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Source: Natural Areas Journal, 29(3) : 301-310

Published By: Natural Areas Association

URL: https://doi.org/10.3375/043.029.0309

CONSERVATION ISSUES

Old Forests and Endangered Woodpeckers: Old-Growth in the Southern Coastal Plain

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Natural Areas Journal 29:301–310

ABSTRACT: Southern old-growth forests are small and rare, but critical in their support of biodiversity. While the remnant old-growth forests contain diversity that is significant regionally and globally, they most likely represent only a portion of the variety that old forests once sustained. High within-habitat diversity and rarity in the landscape magnify the conservation value of these systems. Old-growth stands of two particular communities—longleaf pine (*Pinus palustris*) forests and floodplain (bottomland/swamp) forests—have emblematic links to two notable bird species of concern, the Red-cockaded (*Picoides borealis*) and Ivory-billed (*Campephilus principalis*) Woodpeckers. In addition to conservation importance, southern old forests have social and economic values that are in danger of further impoverishment if these systems are lost to future generations. Summarizing the findings from a recent workshop, we review old-growth status and values, identify current threats, and describe potential strategies to promote greater long-term conservation of old forests across the South.

Index terms: bottomland hardwood forest, cypress-tupelo forest, Ivory-billed Woodpecker (*Campephilus principalis*), longleaf pine forest, old-growth forest, Red-cockaded Woodpecker (*Picoides borealis*)

INTRODUCTION

Forests, particularly old-growth forests, have influenced the human ecology, economic development, and culture of the Southern United States well before the nation's founding. In turn, these forests have been shaped by humans for thousands of years (Carroll et al. 2002). The reported rediscovery of the Ivory-billed Woodpecker (*Campephilus principalis*) in the "Big Woods" of Arkansas (Fitzpatrick et al. 2005) has refocused interest in old-growth forests in the southeastern Coastal Plain. The national attention given to the Ivory-billed by birdwatchers, conservationists, and scientists illustrated the many ways that old forests—and the biodiversity contained therein—can captivate the imagination and inspire awe. The future value of these forests, to the extent that it can be assessed, must be viewed relative to their impact on people in the region and people's impact upon them. In the context of this complex social connection, southern old-growth resources and conservation strategies were discussed at the "Old-Growth Forests Conservation Workshop" held in Thomasville, Georgia, on 30-31 March 2006 and sponsored by the National Commission on Science for Sustainable Forestry. In this paper, we summarize some of the principal workshop findings.

The Southeastern Coastal Plain is home to many forest types, but two communities are notably significant: (1) upland longleaf pine (*Pinus palustris*) forests and (2) floodplain (bottomland hardwood, swamp) forests. Representing opposite ends of a fire-frequency continuum, both are a focus of regional conservation efforts, not the least for their respective associations with two endangered bird species: the Red-cockaded Woodpecker (*Picoides borealis*) of longleaf pine systems and the Ivory-billed Woodpecker of bottomlands and swamps. Southern forests, albeit now different from those first encountered by European settlers, also remain the "wood basket" of the country (Wear and Greis 2002). Both upland and floodplain forests produce valuable timber products; thus, in a region dominated by private land ownership, economic realities influence how old forests may be managed in ways that can serve conservation goals.

Despite the dramatic historic loss of old forests from the landscape, the biodiversity supported by small remnant stands offers compelling testimony to their past significance. Their present rarity also highlights a need to assess their future contributions to the Southern region's ecological heritage from a broader conservation perspective than those which shaped land use in the past. In considering this challenge for the longleaf pine and floodplain forest communities, the workshop addressed four questions: (1) What is the extent of old-growth forests in the present-day southern landscape?, (2) What old-growth attributes provide biodiversity value?, (3) What social values are derived from old-growth forests?, and (4) What practical strategies could enhance old-growth conservation for the future?

STATUS OF SOUTHERN OLD-GROWTH

What is Old-growth?

Defining old-growth attempts to impose the discrete on the continuous, leading to differing concepts and sometimes contentious debate. Most definitions rest on the idea of advanced stand age (without catastrophic disturbance) as a driver of structural and functional properties associated with "late-succession" or "very mature" forest conditions (Moeur et al. 2005). Such forests are thought to have large old trees, a predominance of shade-tolerant species, a mosaic of tree age classes, multi-layered canopies, abundant snags and coarse woody debris, undisturbed soils and complex forest floors, closed hydrologic and nutrient cycling processes, and slow rates of net biomass accumulation. Old-growth concepts originated in large part out of the vast, uncut conifer forests of the Pacific Northwest, where the onset of old-stand conditions may begin at 150 to 250 years of age and then persist for several hundred years (Moeur et al. 2005). The extent to which these concepts apply generally to forests in other regions is open to question.

Old-growth Extent in the South

For the South, efforts to define and inventory old-growth forests are represented mainly by two sources. A group of academic, government, and non-governmental organizations initiated the annual Eastern Old-growth Conference series, an outgrowth of which was publication of a qualitative "old-growth" compilation (Davis 1996, 2003). As part of a national effort in the 1990s, the U.S. Forest Service Southern Region established an Old-growth Task Group to develop scientifically based definitions and standards for use in National Forest planning and inventory (Gaines et al. 1997). The Davis inventory focused on sites considered representative of undisturbed, unlogged "primary" (pre-settlement) forest remnants, but it generally excluded secondary forests that may now have some old-growth characteristics. The Forest Service effort focused on defining forest traits associated with advanced stand age, to allow identification of both existing and potential old-growth regardless of whether forests were primary or secondary. These definitions incorporated quantifiable attributes such as tree density and basal area, age of large trees, number of size classes, snag density, downed log volumes, percentage of canopy in gaps, and number of canopy layers.

To date, the Forest Service has published old-growth definitions and attribute lists for 13 Southern forest types (Table 1). Attribute standards are derived from existing old-growth stands or from historical records, but values may vary with geographic and edaphic factors. The standards are being applied in some current National Forest inventory efforts, but no region-wide old-growth compilation exists as yet. The Eastern Old-growth compilations were based largely on survey responses from federal agency personnel, state natural areas biologists, local naturalists, or other knowledgeable sources. The most recent version (Davis 2003) listed roughly 420 possible old-growth sites of all forest types in the South, with a fairly even distribution across states. In the South-Atlantic states of Virginia, North Carolina, South Carolina, and Georgia, a substantial number of these tracts are located in the Appalachian Mountains rather than the Coastal Plain. Based on an approximate estimate of 274,000 ha, old-growth communities comprise roughly 0.3% of total forest area in the Southern states (Davis 1996).

Longleaf Pine — Longleaf ecosystems range from forests to savannas, with a dominant pine overstory and a well-developed herbaceous understory. Old forests have many large trees (> 50 cm diameter), persistent large snags, large downed woody debris, and patches of different age classes. Stands may begin to develop old-growth characteristics at 115-120 years of age, but a mature old forest has age classes exceeding 150 years and individual trees over

Table 1. Available old-growth descriptions for major Southern forest types.

Forest Type	Published Definition[1]
Cypress-tupelo forests	Devall 1998
Dry and dry-mesic oak–pine forests	White and Thomas 1998
Eastern riverfront forests	Meadows and Nowacki 1996
Evergreen bay forests	McKevlin 1996
Floridian tropical and subtropical subtropical forests	Outcault 1997b
Mixed mesophytic and western mesophytic forests	Greenberg et al. 1997
Red-river bottomland forests	Shear et al. 1997
Sand pine forests	Outcault 1997a
Seasonally wet oak–hardwood woodlands	Kennedy and Nowacki 1997
Southern mixed hardwoods	Batista and Platt 1997
Wet pine systems	Harms 1996
Upland longleaf and Florida slash pine systems	Landers and Boyer 1999
Xeric pine and pine–oak woodlands	Murphy and Nowacki 1997

[1]Available online at http://www.treesearch.fs.fed.us/

200 years old (Platt et al 1988). Notably, the persistence of open-canopy, long-lived stands requires frequent fire (every 1-5 years) because longleaf pine is considered shade intolerant (Landers and Boyer 1999; Varner and Kush 2004).

The longleaf pine ecosystem once dominated southeastern Coastal Plain uplands from Virginia to Texas (see Varner and Kush 2004). Longleaf pine forests were harvested extensively for naval stores and timber, cleared for farming, then converted to loblolly pine (*P. taeda*) plantation forestry after widespread farmland abandonment in the early 20th century. Several of the finest examples of old longleaf pine stands that remain were conserved through management as game-hunting plantations. Based on an estimated 37.2 million ha for the Pre-Columbian extent of longleaf pine forests, the roughly 5100 ha of remaining old-growth is perhaps 0.014% of the original forest area (Varner and Kush 2004). Of 15 well-known old-growth sites, about 3/4 of tracts and nearly 90% of the acreage are in public ownership, but only one tract (on Eglin Air Force Base, Florida) is large (> 1000 ha). Davis (2003) listed an additional group of 27 sites with uncertain documentation that merit further evaluation.

Bottomland Hardwood and Swamp Forests — Applying old-growth concepts to floodplain forests is problematic because river ecosystems are hydrologically and geomorphically dynamic. Bottomland hardwood forests of mixed species composition occur where there is periodic and variable inundation. Flooding, sedimentation, erosion, and channel migrations result in continual site changes augmented by windthrow and canopy gap formation; thus, few stands may remain in the same compositional state for more than 100-200 years (Sharitz and Mitsch 1993; Meadows and Nowacki 1996; Shear et al. 1997). Deepwater swamp forests of baldcypress (*Taxodium distichum*) and tupelos (*Nyssa aquatica, N. biflora, N. ogeche*) occur in relatively more stable sites of prolonged inundation and less dynamic succession; and, thus, may be more likely to persist as "old-growth." Pre-settlement cypress-tupelo forests achieved stand ages of 400-600 years, and ancient trees had diameters > 1 m (Devall 1998).

Nearly all southern bottomland hardwoods and swamps have been harvested at least once, with extensive removals occurring along major rivers in the late 19th and early 20th centuries. An estimated 63% of pre-settlement southern floodplain forests had been lost or altered by the 1970s, with higher local losses in areas such as the Lower Mississippi Valley (Sharitz and Mitsch 1993). There is no comprehensive inventory of extant old-growth floodplain forests, but Davis (2003) lists roughly 69 likely pre-settlement remnants of bottomland hardwood or cypress-tupelo across the South. Of these sites, 57% were in public ownership and 29% in private ownership, with the remaining either jointly owned or undetermined. Because this compilation effort mainly surveyed conservation agencies/organizations and focused on site history rather than stand structure, these ownership estimates may be incomplete. A different ownership pattern emerges from U.S. Forest Service Forest Inventory and Analysis (FIA) data that reflect systematic landscape sampling plus a minimum tree-size criterion (Miles 2008; Figure 1). Among stands of the major floodplain forest types dominated by large trees (> 50 cm diameter), roughly 67% were in private ownership. The FIA data have limited resolution as to forest age and quality because they include secondary stands that contain large trees but may lack other old-

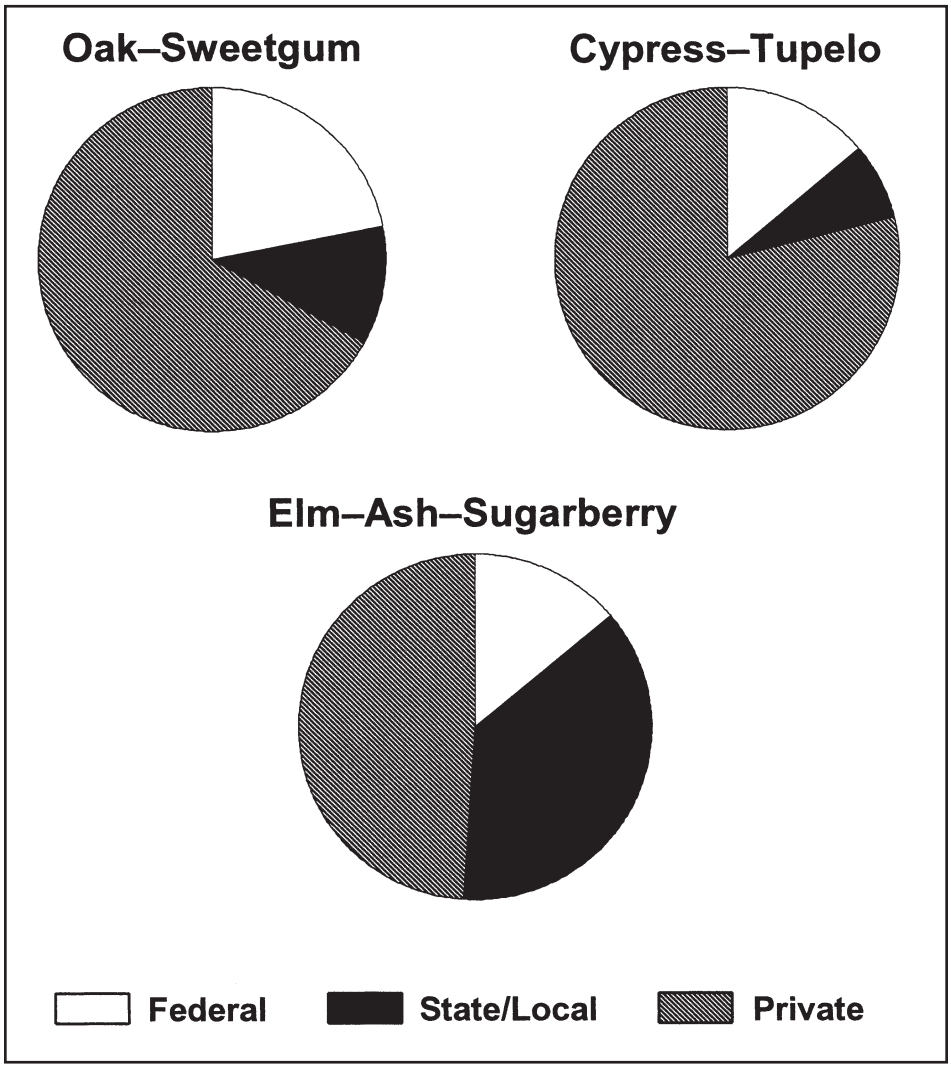

Figure 1. Ownership patterns for stands with large trees (dbh >50 cm) in major bottomland hardwood and swamp forest types of Southern river floodplains. Data are the relative proportion of FIA plots dominated by large trees in each ownership category (Miles 2008)..

growth characteristics. Additional survey and analysis are needed to better assess the status and ownership patterns of Southern old-growth floodplain forests.

BIODIVERSITY VALUES OF SOUTHERN OLD-GROWTH

The scarcity of old forests in the South prevents a full understanding of linkages between biodiversity and old-growth condition. Given that the natural range of variation has been severely constrained and fragmented, the contemporary ecological role of these forests is likely not the historical one. However, some structural and functional traits of old-growth forests now contribute to regional diversity because of their present rarity. Developing conservation and management options to promote forests with such traits is central to enhancing landscape-scale biodiversity. Below, we identify characteristics of old-growth forests to be considered in assessing the conservation value of remnant sites. These characteristics are key elements for identifying high quality stands across the continuum of forests that now exist in highly modified landscapes.

Old Trees and Coarse Woody Debris

Advanced tree age engenders physical characteristics that are rare or absent in younger trees, such as large bole and primary branch size, structural complexity, and proportion of heartwood to sapwood. In longleaf pine forests, old trees are represented in one dominant pine species, although studies of xeric sites have documented oaks > 200 years old as components of the stands (Greenberg and Simons 1999). In floodplain forests, old trees may present a diverse array of potentially 50 canopy species across hydrologic and topographic gradients (Conner and Sharitz 2005). For woodpeckers, old and senescing trees supply quality nesting and foraging habitats. In upland pine forests, the Red-cockaded Woodpecker prefers the largest, oldest trees for foraging (Engstrom and Sanders 1997). Old pine trees are also favored for nesting and roosting cavities because there is sufficient sound or fungus-softened heartwood for excavation, which offsets the undesirable resin flow from sapwood (Conner et al. 2001). In floodplain forests, the Ivory-billed Woodpecker was observed using large dead or partially dead trees for cavities, plus recently dead trees or branches for foraging (Jackson 2002). On the old-growth Singer Tract, Louisiana (one of the last documented historic locations), Ivory-billeds foraged somewhat selectively on various tree species, but generally preferred larger trees over smaller ones (Tanner 1942). Foraging preference was linked to availability of large wood-boring beetle larvae (Cerambycideae and others), an important food.

Old trees also generally produce larger, more persistent coarse woody debris than do young trees. Snags (standing dead trees) and down dead material (logs, limbs, and stumps) are important faunal microhabitats that provide cavities, foraging substrate, and escape cover. For example, many bird species of southern forests use woody debris in some form, and abundances of some breeding bird species were reduced when snags and coarse down wood were removed from pine forests (Lohr et al. 2002). Rotting stumps serve as refuge sites for fossorial amphibians, reptiles, and mammals in the longleaf pine ecosystem (Means 2006). The role of large woody debris has received less attention in floodplain forests; however, hollow logs and cavities appear to provide critical cover, nesting, and basking sites elevated above flooding levels for many vertebrates (Heitmeyer et al. 2005).

Undisturbed Ground Cover

Although old-growth longleaf pine systems have low canopy-species diversity, the ground-layer flora often harbors the most species-rich vegetation in North America and contains numerous rare, threatened, or endemic species (Hardin and White 1989). Ground-layer vegetation free from severe soil disturbance (mechanical or chemical) or from intensive grazing has appreciably higher species richness than that of disturbed sites, even after decades of "recovery" (Hedman et al. 2000; Kirkman et al. 2004a). Thus, preventing management activities from disrupting ground-layer root systems is critical for supporting a diverse forest community. Frequent fire is also needed to maintain the flora of pineland ground cover, particularly pyrogenic grasses such as bluestems (*Schizachyrium* spp.) and wiregrass (*Aristida stricta, A. beryichiana*) (Clewell 1989; Kirkman et al. 2004b). Because wiregrass is vulnerable to soil/root disturbance and re-establishes only very slowly (Clewell 1989; Outcalt 1992), its dominance on a site is an old-growth indicator unrelated to age of the canopy and represents a desired conservation attribute (Kirkman and Mitchell 2006). Excluding fire favors proliferation of hardwoods and decline of ground-layer herbs as a result of shading and litter accumulation (Hiers et al. 2007). An open-canopy longleaf forest represents critical Red-cockaded Woodpecker habitat, in part because there may be a link between ground-cover quality (abundant grass, forbs, and natural longleaf regeneration) and arthropod abundance on the trees (James et al. 1997).

In floodplain forests, plant diversity reflects many woody species within multiple strata. Canopy-tree diversity is strongly related to variations in microtopography and flooding regime; thus, woody species richness can be high in the case of periodically-flooded bottomland hardwoods forests or low in the case of more permanent deepwater cypress-tupelo swamps. The ground-layer vegetation has abundant woody vines that reach into the tree canopy, but herbaceous cover may be relatively sparse owing to flooding, scouring, and reduced light levels, except where canopy gaps allow greater light penetration (Conner and Sharitz 2005). Intact forest-floor microtopography is an important attribute, because interactions between elevation and flooding influence tree seedling regeneration and ground-cover species diversity (Huenneke and Sharitz 1986).

Natural Disturbance Regimes

In contrast to some Pacific Northwestern forests that are characterized by infrequent stand-replacing disturbances, many Southern old-growth forests are shaped by frequent, low-intensity disturbances. In longleaf pine systems, frequent natural fires maintain the open canopy, complex tree age

structure, and high ground-layer diversity characteristic of old-growth stands. Some of the highest-quality longleaf old-growth is represented by stands under long-term prescribed fire management (Varner and Kush 2004). Floodplain forests experience frequent flooding and windstorm disturbances that alter physical microtopography and contribute to high structural complexity in the form of coarse debris, canopy gaps, and regenerating forest patches of diverse species composition (Conner and Sharitz 2005). Disturbances creating large patches of dead trees, whether from storms, fires, insect outbreaks, or flooding by beaver impoundments, were thought important in generating critical habitat and food supply for Ivory-Billed Woodpeckers (Tanner 1942). Maintaining these natural disturbance regimes is critical for old-growth forest conservation and also provides opportunities for promoting other old-growth characteristics in forest management.

Intact Ecotones

Within upland longleaf pine forests, contrasting habitats such as depressional wetlands are commonly juxtaposed. At a landscape scale, the highest plant species richness is associated with frequently burned mesic longleaf sites, in part because ecotones between herb-dominated wetlands and mesic uplands support especially species-rich floras (Kirkman et al. 1998). The wetlands themselves are critically important habitats for breeding amphibians and aquatic invertebrates, because seasonal drying reduces populations of predatory fish (Golladay et al. 1997). Thus, the extent to which communities have been connected by fire across the landscape is an old-growth characteristic and a desirable management component where conserving between-habitat and regional biodiversity is a goal (Means 1996; Kirkman and Mitchell 2006). More broadly, adjacency of old-growth bottomland hardwoods and upland pine forests may have been important for the Ivory-billed Woodpecker (Jackson 2002) and other old-growth dependent species. In Florida, Ivory-billeds were seen foraging on dead trees in both habitats when in close proximity. Extensive intact areas where upland and riparian old-growth forests occur together, such as the Apalachicola River (Florida) and Altamaha River (Georgia) basins, offer the potential for conservation of large-scale ecotones.

Size of Old-growth Stands

While reducing fragmentation is recognized as important, identifying a minimum size for old-growth forest necessary to support wildlife is problematic. Old-growth forests covered vast areas historically, but present-day requirements for minimum habitat area would necessarily depend upon the species of interest and surrounding landscape context. Habitat needs for animals of conservation concern vary widely but suggest a value of larger tract sizes. Based on home range size, approximately 40 ha of fire-maintained habitat would be needed to sustain a minimum viable population of 50 gopher tortoises (*Gopherus polyphemus*) (Eubanks et al. 2002). The same 40-ha area represents the home range of one male Sherman's fox squirrel (*Sciurus niger shermani*) in mature pine or pine-hardwood stands (Conner 2000). Depending on habitat quality, a small Red-cockaded Woodpecker population of 20 nest clusters might require 800-2000 ha of upland pine forest (Engstrom and Sanders 1997). The floodplain forest area and quality necessary to support a viable Ivory-billed Woodpecker population is uncertain (Jackson 2002), but the home range was estimated to be on the order of 1000 ha or more per pair (Tanner 1942). In a landscape-scale conservation and restoration plan for forest interior bird species of bottomlands, desired forest patch sizes ranged from 4000 to 40,000 ha (Twedt et al. 2006). While size of old-growth forests is relevant to conservation, the rarity of even small old-growth stands elevates their importance to conservation despite their diminished size.

SOCIAL VALUES OF SOUTHERN OLD-GROWTH

Concepts of value range over a wide continuum. For some, old-growth forests have intrinsic value irrespective of any benefits to society (Gottfried 1995). For others, potential benefits to people offer practical reasons to support conservation or management. Old-growth forests may have tangible and intangible value as harvestable resources, as biodiversity preserves, as research sites, as emblems of cultural heritage, or as places offering emotional/spiritual growth and renewal. Scientifically, rare old-growth can provide an important "baseline" against which to assess the ecological impacts of contemporary society. Differing views on valuation may conflict, but practical frameworks for conservation can potentially reconcile differences through focusing on common goals and ways to achieve them (Norton 2005).

The Southern landscape has few completely undisturbed forests when compared to the Pacific Northwest, where much of the old-growth controversy originated. Preservation has been the dominant goal for old-growth resources, but there is need for additional strategies. Given the South's long history of human land use, settlement, and forest disturbance—and its future development trajectory (Wear and Greis 2002)—managers are challenged to think more broadly about the values of old-growth forests for biological conservation and for society at large. For example, the potential economic value of forests represents both a threat and an opportunity. Old-growth heart pine is still a high-value resource that places pressure on private landowners to clearcut old stands; yet, the traditional management of longleaf for game hunting and aesthetics produced a selection-harvest system that resulted in the sustainable conservation of high-quality old-growth stands (Varner and Kush 2004). Models for sustainable management of extractive resources can provide tools to enhance current and future old-growth resources. For disturbance-dependent systems such as longleaf pine, some remaining old-growth stands occur on public lands with a multiple-use mandate (e.g., military reservations) and the potential to supplement traditional preservation approaches.

CONSERVING SOUTHERN OLD-GROWTH FOR THE FUTURE

Given the realities of regional threats to forests, workshop participants discussed strategies that might be used to enhance old-growth conservation on public and private lands. The principal ideas are summarized below.

Increasing Awareness

In general, the extent of old-growth forests on public lands in the South is still poorly known, although some identification efforts are underway on National Forests. With formalized qualitative and quantitative definitions (Table 1), an initial step toward conserving regional old-growth would be a comprehensive inventory similar to the approach of Moeur et al. (2005) for the Pacific Northwest. A compilation that included smaller degraded remnants with old-growth characteristics would enable public-lands' managers to address both existing and potential old-growth resources. Inventories that include forests with some old-growth characteristics are needed to identify potential tracts that might buffer and enlarge existing high-quality old-growth forests. New inventories of large patches of mature bottomland forest, which may contain actual old forest, are possible in conjunction with current field efforts to search for the Ivory-billed Woodpecker across the region.

Inventory could also become a springboard for educational efforts to raise awareness of the ecological, cultural, and economic values of old forests. Land-grant universities and federal agencies have the capability to develop continuing education opportunities for resource managers, particularly in ecological and long-rotation forestry, to supplement the traditional emphasis on short-rotation management. Promoting ecosystem and biodiversity-based approaches to forest management may be an increasingly attractive option for some private non-industrial landowners as well, as attitudes have been shifting from mainly commodity-oriented to more environmentally-conscious management (Wear and Greis 2002).

Managing Forest Size and Fragmentation

Southern old-growth forest remnants are rare, small, and often fragmented. While conservation must first focus on preserving and managing those remaining stands, another approach available on lands with biodiversity goals in management would be to identify and conserve individual old-growth elements in forest stands that are not necessarily viewed as old-growth in whole. Moreover, "growing" additional forest with old-growth characteristics can buffer and enlarge existing tracts (Hamilton et al. 2005). The challenges of doing so may depend upon the complexity of management requirements and the surrounding regional context. In forests with multiple-use mandates, old-growth traits may be encouraged through long-rotation timber management or protected set-asides. Partnerships among resource agencies that have existing or potential old-growth forests are promoting the sharing of information about restoration and management strategies. Existing efforts are structured geographically (e.g., Gulf Coastal Plain Ecosystem Partnership in the Florida Panhandle, Lower Mississippi Valley Joint Venture) or around similar habitat types (e.g., Fall-Line Sandhills Partnership).

Managing Disturbance Regimes

Both longleaf pine and southern floodplain forest systems are dependent upon the key natural disturbance processes of fire and flooding, respectively. Improper fire regime represents a serious threat to conserving old longleaf pine forests (Wahlenberg 1946; Robbins and Myers 1992). Fire suppression over the past 50 years has led to declines in biodiversity (Gilliam and Platt 1999) and high ground-fuel accumulations through the formation of duff, a humic O-horizon not normally found in fire-maintained stands (Varner et al. 2005). When prescribed burns are reintroduced to old stands, these novel fuel beds promote catastrophic mortality of large trees from smoldering fires (Varner et al 2007). Thus, burning prescriptions and refined management techniques for restoring fire-suppressed old-growth stands are needed.

Analogous to the key role of fire in longleaf pine forests, flooding patterns largely determine the species that occupy or will occupy floodplain forests. Levees, channelization, and dam regulation have greatly altered river flow patterns (Conner and Sharitz 2005). In many cases, bottomland forests do not flood as often or as long as they once did, altering communities in favor of drier-site species (Darst and Light 2008). In other cases, sites flood more often and for more prolonged periods than previously, reducing stand regeneration potential. Restoring more typical hydrologic patterns, where possible, can potentially be accomplished by returning channelized water courses to their original meanders, by controlled river diversions, by timing dam releases to better mimic natural flooding regimes, or by dam removal. However, socioeconomic constraints make it unlikely that most regulated river systems could be restored fully to their historic hydrologic patterns (National Research Council 1992).

Conserving Old Growth on Private and Public Lands

Strategies to develop awareness, increase forest extent, or improve forest management in the South must consider private landowners, given that a majority of regional forestland is in non-industrial private ownership (Wear and Greis 2002). Because old-growth timber has high economic value, there is strong incentive to harvest these forest resources even though some landowners may desire to retain them. Although governmental land-retirement programs (e.g., Conservation Reserve Program, Wetland Reserve Program) have been successful in reforesting agricultural lands to improve soil and water quality and to support short-rotation forestry (Carmichael 1997), most programs are not well structured to help landowners retain older forests. Long-term forest retention can potentially deliver enhanced benefits for environmental quality and carbon sequestration, but incentives to encourage long-term objectives and prioritize areas of high conservation value may be needed. Some potential approaches include:

Developing incentives for long-rotation forestry — Re-establishing longleaf pine forests would require a structure of continued financial incentives over decades to support initial pine establishment, ground-cover restoration, and management for desired stand structure. Developing such incentives is likely to be difficult, but longer-rotation forestry could provide benefits for game and non-game wildlife while assisting a transition from a lower-value pulpwood economy to a higher-value sawtimber economy. Similarly, to retain tracts of native floodplain forests and streamside forest buffers, incentives supporting long-term sustainable timber management or set-asides may be needed. Some governmental conservation programs provide short-term incentives to protect or establish riparian forest buffers, but the continued persistence of such buffers is uncertain.

Establishing private "forest banks" — As an example of a private-sector incentives program, The Nature Conservancy (TNC) has undertaken an evolving initiative whereby a landowner cedes forest management responsibility to TNC in return for an annualized monetary return in lieu of harvest. Any timber harvesting is then discretionary according to the conservation organization's ecological management standards.

Promoting sustainable forestry networks — For landowners interested in sustainable timber management that promotes old-growth characteristics, an issue is the availability of loggers using techniques and equipment that minimize disturbance to soils, native groundcover, and the residual forest stand. Establishing a consortium of interested landowners who hold sufficient timberlands might provide incentives for more logging contractors to adopt more sustainable harvesting practices in order to gain access to consortium properties.

Restoring old-growth "landscapes" — The most stable old forests will likely reside on federal and state lands; thus, it is critical that public agencies develop a recognition of the values of old forests and a commitment to preserving and managing them. Policies that encourage conservation on public lands and that offer innovative conservation tools on private lands can support a broader old-growth conservation effort.

Few forests in the South are extensively composed of old-growth vegetation. Building larger landscapes to buffer public lands in partnership with private lands could increase the size and value of existing old forests. An example of a large-scale vision is the Florida "Greenways Program" (Hoctor et al. 2000), part of which seeks to connect conserved forest properties across the Florida Panhandle from Eglin Air Force Base to the Apalachicola National Forest, with a linchpin being a large privately owned tract. Similarly, in a large-scale bird conservation plan proposed by the Lower Mississippi Valley Joint Venture, a goal is to develop large patches of bottomland forest habitat by connecting, buffering, and enhancing small tracts through an enormous afforestation effort on private lands (Twedt et al. 2006). Guidelines for long-term management would then encourage development of mature-forest characteristics.

Future Threats

New challenges will complicate the task of conserving old-growth conditions in southern forests. The South is experiencing rapid urbanization (Wear and Greis 2002); the encroaching "wildland-urban interface" impacts the ability to manage fire-dependent habitats with frequent burning, and creates increased pressures to alter river hydrology for flood control and water supply. Urban development of private lands that buffer public-land forests results in land use changes that increase fragmentation, introduce exotic invasive species, and constrain management options. Recent divestitures of large holdings by southern timber companies offer opportunities to move forest lands into public ownership, but competition with high land development values creates prohibitive financial barriers (Block and Sample 2001; Clutter et al. 2005). As an example of these new threats, the Flomaton Tract, Alabama's only documented old-growth Coastal Plain longleaf pine forest, was recently clearcut for subdivision development. The tract had been long fire-suppressed and had lost its open-canopy, biologically rich forest structure. Although a series of restoration-oriented burns was gradually moving the stand back to a more species-rich condition, the potential conservation value of the degraded tract as restored old-growth was not recognized.

Strategies for protecting natural habitats tend to assume that geographic and ecological relationships are static, but future climate change is likely to alter regional environments and shift the distributions of communities and species (Halpin 1997). In the South, the predicted effects of climate change are uncertain but will likely involve altered precipitation, water availability, and occurrence of windstorms and wildfires (Dale et al. 2001). Forests will be more vulnerable to environmental stressors and disturbances; in the face of such changes, current old forests may not remain in "old-growth" condition. For example, higher intensity or frequency of hurricanes and tropical storms would increase the risk of catastrophic windthrows that return forests to earlier successional stages or make them susceptible to insects, pathogens, and invasive species. Greater drought severity could constrain fire management options for longleaf pine forests, and floodplain forests may be exposed to fire risk or damage from altered hydrologic flows. Identifying old forests, managing forests for old-growth characteristics, and using landscape-scale approaches to create forest reserve networks are shorter-term conservation strategies that can protect existing forests and expand the extent of "future" old forests. Long-term strategies will require considering how to manage forests to reduce vulnerability to altered disturbance regimes, ameliorate disturbance impacts, and enhance forest recovery (Dale et al. 2001).

ACKNOWLEDGMENTS

Funding for the workshop was provided by the National Council of Science and Sustainable Forestry, with additional support from the Williams Family Foundation, the Greentree Foundation, and the Robert

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