Chapter 25.

Biodiversity
and Southern Forests

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Biological diversity encompasses all levels of natural variation and includes molecular, genetic, and species levels. All of these factors contribute to diversity accumulated at the landscape scale. However, biodiversity is not equally dispersed across the landscape, but rather clustered in pockets. The Southeastern United States supports several biodiversity hotspots including the Southern Appalachians, the Panhandle of Florida and Alabama, and the Everglades. As landscapes continue to be modified by habitat fragmentation, loss, degradation, and conversion, many species cannot adapt and will eventually be extirpated. While the Southeast remains relatively forested, much of the region's current forest exists as tree plantations. Some plantations have replaced agricultural land and constitute additional habitat for many forest species. Other plantations have been created from natural forested systems, and this kind of conversion has likely resulted in a less diverse and structurally simplified landscape—one that is less beneficial to most native species. Additionally, changes in the frequency and source of disturbance have severe implications for many southeastern ecosystems. For example, pine forests, pine savannas, and prairies all depend on fire for their persistence, albeit at varying frequencies.

South and Buckner (2004) argue that most of the major landscape changes were a direct result of human population growth over the past 200 years. During that period, the population of the area that is now the United States grew from 6 million to the present estimate of 275 million. Fire and field abandonment have helped maintain stands of yellow pine. However, current silvicultural practices and social attitudes toward fire have resulted in a 65-percent reduction in natural yellow pine stands in the Southeast. Unfortunately, present trends suggest that conservation of such stands, and species associated with them, will be difficult if silvicultural practices and public attitudes do not change.

Gordon (2001) provides an excellent overview of some of the key issues related to forest management and its effects on biodiversity. Gordon highlights four important issues: (1) some details about species dependency in relation to southern forests, (2) the history of forestry in the South and its implications for diversity, (3) what changes have recently occurred in forestry, and (4) what lies ahead in the next century. Furthermore, scientists continue to discuss the relative merits of an intensive production-based or conservation-based approach for future forestry. Agricultural forestry seeks to simplify the landscape in terms of structure, pattern, and product. The benefit of this approach is the intense use of smaller plots of land. The drawback is the reduction of biodiversity in and around those managed stands. Contrast this with the conservation-based approach, which focuses on maintaining a complex landscape and supports a greater diversity of species. Gordon provides examples of each approach and concludes that we need to utilize both approaches in the next century while further investigating how to balance them.

Rather than focus on current research issues, Wigley and others (2001) provide a historical perspective on how research on biodiversity, and particularly wildlife diversity, has evolved in the Southeast. Early research focused on game species, but currently includes threatened and endangered species, nongame species, biodiversity, landscape ecology, and sustainable forestry. Participants in this research include universities, Government agencies, nonprofit organizations, consultants, and industry. Several principles have emerged from this research: stand structure is important; larger spatial scales need to be considered; habitat associations may be complex but must be understood; landscape diversity can increase biodiversity; abiotic factors, e.g., disturbance and site quality, can have profound influences on biodiversity; and silvicultural treatments can be used to enhance habitat quality for a variety of species. Wigley and others suggest that future research needs to continue to

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investigate wildlife-forestry issues, especially on managed forests, but that researchers also need to propose affordable and practical techniques for meeting biological objectives.

Bats (*Myotis* spp.) occupy a unique niche and due to several life-history characteristics, are relatively vulnerable to anthropogenic stressors. Unfortunately, very little is known about the ecology of most bat species and how they respond to forest management (Loeb and Krusac 2001). Research priorities for this group should include: (1) determining distribution and status, (2) determining habitat requirement and associations, (3) determining effects of management practices, (4) determining resource partitioning, and (5) developing effective sampling protocols and techniques. Baseline information for bats is largely lacking, and this makes management for this group potentially haphazard. However, some habitat information does exist, and management should focus on bats' use of snags, large-diameter hollow trees, riparian zones, caves, mines, and bridges.

Carter and others (2001) describe the use of multivariate techniques to identify landtypes in the southern loam hills of south Alabama. Using a combination of vegetation, landform, and soil variables, they identify seven landtypes in this system, each with a unique assemblage of plant species. This approach can be used at the landscape scale to identify specific land units, which can be linked to specific management decisions and used to detect assemblages that may contain rare or endangered species.

Linder and others (2004) propose the use of habitat-based population viability analysis (PVA) to assess management alternatives over relatively large spatial scales, e.g., national forests. These models are constructed in a Geographic Information System, which makes it possible to conduct spatially explicit analyses. Models were constructed using widely available data that cover the extent of the study area. The response variable was presence or absence of the target species, while the explanatory variables included stand age, forest type, and a suite of measurements of the physical characteristics of the area in question, such as elevation. By including forest age and type, Linder and others were able to generate and project virtual forests in the future. In this study, they generated five different virtual forests, based on different levels of timber harvesting and natural disturbances, at 10-year increments over a 60-year period. This approach could be applied to additional species or use diversity measures such as species richness to assess potential impacts of various management strategies.

Rather than using future scenarios to aid in management decisions, Bragg (2001) proposes using a historical reconstruction of forest conditions to aid in the reconstruction of forests and the conservation of biodiversity. He demonstrates this approach by showing how it would be applied to shortleaf (*Pinus echinata* Mill.) and loblolly pine (*P. taeda* L.) stands in southern Arkansas. Using a variety of information sources including lumber operation records, travelers, scientific reports, land surveys, and historical photographs, he delineates reference stand conditions. Early evidence suggests that historical basal area was much lower than previously thought, but with more large trees than now occur in old-growth forests. The spatial heterogeneity was also much more complex in historical forests than contemporary forests, but the understory and litter levels of historical forests resemble those of contemporary forests. The goal of this approach is to determine structural and compositional features of ecosystems to which species were historically adapted, which should aid in the preservation of those species.

Harrington and Edwards (2001) explain in detail how they experimentally restored the abundance and diversity of the herbaceous understory in longleaf pine (*P. palustris* Mill.) plantations. They quantified the consequences of competition for light, water, and nutrients, and then compared these consequences to the potential smothering, mulching, or nutrient cycling effects of pine needle fall. Their results show the value of maintaining low-stocking levels of pines and limiting the encroachment of hardwoods or shrubs. Prescribed fire is also beneficial in reducing the needle-fall accumulation on the forest floor. Experiments like this one can be used to show managers how to restore communities and historical ecosystem conditions.

Sites formerly occupied by longleaf pine stands may also be used by restoration ecologists as seed banks for other rare or threatened species. Walker (2001) examined such sites, since converted to loblolly pine plantations, and existing longleaf stands on the Coastal Plain of North Carolina. She conducted vegetation surveys and used the seedling emergence technique to examine the seed bank. Over 35 species and 1,000 individuals germinated, and the seed banks from both sites contained species not recorded during surveys.

Of the 35 species, many were weedy, but many were also indicative of stable longleaf communities. This study suggests that seed banks remain viable in highly disturbed longleaf pine communities, offering one more tool for the restoration ecologist.

Experiments may provide additional insight into how forest management can affect biodiversity. For example, Rosson and Amundsen (2004) examined the impact of harvest disturbance on tree species diversity at the landscape scale. Timber harvesting has been a major disturbance in the South over the past century, and with recent reductions in harvesting in other regions of the country, more pressure has been put on southern forests. Rosson and Amundsen examined data collected in Mississippi by the Forest Inventory and Analysis Research Work Unit of the U.S. Department of Agriculture Forest Service. Tree species richness in plots where no harvesting occurred was compared with tree species richness for harvested and unharvested plots combined. Tree species richness decreased by 11 percent from 1977 to 1994 for all plots combined, but it increased by 44 percent from 1967 to 1994 on the plots that were not harvested. Other factors have certainly contributed to the decline in species richness across forests in the South, but harvesting is suggested to be a significant factor in this study.

Southeastern forests house a rich herpetofauna, but declines in populations of many species have prompted ecologists to examine how management activities may be affecting this group (Russell and others 2004). Lanham and others (2001) studied the herpetofauna in recently harvested gaps in bottomland hardwood forests in South Carolina. Specifically, they compared herpetofaunal use of ephemeral, skidder-created ponds with use of natural depressional wetlands. Salamanders appeared to be affected negatively by skidder trails and gap creation. Response of frogs was mixed, with hylid abundance greater in gaps but *Rana* spp., *Nerodia* spp., *Chelydra* sp., and *Eurycea* sp. more abundant in skidder-created ponds. Species diversity also appeared to increase along skidder trails. Results suggest that overall abundance did not differ between treatments, but community composition may be changed if habitat suitability for some species is changed.

Baughman and Guynn (2001) studied herpetofauna assemblages in intensively managed loblolly pine plantations in South Carolina. The goal of this study was to assess the baseline herpetofauna assemblages before installation of a complex corridor system. These assemblages were consistent with those on other sites in the Southeast in terms of diversity and relative abundances of the groups under consideration (anurans > salamanders > reptiles > turtles). Despite the apparent consistency between sites, small differences in abundance were found, which could lead to misleading conclusions without pretreatment sampling.

Haskell and others (2001) examined how the avian community varied across habitats on the Cumberland Plateau in southern Tennessee. Species richness was consistently lower in loblolly pine plantations than in oak-hickory (*Quercus* spp.-*Carya* spp.) forests, and abundance was lower in most plantations. Plantations had fewer cavity- and tree-nesting species, and fewer Neotropical migrants, than did oak-hickory forests. Thinned forests seemed to have higher avian species richness, evenness, and abundance than oak-hickory forests had. Haskell and others also studied how avian communities change with respect to human development. They found that residential and rural areas exhibited higher species richness, evenness, beta diversity, and abundance than did oak-hickory forests. Using Partners in Flight priority scores, which were assigned to each species, they quantified and ranked the conservation value of each habitat type considered. This approach appears to support results from direct comparisons, yielding a conservation ranking (from greatest to least) of residential-rural areas, thinned forests, oak-hickory forests, and pine plantations.

Many habitats in the Southeast—and in other parts of the world—are threatened by degradation, fragmentation, conversion, invasion by nonnatives, loss, and other problems. If recent demographic trends continue, more stress will be placed on the habitats and biodiversity of the Southeast. Although there is interest in afforestation (conversion of nonforest land to forest), application of afforestation in the areas where this is most economically suitable may actually reduce regional biodiversity (Matthews and others 2002). Consequently, it is likely that pressure on our forest resources will continue to mount. The scientific community has a responsibility to provide landowners and the public with information that help us to meet demands on our natural resources while maintaining native biodiversity. The creation and refinement of tools used by ecologists, e.g., PVA gap analysis, and is one such contribution. Furthermore, because many of the threats to biodiversity involve ecosystem processes or large spatial scales, it will be necessary to have cooperation between universities, nongovernmental organizations, private landowners, and public land managers.

LITERATURE CITED

Baughman, W.M.; Guynn, D.C., Jr. 2001. Herpetofauna assemblages in intensively managed pine plantations. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].

Bragg, D. 2001. Conserving biological diversity through reconstruction of historical forest conditions. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].

Carter, R.E.; MacKenzie, M.D.; Gjerstad, D.H. 2001. Landscape scale classification of longleaf pine ecosystems in south Alabama. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].

Gordon, D. 2001. Impacts of forest management on biodiversity. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].

Harrington, T.B.; Edwards, M.B. 2001. Overstory and understory interactions in longleaf pine plantations: implications for community restoration. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].

Haskell, D.G.; Evans, J.P.; Pelkey, N.W. [and others]. 2001. Vertebrate communities in a changing landscape: a case study of birds and salamanders on the southern Cumberland Plateau. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].

Lanham, J.D.; Cromer, R.B.; Hanlin, H.H. 2001. Functional response of herpetofauna to harvested gaps and skidder-rut wetlands in a southern bottomland hardwood forest. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].

Linder, E.T.; Klaus, N.A.; Buehler, D.A. 2004. Population viability as a measure of forest sustainability. In: Rauscher, H. Michael; Johnsen, Kurt, eds. Southern forest science: past, present, and future. Gen. Tech. Rep. SRS–75. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 307–317.

Loeb, S.C.; Krusac, D.L. 2001. Bats in southern forests: critical research and management needs. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].

Matthews, S.; O'Connor, R.; Plantinga, A.J. 2002. Quantifying the impacts on biodiversity of polices for carbon sequestration in forests. Ecological Economics. 40: 71–87.

Rosson, J.F., Jr.; Amundsen, C.C. 2004. Monitoring tree species diversity over large spatial and temporal scales. In: Rauscher, H. Michael; Johnsen, Kurt, eds. Southern forest science: past, present, and future. Gen. Tech. Rep. SRS–75. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 335–345.

Russell, K.R.; Wigley, T.B.; Baughman, W.M. [and others]. 2004. Responses of southeastern amphibians and reptiles to forest management: a review. In: Rauscher, H. Michael; Johnsen, Kurt, eds. Southern forest science: past, present, and future. Gen. Tech. Rep. SRS–75. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 319–334.

South, D.B.; Buckner, E.R. 2004. Population growth and the decline of natural southern yellow pine forests. In: Rauscher, H. Michael; Johnsen, Kurt, eds. Southern forest science: past, present, and future. Gen. Tech. Rep. SRS–75. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 347–358.

Walker, J. 2001. Advances in rare plant biology: implications for management. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].

Wigley, T.; Guynn, D.C., Jr.; Miller, K.V.; Owen, C.N. 2001. Wildlife in managed forests: the evolution of research in the South. In: Johnsen, K.H.; Rauscher, M.; Hubbard, W.G.; Jordin, J.B., eds. Proceedings of the southern forest science conference. http://www.southernforestscience.net/. [Date accessed: July 20, 2004].