Hamel). 2 = poletimber, 3 = sawtimber.

* = the habitat is marginal for the species and no seral stages in the habitat type are suitable or optimal.

Section 3: Habitats and objectives

Forests:

The effects of the amount and configuration of habitat types and seral stages, and the responses of species and communities both to habitat fragmentation and alteration must be understood if conservation efforts are to be successful in the Ozark-Ouachita physiographic area. Aspects of each of these are discussed in the following subsections.

Factors affecting densities, community structure and reproductive success...

Habitat related factors at both patch and landscape scales have been shown to affect populations of forest-nesting birds in the Ozark/Ouachitas. Whether a species is attracted to a given site is largely the result of the composition and configuration of the vegetation at the site (James 1970), with relative densities changing when disturbances like timber harvest (Thompson and Fritzell 1990; Thompson et al. 1992) or fire (Wilson et al. 1995) alter vegetation structure.

In fragmented landscapes, the number of species occupying a site also has been shown to increase with habitat patch size and to decrease with the degree of isolation among patches (Galli et al. 1976, Askins et al. 1987). In Illinois, for example, 87-98% of the variation in the number of species occupying sites ranging in size from 1.8-600 ha (4.5-1,500 acres) was attributed to patch size (Blake and Karr 1987). Because some birds may be responding more to the total amount of core area (i.e. the area of forest >100m from a forest edge), even relatively large tracts with small interior-to-edge ratios may be unattractive to some species (Temple 1986). Further, bird communities in small woodlots typically are dominated by ecological generalists (Martin 1981, Ambuel and Temple 1983, Blake 1983), a pattern that also appears to be exacerbated where patches are more isolated and where habitat structure in the surrounding matrix is in

sharp contrast to that of the habitat patch (Blake and Karr 1987, Freemark and Collins 1992).

Species that typically inhabit only relatively large fragments are called “area sensitive.” Some species are area sensitive because they have relatively large home ranges (e.g. Pileated Woodpecker, 53-160 ha, Renken and Wiggers 1993; Forman et al. 1976), while others require areas of forest orders of magnitude greater than the area of their territories (Ambuel and Temple 1983) for reasons that largely remain unknown. However, even when patch sizes are large enough to attract area-sensitive species, densities and mating success may be compromised until an even greater size threshold is reached. For example, densities of two PIF priority species, Kentucky Warbler and Ovenbird, were twice as great in an 800-ha (2000-acre) tract of Missouri forest than in two 300-ha (750-acre) forest fragments (Wenny et al. 1993). Pairing success of Ovenbirds in the smaller patches also was low in comparison to the larger tract (Van Horn et.al. 1995, but see Porneluzi and Faaborg 1999). An Ontario study showed that female Ovenbirds chose territories with higher prey biomass than occurred at randomly selected sites, and that prey biomass was 10 to 36 times greater in large woodlots than smaller fragments, perhaps explaining the paucity of female Ovenbirds in small forest fragments (Burke and Nol 1998).

A number of studies in the Midwest have indicated that levels of brood parasitism and nest predation are greater (Temple and Cary 1988, Brittingham and Temple 1983) and that mating success is lower (Gibbs and Faaborg 1990, Van Horn et al. 1995) near edges of forest than in the interior. These phenomena seem to be associated more with the kinds and amounts of habitat in landscapes surrounding patches than internal characteristics of the patch itself (Donovan et al. 1997). In extremely fragmented landscapes, cowbirds and nest predators can saturate tracts of forest even as large as 2000 ha (5000 acres) in size (Robinson and Wilcove 1994, Robinson et al. 1995, Marini et al. 1995, Heske 1995, Porneluzi and Faaborg 1999). In areas with extremely high rates of brood parasitism and nest predation, nesting success can be so low that breeding birds are unable to produce enough offspring to replace themselves and

immigration of individuals from areas where reproductive success is high becomes necessary to sustain local populations (Robinson et al. 1995, Donovan et al. 1995, Porneluzi and Faaborg 1999). Areas of low reproductive success often are referred to as “sinks” and areas with high reproductive success as “sources”. Movements of individuals between sources and sinks appear to be characteristic of much of the Midwest, with offspring from birds breeding in largely unfragmented areas of the Ozarks presumed to be the sources of immigrants for more fragmented areas (Robinson et al. 1995; Donovan et al. 1995; Robinson et al. 1996; Thompson et al. 1996). Species richness and population trends within small fragments can appear stable over time where immigration masks local reproductive failure, misleading managers and conservationists who use that kind of information to assess the health of local populations (Brawn and Robinson 1996).

Although few studies to date have addressed dispersal dynamics and factors effecting survival of post-fledgling birds, predation was found to be the main cause of post-fledging mortality in juvenile Wood Thrush even in a heavily forested region of the Missouri Ozarks (Anders et al. 1997). The risk of mortality varied with age, and was greatest during the period when young began foraging independently of their parents. Approximately three weeks after fledging, when juveniles dispersed into areas of dense vegetation such as mature wooded riparian habitat, clearcuts, and field/forest edges, the probability of predation dropped to zero, emphasizing the need for those habitat components in the landscape (Anders et al. 1998). Juvenile Wood Thrush dispersed into similar habitats in a Virginia study, where researchers felt the bird’s movements were keyed by the availability of food resources (especially fruiting trees and shrubs) and the presence of conspecifics (Vega Rivera et al. 1998). Studies of post-fledging movements and survivorship of other priority species are needed.

Forest birds and silviculture

The two most commonly used silvicultural techniques in the Ozarks/Ouachitas are even-aged and uneven-aged management (also known as “clearcutting” and “single-

tree or group selection", respectively). Forest tracts are not fragmented in the classic sense when trees are harvested by either strategy, but both change the vegetation structure of the stand where the treatment is applied and both increase the amount of "edge" habitat at the site when compared with a mature tract of undisturbed forest. Although edge effects (i.e. elevated rates of brood parasitism and nest predation within proximity to edges) appear to be dependent upon landscape context, and to be more pronounced where isolated forest tracts are embedded in non-forest (especially agricultural) matrices (Donovan et al. 1997), more research along those lines is warranted (see Robinson 1996, Thompson et al. 1996).

Even-aged management can change the vegetation structure at both stand and landscape scales because it eventually produces discrete patches of trees of the same age across a landscape as harvests are rotated among stands. Recently harvested stands with a predominance of saplings/seedlings provide open, shrubby habitats while in their earliest stages of succession (typically stands less than 10 years of age), but attain characteristics of young forests as regeneration proceeds through the sapling and pole-timber stages. Even-aged stands classified as sawtimber (typically 60 years of age or greater) appear most like unharvested mature forest habitat, as they often take on a multi-canopied appearance due to differences in growth and survival among species and individuals.

Forests under even-aged management have been shown to provide suitable-to-optimal habitat for several PIF priority species (see Hamel 1992) even when compared to stands of forest that have not been harvested (Thompson and Fritzell 1990, Thompson et al. 1992). Thompson and colleagues (1992) found that recently clearcut stands in the Missouri Ozarks supported significantly higher densities of Blue-winged Warbler, Prairie Warbler, and Field Sparrow than did older stands under even-aged management or stands where no harvest had occurred, that densities of two other priority species, Worm-eating Warbler and Kentucky Warbler, were greater in sapling stands that resulted from even-aged management in the Missouri Ozarks than in even-aged pole and sawtimber or unharvested stands, and that differences in densities of Acadian

Flycatchers and Ovenbirds were not significantly different in mature stands under management than those that had not been managed. Abundance, species richness and diversity of breeding bird communities in the Ouachita Mountains were found to increase with the intensity of forest management and the presence of pine plantations. For those PIF priority species regularly sampled in the study, relative abundance of Acadian Flycatcher, Carolina Chickadee, Prairie Warbler, Kentucky Warbler, Worm-eating Warbler, Field Sparrow and Summer Tanager increased with management intensity; Ovenbird and Pileated Woodpecker decreased; and Great Crested Flycatcher and Yellow-billed Cuckoo showed no apparent trend (Tappe et al. in press).

To some extent, uneven-aged management to imitates “gap-phase” ecological dynamics by simulating small-scale disturbances, such as tree falls and windthrows, within the stand. Trees are harvested singly or in small groups, resulting in gaps which usually are much smaller than the stand itself (Guldin 1992). Large amounts of internal edge can be created by this technique, however, as a result of the large ratio of perimeter to opening area that results (Johnson 1993). Forests under uneven-aged management typically have a well-developed understory and sub-canopy because of the many gaps, but have fewer large canopy trees than mature even-aged stands. While selectively cut forests can provide habitat for mature forest species, they do not provide habitat for species requiring early-successional habitats (Thompson et al. 1996). While few empirical data exist with which to compare population sizes or sustainability of forest birds under even-aged, uneven-aged, and no harvest strategies, a simulation model developed by Thompson (1993) suggested the largest population would be sustained under the no harvest strategy. Population sizes in forests managed with clear-cutting were greater than those in areas harvested by group selection when edge effects were incorporated. When edge effects were not incorporated into the models, populations were only slightly greater with no harvest than group selection, and were lowest under even-aged management. The model was very sensitive to declines in mean fecundity and survival, suggesting that large scale factors affecting mean demographic rates could be more important than local edge effects.

Until more is known about the response of bird communities to various management treatments, recommendations for the use of one harvest regime over another should be made after some consideration of the amount of each forest seral stage present in the landscape surrounding the timber production area, and the relative value of that part of the physiographic area to certain groups of species. Especially in heavily forested regions, a mix of strategies may be warranted (Thompson et al. 1996). Therefore, habitat objectives and recommendations will be made separately for each subdivision of the physiographic area.

Pine plantations....

Over 2 million acres of the Ouachitas currently are in pine plantations (The Nature Conservancy 1994). Although rotations are relatively short, forests are managed primarily for sawlog production. Trees can attain an average size of 6.3 cm DBH (16 in.) within 35 years (Tony Melchiors, Weyerhaeuser, pers. comm.). Pine plantations effectively contribute to the percentage of the landscape in forest cover, which may play a role in maintaining adequate reproductive rates of birds breeding within the landscape.

Reproductive success of 12 species of birds nesting in pine plantations in the Ouachitas was compared among stands in four age-classes resulting from even-aged management and stands managed with single-tree selection. Nest success varied considerably among species and treatments and differences generally were not significant. However, Summer Tanager was the only PIF priority species to nest exclusively at sites managed with single-tree selection. Carolina Chickadee nested at both even-aged and single-tree selection sites, but Eastern Wood-Pewee, Prairie Warbler, Kentucky Warbler, Worm-eating Warbler Field Sparrow, and Orchard Oriole nested only in stands under even-aged management. The average nest parasitism rate was relatively low (12%). Eighty percent of failed nests were attributed to predation events. Predation rates were positively correlated with relative abundance of birds, suggesting that nest predators may have responded to prey in a density dependent

manner. With the exception of some shrub-nesting species, nesting success of most species was equal to or greater than that found in earlier studies (Barber et al. in press).

Forest stands along perennial and intermittent streams, commonly called streamside management zones (SMZs), frequently are retained in pine plantations for wildlife habitat and watershed protection. SMZs vary greatly in width from less than 20m to greater than 100m. Several PIF priority species (eg. Prairie Warbler, Kentucky Warbler, and Field Sparrow) were found in moderate abundance in relatively narrow streamside management zones in Ouachita pine plantations. In contrast, relative abundance of four PIF priority species (Pileated Woodpecker, Acadian Flycatcher, Eastern Wood-Pewee, and Wood Thrush) was positively correlated with SMZ width and they appeared to avoid zones less than 60m wide (Tappe et al. 1994, Thill et al. 1997). Although a variety of SMZ widths will support both early and late-successional forest species, the needs of species associated with riparian habitats, such as Acadian Flycatcher, Pileated Woodpecker, and Louisiana Waterthrush should be emphasized when SMZ policies and practices are developed. The effects of streamside zone width on reproductive success was not evaluated (Tony Melchiors, pers. comm.).

Fire, savannas and birds...

Historically, fires occurred at varying intervals throughout the physiographic area. An analysis of fire scars on pine trees in the Ouachita's Hot Springs National Park suggested an average fire return interval of 20.5 years on south, southwest, and northwest aspects. Although there were not enough old trees to generate accurate estimates of pre-settlement fire frequency, the oldest shortleaf pine sampled had fire scars from 1788, 1798, 1806, 1811, 1817, 1829, 1847, 1873, 1889, and 1929. Given that fire suppression wasn't a widespread practice in the Ouachitas prior to the 1900s (Smith 1986), this indicates a fire frequency of 9.8 years, with fire-free intervals ranging from 5 to 18 years (Foti and Glenn 1991). Fire scar analysis from 26 sites in oak-pine forest in the Lower Ozarks of Missouri indicates that prior to the 1850's, a 6.3 year fire-free interval was average, with a range of 2-24 years. Average fire frequency increased

to approximately 3.1 years from 1850 - 1940 and shifted from fall to spring burns, coincident with increases in settlement by both native and European Americans. Pine abundance decreased from historic levels during this period at 60% of sites sampled, and was attributed to a lack of pine regeneration during the period of increased fire frequency (R. Guyette, presentation to Missouri Ozark Forest Ecosystem Project symposium, 1997). Thus, while fire appears to be an integral ecological process in the maintenance of oak-pine forests, fire-free intervals must occasionally be long enough for trees to attain a threshold amount of fire resistance that allows regeneration and replacement to occur.

Although oak savannas and forests in more mesic areas of the Midwest were dependent upon fire for oak regeneration historically (Lorimer 1985, Johnson 1993), oak forests in the Ozarks, Ohio Valley and other more xeric regions appear able to sustain themselves in the absence of fire, presumably because water stress and other factors limit competition (Johnson 1993). However, there is evidence that fires occurred repeatedly in the Ozarks and were set primarily by humans, both native and immigrant. Fire-free intervals increased between European settlement and the mid-1950s at some sites, but decreased or remained the same at others. (Richard Guyette, University of Missouri Columbia, unpublished report, 1993). A lack of oak recruitment was documented at a site in the south-central Missouri Ozarks during a period between 1750 and 1810, when the average fire-free interval 4.3 years, implying that for oaks, as with pine, fire-free intervals must be long enough for trees to attain a threshold amount of fire resistance before recruitment can occur (Guyette and Cutter 1991). Johnson (1993) suggests that an oak savanna structure would be maintained by a series of fires at short intervals, interrupted by fire-free periods ranging from 10 to 20 years.

Several PIF priority species are associated with pine (e.g. Red-cockaded Woodpecker, Brown-headed Nuthatch and Bachman’s Sparrow) and oak savannas (most notably Red-headed Woodpecker). Historically, the Red-cockaded Woodpecker was associated with old growth southern pine forests, and its range included Oklahoma, Arkansas, and southern Missouri. It is now Federally listed as Endangered, with isolated populations

scattered across its former range. Both fire suppression and widespread logging of extensive pines stands have led to its decline. The species is extirpated in the Ozarks, but two populations currently exist in the Ouachitas. Both have responded positively to controlled burns, mid-story thinning, and other management techniques used to restore large expanses of its pine savanna habitat. This species has the narrowest requirements of any priority species in the pine savanna suite, preferring open stands of pine with trees at least 80-120 years old for nest sites. Dense stands, or stands with a hardwood understory, typically are avoided (U. S. Fish and Wildlife Service Endangered and Threatened species accounts, FWS region 4). Other Ozark/Ouachita high-priority species associated with managed pine savanna include Northern Bobwhite, Red-headed Woodpecker, Eastern Wood-Pewee, Brown-headed Nuthatch, Prairie Warbler, and Bachman's Sparrow (Hamel 1992, Wilson et al. 1995).

The only definitive work on oak savanna birds in the Midwest was done by Brawn (1998) in Illinois. However, Brawn's study sites were within the highly fragmented Prairie Peninsula physiographic area, and results of his work may have limited application in the heavily forested Ozarks. Nevertheless, several Ozark/Ouachita priority species (i.e. Northern Bobwhite, Yellow-billed Cuckoo, Whip-poor-will, Red-headed Woodpecker, Eastern Wood-Pewee, Great Crested Flycatcher, Bewick's Wren, Brown Thrasher, Loggerhead Shrike, Summer Tanager, Field Sparrow, and Orchard Oriole) were included in Brawn's list of species with exclusive or important habitat associations with oak savannas and woodlands.

Bottomland hardwoods....

Although several high-priority bird species are known to breed in bottomland hardwood forests of the Ozark/Ouachitas (e.g. Prothonotary Warbler, Cerulean Warbler, and Swainson's Warbler) very little work has been done on the ecology and habitat relationships of those species in the physiographic area. However, data on distributions of Cerulean Warblers have now been gathered by canoe survey along several Ozark rivers, and analyses of landscape factors that could be affecting their distributions will

be performed in the near future (Frank Thompson, U. S. Forest Service, Columbia, MO, pers. comm.). Relatively large numbers of Cerulean Warblers were encountered during those surveys along the Current, Black and Eleven Point Rivers in Missouri (i.e. 2-4 singing males/ river mile along some greater than 6 km [10 mi.] stretches), and small populations of Swainson's Warbler have been found breeding in those drainages as well (Thomas 1994). Both Cerulean Warblers and Yellow-throated Warblers appear to be associated primarily with Sycamores (*Platinus occidentalis*), emphasizing the importance of that species in riparian forests (Robbins et al. 1998).

Population objectives and habitat strategies:

Populations of seven priority species (Whip-poor-will, Chuck-will's-widow, Yellow-billed Cuckoo, Blue-winged Warbler, Yellow-throated Warbler, Louisiana Waterthrush, and Summer Tanager) appear stable in the physiographic area (Table 1). Trends for five species are unknown. Four of those species (Brown-headed Nuthatch, Swainson's Warbler, Bachman's Sparrow, and Painted Bunting) are patchily distributed in the planning unit (Jacobs and Wilson 1997, James and Neal 1986), and one (Worm-eating Warbler) has been found to occur primarily in the interior of relatively large tracts of forest (Wenny et al. 1993). As a result, a region-wide system of roadside point counts such as the Breeding Bird Survey may be inadequate to monitor their populations. Monitoring strategies that better sample these species are needed to assess their status in the planning unit. Local population trends of wintering species remain unknown, but we assume that habitat efforts to benefit breeding birds will benefit wintering species as well.

Species showing strong evidence of population decline are associated with a variety of habitat types and seral stages (Table 2). The drastic decline of Red-cockaded Woodpecker, an old growth pine-savanna specialist, can be attributed directly to the loss and degradation of its habitat (U. S. Fish and Wildlife Service Endangered and Threatened species accounts, FWS region 4). Most of the declining species that breed in mature forest, such as Pileated Woodpecker, Ovenbird, Cerulean Warbler and

Kentucky Warbler have been shown to be area-sensitive or have relatively large home range requirements (Robbins et al. 1992, Renkin and Wiggers 1993, Wenny et al. 1993) and may have suffered declines especially in parts of the physiographic area that are less forested and more fragmented. Several of the forest species also reach higher densities in bottomland hardwood forests (e.g. Cerulean Warbler, Prothonotary Warbler, Acadian Flycatcher, Pileated Woodpecker) than in uplands, and the widespread loss of that habitat type also is likely to have had a negative affect on their regional abundance. Declines of early successional species such as Northern Bobwhite, Brown Thrasher, Prairie Warbler, and Field Sparrow may be a result of fire suppression and the regeneration of cleared land to forest within recent decades (Spencer et al. 1992, Rosson and London 1997).

The population objective for declining species is to stabilize or reverse the downward trends. Assuming declines have occurred because

1. Loss of habitat has reduced the total amount of acreage that can support birds,
2. Fragments of habitat support some species at lower densities,
3. Fragmentation results in decreased reproductive success, and
4. Changes in structure at a site can affect both the relative abundance of a given species, and result in shifts in the composition of the bird community

then,

1. increases in acreage should be used to reduce fragmentation at the landscape scale,
2. existing landscapes with the characteristics shown to support source populations should be protected, and
3. habitat efforts intended to bolster populations should attempt to enhance structure to attract priority species.

If populations are to stabilize and then increase, habitat must be improved or new

habitat must be made available to potential breeding individuals produced by the existing population. Acreage needed to increase populations can be estimated by multiplying a desired percentage of increase by the current population size to get the potential number of individuals available to colonize new habitat, and multiplying that by acreage of habitat needed per pair. If the needs of the species with the largest acreage requirements are met, the other species in the suite presumably will increase at a greater percentage. Increases will be limited at some point, however, by the size and strength of existing source populations.

For example, we used relative abundance data from the Breeding Bird Survey to estimate total population sizes of some declining species in the mature forests and early-successional species suites in the Ozark/Ouachitas, and data from the Forest Inventory Analysis (Appendix 4) and landcover estimates from AVHRR satellite imagery (see mapset attached at end of document or at: <http://www.cast.uark.edu/edu/pif/main/maincont.htm>) to estimate the amount of suitable-to-optimal habitat available to each species to estimate densities of birds per habitat type across the physiographic area. BBS-derived densities were then compared with those determined by researchers in a number of relatively small-scale field studies scattered throughout Ozark/Ouachita region. Not surprisingly, BBS-based and published densities, and hence acreage estimates, varied greatly for some species. Differences were expected because of variation in detectability among species on BBS routes, the variation in scale at which populations were sampled, differences in methodology and sample sizes, and because the published densities were from study sites in landscapes with a relatively large amount of forest cover, where densities of species sensitive to fragmentation have been shown to be greater than those in fragments. We then projected the amount of habitat needed to support an additional 1% of the current population, using estimates derived from both BBS-based and published densities, and compared the needs among species in habitat suites (see Appendix 5).

The largest amount of acreage estimated for a 1% population increase for a species in

the mature forest species suite, 92,000 ha (235,000 acres), was based on published densities for Pileated Woodpecker (Appendix 5). Assuming that the other species in the suite also would increase in proportion to the amount of new habitat created, each would increase 1.5- 5%, with a possible increase of over 16% for Ovenbird, the species in the suite with the largest percentage of decline (see Table 1). Because oak-hickory and bottomland hardwoods are the most suitable habitat for Acadian Flycatcher and Kentucky Warbler, the highest priority species in the suite, at least 25,000 ha should be provided in that habitat type. If 92,000 ha of existing crop or pasture land were allowed to revert back to forest, it would reduce crop or pasture by roughly 1.5%.

The largest acreage estimate for a 1% population increase for a species from early-successional forest suite was over 26, 000 ha (65,000 acres), based upon BBS-derived densities for Brown Thrasher. This amount of habitat presumably would increase Field Sparrow and Orchard Oriole from 1-4%, and increase Prairie Warbler, the highest priority species in the early-successional suite, up to 16%. If 26,000 ha of existing mature forest were managed for early successional species, it would decrease that cover type by less than 0.5%. If 26,000 ha were converted from crop and pasture land, it would decrease that cover type less than 0.5%.

Attempts to increase acreage for mature forest birds should first be focused in areas of the planning unit where block size and percentage of forest cover are below a recommended minimum, and where restoration can reduce fragmentation and increase block size in areas. Although the exact acreage and configuration of habitat that separates high densities and source populations from populations that perform poorly are unknown, estimates based upon empirical data from the Central Hardwoods region of the U. S. suggest that substantial reduction in predation and parasitism rates may occur in tracts from 4,000 - 10,000 ha (10,000 - 25, 000 acres; Scott Robinson, pers. comm.). These patches should be as circular or square-shaped as possible to maximize forest interior habitat and minimize exposure to predators and parasites that concentrate along forest edges (Gates and Gysel 1978, Temple 1986, reviewed by Robinson 1996). Landscapes 20 kilometers in diameter, with approximately 70% forest

cover, also have been shown to have relatively low rates of brood parasitism and nest predation and to support source populations of forest birds in the Midwest (Robinson et al. 1995, Donovan et al. 1995, Thompson et al. 1996). Early-successional habitat also may be better for birds when placed within the context of largely forested landscapes to mitigate the negative effects of edge on reproductive success (Donovan et al. 1997). Habitat strategies for subdivisions within the planning unit are suggested in Appendix 6, but can be better defined using Geographic Information Systems to more specifically locate areas where opportunities for conservation are greatest. Opportunity areas for bird and other efforts to conserve biodiversity within the Missouri and Arkansas Ozarks are being delineated by the Missouri Resource Assessment Program, Columbia, MO, and maps will soon be available to the conservation community. Habitat structure within blocks also must be taken into account, so that appropriate substrates required for nest sites, foraging, and other life-history requirements are provided for each species in the habitat suite (see Appendix 7 for the needs of suites by habitat type and successional stage).

Glade, oak-savanna, and native grassland habitats are patchily distributed across the landscapes of the Ozark/Ouachitas, and have been relatively understudied with regard to their use by and ability to support priority bird species in the planning unit. More research is necessary before adequate recommendations can be made regarding their management for birds and juxtaposition among forest types. Management of existing grasslands and shrub-wetlands in the Arkansas Valley, as well as the potential for restoration of those habitat types, should be evaluated especially with regard to their ability to support viable breeding populations of Bell's Vireo, and to provide wintering habitat for Sprague's Pipit and Loggerhead Shrike. Information on how patch size, habitat structure and landscape context affect densities and reproductive success of Cerulean Warbler and Swainson's Warbler is needed to develop appropriate habitat strategies for bottomland forests.

Restoration of pine savanna has positively affected Red-cockaded Woodpecker populations on the Ouachita National Forest in Arkansas and on the McCurtain County

Wilderness Area in Oklahoma, and has benefitted other priority species such as Bachman's Sparrow and Brown-headed Nuthatch as well (Joe Neal, Ouachita National Forest, pers. comm.). It is hoped that the two remnant Red-cockaded Woodpecker populations can someday be linked to form a larger and more stable population (Mark Howery, Pers. comm.). Although pine savanna habitat once supported Red-cockaded Woodpeckers in the Missouri Ozarks (Woodruff 1908), both the habitat and the species are now extirpated. Restoration of pine savanna and introduction of Red-cockaded Woodpeckers should be considered there.

Because urbanization is increasing rapidly in parts of the physiographic area, efforts must be made to work with planners and policy makers to insure that bird conservation areas are established wherever possible. Developers should be encouraged to leave areas of native vegetation intact within and around development sites. Outreach programs should promote "landscaping for wildlife," with special emphasis on native shrubs and trees to provide food for birds during migration.

Research needs:

1. More research is needed to understand the mechanisms that result in reduced densities and/or reproductive success of high-priority bird species in fragmented landscapes, and if those vary depending upon landcover types in the matrix surrounding fragments.

2. More information is needed regarding survivorship and dispersal of priority species in the post-fledging stage.

3. Little is known about the geographic scale at which conservation efforts must be applied to actually affect population change, or the appropriate scale at which to measure population change resulting from habitat efforts at a local scale.

4. Little is known about the habitat requirements of high-priority species that migrate through the Ozark/Ouachitas. More information is needed to test the assumption that habitat needed to support priority breeding and wintering birds is adequate for in-transit migrants.

5. Little is known about the habitat associations of most wintering species. Information also is lacking regarding habitat associations of several breeding species such as Whip-poor-will, Chuck-will's widow, Bewick's Wren, Bell's Vireo, Swainson's Warbler, and Cerulean Warbler.

6. Glade and oak-savanna habitats have been studied very little with regard to birds. More information is needed before specific management objectives can be suggested for priority species in these habitat types.

7. More information is needed with regard to community structure, how relative abundance of priority species change with the size or management of a given site, and where there is a need to juxtapose habitats of varied structure so that the needs of each and all priority species can be met at a scale that produces a desired population response.

8. Silvicultural practices that enhance canopy and other vegetation structure to improve habitat for priority species need to be researched and developed.

9. Monitoring programs for riparian and other species that are not well sampled by the Breeding Bird Survey need to be developed and implemented. Canoe surveys have been a useful inventory technique for riparian species, and their ability to provide population trend information, at least at a local scale, should be evaluated as well.

Outreach:

Outreach efforts should seek to make the public more aware of the value of non-game

birds, their economic impacts, habitat needs, etc., as well as a need for incentive programs for habitat conservation on private land. Education programs also should be tailored to those practicing forestry on private lands, and to city, county and regional landuse planners.

Literature cited:

Ambuel, B. and S. A. Temple. 1983. Area-dependent changes in the bird communities and vegetation of southern Wisconsin forests. Ecology 64:1057-1068.

Anders, A. D., J. Faaborg and F. R. Thompson, III. 1998. Postfledging dispersal, habitat use, home-range size of juvenile wood thrushes. Auk 115:349-358.

Askins, R. A., M. J. Philbrick, and D. S. Sugeno. 1987. Relationship between the regional abundance of forest and the composition of forest bird communities. Biological Conservation 39:129-152.

Barber, D. R., T. E. Martin, M. A. Melchoirs, R. E. Thill, T. B. Wigley. 2000. Nesting success of birds in different silvicultural treatments in southeastern U. S. pine forests. Conservation Biology 14: in press.

Basili, G. And S. A. Temple. 1995. A perilous migration. Natural History 104:40-46.

Basili, G. and S. A. Temple. 1995. A perilous migration. Natural History 104:40-46.

Blake 1983. Trophic structure of bird communities in forest patches in east-central Illinois. Wilson Bulletin 95:416-430.

Blake, J. G. 1991. Nested subsets and the distribution of birds on isolated woodlots. Conservation Biology 5:58-66.

Blake, J. G. and J. R. Karr. 1987. Breeding birds of isolated woodlots: area and habitat relationships. Ecology 86:1724-1734.

Brawn, J. D., B. Tannenbaum, and K. E. Evans. 1984. Nest site characteristics of cavity nesting birds in central Missouri. U. S. For. Serv. Res. Note NC-314.

Brawn, J. D. 1998. Effects of oak savanna restoration on avian populations and communities in Illinois. Final report to the Illinois Natural History Survey.

Brawn, J. D. and S. K. Robinson. 1996. Source-sink population dynamics may complicate the interpretation of large-scale and long-term census trends. Ecology 77:3-12.

Brittingham, M. C. and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31-35.

Burke, D. M. and E. Nol. 1998. Influence of food abundance, nest-site habitat, and forest fragmentation in breeding ovenbirds. Auk 115:96-104.

Carter, M. F., W. C. Hunter, D. N. Pashley and K. V. Rosenberg. 2000. Setting conservation priorities for landbirds in the United States: The Partners in Flight approach. Auk 117:541-548.

Cunningham, B. and C. Hauser. 1992. The decline of the Missouri Ozark Forest between 1880 and 1920. *In* A. Journet and H. Spratt, eds. Toward a vision for Missouri's forests; proceedings from a conference at Southeast Missouri State University, Cape Girardeau.

Donovan, T. M., Thompson, F. R., Faaborg, J. and J. R. Probst. 1995. Reproductive success of migratory birds in habitat sources and sinks. Conservation Biology 9:1380-1395.

Donovan, T. M., P. W. Jones, E. M. Annand and F. R. Thompson, III. 1997. Variation in local-scale edge effects: mechanisms and landscape context. Ecology 78:2064-2075.

Fletcher, P. W. and R. E. McDermott. 1957. Influence of geologic parent material and climate on distribution of shortleaf pine in Missouri. Research Bulletin 625, University of Missouri Agricultural Experiment Station, Columbia.

Forman, R. T. T., A. E. Galli and C. F. Leck. 1976. Forest size and avian diversity in New Jersey woodlots with some land use implications. Oecologia 26:1-8.

Foti, T. L. and S. M. Glenn. 1991. The Ouachita Mountain landscape at the time of settlement. *In*, Restoration of old growth forests in the interior highlands of Arkansas and Oklahoma. Proceedings of the Conference Winrock International, Morrilton, AR, D. Henderson and L. D. Herrick, eds.

Freemark K. and B. Collins. 1992. Landscape ecology of birds breeding in temperate forest fragments. Pgs. 443-454 *In* Ecology and conservation of neotropical migrant landbirds, J. M. Hagan III and D. W. Johnston, eds. Smithsonian Inst. Press, Washington, D.C.

Galli, A. E., C. F. Leck and R.T.T. Forman. 1976. Avian distribution patterns in forest islands of different sizes in central New Jersey. Auk 93:356-364.

Gates, J. E. and L. W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59:871-883.

Gibbs, J. B. and J. Faaborg. 1990. Estimating the viability of Ovenbird and Kentucky Warbler populations in forest fragments. Conserv. Biol. 4:193-196.

Guldin, J. 1992. Uneven-aged Management. *In*: Towards a vision for Missouri's public forests. Journet, A. R. P. And H. G. Spratt, Jr., eds. Southeast Missouri State University, Cape Girardeau, Missouri.

Guyette, R. P. and B. E. Cutter. 1991. Tree ring analysis of fire history in a post oak savanna in the Missouri Ozarks. Natural Areas Journal 11:93-99.

Haggarty, T. M. 1988. Aspects of the breeding biology and productivity of Bachman's Sparrow in Central Arkansas. Wilson Bull. 100:247-255.

Hamel, P. B. 1992. The land managers guide to birds of the South. The Nature Conservancy, Chapel Hill, NC. 436 pp.

Hardin, K. I., T. S. Baskett and K. E. Evans. 1982. Habitat of Bachman's Sparrow breeding on Missouri glades. Wils. Bull: 94:208-212.

Heske, E. J. 1995. Mammal abundances on forest-farm edges versus interiors in southern Illinois: Is there an edge effect? J. Mammol. 76:562-568.

Jacobs, B. and J. D. Wilson. 1997. Missouri Breeding Bird Atlas. Natural History series no. 6. Missouri Department of Conservation. Jefferson City, MO. 430 p.

James, F. C. 1971. Ordinations of habitat relationships among breeding birds. Wilson Bull. 83:215-236.

James, D. A. and J. C. Neal. 1986. Arkansas birds: their distribution and abundance. University of Arkansas Press, Fayetteville. 402 pp.

Johnson, P. S. 1993. Perspectives on the ecology and silviculture of oak-dominated forests in the central and eastern states. U. S. Forest Service, North Central Experiment Station, GTR NC-153.

Lorimer, G. G. 1985. The role of fire in the perpetuation of oak forests. In: Johnson, J. E. ed. Proceedings of challenges in oak management and utilization 1985 March 28-29; Madison, WI: University of Wisconsin Cooperative Extension Service: 8-25.

McNab, W. H. And P.E. Avers, comps. 1994. Ecological subregions of the United States: Section descriptions. Administrative Publication WO-WSA-5. Washington, DC: U.S. Department of Agriculture, Forest Service. 267 pp.

Marini, M. A., S. K. Robinson, and E. J. Heske. 1995. Edge effects on nest predation in the Shawnee National Forest, southern Illinois. Biol. Conserv. 74:203-213.

Martin, T. E. 1981. Limitation in small habitat islands: chance or competition? Auk 98:715-733.

O'Connor, R. J. and J. Faaborg. 1992. The relative abundance of the Brown-headed Cowbird (*Molothrus ater*) in relation to exterior and interior edges in forests of Missouri. Trans. MO Acad. Sci. 26:1-9.

Palmer, B. 1991. Missouri forests: their history, values and management. Missouri Department of Conservation, Jefferson City, MO.

Pell, B. 1983. The natural divisons of Arkansas: a revised classification and description. Natural Areas Journal 3:12-23.

Porneluzi, P. A. and J. Faaborg. 1999. Season-long fecundity, survival, and viability of Ovenbirds in fragmented and unfragmented landscapes. Conservation Biology 13:1151-1161.

Renken, R. B. and E. P. Wiggers. 1993. Habitat characterisitics related to Pileated Woodpecker densities in Missouri. Wilson Bull. 105:77-83.

Robbins, M. B. and D. A. Easterla. 1992. Birds of Missouri: their distribution and abundance. University of Missouri Press, Columbia. 399 pp.

Robbins, M. B., B. R. Barber, and K. Zykowski. 1998. Census of Cerulean Warblers along the upper Current River, with comments on the status of other riparian species. Bluebird 65:10-16.

Robinson, S. K. 1996.Threats to breeding neotropical migratory birds in the Midwest. Pgs. 1-21 *In,* F. R. Thompson III, ed. Management of Midwestern landscapes for the conservation of neotropical migratory birds. U. S. Forest Service North Central Experiment Station. General Technical Report NC - 187.

Robinson, S. K. and D. S. Wilcove. 1994. Forest fragmentation in the temperate zone and its effects on migratory songbirds. Bird Conserv. Int. 4:233-249.

Robinson, S. R., Thompson III, F. R., Donovan, T. M., Whitehead, D. R. And J. Faaborg. 1995. Regional forest fragmentation and the success of migratory birds. Science 267:1987-1990.

Rosson, J. F., Jr., and J. D. London. 1997. Forest statistics for Arkansas' Ouachita Counties - 1995. U. S. Dept. of Agriculture, Southern Research Station, Resource Bulletin SRS-10.

Sauer, J. R., J. E. Hines and J. Fallon. 1996. The North American Breeding Bird Survey results and analysis. Version 96.3. Patuxent Wildlife Research Center, Laurel, MD. http://www.mbr.nbs.gov/bbs

Sauer, J. R., J. E. Hines, G, Gough, I. Thomas and B. J. Peterjohn. 1997. The North American Breeding Bird Survey home page: Partners in Flight analysis. USGS Patuxent Wildlife Research Center, Laurel, MD. http://www.mbr_pwrc.usgs.gov/bbs/pif/pif.html

Sauer, J. R., J. E. Hines, I. Thomas, J. Fallon and G. Gough. 1999. The North American Breeding Bird Survey, Results and Analysis 1966-1998. Version 98.1. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, MD.

Smith, K. L. 1986. Sawmill: the story of the cutting of the last great virgin forest east of the Rockies. Univ. of Arkansas Press. Fayetteville.

Spencer, J. S., Jr., S. M. Roussopoulos and R. A. Massengale. 1992. Missouri's forest resource, 1989: an analysis. U. S. Department of Agriculture, North Central Experiment Station, Resource Bulletin NC-139.

Stone County Historical Society. 1989. History of Stone County Missouri. Stone County Historical Society. Marionville, MO.

Stroud, H. B. and G. T. Hanson. 1981. Arkansas geography: the physical landscape and the historical-cultural setting. Rose Publishing Co. Little Rock, AR.

Tappe, P. A., R. E. Thill, M. A. Melchoirs, and T. B. Wigley. 1994. Wildlife values of streamside management zones in the Ouachita Mountains, Arkansas. Pages 122-138 *in* Riparian ecosystems in the humid U. S. National Association of Conservation Districts, Washington, D.C.

Tappe, P. A., R. E. Thill, M. A. Melchoirs, and T. B. Wigley. 2001. Breeding bird community composition and structure in four watersheds under different management scenarios in the Ouachita Mountains of Arkansas. In press. *In* J. M. Guldin, technical compiler. Symposium on ecosystem management in the Ouachita and Ozark Mountains. USDA Forest Service Gen. Tech. Rep. Southern Forest Experiment Station, Ashville, NC.

Temple, S. A. 1986. Predicting impacts of habitat fragmentation on forest birds: a comparison of two models. Pgs. 301-304 *In*, J. Verner, M. L. Morrison and C. J. Ralph, eds. Wildlife 2000: Modeling Habitat Relationships of Terrestrial Vertebrates. Univ. of Wisconsin Press, Madison.

Temple, S. A. and J. R. Cary. 1988. Modeling dynamics of habitat-interior bird populations in fragmented landscapes. Conserv. Biol. 2:340-347.

The Nature Conservancy. 1994. Ouachita Mountains conservation initiative strategic plan. Arkansas Field Office.

Thill, R. E., P. A. Tappe, M. A. Melchiors, and T. B. Wigley. 1997. Breeding bird communities of streamside management zones in the Ouachita Mountains, Arkansas. Abstr. The Wildlife Soc. Annu. Conf. 4:188.

Thom, R.H. and J. H. Wilson. 1980. The natural divisions of Missouri. Trans. MO Acad. Sci. 14:9-23.

Thom, R.H. and J. H. Wilson. 1983. The natural divisions of Missouri. Natural Areas Journal 3:44-51.

Thomas, B. G. 1994. Habitat selection and breeding status of Swainson's Warblers. M. S. Thesis, University of Missouri-Columbia. 44 pp.

Thompson, F. R., III. 1993. Simulated responses of a forest-interior bird populaiton to forest management options in central hardwood forests of the United States. Conservation Biology 7:325-333.

Thompson, F. R., III. 1994. Temporal and spatial patterns of breeding Brown-headed Cowbirds in the Midwestern United States. Auk 111:979-990.

Thompson, F. R., III, and E. K. Fritzell. 1990. Bird densities and diversity in clearcut and mature oak-hickory forests. USDA Forest Service North Central Experiment Station research paper NC-293. St. Paul, MN.

Thompson, F. R., III, W. D. Dijak, T. G. Kuloweic and D. A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. J. Wildl. Manage. 56:23-30.

Thompson, F. R., III, S. K. Robinson, D. R. Whitehead and J. D. Brawn. 1996. Management of Central hardwood landscapes fro the conservation of migratory birds. Pgs. 117-143 *In,* F. R. Thompson III, ed. Management of Midwestern landscapes for the

conservation of neotropical migratory birds. U. S. Forest Service North Central Experiment Station. General Technical Report NC - 187.

Van Horn, M. A., R. M. Gentry and J. Faaborg. 1995. Patterns of ovenbird *(Seiurus aurocapillus*) pairing success in Missouri forest tracts. Auk 112:98-106.

Vega Rivera, J. H., J. H. Rappole, W. J. McShea and C. A. Haas. 1998. Wood Thrush postfledging movements and habitat use in northern Virginia. Condor 100:69-78.

Wenny, D. G., R. L. Clawson, J. Faaborg, and S. L. Sheriff. 1993. Population density, habitat selection and minimum area requirements of three forest-interior warblers in central Missouri. Condor 95:968-979.

Wilson, C. W., R. E. Masters, and G. A. Bukenhofer. 1995. Breeding bird response to pine-grassland community restoration for Red-cockaded Woodpeckers. J. Wildl. Manage. 59:56-67.

Woodruff, S. E. 1908. A preliminary list of the birds of Shannon and Carter Counties, Missouri. Auk 25:191-214.

Appendix 1. Percentage of forest coverage and forest type by county in the Ozark/Ouachita physiograhic area.

* = county only partly in physiographic area

Missouri subdivisions:

S = Springfield and Salem Plateaus
U = Upper Ozarks
SF = St. Francois Mountains
E = Elk River
W = White River
L = Lower Ozarks

Arkansas subdivisions:

Oz = Ozarks (includes the Springfield and Salem Plateaus)
B = Boston Mtns.
A = Arkansas Valley
Ou = Ouachita Mtns.

Oklahoma subdivisions:

Oz = Ozarks (Springfield Plateau)
B = Boston Mtns.
A = Arkansas Valley
Ou = Ouachita Mtns.

(Not all rows sum to 100%, due to rounding.)

State	County	Natural Section	% total forest	% planted pine	% natural pine	% oak-pine	% oak-hickory	% other forest types
MO	Maries*	U	48	3	6	8	78	4
MO	Crawford*	U	68	0	<1	2	92	6
MO	Washington*	U	77	0	3	11	80	6
MO	Camden	U	64	0	3	2	95	1
MO	Laclede	U	43	3	<1	2	93	1
MO	Pulaski	U	63	5	2	2	87	5
MO	Phelps	U	61	5	3	1	90	2
MO	Wright	U	37	0	2	1	91	6
MO	Dent	U-L	41	0	3	11	85	1
MO	Texas	U-L	56	1	8	16	72	4
MO	Dallas	U-S	41	0	0	10	85	6
MO	Webster	U-S	32	0	10	0	86	4
MO	Benton*	S	44	0	0	1	86	12
MO	Henry*	S	19	0	0	0	37	63
MO	St. Clair*	S	38	0	0	1	81	18
MO	Hickory*	S	40	0	3	13	71	13
MO	Cedar*	S	30	0	0	0	87	13
MO	Polk	S	27	0	14	13	72	1
MO	Greene	S	18	0	4	9	78	9
MO	Dade*	S	13	0	0	9	76	15
MO	Lawrence	S	15	0	0	0	88	12
MO	Jasper*	S	13	0	0	0	72	28
MO	Morgan*	S	50	0	1	2	97	0
MO	Miller*	S	50	0	3	7	84	6
MO	Newton	S-E	24	0	0	0	92	8
MO	McDonald	E	53	0	0	2	97	1
MO	Barry	S-E-W	44	0	5	11	79	5
MO	Christian	S-W	42	0	2	7	85	7

State	County	Natural Section	% total forest	% planted pine	% natural pine	% oak-pine	% oak-hickory	% other forest types
MO	Stone	W	44	0	9	13	75	3
MO	Taney	W	71	1	6	36	50	7
MO	Douglas	W	58	0	3	8	82	7
MO	Ozark	W	58	0	1	21	72	7
MO	Howell	W-L	47	1	5	4	89	1
MO	Shannon	L	83	2	3	11	84	<1
MO	Reynolds	L	83	0	3	5	86	6
MO	Carter	L	87	2	7	15	75	2
MO	Oregon	L	63	0	1	6	90	3
MO	Ripley*	L	67	0	6	2	83	10
MO	Butler*	L	31	0	12	11	70	8
MO	Wayne*	L-SF	83	2	2	6	87	4
MO	Madison*	SF	78	0	4	9	80	5
MO	Iron*	SF	82	0	3	4	89	3
MO	St. Francois*	SF	56	0	4	9	82	5
AR	Benton	Oz	62	0	0	6	91	3
AR	Carroll	Oz	54	0	0	19	78	3
AR	Boone	Oz	44	0	4	7	86	4
AR	Marion	Oz	71	0	3	13	83	0
AR	Baxter	Oz	70	0	6	22	72	0
AR	Fulton	Oz	52	3	6	9	82	0
AR	Sharp	Oz	63	0	5	20	75	0
AR	Randolf	Oz	45	0	4	9	74	13
AR	Izard	Oz	68	3	21	23	54	0
AR	Washington	Oz - B	51	0	5	4	88	4
AR	Madison	Oz - B	66	0	2	7	91	0
AR	Newton	Oz - B	85	0	5	7	88	0
AR	Searcy	Oz - B	71	0	2	12	84	2

State	County	Natural Section	% total forest	% planted pine	% natural pine	% oak-pine	% oak-hickory	% other forest types
AR	Stone	Oz - B	84	2	8	18	72	0
AR	Independence*	Oz - B	45	3	15	21	55	6
AR	Crawford	B - A	62	3	3	27	64	3
AR	Franklin	B - A	61	0	12	15	69	3
AR	Johnson	B - A	73	7	9	20	64	0
AR	Pope	B - A	68	3	17	22	56	2
AR	Van Buren	B - A	80	11	8	25	56	0
AR	Cleburn	B - A	64	12	10	26	50	2
AR	White*	A - Ou	37	8	8	10	45	30
AR	Sebsatian	A	54	0	14	15	49	23
AR	Logan	A	66	<1	28	33	36	3
AR	Yell	A - Ou	72	11	34	22	17	16
AR	Conway	A - Ou	55	0	22	30	30	19
AR	Faulkner	A - Ou	46	8	3	8	65	16
AR	Scott	A - Ou	84	10	40	20	29	2
AR	Perry	A - Ou	82	13	43	19	19	6
AR	Pulaski*	Ou	41	3	19	16	46	16
AR	Polk	Ou	78	13	11	30	45	1
AR	Montgomery	Ou	88	13	27	26	34	0
AR	Garland	Ou	80	25	16	22	36	0
AR	Saline*	Ou	81	22	15	23	31	9
AR	Sevier*	Ou	70	19	4	19	34	23
AR	Howard*	Ou	71	38	8	18	26	10
AR	Pike*	Ou	84	35	23	26	14	2
AR	Clark*	Ou	77	20	20	26	22	12
AR	Hot Spring*	Ou	76	26	11	24	28	11
OK	Atoka*	Ou	55	0	17	12	42	29
OK	Latimer	Ou	69	0	22	31	45	1

State	County	Natural Section	% total forest	% planted pine	% natural pine	% oak-pine	% oak-hickory	% other forest types
OK	Le Flore	Ou	67	12	18	20	42	8
OK	McCurtain*	Ou	73	35	13	16	28	7
OK	Pittsburg*	Ou	49	0	8	19	58	15
OK	Pushmataha	Ou	82	12	30	28	27	3
OK	Adair	OZ-B	62	0	3	0	97	0
OK	Cherokee	OZ-B	61	0	3	3	87	8
OK	Delaware	OZ	47	0	0	3	97	0
OK	Haskell	A-OU	50	0	7	19	52	22
OK	Mayes*	OZ-B	30	0	6	0	83	11
OK	Muskogee*	B	28	0	0	0	95	5
OK	Ottawa*	OZ	16	0	0	0	100	0
OK	Sequoyah	B-A	53	0	0	6	81	14

Appendix 2. Percentage of forest ownership by County in the Ozark/Ouachita physiograhic area.

* = county only partly in physiographic area

Missouri subdivisions:

S = Springfield Plateau
U = Upper Ozarks
SF = St. Francois Mountains
E = Elk River
W = White River
L = Lower Ozarks

Arkansas subdivisions:

Oz = Ozarks (includes the Springfield and Salem Plateaus)
B = Boston Mtns.
A = Arkansas Valley
Ou = Ouachita Mtns.

Oklahoma subdivisions:

Oz = Ozarks (Springfield Plateau)
B = Boston Mtns.
A = Arkansas Valley
Ou = Ouachita Mtns.

% farmer owned = land from which $1,000 or more of agricultural products are produced each year. Does not mean products are forest derived.

(Not all rows sum to 100%, due to rounding.)

State	County	Natural Section	% nat'l forest	% misc. fed'l	% state	% forest industry	% farmer/ rancher	% other
MO	Maries*	U	0	2	3	0	34	61
MO	Crawford*	U	15	3	4	0	22	56
MO	Washington*	U	21	1	3	3	36	36
MO	Camden	U	0	0	0	0	33	67
MO	Laclede	U	13	0	2	0	29	56
MO	Pulaski	U	20	18	0	0	30	32
MO	Phelps	U	24	0	1	0	42	33
MO	Wright	U	5	0	0	0	70	25
MO	Dent	U-L	22	0	9	1	32	36
MO	Texas	U-L	9	0	1	7	54	29
MO	Dallas	U-S	0	0	6	0	45	49
MO	Webster	U-S	0	0	4	0	80	16
MO	Benton*	S	0	12	3	0	37	48
MO	Henry*	S	0	23	1	0	22	54
MO	St. Clair*	S	0	13	0	0	42	45
MO	Hickory*	S	0	13	0	0	46	41
MO	Cedar*	S	2	0	0	0	57	41
MO	Polk	S	0	4	3	0	64	29
MO	Greene	S	0	0	4	0	35	61
MO	Dade*	S	0	33	0	0	54	13
MO	Lawrence	S	0	0	0	0	47	53
MO	Jasper*	S	0	0	0	0	70	30
MO	Morgan*	S	0	0	0	0	41	59
MO	Miller*	S	0	0	0	0	31	69
MO	Newton	S-E	0	9	0	0	49	42
MO	McDonald	E	0	0	2	0	29	69

State	County	Natural Section	% nat'l forest	% misc. fed'l	% state	% forest industry	% farmer/ rancher	% other
MO	Barry	S-E-W	21	0	1	0	53	25
MO	Christian	S-W	29	0	0	0	40	31
MO	Stone	W	12	0	0	0	37	51
MO	Taney	W	19	0	4	0	48	29
MO	Douglas	W	12	0	0	0	46	42
MO	Ozark	W	8	3	2	0	44	43
MO	Howell	W-L	17	0	5	0	38	40
MO	Shannon	L	18	1	13	15	13	40
MO	Reynolds	L	20	4	9	15	17	35
MO	Carter	L	34	0	8	5	5	48
MO	Oregon	L	24	0	0	3	31	42
MO	Ripley*	L	35	0	2	0	28	35
MO	Butler*	L	36	0	2	0	12	50
MO	Wayne*	L-SF	22	2	4	4	10	58
MO	Madison*	SF	16	0	1	0	30	53
MO	Iron*	SF	29	1	0	0	11	59
MO	St. Francois*	SF	1	0	0	2	30	67
AR	Benton	Oz	4	6	6	0	23	61
AR	Carroll	Oz	0	3	0	0	44	53
AR	Boone	Oz	0	0	0	0	46	54
AR	Marion	Oz	<1	0	0	0	43	56
AR	Baxter	Oz	26	6	0	0	2	66
AR	Fulton	Oz	0	3	0	0	36	61
AR	Sharp	Oz	0	0	8	0	28	64
AR	Randolf	Oz	0	0	4	0	44	52
AR	Izard	Oz	0	0	0	0	31	69
AR	Washington	Oz - B	6	0	0	0	25	69
AR	Madison	Oz - B	13	0	4	0	30	53

State	County	Natural Section	% nat'l forest	% misc. fed'l	% state	% forest industry	% farmer/ rancher	% other
AR	Newton	Oz - B	46	0	1	0	13	40
AR	Searcy	Oz - B	9	2	2	0	33	54
AR	Stone	Oz - B	18	0	0	10	29	43
AR	Independence*	Oz - B	0	0	0	15	33	52
AR	Crawford	B - A	39	0	0	0	20	41
AR	Franklin	B - A	40	3	0	0	28	29
AR	Johnson	B - A	56	5	0	0	5	34
AR	Pope	B - A	52	0	2	0	14	32
AR	Van Buren	B - A	9	0	3	13	37	38
AR	Cleburn	B - A	0	0	0	19	24	57
AR	White*	A - Ou	0	0	10	3	48	39
AR	Sebsatian	A	2	0	30	0	26	42
AR	Logan	A	5	0	10	10	32	43
AR	Yell	A - Ou	44	4	4	15	9	24
AR	Conway	A - Ou	3	0	11	7	22	57
AR	Faulkner	A - Ou	0	5	0	0	16	79
AR	Scott	A - Ou	74	0	0	3	3	20
AR	Perry	A - Ou	32	0	2	49	13	4
AR	Pulaski*	Ou	0	14	0	22	16	48
AR	Polk	Ou	44	0	1	24	9	22
AR	Montgomery	Ou	75	2	0	10	3	10
AR	Garland	Ou	33	2	0	35	0	30
AR	Saline*	Ou	13	0	0	39	5	43
AR	Sevier*	Ou	0	4	0	49	13	34
AR	Howard*	Ou	1	4	0	68	20	7
AR	Pike*	Ou	1	0	0	80	4	15
AR	Clark*	Ou	0	3	0	43	15	39
AR	Hot Spring*	Ou	<1	0	0	46	2	51

State	County	Natural Section	% nat'l forest	% misc. fed'l	% state	% forest industry	% farmer/ rancher	% other
OK	Atoka*	Ou	0	10	2	0	8	80
OK	Latimer	Ou	0	0	12	0	18	70
OK	Le Flore	Ou	28	4	0	18	7	43
OK	McCurtain*	Ou	5	7	1	67	9	12
OK	Pittsburg*	Ou	0	4	4	0	35	57
OK	Pushmataha	Ou	0	0	4	45	14	37
OK	Adair	OZ-B	0	0	3	0	27	70
OK	Cherokee	OZ-B	0	3	10	0	62	25
OK	Delaware	OZ	0	0	3	0	50	47
OK	Haskell	A-OU	0	7	0	11	4	78
OK	Mayes*	OZ-B	0	11	6	0	0	86
OK	Muskogee*	B	0	30	0	0	25	45
OK	Ottawa*	OZ	0	0	0	0	64	36
OK	Sequoyah	B-A	0	8	0	0	31	61

Appendix 3: The Partners in Flight Prioritization Scheme and criteria for the development of priority species lists.

The Partners in Flight Species Prioritization Scheme was first developed in 1991, and has been continually reviewed and refined in the years following its inception (Carter et al. 2000). The system ranks each species of North American breeding bird based upon seven measures of conservation "vulnerability". These factors include; 1) relative abundance (interspecific); 2) size of breeding range; 3) size of non-breeding range; 4) threats to the species in breeding areas; 5) threats to the species in non-breeding areas; 6) population trend; and 7) relative density (intraspecific) in a given planning unit compared to the maximum reached within its range. Each species is given a score of 1-5 in each category, with 1 indicating the least amount of vulnerability with regard to that parameter and 5 the most. Scores in each category are then summed to produce a composite score potentially ranging from 7-35. Species with relatively high overall scores are considered most vulnerable to extinction (although they often are not endangered at present) and need at least to be carefully monitored throughout their ranges. Scores for PIF species are posted on the internet at: http://www.rmbo.org/pif/pifdb.html under "Partners in Flight prioritization process".

Perhaps one of the most influential factors that comes into play when identifying species of conservation priority is the species' population trend. Species whose populations are declining rangewide may or may not be declining in a given planning unit. It is important to focus active management in those areas where declines should be stabilized or reversed and to identify the factors responsible for stable or increasing trends in other areas so that similar conditions can be achieved where needed. A declining trend has the greatest effect on a species' total numbers where the populations are greatest, so population trend and measures of abundance often are considered together.

Another measure of a species' importance in a given planning unit is the percentage of its population that occurs there. Physiographic areas with large percentages are able to take greater conservation responsibility for that species because affecting an increase or decrease in a population trend has greater potential impacts in areas where numbers of

individuals are greater. For example, many more individuals are lost by a sustained 3% per year decrease in an initial population of 10,000 than in a population of 100. The rationale for giving an Area Importance score in the PIF prioritization scheme is similar, although it is a relative density score that is independent of the size of a given planning unit while percentage of population is not. Thus, relative density could be the same in a 100,000 and 200,000 sq. kilometer planning unit, but the percentage of the population would be twice as great in the latter.

After taking into account the factors described above, a list of criteria were developed by which species in a given planning unit are identified as priority species. Species are listed only under the first criteria they meet, although they may qualify with regards to two or more. The criteria are as follows:

1a. Its total score (based upon the Partners in Flight Prioritization Process) in the physiographic area is 28 or greater and it occurs in the region in manageable numbers.

1b. Its total score (based upon the Partners in Flight Prioritization Process) in the physiographic area is 22-27 and it occurs in the region in manageable numbers.

This set of criteria is meant to highlight the species that appear most vulnerable based upon the combination of the seven factors used in the prioritization scheme.

2a. Its total PIF score is 19-21, with the sum of Area Importance and Population Trend equal to or greater than eight. Thus, species with moderate total scores and moderate relative densities in the planning unit are included only if their population trends are declining significantly. A species with high relative densities in the area is included if its population trend is unknown or declining.

2b. Its total PIF score is 19-21, and the percentage of the global population breeding in the physiographic area is greater than 7%. Conditions in physiographic areas that have relatively large proportions of individuals of a given species have a greater ability to influence

the species' global population than do areas with smaller numbers of individuals.

3a. It is a PIF "Watch List" species with an AI = 3 or greater. (Watch List species are those with the highest PIF prioritization scores based upon the species' ranks across their entire range. Some Watch List species may already have met criteria 1 or 2.)

3b. A species is federally listed as Threatened or Endangered.

Appendix 4. Percentage of forest by County in the Ozark/Ouachita physiograhic area in shrub/sapling, poletimber and sawtimber successional stages.

* = county only partly in physiographic area

Missouri subdivisions:

S = Springfield Plateau
U = Upper Ozarks
SF = St. Francois Mountains
E = Elk River
W = White River
L = Lower Ozarks

Arkansas subdivisions:

Oz = Ozarks (includes the Springfield and Salem Plateaus)
B = Boston Mtns.
A = Arkansas Valley
Ou = Ouachita Mtns.

Oklahoma subdivisions:

Oz = Ozarks (Springfield Plateau)
B = Boston Mtns.
A = Arkansas Valley
Ou = Ouachita Mtns.

(Not all rows sum to 100%, due to rounding.)

State	County	Natural Section	% total forest	% saw-timber	% pole-timber	% sapling seedling	% non-stocked
MO	Maries*	U	48	46	35	19	0
MO	Crawford*	U	68	50	24	26	0
MO	Washington*	U	77	49	33	19	0
MO	Camden	U	64	65	20	15	0
MO	Laclede	U	43	41	39	20	0
MO	Pulaski	U	63	44	25	31	0
MO	Phelps	U	61	31	36	32	0
MO	Wright	U	37	33	36	32	0
MO	Dent	U-L	41	45	28	27	0
MO	Texas	U-L	56	42	25	33	0
MO	Dallas	U-S	41	43	26	31	0
MO	Webster	U-S	32	47	27	26	0
MO	Benton*	S	44	40	43	17	0
MO	Henry*	S	19	54	22	25	0
MO	St. Clair*	S	38	42	40	19	0
MO	Hickory*	S	40	41	33	26	0
MO	Cedar*	S	30	39	36	26	0
MO	Polk	S	27	37	37	26	0
MO	Greene	S	18	39	26	35	0
MO	Dade*	S	13	19	50	26	<1
MO	Lawrence	S	15	51	27	22	0
MO	Jasper*	S	13	43	49	9	0
MO	Morgan*	S	50	46	31	23	0
MO	Miller*	S	50	56	27	17	0
MO	Newton	S-E	24	45	43	12	0
MO	McDonald	E	53	66	18	16	0
MO	Barry	S-E-W	44	48	28	23	0
MO	Christian	S-W	42	51	19	30	0

State	County	Natural Section	% total forest	% saw-timber	% pole-timber	% sapling seedling	% non-stocked
MO	Stone	W	44	30	42	28	0
MO	Taney	W	71	31	37	33	0
MO	Douglas	W	58	49	31	20	0
MO	Ozark	W	58	44	31	24	<1
MO	Howell	W-L	47	39	29	31	0
MO	Shannon	L	83	46	24	30	0
MO	Reynolds	L	83	56	23	21	0
MO	Carter	L	87	42	29	29	0
MO	Oregon	L	63	45	18	37	<1
MO	Ripley*	L	67	44	28	28	0
MO	Butler*	L	31	57	32	11	0
MO	Wayne*	L-SF	83	49	30	20	0
MO	Madison*	SF	78	45	30	24	<1
MO	Iron*	SF	82	46	37	17	0
MO	St. Francois*	SF	56	55	33	13	0
AR	Benton	Oz	62	62	20	18	0
AR	Carroll	Oz	54	61	19	19	0
AR	Boone	Oz	44	43	36	21	0
AR	Marion	Oz	71	33	37	30	0
AR	Baxter	Oz	70	44	38	19	0
AR	Fulton	Oz	52	18	46	36	0
AR	Sharp	Oz	63	15	56	28	0
AR	Randolf	Oz	45	22	48	30	0
AR	Izard	Oz	68	28	46	26	0
AR	Washington	Oz - B	51	34	47	20	0
AR	Madison	Oz - B	66	47	37	17	0
AR	Newton	Oz - B	85	50	40	11	0
AR	Searcy	Oz - B	71	40	40	20	0

State	County	Natural Section	% total forest	% saw-timber	% pole-timber	% sapling seedling	% non-stocked
AR	Stone	Oz - B	84	32	55	13	0
AR	Independence*	Oz - B	45	46	33	21	0
AR	Crawford	B - A	62	71	21	9	0
AR	Franklin	B - A	61	51	43	6	0
AR	Johnson	B - A	73	47	45	9	0
AR	Pope	B - A	68	45	46	10	0
AR	Van Buren	B - A	80	23	63	15	0
AR	Cleburn	B - A	64	33	41	26	0
AR	White*	A - Ou	37	35	40	25	0
AR	Sebsatian	A	54	25	41	34	0
AR	Logan	A	66	25	46	30	0
AR	Yell	A - Ou	72	55	33	12	0
AR	Conway	A - Ou	55	37	22	41	0
AR	Faulkner	A - Ou	46	19	38	43	0
AR	Scott	A - Ou	84	48	34	19	0
AR	Perry	A - Ou	82	44	34	21	0
AR	Pulaski*	Ou	41	38	35	27	0
AR	Polk	Ou	78	32	49	18	0
AR	Montgomery	Ou	88	59	24	17	0
AR	Garland	Ou	80	38	43	19	0
AR	Saline*	Ou	81	43	28	29	0
AR	Sevier*	Ou	70	30	45	26	0
AR	Howard*	Ou	71	38	32	30	0
AR	Pike*	Ou	84	30	37	33	0
AR	Clark*	Ou	77	54	19	27	0
AR	Hot Spring*	Ou	76	33	39	28	0
OK	Atoka*	Ou	55	29	44	27	0
OK	Latimer	Ou	69	37	45	18	0

State	County	Natural Section	% total forest	% saw-timber	% pole-timber	% sapling seedling	% non-stocked
OK	Le Flore	Ou	67	25	48	27	0
OK	McCurtain*	Ou	73	24	45	31	0
OK	Pittsburg*	Ou	49	35	27	39	0
OK	Pushmataha	Ou	82	25	50	25	0
OK	Adair	OZ-B	62	57	27	17	0
OK	Cherokee	OZ-B	61	33	31	36	0
OK	Delaware	OZ	47	34	28	38	0
OK	Haskell	A-OU	50	26	48	26	0
OK	Mayes*	OZ-B	30	56	33	11	0
OK	Muskogee*	B	28	25	55	20	0
OK	Ottawa*	OZ	16	36	27	36	0
OK	Sequoyah	B-A	53	22	42	36	0

Appendix 5. Density and acreage estimates for declining species in the mature and early successional forest suites.

Density of a species (in pairs) per 100 ha of suitable or optimal habitat was calculated by dividing the estimated total population size (in pairs) of each species by the estimated number of suitable-to-optimal hectares of habitat available in the physiographic area.

The total population size estimates were based on relative abundance data from the Breeding Bird Survey, 1990-1998. (http://www.mbr-pwrc.usgs.gov/bbs/trend/pifreg.html). We assumed that individual birds detected on BBS routes represented a pair of birds, and "total population size" refers to numbers of pairs, one being a territorial male. We next assumed an average detection distance of 128m for all species, with the area sampled then equal to 2.5 km^2. We divided relative abundance by 2.5 to get the number of pairs per km^2 (100 ha), and multiplied that by the size of the physiographic area (158,746 km^2) to get the total population size.

Information on which of three seral stages in four habitat types provide suitable or optimal habitat for each species was gathered from Hamel (1992; see Table 2). Estimates of acreage available of each habitat type in the planning unit were calculated and landcover mapped for PIF physiographic areas by the Center for Advanced Spatial Technology, University of Arkansas, Fayettevill, based upon AVHRR satellite imagery at a resolution of $1km^2$ (see mapset attached at end of document or at: <http://www.cast.uark.edu/edu/pif/main/maincont.htm>). Estimates of each forest type are:

Oak-hickory: 60,884 km^2
Mixed-pine hardwood: 18,799 km^2
Loblolly-shortleaf pine: 15,184 km^2
Bottomland hardwoods: Oak, gum, cypress (54,375) plus elm-ash-maple (126,543) = 1,809 km^2

The ratio of forest in sawtimber, poletimber and shrub/sapling seral stages was estimated from Missouri and Arkansas Forest Inventory Analysis data (Appendix 4). We assumed that the ratio from counties in the Boston Mountains and the Missouri and Arkansas Ozarks (42% sawtimber, 33% poletimber and 24% early-successional) was representative of the oak-hickory forest type and that the ratio from counties in the Arkansas Valley and Ouachita Mountains (37% sawtimber, 39% poletimber and 24% early-successional) was representative of mixed-pine and pine forest types.
Because these proportions were very similar, we used the ratio 40 - 36 - 24 to estimate the percentage of each seral stage in oak-hickory, mixed-pine hardwood and pine forest types. The proportion of bottomland hardwood forest in the three seral stages was assumed to be the same as that of the other forest types. Acreage of suitable/optimal habitat in the forest type used by a species was multiplied by the proportion of habitat in the seral stage(s) providing suitable- to-optimal habitat to estimate km^2 of suitable/optimal habitat available to each species.

For example, ACFL uses stage 3 of both oak-hickory and bottomland hardwood forest types, so 60884 + 1809 = 62693 km^2 x .4 = 25,077 km^2 of suitable/optimal habitat available to the species in the physiographic area. The total population size of Acadian Flycatcher (101,597) divided by 25, 077km^2 of suitable/optimal habitat available (25089) equals a density of 4.0 pairs per 100 ha (km^2).

Densities of birds calculated by the method above (the landscape density) are compared with densities from published field research in the Ozark/Ouachitas (all converted to numbers of territorial males/100 ha) in Table 3.

Table 3. Density estimates of PIF priority species in the Ozark/Ouachita physiographic area, in number of territorial males per 100 ha.

Species	total population size	available habitat in km^2	landscape density	Lower Ozarks	Ozark Border	Western Ozarks	Ouachitas	Southeastern U. S.
Northern Bobwhite	1,092,166	26,412	133.9			5-72	5.5	3
Pileated Woodpecker*	171,447	31,873	5.3				13-15	18 saw cove hardwood; 10 sap/pole
Great Crested Flycatcher	431,786	52,275	11.1			10-18	9-17	6-38
Acadian Flycatcher	101,597	25,089	4.0	14-21	0-4	35	4-6	70 (oak-gum-cypress)
Carolina Chickadee	546,082	83,639	10.9					35-60
Wood Thrush	177,794	63,101	2.9	13 sapling 4 pole/saw	6-10	18		37-45
Brown Thrasher	222,243	26,412	9.8			8-62		
Prairie Warbler	82,547	30,924	3.6	13-50		45-70	8-13	45-108
Kentucky Warbler	222,243	33,711	8.9	1-5, various seral stages	10-18 large forest tract; 9-13 small forest tracts; 118 in clearcut	35		15-20
Ovenbird	139,696	60,559	2.3	25	16-31 large tract; 7-9 small tracts	35	15	32-58

Species	total population size	available habitat in km^2	landscape density	Lower Ozarks	Ozark Border	Western Ozarks	Ouachitas	Southeastern U. S.
Field Sparrow	1,054,067	30,924	46.3		23	48-125		48

*Renkin and Wiggers (1993) found an average density of 1.86 pairs of Pileated Woodpeckers/100 ha at 16 sites in the Missouri Ozarks.

Lower Ozarks: This study took place in the Lower Ozarks natural division in areas with 65% or greater forest cover in the seven county area surrounding the study sites and 95% forest cover in the areas immediately surrounding the sites. Study sites were mixed-pine hardwood. Territories were mapped along eight 500 m transects at each of two study sites. Densities were reported separately in regeneration, sapling and in pole/ sawtimber stands. The study was done to evaluate the response of birds to clearcutting (Thompson et al. 92).

Ozark Border: Based on two reports. One study took place in Boone County, MO on a 900 ha research area. Approximately 80% of the area in a 5km radius surrounding the study site was forested. Territories were mapped on two approximately 20 ha sites within the research area. Densities were reported for forests that had not been clearcut and for areas 3 years following clearcutting (Thompson and Fritzell 1990). The second study also took place on the Boone County research site, though densities at two 300ha sites were from neighboring Callaway County.

Western Ozarks: This study took place at Pea Ridge National Military Park in Benton County, AR. Data from Forest Inventory Analysis in the 1990s indicate the county is approximately 62% forested, but the percentage of forest at the time of the study is unknown. Territories were mapped on 1.6 to 9.4 ha sites representing a variety of seral stages and habitat types (James and Shugart 1973).

Ouachitas:This study took place in the Ouachita National Forest, Scott County, AR. Forest Inventory Analysis indicates the area is approximately 84% forested. The forest type is mixed-pine hardwood, but pine-bluestem areas are being restored as part of a management strategy for Red-cockaded Woodpeckers. Bird densities in unburned and burned stands were derived from fixed-distance point counts (Wilson et al. 1995).

Southeastern U. S.: Densities were derived from Breeding Bird Censuses in the SE U.S. and compiled by Hamel (1992) for various forest types and

seral stages. Numbers in Table 3 are from forest types comparable to those in the Ozark/Ouachitas unless otherwise stated.

Estimates of acreage needed to provide habitat for a 1% increase in population was calculated by multiplying the number of acres needed per pair by 1% of the existing population. Estimates for the suite of upland forest birds are given below:

Species	number of new pairs needing habitat - 1% of existing population	hectares required per pair by BBS estimates	hectares required per pair based upon a "reasonable" density from published work	number of new hectares needed for new individuals based on BBS-based densities	number of new hectares needed for new individuals based on a "reasonable" density from published work
Pileated Woodpecker	1714	19	54	32,566	92, 556
Acadian Flycatcher	1016	25	10	25,400	10,160
Great Crested Flycatcher	4318	9	-	38,862	-
Carolina Chickadee	5461	9	-	50,241	-
Wood Thrush	1778	34	10	60,452	17,780
Kentucky Warbler	2222	11	10	24,886	22,200
Ovenbird	1397	44	4	61468	5588

Estimates for the early successional species suite are given below:

Species	number of new pairs needing habitat - 1% of existing population	hectares required per pair by BBS estimates	hectares required per pair based upon a “reasonable” density from published work	number of new hectares needed for new individuals based on BBS-based densities	number of new hectares needed for new individuals based on a “reasonable” density from published work
Brown Thrasher	2222	10.2	-	26,664	-
Prairie Warbler	825	27.8	2	22,935	1,650
Field Sparrow	10,541	2.2	2	23,190	21,082
Orchard Oriole	2286	2.7	-	6,172	-

The total size of the physiographic area is 15, 874,567 hectares. Assuming a 40-36-24 ratio of sawtimer-poletimber-early successional habitats, the acreages per successional stage of each forest type is as follows:

Species	km^2 of the forest type	km^2 of sawtimber (mature forest)	km^2 of poletimber	km^2 of early successional habitat
Oak-hickory	60,884	24,353	21,918	14,612
Mixed-pine hardwood	18,799	7,520	6,768	4,512
Loblolly-shortleaf	15,184	6,074	5,466	3,644
Bottomland hardwoods	1,809	724	651	434
Pasture plus cropland	57,705			

27,000 ha (270 km^2) of early successional habitat is 1% of that currently available, and less than than 0.5% of the cropland/pasture estimated to be present in the planning unit. If 27,000 ha existing mature forest were managed for early-successional species, it would reduce that cover type by less than 0.5%.

93,000 ha (930 km^2) of mature forest is 1% of that currently available in pole and sawtimber, and 1.6% of the cropland/pasture estimated to be present in the planning unit.

120,000 ha (1200 km^2) of habitat is approximately 2 % of the cropland/pasture estimated to be present in the planning unit.

Appendix 6. Recommendations for implementation strategies in subregions of the Ozark/Ouachita physiographic area.

Missouri:

Upper Ozarks: Counties in the Upper Ozarks range from 37 - 77% forested, although poletimber and shrub/sapling stands predominate. Over 20% of the land in some counties is in public ownership. Uneven-aged forest management should be considered as a timber harvest strategy to maintain or enhance coverage by more mature forests. Management for early successional birds could be encouraged on private lands through incentive programs. If any 20,000 ha (50,000 acre) areas within the subdivision have a 70% or greater forest coverage, they should be identified and steps taken to encourage landowners to keep the landscape at or above this level of forest coverage in the future. Continuous patches of forest greater than 4,000 ha (10,000 acres) also should be identified. Possibilities that exist to reforest even larger areas should be evaluated.

Springfield Plateau: The Springfield Plateau is one of the least forested regions of the physiographic area, with only 2 counties reaching 50% forest cover. A relatively small percentage of the forest that does occur is in the sawtimber stage, and very little public or industrial forest is available to serve as core areas for large tracts. It is unlikely that predominantly forested landscapes occur in the subdivision; conservation of forest birds would probably be helped most by the identification and maintenance of any existing large stand-alone tracts (4,000 ha or greater) with a high ratio of interior to edge habitat. Encouraging landowners to leave grass height above 8 inches would help to reduce cowbird feeding opportunities and the development of more complex edges between field and forest might help to reduce parasitism and predation. Non-forest species such as Field Sparrows and Bewick's Wrens were found throughout the subdivision by Breeding Bird Atlas volunteers, and could be species that would benefit greatly by a focused conservation message in rural areas of the physiographic region.

Elk River: The Elk River is the smallest subdivision within the physiographic area. Less

than half of the area is in forest. No National or State Forests are present. Perhaps the best conservation strategy is that outlined for the Springfield Plateau, described above.

White River: Forest coverage by county ranges from 42 - 71%, with the preponderance of forest in the shrub/sapling through poletimber stage. Both state and National Forests are located within the subdivision. While large expanses of forest could meet the threshold of 70% or greater forest coverage, urbanization has rapidly occurred within the last decade and is likely to continue. Thus, road building and development are likely to further fragment the landscape. Identification of remaining tracts of forest or forest /glade complexes that are 4000 ha or larger as “Bird Conservation Areas” might be the most prudent conservation strategy if those tracts are centered around cores of public land and conservation easements could be acquired from private landowners. Making the location of such potential tracts and the rational for their conservation well known to city and county planners, planning commissions and the general public will be necessary if such tracts are to exist in the future. While securing large blocks of mature forest should be a focus in the subdivision, glades should be conserved for early successional species such as Prairie Warblers, Field Sparrows and Bachman’s Sparrows.

Lower Ozarks: The Lower Ozarks is one of the most heavily forested regions and has the largest remaining amount of oak-pine and pine forest in Missouri. Thus, both oak-hickory and pine-associated bird species should be targeted here, depending upon the type of forest coverage at a given site. The amount of land in public and private industrial forest also is greater than in other sections of the Missouri Ozarks, and thus opportunities for the conservation of forest birds are maximized as well.

Conservation efforts should focus on maintaining the forested landscape as a whole. Habitat for most early successional bird species will be provided by even-aged forest management. However, an increase in shorter harvest rotations to provide forest products for an ever-growing chip-mill industry, especially on private land, may result in a need for public forest to provide the bulk of mature forest habitat for birds utilizing that end of the continuum. Tracts of mature forest also should be consolidated as much as

possible into 800 ha or greater tracts, to insure that minimum area requirements of all species are met. Results from the Missouri Ozark Forest Ecosystem Project will help planners to gain a better understanding of how the juxtaposition of various forest age classes following even-aged management, or the amount within-forest edge resulting from uneven-aged management, affects reproductive rates of forest birds.

St. Francois Mountains: While the St. Francois subdivision differs from the Lower Ozarks geologically, the two regions have very similar conditions with regards to forest coverage, public ownership, etc. Therefore, recommendations for the Lower Ozarks (see above) should be followed in the St. Francois section as well.

Arkansas:

The Ozarks: This section combines recommendations for both the Springfield and Salem Plateau regions of Arkansas. Counties range from 44 - 71% forested, and have oak-pine as well as oak-hickory forest types represented. There are no State Forests in the region, and only Benton and Baxter Counties have tracts of National Forest (4 and 27% of the counties, respectively). The majority of the forests in the subdivision are categorized as poletimber, although roughly 90% of upland hardwood stands on National Forest land is greater than 50 years of age and represent more mature forest types. Shortleaf pine and oak-pine stands on National Forest land are less well represented by older age-classes and development of more mature habitat should be a goal for those properties. Glades and savannas should be restored and maintained on appropriate soil types, although care must be taken to provide the structural features of the habitat that attract priority bird species. Some of the fastest growing counties in Arkansas are located in this subdivision and thus fragmentation of forested landscapes by roads and other developments is likely to occur. Conservation objectives should focus on identifying remaining tracts of forests greater than 4,000 ha (10,000 acres). Once tracts are identified, it will be necessary to work with planners, resource agencies and the general public to develop methods for conservation of large tracts and to see that the rational for the protection of these sites is understood.

Boston Mountains:

Forest coverage ranges from 61 - 84% in counties in the Boston Mountains. However, very large expanses of predominantly oak-hickory and mesic hardwood forest presently exist in areas that still appear relatively unthreatened by development pressures. Thus, forested landscapes 20,000 ha and greater (50,000 acres) that reach 70% or more forest coverage should be identified and protected. In areas where the “landscape” does not reach the threshold level of forest coverage, tracts 4,000 ha or greater (10,000 acres) should be identified for conservation. Some counties have a large percentage of National Forest that could serve as core areas for reserves. It appears that forest coverage overall is represented by younger age classes, so public forests should concentrate on maintaining a high percentage of older, more mature forest age classes. Glades and savannas should be restored and maintained on appropriate soil types, although care must be taken to provide the structural features of the habitat that attract priority bird species.

Arkansas Valley: The Arkansas Valley is 54-80% forested, with a mix of oak-pine, oak-hickory and pine forests. A considerable amount of the subdivision is in National Forest, with 80% or more of its timber in mature age classes. Commercial forest lands also occur within the subdivision but are less prevalent than in the Ouachitas to the south. Overall, the forests in the subdivision appear to be less mature than those on public land, with approximately 40% classified as poletimber and 20% as shrub/sapling. Thus, the USFS should focus on maintaining significant amounts of mature to over-mature forests for species requiring such habitat. Conservation strategies should include identifying large landscapes with 70% or greater forest cover as well as conserving any isolated tracts greater than 4,000 ha (10,000 acres). Threats to the future integrity of the forested landscape should be identified, so that conservation efforts can be initiated if warranted. Restoration and improvement of bottomland hardwood forests and grassland habitats should be encouraged on appropriate soil types.

Ouachitas: Forest coverage is very extensive throughout the subdivision, probably

averaging 70% or greater. Both the forest products industry and the USFS hold large percentages of the Ouachitas' forests, indicating that much of the forest coverage will remain in the future. Issues of forest management are likely to be more important here. Choices between even aged and uneven aged management of forests should be made after consideration of the condition of surrounding landscapes, and should help to provide those kinds of habitats that would be otherwise unavailable. Research on how the juxtaposition of various forest age classes following even-aged management, or the amount of within-forest edge resulting uneven-aged management, affects reproductive rates of forest birds has been conducted on industry and USFS lands in the Ouachitas; results of that research should continue to be incorporated into future planning efforts. Glades and savannas should be restored and maintained on appropriate soil types, with care taken to provide the structural features of the habitat that attract priority bird species.

Oklahoma:

The Ozarks: Forest coverages are similar to those in the Ozarks of Arkansas. Although there are no state of national forests in the Oklahoma Ozarks, the Oklahoma Department of Wildlife Conservation has a large, mostly forested wildlife management area in Delaware County. The conservation recommendation of identifying and maintaining forest tracts greater than 10,000 acres also is appropriate for this portion of the physiographic area. Glades are rare and little work has been done to identify or restore savannas.

Boston Mountains: Conservation recommendations for the Arkansas portion of the Boston Mountains are appropriate for the Oklahoma portion as well. There are no state or national forest lands, but there are two large Oklahoma Department of Wildlife Conservation wildlife management areas, Cookson Hills and Cherokee, that are almost completely forested.

Arkansas Valley: follow the recommendations for the Arkansas portion of the sub-region.

Ouachitas: follow the recommendations for the Arkansas portion of the sub-region.

Appendix 7: Species suites by habitat type and seral stage:

Habitat strata utilized by each PIF priority species for nesting, foraging or other life-history requirements in oak-hickory forest seral stages are given below. Habitat information is from Hamel (1992) unless noted. Each species must have all the strata it needs present to occupy the stand. Not all species will co-occur, but should be supported in the landscape.

Oak-hickory:

Grass/forb through shrub/seedling seral stage: This habitat occurs on recently clearcut sites. The woody vegetation typically is less than 3m in height with a grassy or weedy understory and a fairly good coverage of shrubby thickets and/or saplings.

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Short-eared Owl*	F				roosts in grassy cover or in shrubs.
Bewick's Wren*		N, F			nests built in cavities, crannies or placed on ledges.
Brown Thrasher	F	N, F			
Sprague's Pipit*	F				winters in extensive areas of short grass.
Bell's Vireo		N, F			
Blue-winged Warbler	N	F			
Prairie Warbler		N, F			
Dickcissel	N, F				
Bachman's Sparrow*	N, F	F			
Field Sparrow	N, F	N, F			
Orchard Oriole*			N, F	N, F	uses scattered trees

* indicates the habitat is of marginal value to the species. No seral stages in the habitat type are suitable or optimal for the species.
N indicates the species nests in the strata; F indicates the species forages in the strata.

Sapling/poletimber or young upland deciduous forest:

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Yellow-billed Cuckoo			N, F	F	
Chuck-will's-widow*	N				F - nocturnal; aerial
Whip-poor-will	N				F - nocturnal; aerial
Wood Thrush	F	N, F			prefer moister sites with well developed understory.
Swainson's Warbler	F	N, F			typically associated with cane (*Arundinaria gigantea*) thickets in bottomlands, but sometimes found in moist upland forests with a dense understory.
Ovenbird	N, F				more abundant in mature upland forest with less ground cover
Orchard Oriole*			N, F	N	prefers scattered hardwoods in open country.

* indicates the habitat is of marginal value to the species. No seral stages in the habitat type are suitable or optimal for the species.
N indicates the species nests in the strata; F indicates the species forages in the strata.

Sawtimber or mature upland deciduous forest: In general, species utilizing this habitat require the conditions of large and "older-growth" forests - a well developed understory and somewhat open mid-story, with snags present.

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Yellow-billed Cuckoo			N, F	F	
Whip-poor-will	N				F - nocturnal; aerial

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Red-headed Woodpecker					nests in snags; requires open, mature woods and groves.; forages in bark of trees, but also flycatch and probe the ground for insects.
Pileated Woodpecker					nests and forages in shags in mature, extensive forests.
Eastern Wood-Pewee			N	N	prefers open-medium growth woodlands; F- hawk aerial insects
Acadian Flycatcher			N		F- hawk aerial insects
Great Crested Flycatcher					cavity nesting, arboreal hawking insectivore.
Carolina Chickadee				F	N - snags
Wood Thrush	F	N, F			prefer moister sites with well developed understory.
Cerulean Warbler				N, F	prefer very large tracts of forest with gaps in the canopy and emergent canopy trees.
Worm-eating Warbler	N	F	F		sensitive to fragmentation (see habitat strategies section of this plan).
Swainson's Warbler	F	N, F			typically associated with cane (*Arundinaria gigantea*) thickets in bottomlands, but sometimes found in moist upland forests with a dense understory.
Ovenbird	N, F				more abundant in mature upland forest with less ground cover
Louisiana Waterthrush	N, F				near rocky streams
Kentucky Warbler	N, F	F			associated with moist forests with an abundant understory.

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Summer Tanager				N, F	prefers a more open canopy
Orchard Oriole*			N, F	N	utilizes scattered hardwoods in open country.
Purple Finch				F	favor areas with winter fruit or buds present.

* indicates the habitat is of marginal value to the species. No seral stages in the habitat type are suitable or optimal for the species.
N indicates the species nests in the strata; F indicates the species forages in the strata.

Mixed pine-hardwood forests:

Grass/forb through shrub/seedling seral stage: This habitat occurs on recently clearcut sites. The woody vegetation typically is less than 3m in height with a grassy or weedy understory and a fairly good coverage of shrubby thickets and/or saplings.

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Northern Bobwhite	N, F				
Short-eared Owl*	F				roosts in grassy cover or in shrubs.
Bewick's Wren*		N, F			nests built in cavities, crannies or placed on ledges.
Brown Thrasher	F	N, F			
Sprague's Pipit*	F				winters in extensive areas of short grass.
Bell's Vireo		N, F			
Prairie Warbler		N, F	F		
Bachman's Sparrow	N, F	F			Utilizes 1-3 year old clearcuts with a dense cover of grasses and weeds (James and Neal 1986)
Field Sparrow	N, F	N, F			

* indicates the habitat is of marginal value to the species. No seral stages in the habitat type are suitable or optimal for the species.
N indicates the species nests in the strata; F indicates the species forages in the strata.

Sapling/poletimber or young mixed pine-hardwood forests:

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Whip-poor-will	N				nocturnal aerial insectivore
Chuck-will's-widow	N				nocturnal aerial insectivore
Ovenbird	N, F				
Borwn-headed Nuthatch*					nests in cavaties; forages by probing or gleaning bark or foliage.
Carolina Chickadee			F	F	secondary cavity nester
Purple Finch				F	favor areas with winter fruit or buds present.

* indicates the habitat is of marginal value to the species. No seral stages in the habitat type are suitable or optimal for the species.
N indicates the species nests in the strata; F indicates the species forages in the strata.

Sawtimber or mature mixed pine-hardwood forests:

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Chuck-will's-widow	N				nocturnal aerial forager
Whip-poor-will	N				nocturnal aerial forager
Pileated Woodpecker					feeds on and excavates nests in dead/ dying trees; MAR
Eastern Wood-Pewee			N, F	N, F	
Great Crested Flycatcher					cavity nesting, arboreal hawking insectivore.
Carolina Chickadee			F	F	secondary cavity nester
Brown-headed Nuthatch*					nests in cavaties; forages by probing or gleaning bark or foliage.
Wood Thrush	F	N, F			prefer moister sites with well developed understory.
Yellow-throated Warbler				N, F	

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Ovenbird	N, F				more abundant in mature upland forest with less ground cover
Summer Tanager				N, F	prefers a more open canopy
Purple Finch				F	favor areas with winter fruit or buds present.

* indicates the habitat is of marginal value to the species. No seral stages in the habitat type are suitable or optimal for the species.
N indicates the species nests in the strata; F indicates the species forages in the strata.

Pine forests and plantations:

Grass/forb through shrub/seedling seral stage: This habitat occurs on recently clearcut sites. The woody vegetation typically is less than 3m in height with a grassy or weedy understory and a fairly good coverage of shrubby thickets and/or saplings.

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Northern Bobwhite	N, F				
Short-eared Owl*	F				roosts in grassy cover or in shrubs.
Bewick's Wren*		N, F			nests built in cavities, crannies or placed on ledges.
Brown Thrasher	F	N, F			
Prairie Warbler		N, F	F		
Field Sparrow	N, F	N, F			
Bachman's Sparrow	N, F	F			Utilizes 1-3 year old clearcuts with a dense cover of grasses and weeds (James and Neal 1986)

* indicates the habitat is of marginal value to the species. No seral stages in the habitat type are suitable or optimal for the species.
N indicates the species nests in the strata; F indicates the species forages in the strata.

Sapling/poletimber or young upland pine forest:

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Chuck-will's-widow	N				nocturnal aerial forager
Whip-poor-will	N				nocturnal aerial forager
Carolina chickadee			F	F	N - secondary cavities
Brown-headed Nuthatch*					nests in cavaties; forages by probing or gleaning bark or foliage.

* indicates the habitat is of marginal value to the species. No seral stages in the habitat type are suitable or optimal for the species.
N indicates the species nests in the strata; F indicates the species forages in the strata.

Sawtimber or mature upland pine forest:

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Chuck-will's-widow	N				nocturnal aerial forager
Whip-poor-will	N				nocturnal aerial forager
Red-cockaded Woodpecker					nest in a cavity in the trunk of a live pine; some trees must have proper heartwood conditions for nest cavities; prefer a minimal understory; forage on the bark of pines.
Eastern Wood-Pewee			N, F	N, F	
Great Crested Flycatcher					cavity nesting, arboreal hawking insectivore.
Carolina Chickadee			F	F	secondary cavity nester
Brown-headed Nuthatch*					nests in cavaties; forages by probing or gleaning bark or foliage.
Wood Thrush	F	N, F			prefer moister sites with well developed understory.
Yellow-throated Warbler				N, F	
Summer Tanager				N, F	prefers a more open canopy

Species	Ground	Understory	Mid-canopy	Upper canopy	Other
Purple Finch				F	favor areas with winter fruit or buds present.

* indicates the habitat is of marginal value to the species. No seral stages in the habitat type are suitable or optimal for the species. N indicates the species nests in the strata; F indicates the species forages in the strata.

Bottomland Hardwood Forests:

With the exception of Swainson's Warbler and Prothonotary Warbler, almost all of the species in the bottomland hardwood forest suite can be found in other habitat types (see Table 2). Habitat strata used for nesting, foraging, etc. can be found in the tables above. Swainson's Warbler, nests in the understory of bottomland floodplain forests with a good growth of river cane, and typically forage on the ground and in the leaf litter. Prothonotary Warblers prefer swamps or bottomlands with standing water. They nesting in cavities in stumps or dead trees and generally forage within 5m (15 ft.) of the ground (see Hamel 1992 for species accounts).

****

Front cover illustration from 'All the Birds of North America'
by Jack Griggs, courtesy of HarperCollins publishers.