Compass–Fall 2000
The Southern Research Station
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Acorns, Oaks, and Critters

Black bears, an icon in the Southern Appalachian Mountains, spark emotions—wonder, respect, fear, and greed. About 1,700 bears live in the Great Smoky Mountains National Park, while more than 6,000 roam the Southern Appalachians. During the pre-denning months of August through November, black bears depend on eating acorns and other nuts to store the fat they will need to survive hibernation. Bears favor fall fruit from the dogwood, holly, and poke weed; they devour small animals and insects; they munch on weeds. But bears need nuts—hard mast—and they will travel beyond their normal range if pickings are slim in their own territory.

Preliminary evidence at the Great Smoky Mountains National Park suggests that white oak and red oak mast is limited and spotty. Heavy traffic by bears, wild turkey, deer, and squirrels—also known as the "Fall Shuffle"—indicates these animals are searching for food. Rooting marks by wild hogs demonstrate a significant amount of travel by these non-native predators also.
In 1992 and 1997 chronic mast failures occurred. When hungry bears go to lower elevations to look for food, they get into trouble—raiding garbage, tangling with vehicles, and, rarely but most tragically, coming into conflict with humans.

Acorns take center stage in oak regeneration. Significant oak decline increases interest in acorn production. In **Individual Variation in Acorn Production by Five Species of Southern Appalachian Oaks**, Katie Greenberg, Southern Research Station ecologist, reports on production variability among white, northern red, scarlet, chestnut, and black oaks. This study examines whether tree characteristics or fruiting patterns can be used to identify superior acorn producers and to explain the range of variability among these five oak species. Greenberg also discusses the relevance of stand composition, tree basal area, and diameter at breast height (d.b.h.) to acorn production. Request number **3** to receive this publication.

In another publication, Greenberg teams up with Bernard R. Parresol, Southern Research Station biometrician, to challenge acorn production theory and offer significant management tools. In **Acorn**

Production Characteristics of Southern Appalachian Oaks: A Simple Method to Predict Within-year Acorn Crop Size (Research Paper SRS-20), the authors state that many studies report boom-and-bust acorn production patterns for southeastern oaks. Their analyses found that moderate crop years also occurred frequently in these studies, a fact underemphasized in discussions of masting in oaks. Greenberg and Parresol suggest that the term masting—the fruiting pattern marked by synchronous seed production among individuals within a population—may not appropriately characterize the fruiting patterns of Southern Appalachian oaks.

Interest in practical applications might prompt you to request publication **4**. Greenberg and Parresol provide a method to estimate within-year acorn crop size based on the proportion of trees bearing acorns and the basal area inventory within the survey area for each oak species. These estimates can be applied to any size area within the Southern Appalachians. Wildlife managers can use yield tables to estimate how acorn production will be affected on an average annual basis using different basal area calculations.

Bottomland Hardwood Ecosystems

Before European contact, about 21 to 25 million acres of bottomland hardwoods covered the Mississippi Alluvial Valley, less the areas Native Americans dedicated to agricultural use. Forested lands in the valley stretched from Cairo, IL to the Gulf of Mexico. Between the early 1800's and 1935, about half the original forests were cleared; 96 percent of the land was converted to agricultural use. Engineers re-routed rivers and built dams and levees to keep them in their banks. Many floods and failed crops later, we know much more about the ecosystem we destroyed. Trying to put it back together challenges resources, methodologies, and philosophies. In **Restoring Bottomland Hardwood Ecosystems in the Lower Mississippi Alluvial Valley**, Southern Research Station scientists John A. Stanturf, Emile S. Gardiner, Paul B. Hamel, Margaret S. Devall, Theodor D. Leininger, and Melvin L. Warren, Jr. discuss the history of bottomland hardwood ecosystems and restoration efforts on public and private land. The scientists analyze status and costs of restoration and present possible and promising scenarios for the future of the land and its people.

Ninety-five percent of the remaining bottomland hardwood forests in the valley cover Louisiana, Mississippi, and Arkansas. The Atchafalaya (say *A-cha-fa-LIE-ya*) Basin of Louisiana includes the largest contiguous block of bottomland forests in the Lower Mississippi Alluvial Valley. Separate assessments by The Nature Conservancy and the Defenders of Wildlife identified the South as having high to extreme risk for significant loss of aquatic biodiversity. The World Wildlife Fund regards sustained conservation of native fishes, freshwater mussels, and crayfishes in this region as vital to maintaining a significant proportion of the freshwater fauna of the United States. Partners in Flight targets bottomland systems across the South as the highest priority habitats for breeding populations of Neotropical migratory birds, as well as staging habitats for their migration.

The U.S. Environmental Protection Agency calls the Yazoo-Mississippi basin an area of significant concern for surface and ground water quality. Runoff from its agricultural land contributes 20 percent of the nitrate loading implicated in the biological dead zone in the Gulf of Mexico. Federal and State forest restoration efforts, both on public land and private land, focus on creating wildlife habitat and improving or protecting surface water quality. The strategy for restoring public land includes low-cost planting or direct seeding of heavy-seeded species, such as oaks and pecans, which are valuable to wildlife. Adding light-seeded species—ash, elm, sycamore, sweetgum, and maple—provides diversity and creates forested conditions favorable to wildlife.

Stanturf and his co-authors question the benefits of specific Federal cost-share program guidelines being applied to private land restoration efforts. Spacing hard-mast trees without filling in with light-seeded species results in incomplete site occupancy by trees, lower species richness, and longer time to reach structural diversity. Many at-risk wildlife species require forests of complex structure. Planting a single species in a widely spaced pattern (125 stems per acre at age 3) does not support commercial timber production. Not promoting the growth of merchantable volume eliminates options for timber management, as well as stand manipulation for wildlife habitat, aesthetics, or forest health. Limiting biomass results in loss of potential financial benefits for landowners. Stanturf, project leader for the Center for Bottomland Hardwoods Research, says many oil and manufacturing companies purchase carbon credits by paying others to grow trees for them. This practice allows industrialists to maintain a carbon balance, as per the Kyoto agreement on global warming and carbon emissions.

Rehabilitating wooded areas, wetlands, and rivers in the Lower Mississippi Alluvial Valley—an area covering more than 24 million acres in seven States—appears to be a daunting task. But the project's complexity on paper does not match the intricacy of the ecosystem destroyed long ago. Consider the discussion about restoration versus rehabilitation. An ecosystem grows and connects with the synergy of its components. Rehabilitation puts pieces together and tries to encourage processes to occur. Private landowners control most of the land in the Lower Mississippi Alluvial Valley. Increasing land management options might increase landowners' financial success. A healthy profit margin might bring and keep more land into forested management, increasing benefits for wildlife and soil and water quality. Get the details by requesting publication **2**.

This issue of *Compass* includes Paul Hamel's **Cerulean Warbler (*Dendroica cerulea*)**. Hamel, a wildlife biologist in Stoneville, MS, began studying cerulean warblers in 1984. Request number **8** to receive this publication. **The Birds of North America**, a collection of comprehensive summaries of 700 breeding bird species, provides information to enable conservation management of native birds and to define directions for future research. In 1995 Hamel's species account of Bachman's warbler appeared in **The Birds of North America**. Southern Research Station wildlife biologist Richard N. Conner collaborated with Clifford E. Shackelford and Raymond E. Brown to summarize information about the **Red-bellied woodpecker (*Melanerpes carolinus*)**. This species account in **The Birds of North America** appears as publication **15** in this selection of Southern Research Station research findings.

While focusing on the authors of **Restoring Bottomland Hardwood Ecosystems in the Lower Mississippi Alluvial Valley**, we congratulate Emile S. Gardiner, who received the Presidential Early Career Award for Scientists and Engineers. President Clinton recognized Gardiner for sustained productivity and exceptional promise for significant achievement from research on oak ecophysiology and regeneration biology of bottomland hardwood forest ecosystems.

Paul Hamel, co-author of **Restoring Bottomland Hardwood Ecosystems in the Lower Mississippi Alluvial Valley**, also contributes **Cerulean Warbler (*Dendroica cerulea*)** to this issue of *Compass*. Hamel, a wildlife biologist in Stoneville, MS, began studying cerulean warblers in 1984. Request number **8** to receive this publication. **The Birds of North America**, a collection of species accounts for 700 breeding bird species, provides information to enable conservation management of native birds and to define directions for future research. Southern Research Station wildlife biologist Richard N. Conner collaborated with Clifford E. Shackelford and Raymond E. Brown to summarize information about the **Red-bellied Woodpecker (*Melanerpes carolinus*)**. This account in **The Birds of North America** appears as publication **15** in this group of Southern Research Station research findings.

Southern Pines

Gwaze, D.P.; Bridgwater, F.E.; Byram, T.D.; and others. 2000. **Predicting age-age genetic correlations in tree-breeding programs: a case study of *Pinus taeda* L.** Theoretical Applications of Genetics. 100: 199-206.

A meta-analysis of 520 parents and 51,439 individuals was used to develop two equations for predicting age-age genetic correlations in *Pinus taeda* L. Genetic and phenotypic family mean correlations and heritabilities were estimated for ages ranging from 2 to 25 years on 31 sites in the Southern U.S. and Zimbabwe. Equations for predicting age-age correlations based on *P. taeda* populations from west and east of the Mississippi River proved statistically different. Both predictive equations proved conservative for validation datasets consisting of younger tests in the U.S. and Zimbabwe. Age-dependent log-linear predictive equations were favored over growth-dependent equations. All *P. taeda* predictive equations based on genetic correlations favored earlier selection when compared to a generalized conifer predictive equation based on phenotypic correlations. The age-age correlations structure showed stability independent of planting density and across a wide range of family sizes. **(1)**

Wetlands, Bottomland Hardwoods, and Streams

Stanturf, John A.; Gardiner, Emile S.; Hamel, Paul B.; and others. 2000. **Restoring bottomland hardwood ecosystems in the Lower Mississippi Alluvial Valley**. Journal of Forestry. 98(8): 10-16.

Programs to restore southern bottomland hardwood forests to the floodplains of the Mississippi have been tested on Federal land and are now being applied to private holdings. The initial goals were to provide wildlife habitat and improve water quality, but other benefits—possible income from biomass and carbon credits—may make restoration cost-effective, even for small landowners. One challenge is finding the right mix of tree species that are adapted to soil saturation and root anoxia, can be planted and managed economically, and will produce a closed canopy and complex structure quickly. Bringing back the understory is another challenge. **(2)**

The Southern Appalachians

Greenberg, Cathryn H. 2000. **Individual variation in acorn production by five species of southern Appalachian oaks.** Forest Ecology and Management. 132: 199-210.

Acorns are an important wildlife food resource and seed source for oak regeneration. Most acorn production studies note wide and consistent differences in acorn productivity among individuals, but none clearly demonstrate determinants of productivity. Acorn production by black, northern red, scarlet, chestnut, and white oak was measured from 1993 to 1997 in the Southern Appalachians was measured and compared among species and individuals. [Acorn production by black, northern red, scarlet, chestnut, and white oak in the Southern Appalachians was measured and compared among species and individuals from 1993 to 1997.] To standardize comparisons among different sized trees and simplify for use by forest managers, the number of acorns per tree were converted to the number/m^2 BA (basal area). On average, white oak produced the most acorns and chestnut oak the fewest. Northern red and white oak produced higher green weight and dry biomass than the other three species. There was a significant positive relationship between tree basal area and the number of acorns produced per crown for all species (r^2 between 0.10 and 0.27). However, this is because larger trees have greater crown areas for producing acorns, and not because they produce more acorns per unit area of crown. Alone, BA was significantly, positively correlated with the number of acorns/m^2 BA only in black, northern red ($p < 0.06$) and white oak (not in scarlet or chestnut oak), but explained little of the variation in acorn production among individuals. Trees [25 cm d.b.h. of most species produced significantly fewer acorns/m^2 BA than their larger counterparts. However, many small (<23 cm d.b.h.) scarlet oaks originating from a 1967 clear-cut were prolific producers, whereas white oaks (<25 cm d.b.h.) in the same stand were not. Frequency of acorn production ranged from never to yearly among individuals. Good producers (trees producing μ 5-year species mean) composed 20 percent (chestnut oak) to 46 percent (northern red oak) of sample populations but contributed disproportionately to the acorn crop in moderate and good crop years. Good producers produced acorns more frequently and had more acorns/m^2 BA on fruiting trees than did poor producers. However, in any given year, good and poor producers were similarly represented in the fruiting population. Hence, good producers could not be easily identified by the presence of acorns during poor crop years, nor could poor producers be identified by an absence of acorns in good crop years. **(3)**

Greenberg, Cathryn H.; Parresol, Bernard R. 2000. **Acorn production characteristics of Southern Appalachian oaks: a simple method to predict within-year acorn crop size.** Res. Pap. SRS-20. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 14 p.

We examined acorn production from 1993 to 1997 by black oak (*Quercus velutina* Lam.), northern red oak (*Q. rubra* L.), scarlet oak (*Q. coccinea* Muenchh.), chestnut oak (*Q. prinus* L.), and white oak (*Q. alba* L.) in the Southern Appalachians to determine how frequency of acorn production, levels of intraspecific synchrony, and acorn density per tree influence crop size. We then developed a linear regression model for each species to quantitatively estimate acorn crop size within years using the proportion of trees bearing acorns as the independent variable. We also developed acorn yield tables for each species. Using these equations, land managers can quantitatively estimate within-year crop size per species if they know the proportion of fruiting trees as estimated by simple visual surveys (presence or absence of acorns or both). By applying the estimate (in units of number per square meter basal area) for each species to a basal area inventory of oaks in their area, managers can tailor within-year crop size estimates to specific land management units. Alternatively, acorn yield tables can be applied to oak basal area inventories to tailor estimates of acorn production (the sum of each species) on an average annual basis to any area. Yield tables also can be used to test how acorn production will be affected on an average annual basis using different basal area apportionment scenarios among oak species. **(4)**

Johnson, D.W.; Susfalk, R.B.; Brewer, P.F.; Swank, W.T. 1999. **Simulated effects of reduced sulfur, nitrogen, and base cation deposition on soils and solutions in Southern Appalachian forests.** Journal of Environmental Quality. 28(4): 1336-1346.

Effects of reduced deposition of N, S, and C_B on nutrient pools, fluxes, soil, and soil solution chemistry were simulated for two Appalachian forest ecosystems using the nutrient cycling model. In the extremely acidic, N- and S-saturated red spruce *(Picea rubens* (Sarg.)) forest (Nolan Divide), reducing C_B deposition by 50 percent reduced C_B leaching by -40 percent during the 24-yr simulation period. This was due solely to the effects of C_B deposition on the soil exchanger rather than effects on soil solution. Reducing S and N by 50 percent caused immediate reductions in total anion and cation leaching at Nolan Divide, but the effects on soil solution C_B diminished and C_B leaching was reduced by only 17 percent over the simulation period. Reducing S and N deposition had a greater effect on soil solution aluminum (AI) and molar Ca/AI ratio than reducing base cation deposition at Nolan Divide. In the moderately acidic, N- and S-accumulating mixed deciduous forest at Coweeta, reduced C_B deposition by 50 percent

caused a very slight (<4 percent) reduction in C_B leaching as a result of slightly reduced base saturation and increased soil sulfate adsorption. The effects on reducing S and N deposition by 50 percent on C_B leaching (16 percent over the simulation period) were greater than those of reduced C_B deposition. The system continued to accumulate both S and N even at reduced deposition at Coweeta, although growth and vegetation uptake were slightly reduced (-5 percent) because of increased N deficiency. Base saturation remained well above the AI buffering range at all times at Coweeta and AI was an unimportant component of soil solutions in all scenarios. **(5)**

Mitchell, Katherine A.; Bolstad, Paul V.; Vose, James M. 1999. **Interspecific and environmentally induced variation in foliar dark respiration among eighteen southeastern deciduous tree species.** Tree Physiology. 19: 861-870.

We measured variations in leaf dark respiration rate (R_d) and leaf nitrogen (N) across species, canopy light environment, and elevation for 18 co-occurring deciduous hardwood species in the Southern Appalachian Mountains of Western North Carolina. Our overall objective was to estimate leaf respiration rates under typical conditions and to determine how they varied within and among species. Mean dark respiration rate at 20 °C ($R_{d,mass}$, : mol CO_2 (kg leaf dry mass)$^{-1}$ s^{-1}) for all 18 species was 7.31 : mol kg^{-1} s^{-1}. Mean $R_{d,mass}$ of individual species varied from 5.17 : mol kg^{-1} s^{-1} for *Quercus coccinea* Muenchh. to 8.25 : mol kg^{-1} s^{-1} for *Liriodendron tulipifera* L. Dark respiration rate varied by leaf canopy position and was higher in leaves collected from high-light environments. When expressed on an area basis, dark respiration rate ($R_{d,area}$, : mol CO_2 (kg leaf dry area)$^{-1}$ s^{-1}) showed a strong linear relationship with the predictor variables leaf nitrogen (N_{area}, g N (m leaf area)$^{-2}$) and leaf structure (LMA, g leaf dry mass (m leaf area)$^{-2}$) (r^2 = 0.62). This covariance was largely a result of changes in leaf structure with canopy position; smaller thicker leaves occur at upper canopy positions in high-light environments. Mass-based expression of leaf nitrogen and dark respiration rate showed that nitrogen concentration (N_{mass}, mg N (g leaf dry mass)$^{-1}$) was only moderately predictive of variation in $R_{d,mass}$ for all leaves pooled (r^2 = 0.11), within species, or among species. We found distinct elevational trends, with both $R_{d,mass}$ and N_{mass} higher in trees originating from high-elevation, cooler growth environments. Consideration of interspecies differences, vertical gradients in canopy light environment, and elevation, may improve our ability to scale leaf respiration to the canopy in forest process models. **(6)**

Qualls, R.G.; Haines, B.L.; Swank, W.T.; Tyler, S.W. 2000. **Soluble organic and inorganic nutrient fluxes in clearcut and mature deciduous forests.** Soil Science Society of America Journal. 64: 1068-1077.

The mechanisms by which forest ecosystems retain or lose soluble inorganic nutrients after disturbance are well known, but substantial amounts of soluble organic nutrients may also be released from cut vegetation. Our objective was to compare the leaching of dissolved organic and inorganic nutrients in cut and mature forest stands and to develop hypotheses about factors controlling the retention of soluble organic nutrients after disturbance. Solution chemistry was measured for 2 yr after clearcutting a small area in the surrounding undisturbed deciduous forest on a reference watershed at the Coweeta Hydrologic Laboratory in the Appalachian Mountains. Concentrations of dissolved organic C (DOC) and N (DON) [dissolved organic nitrogen] in slash leachate were 2.6 to 3.2 times the concentrations in throughfall from undisturbed forest. Concentrations in forest floor, A horizon, and B horizon solutions from cut plots were 1.2 to 3.8 times those from undisturbed forest. Dissolved organic P (DOP) concentrations in cut plots were 3.1 and 3.6 times those of uncut plots in solutions from slash and forest floor, respectively, but did not differ in mineral soil. Fluxes of DOC, DON, and DOP in all strata were greater in cut plots than uncut plots. Fluxes of DON were greater than those of ammonium plus nitrate N in all strata of both cut and uncut plots. We hypothesize that the well recognized retention mechanisms for inorganic nutrients combine with equilibrium adsorption of dissolved organic matter to efficiently buffer against leaching of both soluble inorganic and organic nutrients after clearcutting. **(7)**

Rauscher, H. Michael; Lloyd, F. Thomas; Loftis, David L; Twery, Mark J. 2000. **A practical decision-analysis process for forest ecosystem management.** Computers and Electronics in Agriculture. 27: 195-226.

Many authors have pointed out the need to firm up the “fuzzy” ecosystem management paradigm and develop operationally practical processes to allow forest managers to accommodate more effectively the continuing rapid change in societal perspectives and goals. There are three spatial scales where clear, precise, practical ecosystem management processes are needed: the regional assessment scale, the forest-level scale, and the project-level scale. This paper proposes a practical decision analysis process for ecosystem management at the project-level scale. Goals are the focal point of management. To achieve them requires a formal, structured goal hierarchy, desired future conditions, several interesting alternatives, scenario analysis, and monitoring and evaluation of the results. The proposed process is

firmly grounded in the body of theory and practice organized in the scientific literature under the heading of multi-objective decision analysis. An illustrative example of this decision analysis process is presented using the Bent Creek Experimental Forest of the Pisgah National Forest near Asheville, NC as a test case. **(8)**

Large Scale Assessment and Modeling

Hamel, Paul B. 2000. **Cerulean warbler (*Dendroica cerulea*).** In: Poole, A.; Gill, F., eds. The birds of North America—life histories for the 21st century; no. 511. Philadelphia, PA: The Birds of North America, Inc.: 1-20.

This small, canopy-foraging insectivore breeds locally in mature and older deciduous forests with broken canopies across much of the Eastern United States. Sky blue, sky high in the canopy, the Cerulean warbler has been little studied; management actions to enhance its habitat have not yet been specified. Among *Dendroica*, this species forages and nests higher in the canopy, and migrates farther and earlier than most others. Its social system remains poorly understood. Numerous interesting questions about wintering individuals in montane South American forests, where this species associates with others in mixed flocks of canopy insectivores, await investigation.

Although the Cerulean warbler was formerly among the most abundant breeding warblers in the Ohio and Mississippi River valleys, its numbers plummeted in the 1900's. Concern for the future of this species is warranted. Yet even in the face of these steep declines, some populations are currently expanding. **(9)**

Kim, Geneho; Nute, Donald; Rauscher, H. Michael; Loftis, David L. 2000. **AppBuilder for DSSTools; an application development environment for developing decision support systems in Prolog.** Computers and Electronics in Agriculture. 27: 107-125.

A programming environment for developing complex decision support systems (DSSs) should support rapid prototyping and modular design, feature a flexible knowledge representation scheme and sound

inference mechanisms, provide project management, and be domain independent. We have previously developed DSSTools (Decision Support System Tools), a reusable, domain-independent, and open-ended toolkit for developing DSSs in Prolog. DSSTools provides modular design, a flexible knowledge representation scheme, and sound inference mechanisms to support development of any knowledge-based system components of a DSS. It also provides tools for building the DSS interface and for integrating other non-Prolog components of a DSS such as simulation models, databases, or geographical information system, into a multi-component DSS. DSSTools does not provide project management, and its complex syntax makes rapid prototyping difficult. AppBuilder for DSSTools is a GUI-based [graphical user interface-based] application development environment for developing DSSs in DSSTools that supports rapid prototyping and project management. AppBuilder's easy-to use dialogues for managing and building knowledge-based and top-level control components of a DSS free developers from having to memorize complex syntax and reduce development time without sacrificing the flexibility of the underlying toolkit. AppBuilder has been used to develop the Regeneration DSS, a system for predicting the regeneration of Southern Appalachian hardwoods. AppBuilder is an application development environment for both prototyping and developing a complete DSS. **(10)**

Li, Harbin; Gartner, David I.; Mou, Pu; Trettin, Carl C. 2000. **A landscape model (LEEMATH) to evaluate effects of management impacts on timber and wildlife habitat.** Computers and Electronics in Agriculture. 27: 263-292.

Managing forest resources for sustainability requires the successful integration of economic and ecological goals. To attain such integration, land managers need decision support tools that incorporate science, land-use strategies, and policy options to assess resources [resources'] sustainability at large scales. Landscape Evaluation of Effects of Management Activities on Timber and Habitat (LEEMATH) is a tool for evaluating alternative management strategies from both economic and ecological perspectives. The current version of LEEMATH emphasizes timber production and wildlife habitat in industrial forest landscapes. LEEMATH provides a framework upon which various models can be integrated. It is generic because it is designed to model stand growth, habitat attribute, and habitat suitability as they exist generally throughout the American Southeast. It is dynamic because it examines effects of management strategies on timber production and habitat quality over time, especially the balance between habitat loss and regrowth at the landscape scale. It is spatially explicit because it evaluates landscape configuration for its effects on habitat in terms of adjacency requirements and dispersal potential. It is heuristic because it simulates the dynamics of forest stands under different

management scenarios and allows land managers to ask “WHAT-IF” questions to explore management alternatives and their possible effects over time. In this paper, we discuss how to integrate different models into a decision-support system, and how to evaluate habitat suitability at the landscape level. We also discuss the gaps in our knowledge of landscape habitat assessment and the limitations of LEEMATH. Finally, we apply LEEMATH to a forested landscape on the Coastal Plain of South Carolina, USA, to demonstrate its usefulness in management planning with multiple interests. We show the effects of two management regimes on timber production, habitat attribute dynamics, and habitat quality of three target wildlife species at both the stand and the landscape scales. **(11)**

Potter, W.D.; Liu, S.; Deng, X.; Rauscher, H.M. 2000. **Using DCOM to support interoperability in forest ecosystem management decision support systems.** Computers and Electronics in Agriculture. 27: 335-354.

Forest ecosystems exhibit complex dynamics over time and space. Management of forest ecosystems involves the need to forecast future states of complex systems that are often undergoing structural changes. This in turn requires integration of quantitative science and engineering components with sociopolitical, regulatory, and economic considerations. The amount of data, information and knowledge involved in the management process is often overwhelming. Integrated decision support systems may help managers make consistently good decisions concerning forest ecosystem management. Integrating computer systems using a system-specific or custom approach has many disadvantages. We compare a variety of current approaches, suggest characteristics that an approach should have, and propose that the Distributed Component Object Model is an approach that is very suitable for forest ecosystem decision support system integration. **(12)**

Prestemon, Jeffrey P.; Wear, David N. 2000. **Linking harvest choices to timber supply.** Forest Science. 46(3): 377-389.

Aggregate timber supply by ownership was investigated for a small region by applying stand-level harvest choice models to a representative sample of stands and then aggregating to regional totals using the area-frame of the forest survey. Timber harvest choices were estimated as probit models for three ownership categories in Coastal Plain southern pine stands of North Carolina using individual permanent and remeasured stand-level data from last two available USDA Forest Service Forest Inventory and

Analysis (FIA) surveys. The timber harvest decision was modeled as a function of timber values, a cost factor, and stand volume as a proxy for nontimber values. Probit models were statistically significant at 1 percent for all ownerships. Area expansion factors (the portion of forest area in the region represented by the sampled stand) were then combined with harvest probabilities to model the aggregate effects of price changes on timber supply, given a fixed forest area. Implied price elasticities were estimated using this modeling of aggregate effects, and a bootstrapping procedure was applied to estimate confidence limits for supply elasticities with respect to price. Our results showed that NIPF and industry were elastically responsive in the aggregate when price increases are perceived as temporary, but much less elastically and usually negatively responsive when increases are perceived as permanent. Results are consistent with theory of optimal rotations and highlight the critical influence of both existing inventory structure and expectations on aggregate timber supply. **(13)**

Rauscher, H. Michael; Plant, Richard E.; Thomson, Alan J.; Twery, Mark J. 2000. **Foreword.** Computers and Electronics in Agriculture. 27:1-6.

This article includes the central themes of the keynote speakers for the scientific conference "The Application of Scientific Knowledge to Decisionmaking in Managing Forest Ecosystems." This International Union of Forestry Research Organizations (IUFRO) conference presented the latest developments concerning the entire range of topics dealing with ecosystem management decision support systems. Conference sessions included data management, knowledge management, quantitative and qualitative simulation modeling, and decision support systems. **(14)**

Shackelford, Clifford E.; Brown, Raymond E.; Conner Richard N.
Red-bellied woodpecker (*Melanerpes carolinus*). In: Poole, A.; Gill, F., eds. The birds of North America—life histories for the 21st century; no. 500. Philadelphia, PA: The Birds of North America, Inc.: 1-24.

This familiar, Eastern U.S. woodpecker is an active and vocal species, with a preference for humid forests dominated by pines or hardwoods, or a mixture of both. It seldom excavates wood for insects; instead, depending on season, it forages opportunistically for a wide range of fruit, mast, seeds, and arboreal arthropods. It is also known to take small or young vertebrate prey as well. The red-bellied woodpecker has expanded its range northward and westward in the latter half of the twentieth century. Most

populations are resident year-round, although northern birds show some seasonal movement by retreating south during cold winters. In the Southeastern United States, it is the most abundant woodpecker; in the northern half of its range, it is much less common. This woodpecker does well in urban settings, but also occurs in more remote, wilderness sites. Its generalistic foraging and nesting habits have helped in its range expansion.

Many aspects of the life history of this species have been well studied. Its nutrition, physiology, and short-range movements remain little studied. It does not appear to be a species of concern; much of its population is either stable or increasing. **(15)**

Simons, Theodore R.; Pearson, Scott M.; Moore, Frank R. 2000. **Application of spatial models to the stopover ecology of trans-Gulf migrants.** Studies in Avian Biology. 20(4): 4-14. (Editor's Note: The Evaluation of Watershed Ecosystem Responses to Natural, Management, and Other Human Disturbances research work unit,Coweeta Hydrologic Laboratory, provided partial funding for this publication.)

Studies at migratory stopover sites along the northern coast of the Gulf of Mexico are providing an understanding of how weather, habitat, and energetic factors combine to shape the stopover ecology of trans-Gulf migrants. We are coupling this understanding with analyses of landscape-level patterns of habitat availability by using spatially explicit models to simulate avian movements through stopover habitats. The probability that an individual migrant will complete a migration successfully is determined by the bird's energetic status and flight morphology, and the quality, quantity, and spatial pattern of habitats encountered during migration. The models evaluate habitat patches according to their distance from the coast, isolation from other patches of suitable habitat, and habitat quality. Evaluation procedures have been developed from available data on the arrival condition of migrants, energetic and morphological constraints on movement, and species-specific habitat preferences. Window analysis and individual-based modeling are used to demonstrate how the abundance, quality, and spatial pattern of habitats interact with the arrival energetic state of migrants to determine the suitability of migratory stopover habitats along the northern Gulf coast. Our goal is to understand how landscape-scale patterns of habitat conversion may be affecting populations of trans-Gulf migrants. **(16)**

Twery, Mark J.; Rauscher, H. Michael; Bennett, Deborah J.; and others. 2000. **NED-1: integrated analyses for forest stewardship decisions**. Computers and Electronics in Agriculture. 27: 167-193.

NED is a collective term for a set of software intended to help resource managers develop goals, assess current and potential conditions, and produce sustainable management plans for forest properties. The software tools are being developed by the USDA Forest Service, Northeastern and Southern Research Stations, in cooperation with many other collaborators. NED-1 is a Windows-based program that helps analyze forest inventory data from the perspective of various resources on management areas as large as several thousand hectares. Resources addressed include visual quality, ecology, forest health, timber, water, and wildlife. NED-1 evaluates the degree to which an individual stand or an entire management unit may provide the conditions required to accomplish specific goals. NED-1 users select from a variety of reports, including tabular data summaries, general narratives, and goal-specific analyses. An extensive hypertext system provides information about the resource goals, the desired conditions that support achieving those goals, and related data used to analyze the actual condition of the forest, as well as detailed information about the program itself and the rules and formulas used to produce the analyses. The software is constructed in C+ + using an application framework; the inferencing component that handles the rule bases uses Prolog. **(17)**

Vose, James M.; Swank, Wayne T.; Harvey, Gregory J.; and others. 2000. **Leaf water relations and sapflow in eastern cottonwood (*Populus deltoides* Bartr.) trees planted for phytoremediation of a groundwater pollutant.** International Journal of Phytoremediation. 2(1): 53-73.

Plants that remediate groundwater pollutants may offer a feasible alternative to the traditional and more expensive practices. Because its success depends on water use, this approach requires a complete understanding of species-specific transpiration patterns. The objectives of this study were (1) to quantify tree and stand-level transpiration in two age classes (whips and 1-year-old seedlings) of eastern cottonwoods (*Populus deltoides* Bartr.), and (2) to determine climatic and physiological driving variables at the Carswell Air Force Base in central Texas, USA. Trichloroethylene (TCE) was detected in shallow (2 to 3 m) groundwater in the early 1980's. Cottonwood whips and 1-year-old potted seedlings were planted in two separate 0.15-ha plantations in spring 1996. Sapflow gauges determined sapflow on 14 to 16 trees in May, June, July, August, and October 1997. Without adjusting for differences in tree size, sapflow rates were greater for 1-year-old trees than whips (peak values were 0.75 and 0.53 kg hr^{-1} $tree^{-1}$, respectively). When adjusted for tree size, the pattern reversed, with whips having significantly greater sapflow rates than 1-year-old trees (peak values were 0.053 and 0.045 kg cm^{-2} hr^{-1}, respectively). Temporal variation (diurnal and seasonal) in sapflow rates was principally related to VPD [vapor pressure

deficit], solar radiation, and leaf conductance. Extrapolating to the stand and across the growing season, the plantations transpired ~25 cm of water. Early attainment of high levels of transpiration indicates that the stands will transpire considerably more water as leaf area and root exploitation increases with stand development. **(18)**

Yeakley, J. Alan; Moen, Ron A.; Breshears, David D.; Nungesser. 1994. **Response of North American ecosystem models to multi-annual periodicities in temperature and precipitation.** Landscape Ecology. 9(4): 249-260. (Editor's Note: The Evaluation of Watershed Ecosystem Responses to Natural, Management, and Other Human Disturbances research work unit, Coweeta Hydrologic Laboratory, provided partial funding for this publication.)

Ecosystem models typically use input temperature and precipitation data generated stochastically from weather station means and variances. Although the weather station data are based on measurements taken over a few decades, model simulations are usually on the order of centuries. Consequently, observed periodicities in temperature and precipitation at the continental scale that have been correlated with large scale forcings, such as ocean-atmosphere dynamics and lunar and sunspot cycles, are ignored. We investigated how these natural climatic fluctuations affect aboveground biomass in ecosystem models by incorporating some of the more pronounced continental-scale cycles in temperature (4, 11, 80, 180 year periods) and precipitation (11 and 19 year periods) into models of three North American forests (using LINKAGES) and one North American grassland (using STEPPE). Even without inclusion of periodicities in climate, long-term dynamics of these models were characterized by internal frequencies resulting from vegetation birth, growth, and death processes. Our results indicate that long-term temperature cycles result in significantly lower predictions of forest biomass than observed in the control case for a forest on a biome transition (northern hardwoods/boreal forest). Lower-frequency, higher-amplitude temperature oscillation caused amplification of forest biomass response in forests containing hardwood species. Shortgrass prairie and boreal ecosystems, dominated by species with broad stress tolerance ranges, were relatively insensitive to climatic oscillations. Our results suggest periodicities in climate should be incorporated within long-term simulations of ecosystems with strong internal frequencies, particularly for systems on biome transitions. **(19)**

Inventory and Monitoring

Clark, N.A.; Wynne, R.H.; Schmoldt, D.L.; Winn, M. 2000. **An assessment of the utility of a non-metric digital camera for measuring standing trees.** Computers and Electronics in Agriculture. 28: 151-169.

Images acquired with a commercially available digital camera were used to make measurements on 20 red oak (*Quercus* spp.) stems. The ranges of diameter at breast height (d.b.h.) and height to a 10 cm upper-stem diameter were 16 to 66 cm and 12 to 20 m, respectively. Camera stations located 3, 6, 9, 12, and 15 m from the stem were studied to determine the best distance to be used with the maximum wide angle setting on the camera. Geometric mean diameter estimates from the 12 and 15 m distances were within ± 4 cm at any height (95 percent P^2). Though unbiased, measurement variation was found to increase with stem height. Using camera-derived heights and diameters, volumes were found to be within 8 percent of volumes calculated using taped measurements of individual stems two times out of three—an improvement over existing d.b.h.-height volume equations. This preliminary work demonstrates the ability of using a digital camera to acquire stem diameters and heights. Some limitations of the current technology are also noted. By combining equipment and procedural modifications with improved data flow from imagery to information, terrestrial digital imagery may revolutionize stem or even plot level data collection. **(20)**

Schweitzer, Callie Jo. 2000. **Forest statistics for Tennessee, 1999.** Resour. Bull. SRS-52. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 78 p.

This report summarizes a 1999 inventory of the forest resources of the State of Tennessee. Major findings are highlighted in text and graphs; detailed data are presented in 51 tables. **(21)**

Zarnoch, S.J.; Bechtold, W.A. 2000. **Estimating mapped-plot forest attributes with ratios of means.** Canadian Journal of Forest Research. 30: 688-697.

The mapped-plot design utilized by the U.S. Department of Agriculture (USDA) Forest Inventory and Analysis and the National Forest Health Monitoring Programs is described. Data from 2458 forested mapped plots systematically spread across 25 States reveal that 35 percent straddle multiple conditions. The ratio-of-means estimator is developed as a method to obtain estimates of forest attributes from mapped plots, along with measures of variability useful for constructing confidence intervals. Basic

inventory statistics from North and South Carolina were examined to see if these data satisfied the conditions necessary to qualify the ratio of means as the best linear unbiased estimator. It is shown that the ratio-of-means estimator is equivalent to the Horwitz-Thompson, the mean-of-ratios, and the weighted-mean-of-ratios estimators under certain situations. **(22)**

Foundation Programs Research

Mercer, Evan; Aruna, P.B. 2000. **Assessing the impacts of forests on human welfare: preliminary results from the Mid-Atlantic Integrated Assessment.** Environmental Monitoring and Assessment. 63: 43-63.

This paper presents results from the first phase of the socio-economic assessment of forest ecosystems in the Mid-Atlantic Integrated Assessment (MAIA). First, we present results of the analysis of changes in the distribution of human population and forest land use in the region. Then, trends in wood products employment and income between 1975 to 1995 are used to examine the economic contributions of forest-based industries in the Mid-Atlantic region. Between 1970 to 1990 the population of the MAIA region increased by 14 percent (4.3 million people), resulting in the average population density increasing by 25 people per square mile, from 179 to 204 people per square mile. Nevertheless, population density was lower in large parts of the region in 1990 than in 1950. Although forests dominate the MAIA landscape, the trend is toward more people owning smaller forest land holdings, with developed lands increasing by 21 percent and rural lands decreasing by 2.64 percent between 1982 to 1994. All of this suggests increasing forest fragmentation in all States of the region except New York, Pennsylvania, and West Virginia. Forest industry has been an important contributor to the economy of the MAIA region, producing an average of a quarter million jobs (2.03 percent of all wage employment) and generating $4.5 billion in wages and salaries each year between 1975 to 1995. If recent trends continue, forest industry will continue to be an important source of employment and income for parts of some States in the MAIA region; however, the forest industry's importance relative to the entire mid-Atlantic economy will likely continue to decline in the 21st century. **(23)**

Schmidt, A.; Doudrick, R.L.; Heslop-Harrison, J.S.; Schmidt, T. 2000. **The contribution of short repeats of low sequence complexity to large conifer genomes.** Theoretical Applications of Genetics. 101: 7-14.

The abundance and genomic organization of six simple sequence repeats, consisting of di-, tri-, and tetranucleotide sequence motifs, and a minisatellite repeat have been analyzed in different gymnosperms by Southern hybridization. Within the gymnosperm genomes investigated, the abundance and genomic organization of micro- and minisatellite repeats largely follows taxonomic groupings. We found that only particular simple sequence repeat motifs are amplified in gymnosperm genomes, while others such as $(CAC)_5$ and $(GACA)_4$ are present in only low copy numbers. The variation in abundance of simple sequence motifs reflects a similar situation to that found in angiosperms. Species of the two- and three-needle pine section *Pinus* are relatively conserved and can be distinguished from *Pinus strobus*, which belongs to the five-needle pine section *Strobus*. The hybridization pattern of *Picea* species, bald cypress, and gingko were different from the patterns detected in the *Pinus* species. Furthermore, sequences with homology to the plant telomeric repeat $(TTTAGGG)_n$ have been analyzed in the same set of gymnosperms. Telomere-like repeats are highly amplified within two- and three-needle pine genomes, such as slash pine (*Pinus elliottii* Engelm. var. *elliottii*), compared to *P. strobus*, *Picea* species, bald cypress, and gingko. *P. elliottii* var. *elliottii* was used as a representative species to investigate the chromosomal organization of telomere-like sequences by fluorescence in situ hybridization (FISH). The telomere-like sequences are not restricted to the ends of chromosomes; they form large intercalary and pericentric blocks showing that they are a repeated component of the slash pine genome. Conifers have genomes larger than 20 000 Mbp, and our results clearly demonstrate that repeats of low sequence complexity, such to $(CA)_8$, $(GA)_8$, $(GGAT)_4$ and $(GATA)_4$, and minisatellite- and telomere-like sequences represent a large fraction of the repetitive DNA of these species. The striking differences in abundance and genome organization of the various repeat motifs suggest that these repetitive sequences evolved differently in the gymnosperm genomes investigated. **(24)**

Schmoldt, Daniel L.; He, Jing; Abbott, A. Lynn. 2000. **Automated labeling of log features in CT imagery of multiple hardwood species.** Wood and Fiber Science. 32(3): 287-300.

Before noninvasive scanning, e.g., computed tomography (CT), becomes feasible in industrial sawmill operations, we need a procedure that can automatically interpret scan information in order to provide the saw operator with information necessary to make proper sawing decisions. To this end, we have worked

to develop an approach for automatic analysis of CT images of hardwood logs. Our current approach classifies each pixel individually using a feed-forward artifical [artificial] neural network (ANN) and feature vectors that include a small, local neighborhood of pixels and the distance of the target pixel to the center of the log. Initially, this ANN was able to classify clear wood, bark, decay, knots, and voids in CT images of two species of oak with 95 percent pixel-wise accuracy. Recently we have investigated other ANN classifiers, comparing 2-D versus 3-D neighborhoods and species-dependent (single species) versus species-independent (multiple species) classifiers using oak (*Quercus rubra* L. and *Q. nigra* L.), yellow-poplar (*Liriodendron tulipifera* L.), and black cherry (*Prumus serotina* Ehrh.) CT images. When considered individually, the resulting species-dependent classifiers yield similar levels of accuracy (96 to 98 percent). 3-D neighborhoods work better for multiple-species classifiers, and 2D is better for the single-species case. Classifiers combining yellow poplar and cherry data misclassify many pixels belonging to splits as clear wood, resulting in lower classification rates. If yellow poplar was not paired with cherry, however, we found no statistical difference in accuracy between the single and multiple-species classifiers. **(25)**

Schmoldt, Daniel L.; Occeña, Luis G.; Abbott, A. Lynn; Gupta, Nand K. 1999. **Nondestructive evaluation of hardwood logs: CT scanning, machine vision and data utilization.** Nondestructive Testing and Evaluation. 15: 279-309.

Sawing of hardwood logs still relies on relatively simple technologies that, in spite of their lack of sophistication, have been successful for many years due to wood's traditional low cost and ready availability. These characteristics of the hardwood resource have changed dramatically over the past 20 years, however, forcing wood processors to become more efficient in their operations. In spite of some recent advances, the breakdown of hardwood logs into lumber continues to be hampered by the inability of sawyers to "see" inside of the log prior to making irreversible cutting decisions. The need for noninvasive assessment of hardwood logs prior to breakdown is well accepted, but is difficult to realize because industrial scanning, in this context, is unique in several respects. For example, large volumes of material must be inspected quickly over an extended duty cycle, the wood material still possesses relatively low value compared to other industrial materials that require internal scanning, and many wood processors are small operations located in rural areas. Successful implementation of new scanning technology, however, will have tremendous payback for wood processors, and for timber resource conservation efforts. The research program reviewed here applies a three-pronged approach to address this situation. First, a relatively

new and innovative CT scanning technology is being developed that can scan hardwood logs at industrial speeds. Second, machine vision software has beeen [been] created that can interpret scanned images rapidly and with high accuracy. Third, we have developed 3-D rendering and analysis techniques that will enable sawyers to apply image assessment to actual log breakdown. This integrative research direction combines hardware and software systems to scan logs, process images, and apply imaging to real-time, industrial decision-making. **(26)**