PROCEEDINGS OF THE

ELEVENTH SYMPOSIUM

ON

THE NATURAL HISTORY OF

LOWER TENNESSEE AND CUMBERLAND RIVER VALLEYS

BRANDON SPRING GROUP CAMP

LAND BETWEEN THE LAKES

APRIL 1 AND 2, 2005

SPONSORED BY

AUSTIN PEAY STATE UNIVERSITY

THE CENTER OF EXCELLENCE FOR FIELD BIOLOGY

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LAND BETWEEN THE LAKES NATIONAL RECREATION AREA

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LAND BETWEEN THE LAKES NATIONAL RECREATION AREA

Austin Peay State University

PROCEEDINGS OF THE 11TH SYMPOSIUM ON THE NATURAL HISTORY OF LOWER TENNESSEE AND CUMBERLAND RIVER VALLEYS

HELD AT BRANDON SPRING GROUP CAMP
LAND BETWEEN THE LAKES
APRIL 1 AND 2, 2005

Sponsored by:

The Center of Excellence for Field Biology
Austin Peay State University, Clarksville, Tennessee

and

The Center for Reservoir Research
Murray State University, Murray, Kentucky

and

U.S. Department of Agriculture, Forest Service
Land Between The Lakes National Recreation Area
Golden Pond, Kentucky

****

EDITED BY:

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The Center of Excellence for Field Biology
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PREFACE

The 11th Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys was convened at Brandon Spring Group Camp at 1:30 p.m. on Friday, April 1, 2005. Dr. Andrew N. Barrass, Director of the Center of Excellence for Field Biology, Austin Peay State University welcomed the assembly on behalf of the Center. Dr. Gaines Hunt, Dean of the College of Science and Mathematics, at Austin Peay State University followed with welcoming comments on behalf of the college. Dr. David S. White, Director of the Hancock Biological Station and the Center for Reservoir Research, Murray State University, greeted the group on behalf of those entities. Representing Land Between The Lakes National Recreation Area, Environmental Stewardship Department Manager Judy Hallisey welcomed the group to LBL.

Following the welcoming comments, Dr. Barrass moderated the invited paper session, which was themed "Sustaining Biocomplexity Through Natural Resource Management." The first invited speaker was Laurina I. Lyle, Environmental Education Coordinator for The Center for Field Biology at APSU. Her presentation was entitled "Environmental Education and The Center of Excellence for Field Biology: The Past, Present, and Future." An abstract of this presentation is published in these proceedings. The second invited speaker was Dr. Jonathan P. Evans, Director of the Landscape Analysis Laboratory and Associate Professor of Biology at the University of the South in Sewanee, Tennessee. Dr. Evans' presentation "Assessing Forest Loss on the Cumberland Plateau: Implications for Forest Policy Reform in Tennessee" provided a critical analysis of destructive forest practices on the plateau. A full manuscript of this presentation is published here. Following dinner, Judy Hallisey, LBL Environmental Stewardship Manager, spoke about the development of a Land and Resource Management Plan that is projected to direct management of LBL for at least another decade. A short communication of this presentation is published in the proceedings.

The Saturday morning contributed papers were presented in two concurrent sessions. Session I, Botany, was moderated by Ms. Lyle and Session II, Aquatic Biology and Zoology, was moderated by Dr. Mack T. Finley. The Botany session was comprised of 14 papers, three of which are published in these proceedings as full manuscripts. Abstracts of the remaining eleven papers are included herein. The twelve papers presented in the Aquatic Biology and Zoology sessions are published here as abstracts.

These proceedings of the 11th symposium follow the format of previous proceedings published by the Center of Excellence for Field Biology. Papers and abstracts were reviewed by the staff of the Center for style, structure, content and scientific merit. We thank the authors for their diligence in submitting manuscripts and abstracts and hope that our efforts have resulted in a quality presentation of their research.

ACKNOWLEDGMENTS

The editors thank Sarah Johnson and Jean Langley, past and current secretaries of the Center, for their assistance in preparation of these proceedings. Additional thanks go to Ms. Johnson for her effort in organizing and managing the two-day symposium. In addition, we appreciate the efforts of the many Center for Field Biology undergraduate and graduate research assistants for their help in preparing, assembling, running and disassembly of the symposium. Thanks also to the staff of Brandon Spring Group Camp for the help and hospitality.

SYMPOSIUM REGISTRANTS

Following, in alphabetical order, is a list of those individuals who registered at the 2005 symposium. Institutional affiliation (when available), city (of the person's institution or home), and state are also given.

Amy Archer – Austin Peay State University, Clarksville, TN; Claude Bailey – Tennessee Division of Natural Heritage, Nashville, TN; Rex Barber – Volunteer State Community College, Gallatin, TN; Joy Broach – US Army Corps of Engineers, Nashville, TN; Angelo Bufalino; Jon Davenport - Austin Peay State University, Clarksville, TN; Hal De Selm – University of Tennessee, Knoxville, TN; Jocqueline Doyle – Murray State University, Murray, KY; Julia Earl; Wayne S. Easterling – US Army Corp of Engineers, Nashville, TN; Craig Emerson - Austin Peay State University, Clarksville, TN; Joshua Ennen - Austin Peay State University, Clarksville, TN; Erin Muldoon - Austin Peay State University, Clarksville, TN; Jonathan Evans – University of the South, Sewanee, TN; Mack T. Finley - Austin Peay State University, Clarksville, TN; Kevin Fitch – Arnold Air Force Base, Hillsboro, TN; James Fralish – Southern Illinois University, Carbondale, IL; Nicole Gerlanc – Murray State University, Murray, KY; John Groninger – Southern Illinois University, Carbondale, IL; Judy Hallisey – USDA Forest Service LBL NRA, Golden Pond, KY; Debbie Hamilton – Clarksville, TN; Steven W. Hamilton - Austin Peay State University, Clarksville, TN; Steve Hanna – USDA Forest Service LBL NRA, Golden Pond, KY; Wendy Hesson – Volunteer State Community College, Gallatin, TN; JoVonn Hill – Mississippi Entomological Museum, MS; Michael J. Hill – Volunteer State Community College, Gallatin, TN; Jin Hwa-Seong – Murray State University, Murray, KY; Rebecca Ijames – Murray State University, Murray, KY; Sarah Johnson - Austin Peay State University, Clarksville, TN; Angela Knowles - Austin Peay State University, Clarksville, TN; Beth Kobylarz – Murray State University, Murray, KY; John Koons – Jackson State Community College; Chad Lewis – Mainstream Commercial Divers, Inc., Murray, KY; Laurina Lyle - Austin Peay State University, Clarksville, TN; Josh Maloney - Austin Peay State University, Clarksville, TN; John Maxwell – Jackson State Community College; Mark Mayfield – Kansas State University, Manhattan, KS; Amber McBride - Austin Peay State University, Clarksville, TN; Jon McMahan - Austin Peay State University, Clarksville, TN; Laura Mills – Austin Peay State University, Clarksville, TN; Adam Neblett – Dunbar Cave Natural Area, Clarksville, TN; Matthew Neimiller – Middle Tennessee State University, Murfreesboro, TN; Nathan Parker - Austin Peay State University, Clarksville, TN; Elizabeth Raikes – USDA Forest Service LBL NRA, Golden Pond, KY; Michelle Rogers - Austin Peay State University, Clarksville, TN; Charles Ruffner – Southern Illinois University, Carbondale, IL; Joe Schibig – Volunteer State Community College, Gallatin, TN; A. Floyd Scott - Austin Peay State University, Clarksville, TN; Jim Sickel – Murray State University, Murray, KY; Jack Tortelson; Mark Vance – Tennessee Technological University, Cookeville, TN; David White – Murray State University, Murray, KY; Howard Whiten – Murray State University, Murray, KY; Barbara M. Wysock – USDA Forest Service LBL, Golden Pond, KY; James Zaczek – Southern Illinois University, Carbondale, IL

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SUSTAINING BIOCOMPLEXITY THROUGH NATURAL RESOURCE MANAGEMENT

Friday, April 1, 2005

Moderator:

Dr. Andrew N. Barrass
Director, The Center of Excellence for Field Biology
Austin Peay State University

ASSESSING FOREST LOSS ON THE CUMBERLAND PLATEAU: IMPLICATIONS FOR FOREST POLICY IN TENNESSEE

JONATHAN P. EVANS, PH.D.

Professor of Biology &
Director, Landscape Analysis Laboratory
University of the South, Sewanee, TN 37383

The Cumberland Plateau is one of the most beautiful and biologically diverse places on the planet, and yet it is being clear cut, vast tracts of land owned by timber companies are on the market, and in many cases are being bought by speculators from out of state. Nothing good can come of this.
-- TN Governor Phil Bredesen, State-of-the-State Address 2005

ABSTRACT. In his 2005 State-of-the-State address, Tennessee Governor Phil Bredesen highlighted the dramatic loss of forest cover occurring on the biologically diverse Cumberland Plateau as a result of industrial clearcutting. Using remote-sensing and GIS technology, Landscape Analysis Lab (LAL) at the University of the South was the first to quantify forest loss on the Plateau and bring it to the attention of state officials. In this paper, I present recent LAL data that show the rate of forest loss continuing to increase on the Cumberland Plateau and describe the ecological impacts that have resulted from this change. I also discuss the role that biologists need to play in order to better ensure that good science informs forest policy in Tennessee.

INTRODUCTION

Native forests of the southern United States are currently undergoing dramatic changes due to shifting patterns in land use. In recent years, urban sprawl and the establishment of pine plantations have emerged as dominant forces of change and have been predicted to be major causes of native forest loss in the future (Wear and Greis 2002). In the southeast where the vast majority of the land base is privately owned, the forests change as a function of the many individual land use decisions made over a period of time. These land use decisions involve not only the myriad of forest owners spread across the region, but also the resource professionals who advise them and the government officials who enforce regulations and provide incentives to them. If forest values such as biodiversity, water quality, and wood fiber are to be sustained in such a mosaic of decision-making, then landscape-level information must be made available to all parties in order to guide land use activities in an informed and comprehensive manner. Information must be generated to allow each land use decision to be made within the context of what is happening to the greater landscape and information must be provided at an appropriate spatial and temporal scale. For example, land use information produced every ten years with a spatial resolution appropriate only at the state level will have little value to decision-makers operating at the county or sub-county level, particularly in areas of rapid change.

The biologically rich hardwood forests of the Cumberland Plateau in Tennessee are considered by many organizations (including the Doris Duke Charitable Trust, The Nature Conservancy, Natural Resource Defense Council, and World Wildlife Fund) to be among the highest conservation-value forests remaining in North America today. This is partly due to the fact that this region contains some of the largest remaining tracts of privately owned contiguous temperate deciduous forest left on the continent. These forest tracts represent critical neotropical migratory songbird habitat (Haney and Lydic 1999) and serve as the headwaters to the most biologically diverse, freshwater stream systems found in the world (Ricketts et al. 1999). The Cumberland Plateau has some of the highest predicted reptile and amphibian diversity in the state (Durham 1995) and contains one of the most diverse vascular plant communities in the eastern United States (Ricketts et al. 1999; Fleming and Wofford 2004). The drought-prone, sandy soils of the plateau surface have a low nutrient content that limits productivity, making the system highly sensitive to the nutrient removal effects of whole-tree harvesting and acid precipitation (Adams et al. 2000).

The Cumberland Plateau in Tennessee is also now considered to be a major hotspot of forestry-related, landscape-level change within the Southeast (Eilperin 2004). There has been considerable debate as to the rate and scope of forest change occurring on the Plateau and throughout Tennessee (Schweitzer 2000; Countess and Arney 2001; Pelkey and Evans 2001; Pelkey, Evans and Haskell 2001) and there exists a multitude of concerns relating to the impact of this landscape change on forest values. In this paper, I provide a summary of research conducted by the Landscape Analysis Laboratory at the University of the South that focuses on forest change on the southern Cumberland Plateau in Tennessee. After providing a description of the forest ecosystem associated with the surface of the Plateau and brief overview of landuse history, I review recent trends of forest loss in this region and discuss its associated ecological impacts and economic drivers. Finally I discuss the implications of this research to forest policy reform in Tennessee.

CASE STUDY: FOREST LOSS ON THE SOUTHERN CUMBERLAND PLATEAU

Plateau Ecosystem

The Cumberland Plateau represents the southern extension of the Appalachian Plateau and extends from West Virginia and Kentucky through Tennessee, terminating in Alabama. It is considered the western-most part of the Southern Appalachian region (SAMAB 1996), bounded by the Ridge and Valley Province to the east and the Interior Lowland Plateau to the West. In southern Tennessee, the topography of the Cumberland Plateau is flat to gently rolling. Where drainages have breached the highly resistant Pennsylvanian sandstones (Pottsville series) that make up the surface of the plateau, the less resistant Mississippian limestones which underlie the plateau have eroded to form extensive steep-sided coves that define the boundary of the plateau's surface (Fenneman, 1938). The soils of this region reflect their underlying substrate and this, along with topographic position, is responsible for the large compositional differences between the forest of the Plateau surface (hereafter referred to as plateau forest) and that of the coves (hereafter referred to as cove forest).

The plateau forest canopy is predominantly of a mixture of oak species (*Quercus prinus*, *Q. coccinea*, *Q. velutina*, *Q. alba*, *Q. stellata*) and hickory species (*Carya glabra*, *C. pallida*, *C. tomentosa*), as well as sourwood (*Oxydendrum arboreum*), black gum (*Nyssa sylvatica*), and red maple (*Acer rubrum*) (Ramseur and Kelly, 1981). The understory of the plateau forest is composed of a variety of woody shrubs including blueberries (*Vaccinium* spp.), wild azalea (*Rhododendron* spp.), and mountain laurel (*Kalmia latifolia*) along with a large number of grasses, sedges, and fall blooming composites (Clements and Wofford, 1991). Shortleaf pine (*Pinus echinata*) and Virginia pine (*Pinus virginiana*) are native to the plateau forest and tend to be disturbance-dependent, increasing in abundance after fires, agricultural land abandonment, road clearings, and mining events. Shortleaf is also common in shallow soil areas along south facing slopes and bluff edges. Pollen analyses from sediment cores indicate that the arboreal flora of the Cumberland Plateau in Tennessee has changed very little over the last 9500 years and that native pine has never been a major component of the Plateau forests (Delcourt, 1979). Loblolly pine (*Pinus taeda*) is not native to the plateau forest, but was introduced in the mid-1900s and has been planted abundantly in plantations since that time (Hinkle et al., 1993).

It can be shown from published floras for the Cumberland Plateau in southern Tennessee (Clements and Wofford 1991: Wolf Cove, Franklin County; Wofford et al. 1979: Savage Gulf, Grundy County), that less than 25% of the vascular plant species found in the plateau forest are also found in the cove forest. These studies also reveal that despite this dissimilarity, the plateau forest is just as diverse as the cove forest with plateau forest species representing 48% of the total flora in both study areas.

There has been a tendency in the literature to generalize about the forests of the Cumberland Plateau by lumping the plateau and cove forests together into what has been referred to as the "Mixed Mesophytic Forest Region" (Braun 1950, Hinkle 1993). Braun began this trend with the notion that the plateau forest constituted a "physiographic climax" that would somehow eventually shift to the mixed mesophytic (cove-like) "climatic climax" over time. This concept of a regional climax forest, such as originally espoused by Frederick Clements in the 1920s, is no longer considered valid today (Sprugel 1991). Nonetheless, it has contributed to the false impression that the plateau forest should somehow be more like the cove forest but is not currently manifesting this potential due to its history of human interaction and land use.

Upland plateau forest dynamics are driven to a large degree by limited soil resource availability (Hinkle 1989). This is in distinct contrast to cove forest dynamics, which are controlled to a greater degree by limiting light availability (Martin 1992). The soils of the plateau surface, being derived from the underlying sandstone, have a very high sand content. This condition makes these soils nutrient poor (low ion exchange capacity), drought prone and highly acidic with little buffering capacity (Francis and Loftus 1977; Mays et al. 1991). Most of the fine root matter within the plateau forest soil is located in the upper 5cm of the organic layer. This carpet-like mat of roots suggests that soil resource input (water and nutrients) is mostly coming from above through precipitation and litter turnover. In a study examining the potential impact of increased acid precipitation on cation-poor forest systems, Kelly (1988) found there to be an annual net loss of base cations (principally Ca^{2+} and Mg^{2+}) from two completely forested plateau watersheds (Cross Creek, Franklin County and Camp Branch, Bledsoe County) over a five year period. Kelly (1988) predicted that "in the absence of significant weathering and at current rates of export, exchangeable levels of soil Mg^{2+}, for example, would be substantially reduced in a matter of decades." Calcium has a lower availability than magnesium in plateau soils and Kelly (1988) found it had a higher degree of retention within the plant-soil system.

The high plant species diversity in the plateau forest can partly be attributed to the mosaic of habitat conditions created by the continuous variation in soil drainage and soil depth across the plateau (see Smalley 1982). Slow moving stream drainages on the Plateau create swamp forest habitats characterized by a red maple – black gum canopy and a variety of herbaceous species. Shallow depressions in the sandstone substrate can create small ephemeral wetlands that dot the plateau landscape. These bogs and ponds represent critical breeding habitat for plateau amphibians (Evans *unpubl. data*). In a floristic survey of wetland habitats on the Plateau, Jones (1989) found 368 species of vascular plants, 15 of which were considered endangered, threatened or of special concern in Tennessee. Most of these wetland areas are too small in size to show up on wetland maps such as those produced by the National Wetlands Inventory (Cowardin et al. 1979). Shallow soil areas and rock outcrops along ridges and bluff-lines also provide unique habitat for a variety of rare and endemic plant species and a suite of xeric species (Walck et al. 1996).

Both prehistorically and historically, fire has represented an important disturbance regime on the Cumberland Plateau in southern Tennessee. It is believed that natural and anthropogenic fires started by Native Americans have been a constant part of the plateau landscape for thousands of years (Hinkle et al. 1993). With the advent of European settlers and the railroad in the late 1800's and early 1900's, it is believed that fire frequency actually increased across parts of the Plateau (Strohmeier, *pers. comm.*). Into the mid-1900s and to the present, with the widespread policy of fire suppression, fire frequency has dropped dramatically. This may have contributed to a decrease in the native pine component of the plateau forest and may be contributing to a regeneration failure among certain oak species (Abrams 1992, Evans *unpubl. data*). Many of the woody plant species of the plateau forest manifest distinct adaptations associated with fire, such as root sprouts (sassafras, *Sassafras albidum*; black locust, *Robinia pseudo-acacia*) and root collar sprouts (oaks, *Quercus* spp.) (Del Tredici 2001). These same adaptations can promote the regeneration of original genetic individuals following logging events thus leading to less compositional change following a timber harvest as compared to cove forests where sprouting is less common (Evans *unpubl. data*). The sprouting nature of overstory and understory woody species on the plateau is one of the reasons for the extensive mechanical and chemical soil treatments that occur in association with site preparation for loblolly pine plantations on the plateau (M. Black *pers. comm.*).

It is believed that the high fire frequency on the Plateau may have limited the distribution and abundance of American chestnut (*Castanea dentata*), which was far more prevalent elsewhere in the Southern Appalachians (Hinkle 1989; White and Lloyd 1998). Chestnut disappeared from the plateau forests by the 1930s with the spread of the introduced chestnut blight. Starting in the 1980s, there has been a dramatic decline in American dogwood (*Cornus florida*), a once prevalent understory tree species in the plateau forest, due to the spread of the introduced dogwood anthracnose blight (Hiers and Evans 1997). Given the role that dogwoods play in mobilizing calcium, Hiers and Evans (1997) believe that their loss could further exacerbate the decline in available calcium in plateau forests and this may have implications for successful egg formation in breeding songbirds.

Other natural disturbance regimes associated with the plateau forest include ice storm damage, localized wind storm blow-downs, and southern pine bark beetle (*Dendroctonus frontalis*) outbreaks. Pine bark beetle outbreaks reoccur on a 10-12 year cycle on the Cumberland Plateau and epidemics have been more spatially extensive in recent years (Price et al. 1992).

History of Land-Use on the Plateau

The plateau forests have experienced considerable impacts from land use over the last 150 years. Due to the poor, infertile nature of the soils, original attempts by the first settlers to grow crops on the plateau failed and subsequent agricultural activity has been relatively limited (as compared to the extensive clearing of forests for agriculture on the adjacent Highland Rim and Ridge and Valley Provinces) with low intensity pasturing of livestock being the most common (Nicholson 1982). Free-range livestock grazing in the forest was a common practice throughout the plateau in the late 1800s and into the 1900s (Foley 1903). Coal mining during the 20th century - first shaft mines and wildcat mines, then strip mines in the 1950s and 1960s (Nicholson 1982) - resulted in locally intensive forest clearings in specific locations across the plateau (Hinkle et al. 1993).

Some residential and urban encroachment on forests has occurred near the larger established towns, particularly in the Monteagle-Sewanee area. Other forest clearing activity has been associated with the creation of roads, utility corridors and reservoirs. Deer on the southern Cumberland Plateau have been on the rise since their re-introduction in the middle part of last century (TWRA 1997). Locations on the Plateau that represent refuges from hunting, such as forests near residential areas, leased hunting lands, and state park lands, are starting to show signs of overgrazing by deer (Evans *pers. obs.*).

Selective harvesting of timber on the Plateau has been a widespread practice throughout the last 150 years. Given the relative accessibility of much of the landscape, it is not likely that any areas of the Plateau surface escaped logging activity during this period with some areas having had trees cut multiple times at varying levels of intensity. Clearcut timber harvesting has become a common practice on the Plateau since the 1960s (Strohmeier *pers. comm.*). Starting in the 1950's and through to the present, increased amounts of native forest have been converted to loblolly pine plantations consistent with the rise in chip mill activity in this general region (Draper 1999).

Despite what would appear to be a complex history of land-use on the Plateau, it is important realize two things from a conservation perspective: 1) Unlike in New England and other temperate deciduous forested areas in the world, the native forests of the Plateau represent the original forest (with the original intact soil structure) and have not regenerated following a history of agricultural usage; 2) This forest still exists in large unfragmented tracts.

Current Trends in Forest Conversion on the Plateau

The Landscape Analysis Lab at the University of the South used aerial photography, satellite images, and on-the-ground assessment to measure changes in forest cover between 1981 to 2003 across a seven-county, 614,000-acre portion of the Cumberland Plateau in southern Tennessee (Fig. 1). During this 22 year period, approximately 20% (95,000 acres) of the native forest was cleared or converted to other uses (Evans et al. 2002; Evans, Hollinghead and Haskell *unpubl. data*). The annual rate of forest conversion accelerated during this time period such that nearly as much forest was lost between 2000 and 2003 as was lost in the 16 years between 1981 and 1997 (Fig. 2). The highest rate of conversion to pine plantations occurred between 1997-2000. Between 1981 and 1990, conversion to pine plantations accounted for 64% of all conversion activity. However during the 2000-2003 interval, pine conversion accounted for only 10% of native forest lost. The majority of recently converted lands remain in an unmanaged or undeveloped state, characterized by exposed soils with a sparse cover of early successional species (Evans, Hollinghead and Haskell *unpubl. data*).

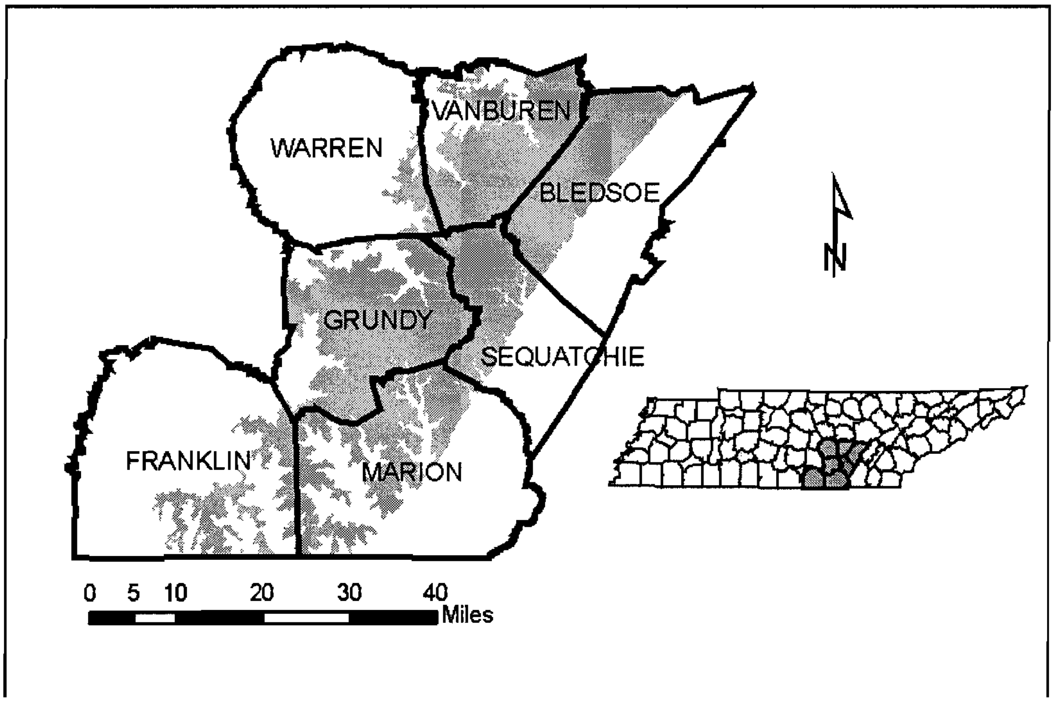

Figure 1. The 614,000-acre portion of the Cumberland Plateau spanning portions of seven counties in southern Tennessee that served as the study for the forest assessment studies conducted by the Landscape Analysis Lab.

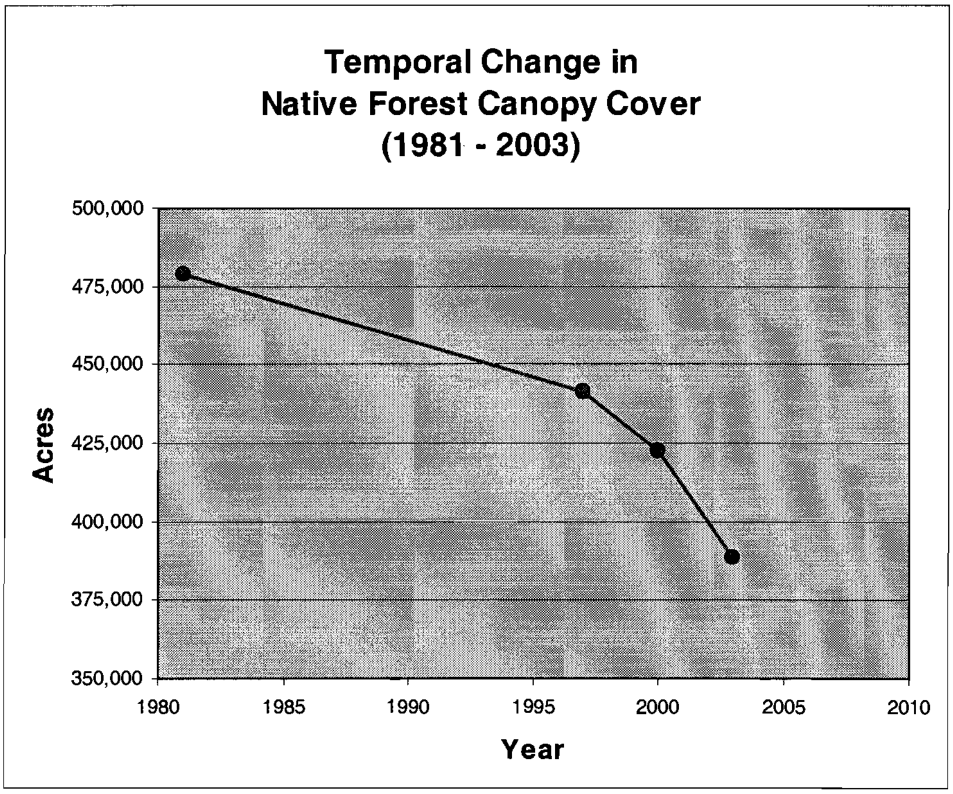

Figure 2. Temporal change in the area of native forest cover on the Cumberland Plateau surface in southern Tennessee. Rate of forest loss between 1981-1997 was -0.5%/yr as compared to -1.4%/yr between 1997-2000 and -2.7%/yr between 2000-2003.

The rate and magnitude of pine conversion and native forest loss varied across counties and watersheds within the study area. However, all counties showed a net loss of native forest, with Van Buren County being the highest. Pine conversion activity was highly clustered, causing a concentration of impact in certain counties and watersheds (Evans et al. 2002).

The trends in clearing/conversion of intact native forests for pine conversion were observed mainly on land parcels owned by forestry industry corporations that claimed to be compliant/certified with forestry industry standards for sustainable forestry practices. From 1997 to 2000, 90% of all native forest removal resulted from clearings that were greater than 40 acres in size (Forest Stewardship Council (FSC) certification limit) (Evans et al. 2002). Seventy percent of this native forest removal resulted from clearings that were greater than 120 acres in size (Sustainable Forestry Initiative® certification average clearcut size limit – the Sustainable Forestry Initiative® is a registered service mark of the American Forest and Paper Association).

On the Plateau, the primary use of clearcutting is forest removal, not the regeneration of hardwoods. Clearcutting is the first step in the conversion process from hardwood to pine plantation, agriculture or residential development. Clearcutting for hardwood regeneration increases the likelihood of future conversion to other land uses. Only 50% of land that was clearcut for this purpose in 1981 was still in hardwood by 2000 (Evans et al. 2002). Forest conversion on the Plateau is currently unidirectional process. Between 1980 and 2003 less than 2% of the land in pine plantation, agriculture of residential had been allowed to revert back to native hardwood (Evans, Hollinghead and Haskell *unpubl. data*).

Socio-economic Drivers of Forest Conversion on the Plateau

Land ownership data from 2001-2002 for the 614,000 acre Plateau study area described above revealed a very high level of land concentration (McGrath et al 2004; Gottfried *unpubl. data*). One percent of landowners held 52% of all land parcels over 10 acres in size. Fifty-seven percent of the land was owned by entities from outside of the county or a neighboring county. These non-resident land owners account for the vast majority of forest conversion described above. Thirty-eight percent of the land is owned by someone outside of the state of Tennessee. Timber companies own 19% of the Plateau study area while non-timber businesses own an additional 18%. Within the last 5 years there has been an accelerated sell-off of timber company lands such that today only one timber company (the Bowater Corporation) has holdings within the Plateau study area.

When owners are ranked by total acres owned in the study area, the largest ten percent of owners hold 78% of the area, while the largest 20% own 86%. Thus, land use change, and its corresponding environmental impact, originates from the actions of large landowners, many of whom reside outside of the area and of Tennessee (McGrath et al. 2004).

If appraised land value per acre (exclusive of improvements) is an indicator of development pressure, preliminary inspection reveals that most development pressure on parcels ten acres and above appears to occur on land near previously settled areas and near roads (Gottfried *unpubl. data*). Appraised value per acre of bluff sites, which can possess great scenic amenity values, so far appears highest in the Sewanee/Monteagle areas, not throughout the region. Whether the recent divestiture of corporate timber lands may lead to a development boom remains to be seen. For now however, the demand for residential land appears to be concentrated in certain areas (Gottfried *unpubl. data*).

In a 1999 survey (n=430) of non-industrial private landowners in Marion, Grundy and Franklin counties, it was found that 87% had no plans to convert to another land use in 10 years and a large majority of landowners were managing for non-timber values such as recreation, hunting or conservation (Brockett, Gottfried and Evans *unpubl. data*). Of those landowners managing for timber, 86% use selective harvesting methods. Of this same group, 60% said that private landowners should not have the right to do with their lands what they choose regardless of the impact on the environment (23% said they should be able to).

Ecological Impacts of Forest Conversion on the Plateau

Evans et al. (2002) found that forest conversion resulted in significant impacts on the diversity of bird communities on the Plateau. Pine plantations were shown to have the lowest bird diversity and had the lowest conservation value, as measured by independently-derived Partners in Flight (PIF) priority scores. The intact native forests had the next highest diversity and PIF conservation value. Native forests on the Plateau had some of the highest levels of bird diversity found anywhere in the forests of the south-eastern U.S., indicating that this region offers high quality habitat for forest-dwelling birds. Neither pine plantations nor residential areas can support the bird communities found in the native forests of the Cumberland Plateau. However, residential areas do provide habitat for several species that are found in no other habitat types on the Plateau. In addition, residential areas, young pine plantations, and thinned native forests all provide habitat for a few specialist bird species that require a more open or grassy habitat. Some of these specialists are also present in patches of natural disturbance in native forests. Evans et al. (2002) suggest that the species-rich bird communities of the Cumberland Plateau are more vulnerable to loss of bird diversity when subjected to intensive timber management than are bird communities with relatively low species richness in other regions such as boreal and sub-boreal forests.

In a study comparing the effects of whole-tree harvesting on the cation budgets of several forests throughout the United States, Johnson et al. (1988) found that a forest site on the Cumberland Plateau was one of the few sites studied where cation export from whole-tree removal greatly exceeded loss due to leaching. This was partly attributable to the large amount of stored calcium in the dominant plateau tree species. Federer et al. (1989) examined the effect of whole-tree harvest on change in percent total nutrient pool in six eastern US forest sites and found that the oak-hickory forest type near Oak Ridge, TN was the most sensitive to repeated harvests. They predicted that the combination of leaching loss and whole-tree harvest at short (40-yr) rotations could remove more than 50% of biomass and soil calcium in only 120 years. McGrath et al. (2004) examined the biogeochemistry of hardwood conversion to pine plantations on the Plateau. This study revealed that a considerable loss of calcium and other nutrients from the system occurs by the second rotation of pine. They suggest that this nutrient depletion process can seriously impact the productivity of future rotations of pine as well as potentially alter the species composition and reduce the long-term health of any native forest that is restored to lands previously dominated by pine plantations. Adams et al. (2000) note that there is a "serious need" for the creation of soil sensitivity maps for the Cumberland Plateau province in Tennessee so as to inform forestry decision-making.

Between 1998 and 2002, vast acreages of loblolly pine plantations on the Plateau were decimated by southern pine bark beetle (*Dendroctonus frontalis*) whose epidemic-level infestations occurred at unprecedented proportions (TDF 2002). Pine stands located on state recreation lands and owned by small landowners were also severely affected. The economic loss associated with this recent southern pine bark beetle (SPB) epidemic on the Plateau in TN has been estimated at over 100 million dollars (TDF 2002), in a region already considered to be one of the most economically depressed in the nation. The drought-prone, upland environment of the Cumberland Plateau is outside the native range of loblolly pine, a species adapted to bottomland, coastal plain environments (Perkins and Matlack 2002). Heavily stocked stands of loblolly pine (such as those intended for pulping) and loblolly stands that are stressed by limited water availability have been shown to be particularly susceptible to epidemic-level SPB infestations in which immature and healthy trees are killed (Lorio 1988). The presence of these large continuous monocultures of pine has greatly enhances the dispersability and outbreak intensity of SBP across the landscape (Perkins and Matlack 2002). Ecological models predict that the SPB range will expand northward in the coming decades and become more established in areas such as the Cumberland Plateau (which is currently on the edge of its range) as major epidemics in plantations become less inhibited by low winter temperatures (Ungerer et al 1999). All available evidence suggest that epidemic-level outbreaks of SPB are not going to go away in landscapes such as the Cumberland Plateau that are becoming increasingly dominated by pine plantation activity, putting into question the future sustainability of this enterprise.

Policy Implications

Given the clear impacts on forest sustainability and habitat loss resulting from forest conversion on the Cumberland Plateau, why has forest policy in Tennessee failed to detect or ameliorate these impacts. The proximate reasons for this include: 1) there is inadequate monitoring of forest ecosystems in Tennessee (Pelkey and Evans 2001); 2) there is no regulatory authority to enforce sustainable forestry practices; and 3) existing state conservation incentive programs are ineffective (Williams et al. 2003; Brockett, Gottfried and Evans 2004).

The ultimate reason, however, boils down to values. While Tennessee's forests are cherished by the people of this state for the myriad of values they provide (timber and wood fiber products, habitat for pollinators, places to hunt and fish, watershed protection, firewood, maintenance of soil fertility, splendid fall vistas, places for people to live, habitat for thousands of plant and animal species, hiking opportunities, and rural tourism), forest policy in this state has traditionally reflected only one dominant value -- wood fiber.

By disregarding this complex matrix of forest values and treating forests as crops, we promote the following within state government: 1) control of forest policy by the agricultural sector as promoted by a tight relationship between the forest industry, the state division of forestry and the state forestry school; 2) misuse and manipulation of science to justify economic agendas of large corporations (i.e. short term economic gain from wood fiber); 3) lack of consideration given to non-timber values from forests such as those important to local communities.

The simple fact of the matter is that we expect far more from a forest than we do from an agricultural field. In order to maintain the ecological goods and services that forests provide, it is necessary to treat forests as the complex biological systems that they are. If these systems are to function properly, their various parts must be kept in good working order. Tracking the ecological integrity, health, and sustain-ability of our forests requires that we have a comprehensive, scientific understanding of forest dynamics and that we develop rigorous processes of forest assessment throughout Tennessee to track forest change.

The protection and sustainability of Tennessee's forests require not only that land-use decisions impacting forests be directed by the best possible science, but also that we develop a renewed sense of public and private stewardship and responsibility within the state. Leadership on both of these fronts must begin with state government. We currently lack a comprehensive forest policy in Tennessee, allowing only the market to control the rate and intensity of timber extraction and forest clearing. Such a situation might be fine if all of our forests were indeed just a crop, but this view of forestry fails to protect the diversity of values that people have come to expect from Tennessee's forests.

On the Cumberland Plateau and throughout the state, forests are currently being impacted by a multitude of changes: urban development, conversion to pine monocultures, air pollution, and the invasion of exotic species. These changes are causing the degradation and loss of forest habitats and are associated with the local extinction of species within the state. Each forest ecosystem in Tennessee is unique and so are the subregional factors that currently impact these forests. For example, patterns of land-use change on the Cumberland Plateau are very different from patterns of land-use change in the Mississippi River region of West Tennessee. State-wide generalizations made over 10-year time periods by state government provide little value to Tennesseans who are concerned about what is happening right now in forests near their backyards (Evans et al. 2002). Computer mapping and remote sensing technology associated with Geographic Information Systems (GIS) has dramatically improved our ability to track the pulse of forest change in Tennessee (Evans et al. 2002, Lemoine et al. 2006). It is time for state government to step up to the plate and begin to take advantage of this technology for this purpose.

In Tennessee, the promotion of clear-cutting as the best silvicultural option ignores the tremendous ecological consequences that this activity can have on a landscape scale. Clear-cutting is not simply an aesthetic problem (as TN Department of Agriculture officials argue) but a serious ecological concern that can have major consequences for species habitats when applied to vast acreages. As has been presented in this paper, industrial scale clear-cutting and subsequent conversion of native hardwood forest to pine plantations has potentially resulted in significant declines in non-game wildlife habitat and soil fertility on the southern Cumberland Plateau.

Unfortunately, there are no biologists employed by the TN Division of Forestry, the agency assigned the responsibility of overseeing the sustainability of Tennessee's forests, and landscape-level ecological impacts on forests (such as are occurring on the Cumberland Plateau) are not being assessed by state government.

Leadership is needed within state government to develop a progressive forestry policy that is premised on the understanding that our forests are complex biological systems. Such a forest policy must be developed using the best possible science and should take advantage of recent advances in technology to track changes and monitor forest conditions. We need to have the involvement of scientists representing the broad range of forest-related disciplines from institutions throughout the state. Because each part of the state has its own unique set of problems regarding forest change and loss, we need a progressive forest policy that reflects the fact that land-use decision-making and forest sustainability is a local issue. This policy should recognize that small, resident landowners in Tennessee are typically not responsible for the major changes to forests occurring across the landscape at present. We need a progressive forest policy that employs both a carrot and a stick approach: establishing an effective set of enforceable regulations that ensure proper forest stewardship while protecting private property rights, and offering a creative array of incentives that foster protection of public values. We need a progressive forest policy that encourages and promotes forest sustainability as a vital part of economic rejuvenation programs in rural counties. Finally, we need state natural resource agencies empowered with the appropriate personnel and policies so that state government can effectively promote the ecological values of Tennessee's forests.

The forests of Tennessee and the Cumberland Plateau are at a crossroads. Profitable forestry practices, sustainable development and the protection of ecological values can go hand in hand if we work together within the state to make this happen. We have an opportunity to put in place policies that will protect our forests for future generations while respecting private property rights. We can make Tennessee a leader among Southern states in the new field of ecosystem-based forest management. Our state has the intellectual resources and natural capital to make this happen, all that remains now is the political will by elected officials.

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FOCUS ON THE FUTURE AT LAND BETWEEN THE LAKES

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Land Between The Lakes National Recreation Areas (LBL) completed an intensive study of all resources in December 2004 and developed a Land and Resource Management Plan (Area Plan) to direct management for the next 10-15 years. The Area Plan satisfies a requirement of the LBL Protection Act of 1998. Congress gave specific direction to LBL through its mission statement to protect and manage the resources of LBL for optimum yield of outdoor recreation and environmental education for the American people. In so doing, to utilize the demonstration assignment to authorize, cooperate in, test and demonstrate innovative programs and cost effective management; to help stimulate the development of the surrounding region; and to extend the beneficial results as widely as possible. The Area Plan is in line with our mission as it demonstrates innovative and cost efficient management. LBL completed this very complex document in less than two years, saving taxpayers millions of dollars. Although the Area Plan was developed under the 1982 planning regulations, the format of the plan follows the prototype of the new 2005 national planning regulations. The National Forest Service website displays LBL's Area Plan as an example for other forests to follow. However, its new format and measures may be confusing to some public interests who are accustomed to the older format. This Plan is a strategic document, a road map to where LBL is going. Documents are available online at ***http:// www.lbl.org***.

Beginning January 10, 2005, the Forest Service moved into the exciting time of implementation. Before looking to where LBL is going, a review of where we have been and what we have done to this point is needed. First development of a background planning document determined what change if any was needed in management of LBL's resources. Based on scoping for public concerns and their input to the background document, three major issues emerged where some changes were desired: recreation and environmental education; vegetation management; and special designations. A Vision statement describing future conditions in 10-15 years was created as the focal point for management. Four alternatives, different paths to the vision's destination, were developed and analyzed, following the National Environmental Policy Act regulations (USDA Forest Service 2004a).

The Area Plan's selected alternative highlighted nature watch areas, oak-grassland demonstration areas, emphasis on partnerships and cooperation with community organizations and other agencies, active forest and open land management, weaving environmental education into all programs and continuing LBL's role in the regional tourism field as a destination point.

Area-wide goals were identified to achieve LBL's vision and desired conditions (USDA Forest Service 2004b). They are 1) Prioritize and integrate projects to provide the greatest recreation, environmental education and resource benefits. 2) Emphasize partnerships with organizations and agencies. 3) Provide an environmental education message to every visitor. 4) Reduce erosion and improve riparian and watershed conditions. 5) Maintain or restore diverse habitats to support species viability and wildlife related recreation. 6) Export demonstration products. 7) Enhance dispersed recreation and environmental education and 8) Support national strategic goals. Each goal has several related objectives - concise statements of measurable desired results and expected levels of outcomes that the Area Plan is capable of producing in the next decade.

Examples of some objectives for the recreation and environmental education programs are for 80% of all special projects to have identified integrated benefits to recreation, environmental education and resource stewardship; to complete one interpretive project annually within nature watch and oak grassland areas; to reconstruct 10-15 miles of trail annually; and to address one user impact challenge annually through environmental education, such as responsible OHV use.

Natural resources objectives provide strategies and tools for management of the general forest and the core area land allocation. Twenty-five percent of LBL's land base remains as core areas, designated to receive passive management, to serve as monitoring baselines and offer semi-primitive experiences. Ecological diversity will be achieved through active management of the general forest and open lands with the aim of supporting and enhancing wildlife habitat, forest health and recreation and environmental education opportunities. Specific objectives over the next decade include increasing native warm season grass restoration another 750 acres; improving two watersheds towards fully and properly functioning condition, and decommissioning 10-30 miles of road. Objectives for active vegetation management dictate moderate changes in forest structure and age over the short term with more notable changes over the long term (Figs. 1 & 2).

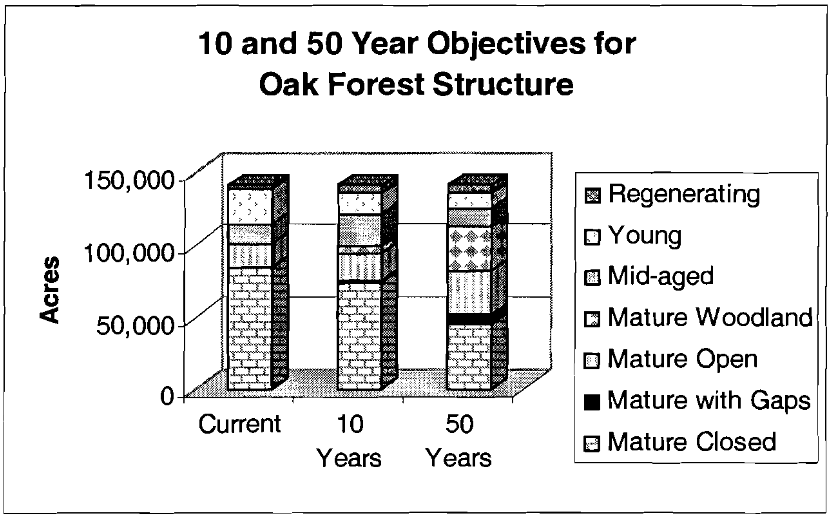

Figure 1. Active management of the mature oak forest will focus on increasing open and woodland type structure for the benefit of wildlife and recreation.

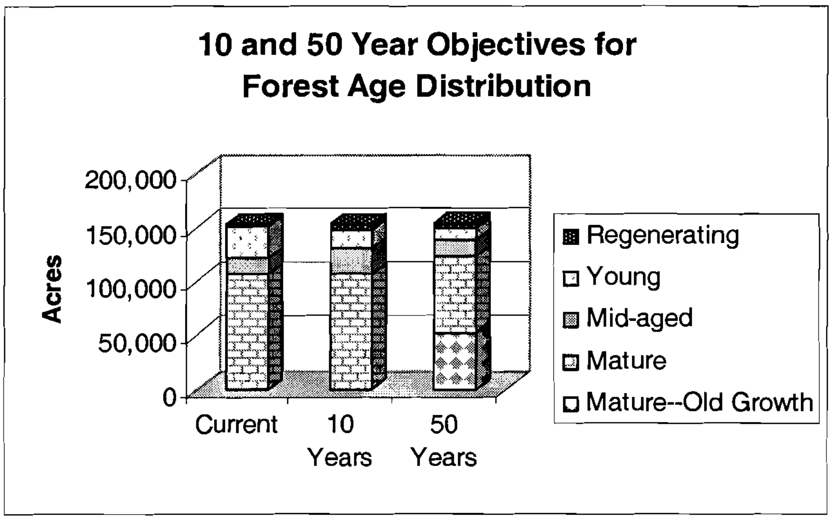

Figure 2. Mid-aged forests will mature slightly over the next 10 years with a large increase seen over 50 years. Young forest is expected to decrease. Old growth habitat will not be present during the life of the Area Plan but will increase within 50 years.

Mature forest with open canopy and a rich diverse understory of forbs and grasses supports species such as quail, prairie warbler, wild turkey and eastern meadowlark. Creation of 5000 acres of oak grasslands in Tennessee began this spring. Oak grasslands will offer many benefits not only to wildlife but to recreation and environmental education as well. Prescribed fires will help establish and maintain these conditions. Open areas and grasslands need frequent fire use, with a fire return interval as short as 6 years on some sites. The objective for prescribed fire calls for an average of 10,000 acres annually by the end of the first decade.

Beyond the Area Plan, there are other influences to LBL's management, manifested in budget allocations and expected annual accomplishments. Current national strategies are the Forest Service Chief's Four Threats, the National Fire Plan, the Healthy Forest Restoration Act and the national emphasis on stewardship and partnerships. Linked by the 8th goal of the Area Plan, current LBL management applies the principles of these national strategies. The Four Threats are: 1) Fire, Fuels and Forest Health; 2) Invasive Species; 3) Loss of Open Spaces; and 4) Unmanaged Recreation (USDA Forest Service 2005). Preserving and maintaining the health of the Nation's forests and grasslands is one of the top priorities of the Forest Service. Fuels build-up and change in species composition is subtle at LBL but risk to forest health and bio-diversity is a concern. An increase in fire use will be one of the more visible activities as the Area Plan is implemented, with a positive change in biodiversity and return of native vegetative communities expected. In 2005 LBL has burned over 2300 acres. Still, this is small acreage relative to other forest units. Fire risk to wildland urban interface areas is a national concern. Roughly 20,000 communities are located in or adjacent to over a billion acres of rural/urban American that are vulnerable from wildfire. Fortunately LBL does not have a high risk of wildland urban interface. Perhaps the key role for LBL in the National Fire Plan and Healthy Forest Restoration Act is in its environmental education programs to interpret fire use as a management tool for sustaining habitats and promote the Fire Wise program. LBL has the unique opportunity to reach 2 million visitors each year with its environmental education. Visitors would take home lessons about the role of fire. Lessons learned may save someone's home in the future.

Recreational activities provide an easy transportation vector for invasive species. Campers, boats, OHV and livestock make LBL vulnerable to invasive species introduction. LBL's invasive species list includes Johnson grass, kudzu, Japanese stiltgrass, Sericea lespedeza and many others. Management of non-native species and invasive species is be made through open land management and native grass restoration.

With 300 miles of undeveloped shoreline and 170,000 acres of Federal administrative lands, LBL does not lack for open spaces (Peavy 2004). The Area Plan concluded LBL is over 80% forest cover. LBL's mature and future old growth forests will support many species dependent on unfragmented forest cover. The Southern Region, however, has a high density of population with highly fragmented forests and large occurrence of wildland-urban interface. The density of regional populations results in high visitation to LBL in search of open space. LBL has a high use ratio (12 visitors per acre) compared to that national average of 1:1. LBL is the most visited site in Kentucky and third most visited in Tennessee.

The fourth threat, unmanaged recreation, is closely policed at LBL. LBL monitors conditions of its natural resources and guards against negative impacts resulting from high recreational use. Well managed recreational facilities and activities carefully weighed and balanced with wise use of natural resources reduce the occurrence of this threat at LBL. This allows the continuation of high visitation.

LBL's goal of expanding partnerships falls in line with the national emphasis on partnerships and stewardship. Developing partnerships with other agencies and organizations reduces costs, increase efficiencies and more importantly, results in good land management on the ground. The new oak grasslands and nature watch areas are in need of partnerships to achieve LBL's goals and objectives and to monitor trends toward achieving the LBL vision.

Biomass utilization is of high national interest, with grants available to pursue marketing and alternative energy projects. Biomass utilization reduces fuels treatment costs, reduces carbon emissions, provides alternative energy and can be an opportunity for community economic development. A market for this product is desperately needed in this region if LBL is to actively manage its vegetation and achieve its age and structure objectives.

The focus is on the future of LBL. The planning team did an outstanding job on the Area Plan and developing its vision for the future. Join LBL in partnership now for exciting times ahead.

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ENVIRONMENTAL EDUCATION AND THE CENTER FOR EXCELLENCE FOR FIELD BIOLOGY: THE PAST, PRESENT, AND FUTURE

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ABSTRACT. The mission statement of The Center of Excellence for Field Biology at Austin Peay State University (APSU) in part is "to bring together scholars from various biological disciplines to conduct research on biotic communities in the Land Between The Lakes (LBL) region, Tennessee, and adjacent eco-regions. These studies continue in the Tennessee-Kentucky and adjacent eco-regions, as well as experimental programs that contribute to the development of general ecological theory, definition of biodiversity, and applied biological science, and community outreach through environmental education programs." Past, present, and future environmental education projects are highlighted. These projects include collaborations with Center Principal Investigators as well as organizations such as the Cumberland River Compact, The Nature Conservancy and the National Geographic Educational Foundation. Additionally, projects supported and funded by agencies such as The Tennessee Department of Agriculture, Non Point Source Pollution Prevention and The Tennessee Department of Environment and Conservation are included.

CONTRIBUTED PAPERS

SESSION 1: BOTANY

Saturday, April 2, 2005

Moderator:
Laurina Lyle
Austin Peay State University

VEGETATION RESULTS OF 1792-1794 AND 1812-1815 LAND SURVEYS IN EAST TENNESSEE

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ABSTRACT. Metes and bounds survey records from the eighteenth century and early nineteenth century in East Tennessee have been used to reconstruct forest composition. Comparisons have been made in similar topography across decades, within one data set between geographic areas, and the early data is compared with fairly modern forest inventory data. Early chronologic comparisons reveal forests surprisingly similar in these two independent samples. The forests were largely comprised of oak species. A comparison of tree percent in the Cumberland Mountains versus Ridge and Valley reveal more mesophytes and less oak cover in the Mountains than in the Ridge and Valley. Ridge and Valley black and post oak percentages were as high as those of white oak. The reasons for this are not known. Comparisons of tree percentages with fairly modern forest inventory data reveal losses of mesophytes and oaks due to changes in land use, increases in pine, poplar and cedar due to disturbance (and pine planting), and loss of chestnut due to disease.

INTRODUCTION

Knowing the causes of species and community distributions using known environmental and historical information is an objective of the vegetation ecologist (Mueller-Dombois and Ellenburg 1974). While the geographic range of a species (as a tree) may be well known (Little 1971), its importance within its range varies by site/community (Martin 1978) and both range (Thompson et al. 2000) and local importance change with e.g., climatic change (Iverson et al. 1999). Land use changes have disrupted local distribution patterns to the extent that land surveys have been used in reconstructions. The rectilinear surveys of the congressional land survey have been used extensively (Thrower 1966, Shanks 1953). There are some state surveys used in this way (as De Selm 1994). Metes and bounds surveys, with very little chronological nor geographic pattern between entries and inadequate knowledge of location of starting points, have resulted in less use. However, such surveys constitute a source of untapped information about plant species or species groups and plant communities of the survey periods (De Selm 2003).

This paper reports vegetation composition results from land surveys of the periods 1791-1795 and 1809-1815 and compares the latter with survey records from 1807-1810 (De Selm 1995). These are compared with more modern inventory results. Similar studies of East Tennessee areas are De Selm (1995, 1997, 1999, 2001, 2003), and De Selm and Rose (1995).

Character of the Surveyed Areas

The Jefferson County of North Carolina land sales is an area believed to include Greene and Hawkins counties of the Territory South of the Ohio River (this unit created in 1790) now the modern Tennessee counties of Sevier, Cocke, Greene, Hawkins, Hamblen, Grainger, Jefferson, Knox, and parts of Union, Blount, Hancock and Claiborne counties (Fig.1, Foster 1923). The Fifth District included all of modern Claiborne, and Union counties, most of Grainger, Jefferson, and Knox counties and parts of Anderson, Campbell, Hamblen and Hancock counties. Surveyed areas included part of the Cumberland Mountains and the central Ridge and Valley of Tennessee. Elevations rise above 3500 feet in the Cumberlands, they rise in the Ridge and Valley above 3200 feet on Clinch and Powell Mountains, less on other ridges and fall 800-1100 feet in the valleys (Fenneman 1938).

Topography of the Cumberlands is that of a few high mountain ridges with many lower ridges and valleys extending in all directions—these are underlain chiefly by Pennsylvanian sandstones and shales. Ridges and valleys of the Ridge and Valley Province extend northeast-southwest and are underlain by Silurian, Ordovician and Cambrian dolomites. Shales weather to rolling, knob or valley topography and limestones weather to valleys (Rodgers 1953, Hardeman 1966).

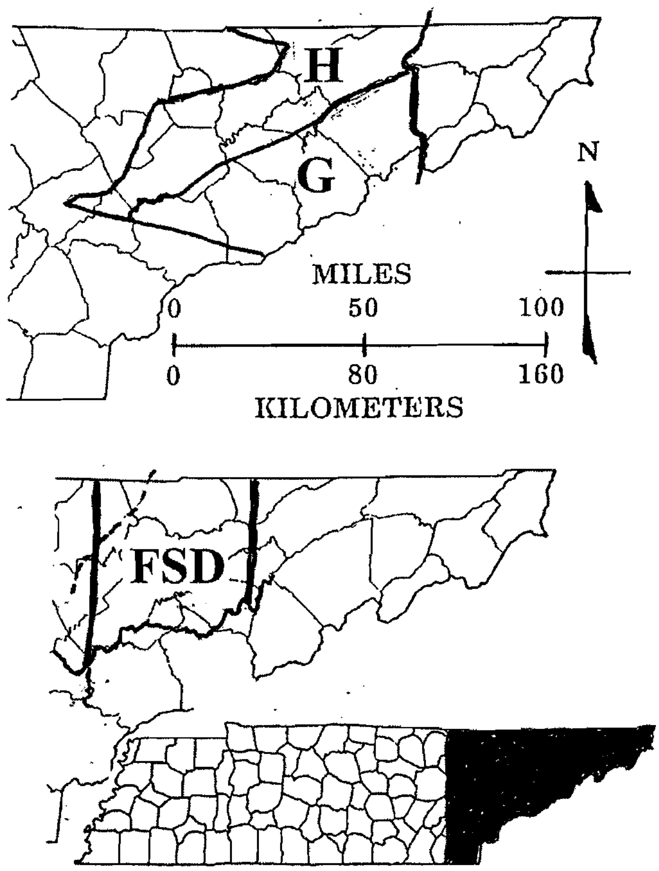

Figure 1. Modern base maps of East Tennessee showing Greene (G) and Hawkins (H) counties of 1790 (Foster 1923) and the Fifth Survey District (F) established in 1806 (Crouch 1968) – dashed line is the eastern edge of the Cumberland Mountains. Boundaries are somewhat approximate.

Soils of the Cumberlands are mainly Dystrochrepts and are generally steep, rocky, sandy, may be deep or shallow and are usually acid. Soils of certain Valley ridges are similar but soils of other ridges and valleys are Hapludalfs, Paleudults and Eutrochrepts and vary from shallow to deep, stony or less stony, loamy or clayey and arid or calcareous. Along major and minor streams, floodplain and terrace soils may be nearly level, fertile, and moist or poorly drained. They are Paleudults, Haplaquets and Haplaquents (Springer and Elder 1980).

The climate is warm temperate (Dickson 1960) but tornado winds (Vaiksnoras 1977), winter and spring floods occur (Tennessee Valley Authority 1957) and droughts during the growing season are common (Safley and Parks 1974).

The flora of the area is well known (Chester et al. 1993, 1997). General descriptions of the vegetation are found in Braun (1950), De Selm (1984), Hinkle et al. (1993), Stephenson et al. (1993), Martin (1971, 1978), and Martin and De Selm (1976). Barrens and glades examined by De Selm (1993) and Finn (1968). Upland forests were of oak, pine, or cedar types, ravine forests were dominated by mesophytic taxa and floodplains and flat terraces were forested by various wetland taxa.

Human History of the Area

Shortly after the end of the last cold phase of the Pleistocene, Native Americans entered the area. The first hunter-gatherers were followed by civilizations which established villages, fields and cemeteries but moved these periodically. Habitat destruction occurred near villages which were chiefly along major rivers, but hunters and herb gatherers ranged widely and fire was used which modified terrace and some upland habitats (Hudson 1976, Lewis and Kneberg 1958, Williams 1989). Euroamericans entered the areas about 1780 after treaties with the Native Americans made land available (Folmsbee et al. 1969). Logging and drainage of bottoms was carried out to make land available for agriculture. Most slopes were logged at least lightly for local use, stock was turned into the woods and spring fires were set in the woods to increase forage (Killebrew et al. 1874, De Selm 1993). Surveying preceded, accompanied and followed settlement. Fifth District deeds were registered in Knoxville.

Nature of the Records and Methods

Just preceding and during the surveying periods, counties were established although their boundaries may have been imperfectly known: by the State of North Carolina, Washington in 1777, Green(e) in 1778, and Hawkins in 1786 (Foster 1923). In 1789 the State of North Carolina deeded its western lands to the federal government and the 1790 administration of the Territory South of the River Ohio was functioning (Giddings 1926). In 1792, Jefferson County was established by the Territory (Foster 1923); however, on General Daniel Smith's 1794 map, "A map of the Tennessee government" no county boundaries appear (Wells 1976). Deeds/grants from the Grant Book of 1792-1794 (actually 1791-1795) (Douthat 1981) locate the deeds in various ways: 1791-1793 in the State of North Carolina and/or in the Territory south of the River Ohio and in the North Carolina or Territory proclaimed county of Jefferson and in the North Carolina proclaimed counties of Green or Hawkins. During the period 1793-1795 deeds are almost all stated as located in the State of North Carolina in the counties of Green or Hawkins. Apparently, proclaimed boundaries (but probably not surveyed boundaries) of Jefferson County overlapped with the previously proclaimed (but probably not surveyed) boundaries of Green and Hawkins counties. The land was subject to rampant land speculation and probably overlapping survey fraud (Jones 1968).

Those surveys from the 1800s were from the Fifth Tennessee Survey District, established in 1806, which lay between the Tennessee and French Broad rivers to the south and the Kentucky border (Crouch 1968, Figure 1). The "1812 Survey Book for the District" was actually for the period 1809 to 1815 and was found in the Special Collections of the Library of the University of Tennessee, Knoxville. The book was 257 pages, handwritten on both sides of each page (Anonymous 1809-1815).

Surveys were of the metes and bounds type. Points of origin were usually an edge or corner of a previous survey. Surveying was usually done from tree to tree but some stakes or "pointers" were used instead. Traverses were usually in cardinal directions, or sometimes a specified angle from north, or sometimes followed the topography or an earlier marked survey line. Distances were in poles or chains and links—it is likely that both 33 and 66 feet chains were in use (Rose 1993). Distances between trees were usually so large that sequential trees only occasionally fall in the same community. No tree diameters or point-to-tree distances are in the records. The precise present location of the surveys is unknown—there has been no attempt to locate survey lines on the ground. Vegetation traversed during surveys, sometimes referred to as vacant land, was not specifically referred to as forest, but it is presumed to have been largely forest including a few trees at the edges of "improvements" (fields, farm building lots).

Topographic features reported were rivers, creek branch, spring, banks of streams/rivers, head (of stream) draft, island, pond. Upland features were mountain, ridge, knob, clift (cliff), gap, sinkhole, dry valley, bluff, hollow, salt peter cave, and buffalo wallow.

Man-made features in the Fifth District surveys were improvement, field, plantation, orchards, old still house, and McBees Ferry, transportation features were path, wagon road, great road, Cheek's crossroads, Kentucky Road, Natchee Road. Other surveys seen were the Henderson and Company line, an old Indian boundary line, the 1000 acre survey of Stokley Donalson and the Walker line. These are in addition to the many smaller private survey/ownership lines to which the new surveys were adjacent. Man-made features reported in the 1700s survey lines were stakes, marked trees, an old Indian camp, a schoolhouse place, a path, a lane, post road, "rodehouse," lead mines, a crossing at a forge and Kelso Mill (creek).

Most survey place names are still to be found on modern 7.5-minute topographic maps and in the gazetteers (Fullerton 1974, U.S. Geological Survey 1991). Some exist in modified form as Coxes Mill Creek = Cox Creek. Other local place names as Roddy's Ferry or Shallowford Place have disappeared. The large number of landscape feature names in the surveys indicates that the surveyors and first settlers gave names to places immediately and then continued using these names for land features. Their persistence into the twentieth century suggest continued use by custom and those necessitated by their presence in legal descriptions of property lines.

Survey trees were identified to the best of the surveyors' ability and the current state of understanding. They are variously described as a sapling, small, young, a spout, a grub, a bunch of, large, double, forked, dead, a stump, fallen down, sloping (leaning) marked or marked with chops or letters or burned with letters. A few words were illegible and abbreviations often used were P = pine, S tree = sugar tree = sugar maple.

The 1700s records of surveys included the grant date and number of the State of North Carolina and were granted by any of three governors: Richard Caswell, Richard R. Spaight or Alexander Martin. There are 93 grants surveying to 311 tree stems (bunches of stems were counted as one).

The Fifth District surveys numbered 460 with 2944 trees. Survey numbers were Jefferson 157, Grainger 153, Knox 59, Claiborne 49, Campbell 31, Anderson 7 and Sevier County 4. Data from Anderson and Sevier counties have been combined with those from Knox County. Surveyors were Robert Armstrong, John Brown, Joseph Cobb, Walter Evans, William Hagehead (Hogshead?), Joseph Hart, Thomas McCuiston and Thomas Patterson.

Stakes were used at some corners in both sets of surveys; in the Territory set, they numbered 141 and in the Fifth District they numbered 481—both represent considerable loss of tree-presence information.

RESULTS

Compilation of the Fifth District 1812-1815 land survey tree presence records by county permits comparison of the data with records from earlier Territory surveys there (Douthat 1981) (Table 1). Between the two sets of surveys, 20 taxa are in common. Mostly the percentages of occurrence are similar. Slight differences may represent differences in sample size, or sites sampled. The substantial percentage differences in the two survey periods in pine (decline) and black oak (increase) may represent pine removal from a widespread vegetation type and relative increase in black oak (and posted oak and hickory). The unusual high (1812-1815) black to white oak ratio will be discussed later. Change (loss) of *Quercus* spp. may simply represent more knowledgeable, later surveyors.

Comparison of the early land surveys with that of the Tennessee Valley Authority (1968) showed increased importance of pine, cedar and poplar which are invader species with disturbance (Burns and Honkala 1990), and with significant areas of old field locust and sassafras-persimmon types. Pine is also planted. Modern oak forest loss—tree percentages totaling 25.7 when present, contrasts with early survey percentages totaling 53.0 and 60.6 percents (loss of oak forest acreage to development especially agriculture).

Compilation (Table 2) of the tree percentage in the Fifth Survey District data, made first by county, revealed that the data of several important tree species from Campbell and Claiborne counties were similar and the data from Grainger, Knox and Jefferson were similar. The data from these two sets of counties were pooled separately. Differences by species vary by as much as 16 percent (post oak). Large differences between the sets (5-10 percent) occur for sugar maple, hickory, beech, ash, poplar, pine, and white, post and black oaks. In several other taxa, as buckeye and hornbeam and perhaps 10 other taxa the differences are smaller. Clearly, the surveying was carried out in different vegetation.

Table 1. Percentage composition of surveys in the Territory 1792-1794 (Douthat 1981) and Jefferson County Fifth District 1812-1815 (Anonymous 1809-1815), and Tennessee Valley Authority 1968.

Taxa	Surveys 1792-94	Surveys 1812-15	Inventory TVA 1968[1]
	Numbers of Stems: 311	Numbers of Stems: 754	
	Percent		
Acer rubrum, maple, red maple		<1	
A. saccharum, sugar maple, *A. nigrum,* black maple	<1	<1	2.7
Carya spp., hickory	8.7	12.3	11.9
C. ovata, white hickory	<1		
Castanea dentata, chestnut	1.0	3.1	
Cornus cf. *florida*, dogwood	3.2	2.8	
Fagus grandifolia, beech	1.9	<1	1.9
Fraxinus, spp. ash	1.6	<1	
Gleditsia triacanthos, honey locust	<1		3
Gleditsia sp./*Robinia* sp. locust	<1	1.0	3.0 area[3]
Juglans spp., walnut	1.0	1.5	
J. nigra, black walnut	1.9	<1	2.1
Juniperus virginiana, cedar			4.4
Liriodendron tulipifera, poplar	1.9	1.6	4.3
Morus rubra, mulberry	<1		
Pinus spp., pine	21.4	20.0	27.2
Platanus occidentalis, sycamore	<1	<1	
Prunus sp., plum	<1		
Quercus spp., oak	3.8	<1	
Q. alba, white oak	14.5	12.2	3.8[2]
Q. falcata, Spanish oak, southern red oak	<1	<1	
Q. prinus, chestnut oak			10.2
Q. rubra, red oak	1.3	1.0	
Q. stellata, post oak	21.7	25.1	
Q. velutina, black oak	10.7	11.9	
Q. velutina, Q. rubra, Q. falcata, Q. coccinea, black northern, southern red, scarlet oaks			11.7
Sassafras albidum, sassafras			2.0 area[3]
Tilia cf. *heterophylla*, lynn, linden	<1	1.2	
Ulmus spp., elm, black elm	1.0	<1	5.0 area[3]

[1]Percentage data excludes 0.7 percent non-merchantable species stems and 6.4 percent cull trees.
[2]May include *Q. stellata*, post oak.
[3]Commercial forest area: locust type, sassafras-persimmon type and elm-ash-soft maple type.

Table 2. Percentage composition of surveys in the Fifth District 1807-1810 (De Selm 1995), 1810-1815 Grainger- Knox- Jefferson counties and Campbell and Claiborne counties (Anonymous 1809-1815) and inventories as Claiborne County (TVA 1960) and Grainger-Hamblen-Hawkins-Jefferson counties (TVA 1968).

Taxa	Surveys			Inventories	
		1812-1815			
	1807-1810	Grainger-Knox-Jefferson	Campbell-Claiborne	Claiborne 1960	Grainger 1968
Acer negundo, box elder	<1	<1			
A. rubrum, *A. sacharinum*, maple	<1	<1	2.7		5[4]
A. saccharum, sugar maple, *A. nigrum*, black maple	2.8	1.4	7.2		2.7
Aesculus flava, buckeye	<1	<1	1.4		
Carpinus caroliniana, hornbeam	<1		1.4		
Carya spp., hickory	11.3	12.8	8.6	12.4	11.9
C. ovata, white, shagbark hickory		<1	<1		
Castanea dentata, chestnut	1.9	3.3	2.5	<1[1]	
Celtis sp., hackberry	<1	<1			
Cercis canadensis, redbud	<1				
Cornus cf. *florida*, dogwood	3.7	3.5	5.1		
Crataegus sp., thornbush		<1			
C. sp./*Viburnum* sp., hawtree		<1			
Diospyros virginiana, persimmon	<1	<1			2[5]
Fagus grandifolia, beech	4.0	2.1	15.1	3.6	1.9
Fraxinus spp., ash	2.2	1.3	6.8		5[4]
Gleditsia sp./*Robinia* sp., locust	<1	1.0	<1		
Juglans spp., walnut		1.0	<1		
J. cinerea, white walnut	<1	<1	1.1		
J. nigra, black walnut	2.2	1.0	<1	1.5	2.1
Juniperus virginiana, cedar	<1	<1	1.1	2.5	4.4
Liquidambar styraciflua, sweetgum		<1			
Liquidambar/*Nyssa* sp., gum	<1	<1	<1		
Liriodendron tulipifera, poplar	3.4	3.0	8.1	7.0	4.3
Magnolia acuminata, cucumber	<1	<1	<1		
Morus rubra, mulberry	<1	<1	<1		
Nyssa sylvatica, black gum	<1	<1	1.4	1.9	
Ostrya virginiana, ironwood	<1	<1	<1		
Oxydendrum arboreum, sourwood	<1	<1	1.4		
Pinus spp., pine	6.7	8.3	1.8	7.3	27.2
Platanus occidentalis, sycamore	<1	<1	<1		
Prunus spp., cherry	<1	<1			
P. spp., plum	<1	<1			
Quercus spp., oak	<1	<1			
Q. alba, white oak	14.9	15.2	19.4	10.2[2]	3.8[2]
Q. falcata, Spanish oak	2.3	1.7	1.8		
Q. marilandica, blackjack oak	<1	<1			
Q. prinus, chestnut oak	<1	<1	<1	10.6	10.2
Q. rubra, red oak	<1	1.0	2.5		
Q. stellata, post oak	15.4	18.0	1.8		
Q. velutina, black oak	16.7	20.1	8.6		

Taxa	Surveys			Inventories	
		1812-1815			
	1807-1810	Grainger-Knox-Jefferson	Campbell-Claiborne	Claiborne 1960	Grainger 1968
Q. velutina, Q. coccinea, Q. rubra, Q. falcata, black, scarlet, northern and southern red oaks			34.2	10.8	11.7
Ribes sp., wild currant			<1		
Robinia pseudoacacia, black locust				3.5	3[6]
Sassafras albidum, sassafras	<1	<1			2[5]
Tilia cf. *heterophylla*, lynn	1.3	<1	1.1		
Tsuga canadensis, hemlock, spruce/pine	<1		<1	1[3]	
Ulmus spp., elm, black elm	1.2	<1	2.0	5[4]	
U. americana, white elm			<1		

[1]Cubic feet volume.
[2]May include post oak.
[3]Percent commercial forest area, hemlock-hardwoods percent.
[4]Percent commercial forest area of elm-ash-soft maple type.
[5]Percent commercial forest area of sassafras-persimmon type.
[6]Percent commercial forest area of black locust type.

Comparison of the Campbell-Claiborne data and Grainger-Knox-Jefferson counties data of the Fifth Survey District in 1812-1815 with that from the District data from 1807-1810 (Table 2, data from De Selm 1995) reveals fairly large similarities in 37 species percentages between the 1807-1810 survey data and the Grainer-Knox-Jefferson data from 1812-1815. This suggests that both sets of surveys were through similar vegetation. Stream names were used to approximately locate surveys in the 1812-1815 set. Those names indicated that indeed the Grainger County group were from the Ridge and Valley and the Campbell-Claiborne set came from the Cumberland Mountains.

The taxonomic composition of the two sets of surveys was very similar; 80 percent of the names are the same on the two surveys of 1807-1810 versus 1812-1815 (Grainger-Knox-Jefferson counties) in spite of the time, and different locations, and surveyors involved. Percentage differences within a "species" varied from none or slight (both <1 percent) to 3.4 percent.

Comparison of the 1812-1815 Campbell and Claiborne counties survey records with the TVA (1960) is instructive (Table 2). The TVA records were based on 150 one-fifth acre plots distributed throughout the forest area of Claiborne County in 1958. Higher percentages in the 1968 report compared to the 1812-1815 surveys are considered an increase proportion as in pine and locust which are both invader-increasers after disturbance (Smith 1968, Burns and Honkala 1990). The "increase" in hickory may be the result of its being selected against during logging because of the mechanical properties of the wood or the absence of a local hickory wood-using industry. The "increase" in chestnut oak probably represents modern sample placement on ridges where there are still forests compared to earlier surveying mainly in valleys—potentially good agricultural land. The "decreased" percentages of chestnut and elm represent disease effects (Hepting 1971). The overall loss of beech and oaks (less chestnut oak) represent conversion of this land to agricultural and other uses.

Comparison of the 1812-1815 survey records for Grainger, Knox, and Jefferson counties with the TVA (1968) inventory of forests of Grainger, Hamblen, Hawkins and Jefferson counties reveals some trends. The large "increase" in percentage of cedar and pine are to be expected as a result of forest disturbance (Burns and Honkala 1990, Smith 1968). The "increase" in chestnut oak is doubtless due to modern sample placement in remaining ridge forests. The low but significant landscape forest type area of black locust and sassafras-persimmon types also indicates the occurrence of successional-disturbed areas. The area of elm-ash-soft maple is in part river edge forest not previously sampled, and successional vegetation following logging of mesic forests. The elm fraction has lost American elm, especially, as the result of disease (Hepting 1971) with replacement by red and winged elms. Apparent "decline" in percentage of beech, white oak, and the red oak group (black, scarlet, northern red, southern red and Shumard) are the result of the conversion of mesic and submesic forest sites to agricultural uses. The absence of reported chestnut is the result of losses due to chestnut blight (Hepting 1971).

Results of Fifth District surveys in Campbell and Claiborne counties versus Grainger, Hamblen, Hawkins, and Jefferson counties show lower percentages black and post oaks and higher percentage mesophytes as sugar maple, buckeye, beech, ash, linden and poplar in the former. The total percentage mesophytes is 2.7 x higher in the rough topography where most soils are rocky and sandstone derived. The pine percentage is lower and the white oak percentage is slightly higher than in the Ridge and Valley samples (Grainer, etc. counties). Oak forests, especially white oak forests, and mixed mesophytic forests are both common in the Cumberlands (Hinkle 1975, 1989, Hinkle et al. 1993).

Non-Forest Observations

In the Territory surveys a marsh is recorded in Greene County on the French Broad River on lands deeded to Hugh Kelso—the marsh was nearest the "Shield's farm". In Greene County on an Adam Meek deed, a "stake" in a glade on Mossy Creek 40 poles from "Johnsons lines" was recorded. In Hawkins County, in a James Lea deed, "in the Newell Valley beginning near Campbell Lane on a bald hill. . . ." Newell Valley is not a name in present map usage (U.S.G.S. 1990) and it is not known whether it is a settler-cleared hill or a pre-settlement bald hill. In Greene County on a deed to Thomas Foullen the survey begins, "on the south side of Clear Creek in the barrens . . . beginning at two post oaks. . . ."

In the Fifth District surveys, vegetation presumed to be thickets (shallow soil or a fairly recent disturbance) were recorded as a hickory bush on the Richland Knobs in Grainger County and pine bush on Flat Creek in Knox County. Barrens were recorded, "south of the Richland Knobs" in Grainger County, "on the south side of the Holston River about a mile and a quarter from Danton Springs" in Grainger County, and "northwest of Dumplin Creek" in Jefferson County. The place name Danton Springs is not in current usage in Grainger, Hamblen nor Union counties (Fullerton 1970).

Marshes (De Selm in progress), glades and barrens (De Selm 1993) are known from studies of present-day vegetation and are thought to have been part of the pre-settlement landscape of the Ridge and Valley of East Tennessee.

DISCUSSION

Examination of species/species group presence in Tables 1 and 2 indicates that surveys of both the Territory and Fifth District were made in several kinds of topography: wetland, mesic, xeromesic and xerophytic tree taxa are included. The survey line descriptions also use lowland and upland topographive descriptors. The low percentages of box elder and sycamore indicate that, while surveys sometimes started at river or creek banks, and crossed creeks, few surveyed much distance in the less useful flood zone although creeks and rivers sometimes because parcel boundaries. Oak percentages total in the Territory surveys near half; in the Fifth District surveys at a little over a third to over half in the two groups of counties. Oak-hickory-chestnut percentages totals range from nearly half to nearly three-fourths of the totals. In the Territory surveys, the absence of chestnut oak, black gum and sourwood indicates little surveying of xeric ridgetops (Table 1). Similarly, in the Fifth District surveys these three taxa total from <1 to 2.8 percent in the two county groups (Table 2), again arguing for few surveys on the most xeric ridgetops. Pines commonly occur in ridgetop forests and in disturbed areas and the borders of glades and barrens (Martin and De Selm 1976, Burns and Honkala 1990, De Selm 1976); the paucity of apparent ridgetop surveys, disturbed vegetation and glades and barrens argues for pines occurrence in forests of shallow to deep soil on more gentle topography.

Multiple Stems Per Survey Point—Possible Communities

The original survey data from both the Territory and Fifth District (78 percent sample) was examined for multiple stem or multiple species occurrence at the same survey points. White oak was mentioned with itself once or twice 21 times in the combined surveys, with black oak 19 times, with hickory seven, with pine five with sugar maple four, and other taxa fewer times. Black oak occurred with itself 25 times, with hickory 17 times, with post oak seven times, with pine twice, and with other taxa less frequently. Post oak occurred with itself 20 times, with black oak 14 times, with pine 10, with hickory five, and with white oak twice. (Single trees at corners were most common. Black and post oaks occurred alone at 218 and 98 corners, respectively.) Red oak occurred with itself and with hickory each twice and with a few other taxa. Spanish (southern red) oak occurred with other taxa a few times. The hickories occurred in twos or threes together 12 times and also with other taxa. Chestnut occurred in twos or threes six times and also with other taxa. Pine occurred by itself 12 times and also with other taxa. Poplar occurred by itself in twos or threes five times, with walnut thrice and with sugar maple twice and also with other taxa. Cedar was only recorded two points, with itself and redbud and with ash. Beech occurred by itself in twos or threes five times and with other taxa, especially mesophytes as sugar maple, linden, and buckeye. Sugar maple occurred by itself three times and with other taxa especially mesophytes. Linden, well known for its basal sprouting, only occurred as a double once but also occurred with other mesophytes. Ash occurred with other taxa especially mesophytes. Maple occurred with other taxa. Black and white walnuts occurred by themselves at two or three stems together three times and with sugar maple and many other taxa. An elm stem pair occurred once but was elsewhere associated with ash, hackberry, sycamore, ironwood and sassafras. In a survey on the north side of the Holston River in Grainger County there was at the "beginning a sycamore and two box elders" and then the survey moved upslope.

The relatively high percentage presence (Tables 1, 2) of white, black and post oaks with hickory suggests that there were communities dominated by these taxa. The numbers of times these taxa occurred in multiples at survey corners also suggests this. The numbers of times these taxa occurred together at corners suggests mixed oak forests. Double one-species occurrence of poplar and pine also suggest communities. The mesophytes beech, sugar maple, linden, buckeye ash, and walnuts suggest some kind(s) of mesophytic forest. Although few, the association of elm, sycamore, box elder, ash and hackberry suggest one or more wetland forest types.

Martin's sampling of surviving forest remnants in the central Ridge and Valley of East Tennessee (Martin 1971, 1978) resulted in description both nearly pure white oak forests and white oak with mixed oaks, with (northern) red oak, black oak, southern red oak, with various hickories, with pines, and with poplar as most important associates. These may be derived from white oak forests seen in the eighteenth and nineteenth century surveys as suggested by co-occurrences noted above. Martin's types occurred in 44 stands on all upland landforms and a few high terraces. The high percentages of post and black oak (Tables 1, 2) and high numbers of self-co-occurrences and with other taxa as oaks, hickories, poplar and pine suggest communities dominated by these taxa separately or together. However, such communities were rarely found by Martin (1971) who reported only one stand dominated by black oak and one stand dominated by post oak. Have the flat terrace sites of the post oak-shortleaf pine-black oak and the knob sites of the black oak-scarlet oak communities of Martin (1971) been so thoroughly agriculturized that almost none now exist? Surely the taxonomic decisions of the surveys in the oak group was faulty, "black" oak included scarlet, Shumard and perhaps some northern or southern red oaks. Also, as the settlers began cutting the valuable white oak and other oak forests for white oak, black oak left in the stand "increased" in percent of the stand, and may have also begun to increase by reproduction in the more open forest. Post oak was present as an associate in some of Martin's (1971) white oak types and was stand dominant on the flat terrace land above the annual flood zone—moist, flat soils would have been among the first cleared for agricultural uses.

In a seven-county 175 stand count of upland oak forest in the writer's data (De Selm in progress) black oak and scarlet oak dominated stands were only nine (compared to 155 of the white oak or mixed oak dominated stands); they occurred on Knox Group dolomitic soils, Sevier shale, and on limestone on ridge to rolling to gentle topography. Post oak dominated stands were six; they occurred on gentle Chickamauga limestone soils (as Colbert) and on shale and one stand was on a flood plain. These bedrocks and their soils are widespread in the Ridge and Valley (Rodgers 1953, Springer and Elder 1978) and it is possible that black oak and post oak types were also widespread here but the evidence from these two fairly intensive surveys in the 1960s and 1990s is slight. Thus, while it is possible that these were widespread, even common, black oak (and/or scarlet oak) and post oak dominated forests, the occurrence of these taxa as important associates in white or mixed oak forests is likely and that their increase in importance with the first selective logging for white oak, pine and poplar occurred.

Forests high in black, scarlet, post and southern red oaks are reported in the Chickamauga Valley part of the Ridge and Valley of north Georgia (Wharton 1977). In the survey records of Floyd County, Georgia, Lipps (1966) found in two different survey districts, black oak percentages exceeding white oak by nearly three times and post oak exceeding white oak by nearly eight times. Plummer (1975) also reports high post oak in survey records in Gordon County, Georgia. Mohr (1905) mentions in the Coosa Valley floor of Alabama low forest stands of oak, including post oak, and pines.

Other Characteristics

The importance of chestnut in this area, as viewed by later foresters as Zon (Shantz and Zon 1924) and ecologists as Braun (1950), who classed the Ridge and Valley part of this area the oak-chestnut-poplar region and oak-chestnut forest region, respectively, is scarcely borne out. Chestnut percentages vary from 1.0 to 3.3; its relative density is exceeded, in each of the old survey data sets, by five to 10 other taxa or by two to seven taxa excluding oaks.

No mention of fire in the forest or burned land is mentioned in any survey. Apparently large or destructively burned areas were not seen but spring understory burns may have been common enough not to have merited recording.

In studies of most survey sets, the surveying was accomplished in the 1800s—here at least 95 percent of the surveys have their beginning and ending point on the perimeter of another existing legally recorded survey. That makes the new survey recordable, mapable and presumably legal. In this earlier survey set (1792-1794) 28 percent begin at a point (as tree or creek mouth) without reference to a previous survey (fewer survey lines present by those dates). This independent point of origin of the survey should be characteristic of the earliest surveys.

Early surveys are also extended through the potentially best agricultural land—river and creek bottoms and terraces, references to ridges, hills and knobs are fewer and on this 1792-1794 set of surveys the ratio of the mention of ridge, knob, and hill to river, creek, branch, spring and marsh was 11/100. In the late surveys, 1812-1815 this ratio was 34/100. Clearly, as the lowlands were already owned, later potential owners were surveying upslope. However, these ratios may be influenced by other factors; the ubiquitous mention of streams in survey line descriptions suggests that inclusion of such information may have been part of the surveyor's instructions. Also, mention of topography may be a function of the interest (?) of the surveyor. Robert Wear, surveying in Blount County, 1824-1826 mentioned only 10/100 hill to creek, etc., features (other of Wear's results in De Selm 2001).

SUMMARY AND CONCLUSIONS

In the area of East Tennessee, where there was no Congressional Land Survey data to use in pre-settlement or early settlement vegetation, metes and bounds survey records are a substitute. In this study comparisons of relative tree density are made between late seventeenth and early eighteenth century surveys in the Fifth Survey District Ridge and Valley, eighteenth Century surveys in the Cumberland Mountains and Ridge and Valley, and comparison of the early survey forest data with modern inventory records. In the comparison of the late seventeenth and early eighteenth century records from probably much the same geographic area the most outstanding change was the decrease in pine percentage suggesting its use in construction; percentage changes in several other taxa suggest changes in forest composition due to differential tree use. In another study involving chronology 1807-1812 and 1812-1815 only slight (0-3.4 percent) changes occurred (in 40 taxa changes were 0-1.0 percent). The 1812-1815 Fifth Survey District data was compiled by surveying through rough mostly Cumberland Mountain topography and gentler Ridge and Valley topography. The former set includes many mesophytic taxa in abundance in the Cumberlands and about one-third oaks. The Valley set includes lower mesophyte percentages, much white oak (as the Cumberlands) but the set has relatively high black and post oak percentages; the percentages of oaks total nearly 60 percent. Modern (1960s and 1990s) vegetation surveys found the black oak and post oak forest types uncommon but black and sometimes post oak occurred as associates in other sampled types. The possibility exists that early forests contained more extensive black oak and post oak forests types than seen now, or that early forest modification, as removal of white oak, pine and poplar left the black and post oaks relatively more abundant early in the settlement period.

The metes and bounds survey data contain deficiencies and/or unknowns. Relatively few forest tree taxa were recognized—this is partly sample size and partly the level of taxonomic expertise of the surveyors. It is not known for sure whether surveyors noted corner trees at random. The location of the survey lines is unknown exactly. A few small trees were used at corners. Despite these problems, the metes and bounds survey results constitute the only quantitative record of vegetation present near the time of settlement. They contribute greatly to our historical-geographic-botanical knowledge.

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FLORA OF SEVERAL CLAIBORNE AND HANCOCK COUNTY MESIC FOREST STANDS

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ABSTRACT. A study of the flora of 15 mixed mesophytic forest sample has been made from stands in the northern Ridge and Valley of Tennessee. Stands were on various topographic positions on geologic bedrocks including sandstone, limestone, dolomite and shale with a variety of aspects but chiefly on rocky soils. Three stands were on the banks of the Powell River and six on the Clinch River just above the annual flood zone; five stands were in ravines and one was on open slope. Stands were dominated by mesic hardwoods with hemlock (three), beech-white oak (one), sugar maple-beech (two), sugar maple-yellow oak (two), and mixtures of sugar maple-buckeye-basswood and poplar (seven). Samples were too few for either site or overstory to predict understory floristic composition well.

Total flora was 381 taxa of which only 3.7 percent were introduced; proportions among floristic elements were similar to those of other local studies. Most taxa have been reported in studies of other local areas. About one-third of the Smoky Mountains flora with known (fossil) Arcto-Tertiary Geoflora relationships occur in this flora.

INTRODUCTION

The flora of forests of the Southern Appalachians is well known. The flora of mesic stands compared to submesic, subxeric and xeric upland stands is known in a few places particularly in the Blue Ridge and Appalachian Plateaus (Whittaker 1956, White 1982, Schmalzer et al. 1988, Hinkle 1975, Fleming and Wofford 2004, Murrell and Wofford 1987). Many studies have focused on the overstory (Braun 1950, Whittaker 1956, Golden 1974, Stephenson et al. 1993) with only the most frequent herbs or those with the most cover noted. Notable among the gaps in our knowledge is that of the vascular flora of Tennessee Ridge and Valley mesic forests, where although the overstory has been examined (Martin 1978, Martin and De Selm 1976, Hedge 1979, De Selm in progress), here there are few studies of understory taxa (but see Hedge 1979, Oxendine 1971). This paper includes results from year-long floristic examination of 15 mesic forests stands in the northern Ridge and Valley of Tennessee. More intensive study of the area was prompted by results from vegetation sampling in 2002, collections by A.J. Sharp at TENN (Herbarium, University of Tennessee, Knoxville) and reports in the Clinch River valley of Tennessee by Bullington (1997) and of Virginia by Ogle (1989 and papers cited therein).

THE STUDY AREA

The Ridge and Valley Physiographic Province extends from the Hudson River valley of New York southward into Alabama (Fenneman 1938). It is bordered by the Cumberland Plateau and Mountains to the west and by the Blue Ridge to the east in Tennessee. The area of concern here lies within the upper Tennessee River drainage. Here the Ridge and Valley landscape is underlain by Paleozoic sandstones, limestones, dolomites and shales which have been extensively folded and faulted. The resulting landscape is characterized by mountain ridges underlain by erosion-resistance rocks and rolling lands and valleys underlain by less-resistant limestones and shales; all these trend in a northeast to southwest direction (Rodgers 1953, Hardeman 1966). Most elevations are from about 800 to 1500 feet. Soils are mapped as Udults and Inseptisols: Eutrocrepts (U.S. Soil Conservation Service 1970). In this area, at the state level, Talbott-Rock outcrop, Fullerton-Dewey and Wallen-Tabott-Montevallo associations are mapped (Elder and Springer 1978). In the county surveys, Rough stony land-Talbott material, Muskingham stony fine sandy loam, Clarksville cherty silt loam, Calvin-Wallen Complex, Montevallo-Talbott Complex, Claiborne silt loam, and Litz shaly silt loam are mapped on the study areas. Soils are stony, steep, shallow to deep, and near neutral to acid (Austin et al. 1948, Moore et al. 1979).

This temperate climate is characterized by well-distributed precipitation, mainly rainfall of 44 to 48 inches (Dickson 1960, 1931-1960 data) or 47-51 inches (De Selm and Schmidt 2001, 1961-1990 data). However, summer droughts of usually short duration are common. Mean minimum temperatures are near 30° in January, mean maximum temperatures in July are near 88°F (Dickson 1960). At Rogersville, the nearest weather station, which is in Hawkins County, the January average minimum was 44.3°F and the July maximum was 86.5°F (1961-1990 data, Owenby and Ezell 1992).

Precipitation in the Tennessee River basin was monitored and reported for many years on a monthly and annual basis and summarized for the 1935-1959 period (Tennessee Valley Authority Division of Water Control Planning 1959). Some floods were also reported (Tennessee Valley Authority Division of Water Control Planning 1949); the flood of 11-15 February 1948 resulted from 4-6 inches of precipitation during that period and the Norris Reservoir water level, downstream, was raised nearly 40 feet. The 1867 flood crested at Knoxville at over 46 feet above expected river level (Knoxville News-Sentinel 1967). The "big flood" on the Powell River of April 1977, according to local informants, flooded a house near the Yeary Road sample site. This would have put almost all of the sample area underwater for a few days. It seems likely that the 10 river edge sample areas have been at least partially flooded with an unknown frequency in the past.

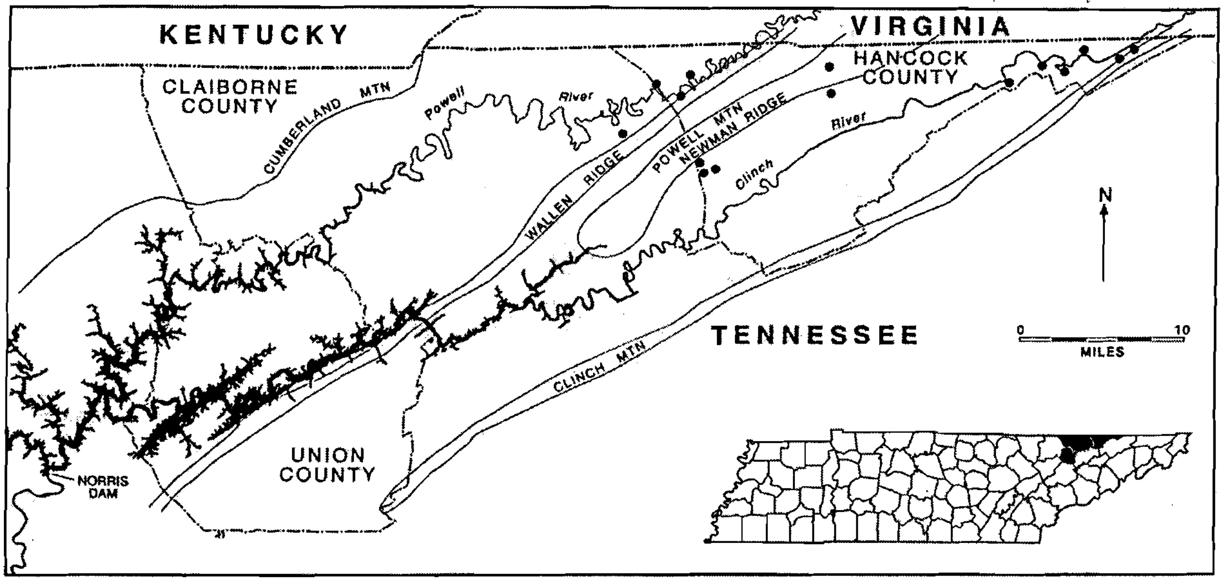
The size of the flora of the Tennessee Ridge and Valley is not known. Sizes of county floras and the Oak Ridge Reservation flora (842 taxa, Mann et al. 1985) suggest that it may be near 1500 taxa. In 2000 (University of Tennessee Herbarium 2000) the Claiborne County known flora was 495 taxa, that of Hancock County 131 taxa. Recent collections and gifts to the Herbarium have increased those numbers. The vegetation ecology of this area has been summarized by Braun (1950), De Selm (1984) and Stephenson et al. (1993). Stephenson et al. (1993) placed this sample area in the Appalachian Oak Forest Region (of the eastern Deciduous Forest); the region extends from West Virginia to Georgia. Mixed mesophytic forests here have been described.

According to Graham (1999), the flora of the Deciduous Forest began evolving chiefly in the late Cretaceous and Tertiary periods and evolved and spread across Eurasia, North America and elsewhere during these periods. Cool Pleistocene episodes eliminated the flora northward in the glaciated areas and may have severely restricted its occurrence southward to about 34 degrees north because of climatic change and invasion of spruce and northern pine dominated vegetation (Graham 1999, Delcourt et al. 1993). The warm interglacial periods and a post-glacial warm period, the Hypsithermal, caused some species ranges to contract and others to expand. It is likely that the areas of stands of mixed neophytic forest were severely constricted or only survived cold periods of the Pleistocene to the south. It is not known for sure whether these lower slope forest sites would have been influenced by higher temperatures and evapotranspiration rates of the Hypsithermal.

At the end of the Pleistocene, North America and soon the eastern deciduous forest was invaded by landscape managers, the Native Americans. They used plants in many ways in their need to survive and burned the upland landscape near their villages and hunting areas (Lewis and Kneberg 1958, Delcourt and Delcourt 1998, Swanton 1946). After about 1790 the area was opened for settlement by Euroamericans who logged the forest, cultivated row crops in valleys and on the low slopes where soils were deep and put out stock to graze in the forests. Fires were set in the forests to increase spring forage available for stock (Folmsbee et al. 1969, Killebrew et al. 1874). Stock grazing and fires may have influences on some of the study stands. As human populations grew, pressure on private forests stands increased resulting in more logging, herb collecting by owners and their neighbors and by stock and deer, and weed invasion and foreign insect and disease introduction (cf. Nolt et al. 1997, Nash 1999).

METHODS AND SAMPLE AREAS

Stand examination in Claiborne and Hancock counties, Tennessee, in 2002 included those of 41 mesic stands for which a ca. one hour inventory of overstory and understory was obtained. Fifteen stands were selected for examination from March to November on one day every ca. 21 days during 2003 or 2004 for inventory of the vascular floras (Fig. 1, Table 1). Stands were selected with no recent evidence of disturbance, and with a closed tree canopy which included a wide variety of tree diameters from five inches to the 24-30 inch class. Stands used were chosen from the floristically rich of 2002 or from those seen in 2003 or 2004 with spring forb richness.



Map Courtesy of UT Cartographic Services Laboratory

Figure 1. Map of the study area showing significant topographic features and locations of the 15 stands (black dots).

At each site an approximately 200 meter long transect was walked during each period of observation. The return transect approximated the route of the first. Specimens were collected and determined and ranges determined using standard manuals and with the aid of personnel and facilities at TENN. Sources included Gleason and Cronquist (1991) and appropriate volumes of the North American Flora (Flora of North American Editorial Committee 1993 et seq.), Chester et al. 1993, 1997, Case and Case 1997, and Jones 2005. Nomenclature follows these sources from which authorities may be found. Floras were compiled by sample site. Site geology is derived from the maps in Rodgers (1953).

RESULTS

The Flora as a Whole

The flora of these mesic stands totaled 380 vascular taxa (Appendix). This included 3.7 percent introduced, 20.9 woody, 6.2 pteridophytes, 7.8 grasses and 5.9 percent sedges. Intraneous taxa were 50 percent, local intraneous an additional 5.8 percent; northern taxa were 25.3 percent, southern 9.5 percent, and western taxa only 1.6 percent. There proportions were similar to those of Oxendine (1971) and Hedge (1979) who also sampled local Ridge and Valley forest floras. Many taxa are in common with the Oak Ridge Reservation flora which borders the Clinch River downstream (Mann et al. 1985) and Clinch River taxa seen downstream by Bullington (1997) and the Hawkins County flora upstream (Wolfe 1956).

The Claiborne-Hancock samples were typical of other nearby mesic forest floras. Eighty-one percent of the cove forest understory taxa (Oxendine 1971) occurred on this list; of the Schmalzer et al. (1988) Cumberland Plateau Obed River cove forest list of 281 taxa, 61.5 percent occurred on this mesic forest list. Of Cain's (1943) Smoky Mountain spring and summer cove forest list of 155 species, 59.4 percent occurred here. Sixty-seven percent of the Lilley Cornett Woods (Letcher County, Kentucky) tree and shrub flora occurred on this mesic forest list (Martin and Stepherd 1973).

The rare taxa *Cimcifuga rubifolia*, *Poa languida* and *Ruellia purshiana* occurred (cf. Bailey 2004) along with the rare grasses *Poa wolfei* known in Tennessee by Gattinger (1901) and *Bromus latiglumis* both seldom reported since. *Solidago faucibus* (cf. Wiebolt and Semple 2003) occurred in one stand; this taxon has been described by Weibolt and Semple (2003).

Table 1. Sites used in Claiborne-Hancock counties mesic forest flora.*

1. Cope Hollow, 02-304, Hancock, 2004, ravine, Rome Form. ss, NE, 62%, hemlock-beech.
2. Flea Creek, 02-302, Hancock, 2003, ravine, Pennington Form. ss, E, 50%, basswood-hemlock.
3. Barnard Hollow, 02-300, Hancock, 2004, ravine, Rome Form. ss, NW, SE, 40%, beech-hemlock.
4. Little Valley Road at Cunningham, 02-294, Claiborne, 2004, ravine, Silurian ss, sh, SE, 38%, beech-white oak.
5. Turner Hollow, 02-378, Hancock, 2004, ravine, Knox Group dol, NW, SE, 30%, sugar maple-beech-poplar.
6. Rt. 63, Powell River, 02-324, Hancock, 2003, Powell River slope, Chickamauga ls, NE, 90%, sugar maple-buckeye-basswood.
7. Alder Road, 02-327, Hancock, 2003, Clinch River slope, Grainger Form. ss, NE, 70-105%, sugar maple-buckeye-basswood.
8. Horton Ford Road mile 6.3, 03-003, Hancock, 2003, Clinch River slope, Chickamauga ls, NE, 65%, sugar maple-basswood-buckeye.
9. Horton Ford Road near Manis Road, 04-15, Hancock, 2004, Clinch River slope, Chickamauga ls. NE, 61%, basswood-buckeye-sugar maple.
10. Horton Ford Road mile 11.3, 04-17, Hancock, 2004, Clinch River slope, Conasauga sh, NW, 58%, sugar maple-poplar-buckeye.
11. Powell River Road, 02-322, Claiborne, 2003, Powell River slope, Newalla Form. ls, sh, SE, 39%, basswood-sugar maple-buckeye.
12. Horton Ford Road mile 10.4, 04-16, Hancock, 2004, Clinch River slope, Conasauga Group sh, NW, 60%, buckeye-sugar maple-basswood.
13. Yeary Road, 02-293, Claiborne, 2004, Powell River slope, Newalla Form. ls, sh, SW, 48%, sugar maple-white oak-yellow oak.
14. Johnson Ridge, 04-14, Hancock, 2004, open slope, Conasauga Group sh, NW, 60%, beech-sugar maple
15. Big Springs Road, 04-18, Hancock, 2004, Clinch River slope, R-R-M Form. ls, sh, SW, 53%, Sugar maple-yellow oak-white ash-beech.

*Sequence and abbreviations: number, stand name, stand number, county, year studied, location/position, geologic formation, bedrock type, aspect, average slope angle, canopy dominants based on relative density. ss = sandstone, sh = shale, ls = limestone, dol = dolomite, Form. = formation, R-R-M = Rutledge-Rogersville-Maryville. Stand sequence 1-15 follows the mesic to submesic array discussed in the text.

A few Appalachian endemics occurred (De Selm 1984, White 1982—lists based in part on the work of Harper 1947, 1948). The fairly narrow habitat range selected only a few taxa (11)—or only 9.6 percent of the potential extended list of 115 (De Selm 1984) with but 2.9 percent of this flora (versus 7.8 percent of the Smoky Mountains flora (White 1982).

Presence classes were used to distinguish parts of the flora. A total of 56.8 percent was in the rare class, 12.8 in the seldom occurring class. The constant class was 9.4 percent and nearly constant at 6.5. The often seen class was at 11.9 percent. Note that the constant class exceeds that of the nearly constant class as in the case of percent frequency (Oosting 1956).

Comparison of Stands

Floras of sample sites varied in size from 95 to 172 taxa—average 120. Fourteen stands ranged from 95-137, whereas the Yeary Road site on the Powell River with a southwest aspect and a sugar maple-oak-beech dominated canopy had 172 taxa.

Comparison of stand floristic richness by site was of interest. Five ravine floras averaged 125 taxa, three Powell River stands averaged 132, six Clinch River stands averaged 115, and the middle slope Jackson Ridge stand had 95 taxa. Perhaps moisture stress was operating on that upslope position restricting development of mesic taxa.

Comparison of floristic richness by overstory dominants was also of interest. Three hemlock-mixed mesophytic stands averaged 127 taxa, three beech-mixed mesophytic averaged 144 taxa, seven buckeye-basswood mixed mesophtyic averaged 112 taxa and two sugar maple-oak-beech stands averaged 137 taxa. Is some perhaps allelopathic factor (Rice 1984) or some other factor influencing the understory composition of the buckeye-basswood stand?

Richness between ravine mixed mesophytic stands dominated by hemlock and hardwood mesophytes, three stands, averaged 127 taxa, versus sugar maple-beech-poplar, two stands, averaged 124 taxa. Hemlock, sometimes thought by its shade or acid litter (and *Rhododendron* understory, here sparse) to inhibit understories (Daubenmire 1930, Potzger and Friesner 1937, Pearson et al. 1998) does not seem effective.

The taxa were sorted by stand bedrock types. Fifty-two taxa occurred here only on sandstone. However, none was thought to be confined to sandstone over their range. Of these, 29 were with hemlock, of these several are commonly seen with hemlock: *Amelanchier laevis, Betula lenta, Chimaphila maculata, Dryopteris intermedia, Epigaea repens, Goodyera pubescens, Rhododendron maximum, Solidago faucibus* (according to Wiebolt and Semple 2003) and *Viola pallens*. Some of these occur with hemlock according to Whittaker (1956) and Oosting and Billings (1939). Twenty-six taxa were in common with the sandstone gorge hemlock type and sandstone boulder type in the Obed River region (Schmalzer et al. 1985); but only seven taxa were confined to sandstone in this Claiborne-Hancock sample set.

Eighteen taxa occurred only on the Chickamauga limestone; some I have commonly seen on limestone are *Angelica venenosa, Asplenium ruta-muraria, Aquilegia canadensis, Galium pilosum, Polymnia uvedalia, Ptelea trifolia* and *Verbena urticaefolia*. The occurrence of stands on the calcareons Consasuga shale and carbonaceous Knox Group dolomites reduced the numbers of taxa confined to limestone.

The upland topographic features of the Ridge and Valley, the Tennessee River and its tributaries, the Clinch and Powell river borders, and the Cumberland Plateau escarpment may well have been migration routes of the deciduous flora north (Delcourt and Delcourt 1987) or outward from its late Pleistocene refugia. Site floristics do not indicate preferred routes. The largest site flora on Yeary Road on the Powell River may represent an historically protected site, for some unknown reason, or a submesic slope forest which Whittaker (1956) considered richer than cove bottom stands.

The 15 sample areas were arrayed from mesic to submesic. The occurrences of the 372 native taxa were examined across this array. In this old, well-adapted flora 213 (55.3) percent occurred across the array, 22.6 percent were confined to the mesic half and 22.1 were confined to the submesic half. The 25 pteridophyte taxa exhibited the same distribution pattern. Woodruff (1935-36, 1938) found some local pteridophytes restricted to soils with narrow pH ranges and others tolerant to a wide range of soil pH. The 22 sedge taxa had 86.4 percent across, in the middle part, and on the mesic section of the array. The 29 grass taxa ranged 82.8 percent across, in the middle section, and in the submesic side of the array.

The Asian Connection

The long geologic history of the landscape and vegetation of eastern North America indicates that the historically widespread, indeed transcontinental and intercontinental distribution of genera are a consequence of geologic, climatic and evolutionary forces of the past. Our flora and vegetation are descendants of past biotas as modified by history and evolution. The floristic tie to eastern Asia is particularly strong (Graham 1999).

At least since the time of Asa Gray (1840, 1846), American plant geographers and others have been interested in the relationship between the floras of eastern North America and eastern Asia. What caught Gray's attention were the similarities between certain taxa which he called species pairs. Li (1972) points out more than a dozen pairs in wide-ranging genera and Hara (1939, cited by Li 1952) listed plants common to Japan and North America in many genera. The relationship between the Asian and Appalachian moss floras were well known (Iwatsuki 1958). Ying (1983) and Little (1983) listed common genera between Asia and eastern North America; Ying thought they totaled 115. Zhengy (1983) listed 116 genera and these can be supplemented by disjunct fern genera proposed by Kato and Iwatsuki (1983), woody plants by Little (1983) and various woody and herbaceous genera listed by Li (1952). In the Great Smoky Mountains flora, 108 genera have taxa disjunct in Asia (25 percent of the native vascular plant genera) (White 1983). In this 2003-2004 Claiborne and Hancock counties samples, 90 or 33.6 percent of the native genera are represented in eastern Asia. White (1983) pointed out that many plants are of terrestrial, mesic, forested habitats, often from primitive families, woody or herbaceous, and the herbs often geophytes.

Cain (1943) listed a spring and early summer flora from 31 cove hardwood samples from the Greenbrier region of the Great Smoky Mountains. Eighty-one percent of the genera were represented in Asia (in the fossil Arcto-Tertiary Geoflora). Eighty-two percent of this list of genera and 66 percent of the Smokies Arcto-Tertiary genera occur among this Claiborne-Hancock county mesic forest list of 217 native genera. Had the Smokies list included more late summer and autumn taxa, the percentage of genera in common would undoubtedly have been higher.

CONCLUSIONS

The group of mesic forest stands were representative of mixed mesophytic vegetation seen in the Tennessee Ridge and Valley (De Selm in progress) and reported by Braun (1950), Martin and De Selm (1976), De Selm (1984), Hedge (1979), and Stephenson et al. (1993). Canopy dominants vary from hemlock to beech, sugar maple, basswood, buckeye and white oak presumably in response to differing site conditions which vary by aspect, slope position, slope form, protection and bedrock as has been reported by the above authors. Past stand history has had effects, largely unknown, on dominance. Whole stand floras including understory taxa also vary in composition in response to overstory composition, history, and the above and other site factors (see Oxendine 1971, Hedge 1979). The total flora of the 15 sample stands is representative of local Ridge and Valley floras (Oxendine 1971, Hedge 1979) and similar to nearby floras (Hinkle 1975, Pounds et al. 1989, Mann et al. 1985, Bullington 1997). Stand richness is weakly predicted by site factors based on these few sample areas and varies from 95 to 173 taxa per stand. Percentage of mesophytes but not necessarily total richness declines with site south aspect. The flora of that of eastern United States and especially the Southern Appalachians, has a strong generic representation in eastern Asia with common ancestry in the Arcto-Tertiary Geoflora (Graham 1999). About two-thirds of the Smoky Mountain cove hardwood spring and early summer flowering genera (Cain 1943) of the Arcto-Tertiary fossil flora also occurred here.

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APPENDIX
List of Plants

Taxa of the mesic forests are listed alphabetically below. An "X" following the name indicated an introduction. Numbers are sites from Table 1.

Acalypha sp. – 6
Acer negundo – 3, 4, 5, 6, 7, 9, 11, 13
A. nigrum – 6, 8, 11
A. rubrum – 1, 2, 3, 4, 5, 13
A. saccharum – all
Actaea pachypoda – 2, 9
Adiantum pedatum – 1, 2, 3, 4, 6, 7, 8, 9. 10, 11, 12, 14
Aesculus flava – all
Ageratina altissima – 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15
Agrimonia pubescens – 2, 5, 14
A. rostellata – 13, 15
Agrostis gigantea – X – 6, 11
Ailanthus altissima – X – 2
Alliaria petiolata – X – 6, 7, 8, 9, 10, 12, 13, 15
Allium cernuum – 5, 12, 13
Alnus serrulata – 4
Amelanchier arborea – 1, 3
A. laevis – 3
Amphicarpaea bracteata – all
Anemone virginiana – 1, 2, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15
Anemonella thalictroides – all
Angelica venenosa – 8
Apios americana – 4
Aquilegia canadensis – 8
Arabis laevigata – 6, 7, 8, 9, 11, 12, 13, 15
Aralia racemosa – 1, 3, 6, 9, 10, 11
Arisaema triphyllum – 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 15
Aristolochia tomentosa – 1, 2, 6, 7, 8, 9, 10, 11, 12, 15
Arnoglossum atriplicifolia – 3, 4, 5, 10, 13, 15
Aruncus dioicus – 1, 7
Arundinaria gigantea – 6, 7, 11, 13, 15
Asarum canadense – 6, 10, 11, 12, 14
Asclepias exaltata – 1
Asimina triloba – 1, 4, 5, 6, 7, 8, 10, 11, 12, 14, 15
Asplenium montanum – 1
A. platyneuron – 1, 2, 3, 6, 7, 8, 11, 14, 15
A. resiliens – 2, 7, 8, 12, 13
A. rhizophyllum – 4, 6, 7, 8, 10, 12, 13, 14
A. ruta-muraria – 8
Astilbe biternata – 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 15
Aureolaria virginica – 14
Betula lenta – 1, 2, 3
Bidens frondosa – 8, 13
Bignonia capreolata – 2, 7, 11, 12, 13, 14, 15
Blephilia hirsuta – 10
Boehmeria cylindrica – 4, 5, 8
Botrichium dissectum – 5
B. virginianum – 2, 5, 13
Brachyelytrum erectum – 13
Bromus latiglumis – 6, 15
B. pubescens – 5, 6, 8, 13, 14, 15
Calystagium sepium – 13, 15
Campanula divaricata – 6
Campanulastrum americana – 1, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15
Campsis radicans – 5, 7, 8, 13, 15
Cardamine diphylla – 2, 3, 4, 5, 6, 7, 9, 10, 11, 12
C. heterophylla – 2, 6
C. laciniata – 3, 6, 7, 8, 9, 10, 14
Carex albicans – 7, 13
C. amphilbola – 3
C. blanda – 3, 4, 5, 8, 10, 13
C. crebriflora – 3
C. debilis – 3
C. digitalis – 5

C. eburnea – 7
C. festucacea – 7
C. granularis – 3
C. grisea – 13
C. kraliana – 1, 3, 4, 5, 6, 10, 11, 13, 14, 15
C. laxiflora – 1, 2, 3, 4, 7, 9
C. muehlenbergii – 5
C. nigromarginata – 3, 10, 13
C. pensylvanica – 1, 7
C. plantaginea – 1, 7, 8, 9, 10, 11, 12
C. platyphylla – 7
C. prasina – 5
C. rosea – 3, 5, 13
C. sparganioides – 2
C. styloflexa – 3, 13
C. virescens – 3
Carpinus caroliniana – 1, 3, 4, 5, 7, 8, 10, 13, 14, 15
Carya glabra – 3, 6, 9, 10, 11, 12, 13, 15
C. ovata – 6, 7, 10, 11
C. tomentosa – 13
Caulophyllum thalictroides – 10, 11, 12
Celastrus scandens – 7, 8, 14, 15
Celtis laevigata – 13
C. occidentalis – 13, 14, 15
Cercis canadensis – 1, 2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15
Chasmanthium latifolium – 13, 15
Chelone glabra – 5
Chimaphila maculata – 2
Cimicifuga racemosa – 1, 2, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14
C. rubifolia – 1, 6, 8, 9, 10, 11, 12
Cinna arundinacea – 5, 13
Circaea lutetiana subsp. *canadensis* – 1, 2, 4, 5, 8, 10, 11, 12
Claytonia caroliniana – 8, 9, 10, 12
C. virginica – 13
Clematis virginiana – 1, 4, 5, 6, 8, 10, 11, 12, 13, 15
Clintonia umbellulata – 1, 10
Collinsonia canadensis – 1, 2, 4, 7, 13
Cornus amomum – 13
C. florida – 1, 3, 4, 5, 10, 11, 14, 15
Corylus americana – 1
Cryptotaenia canadensis – 1, 2, 3, 4, 5, 8, 13, 14
Cynoglossum virginianum – 5
Cystopteris bulbifera – 3, 6, 7, 8, 9, 10, 11, 12
C. protrusa – 5, 6, 7, 8, 9, 12
Danthonia spicata – 14
Dennstaedtia punctilobula – 11
Deparia acrosticoides – 3
Desmodium canescens – 2, 8
D. glutinosum – 5, 13
D. laevigatum – 11
D. nudiflorum – 4, 5
D. paniculatum – 4, 15
D. pauciflorum – 10, 12, 13
D. perplexum – 4, 7, 8, 13, 15
D. viridiflorum – 5
Dianthus armeria – X – 13
Dicentra canadensis – 6, 8
D. cucullaria – 8, 9
Dichanthelium boscii – 1, 2, 3, 13, 15
D. clandestinum – 2, 5
D. commutatum – 4
D. dichotomum supsp. *dichotomum* – 5, 13
D. dichotomum subsp. *microcarpon* – 13
D. dichotomum subsp. *yadkinense* – 13
Dioscorea palystachya – X – 1, 2, 4, 5, 6, 7, 8, 9, 11, 15
D. villosa – 1, 2, 3, 4, 5, 7, 8, 9, 11, 13, 14, 15
Diospyros virginiana – 2
Diplazium pycnocarpon – 10, 14
Disporum lanuginosum – 1, 2, 3, 9, 12
Dryopteris intermedia – 2
D. marginalis – 1, 2, 3, 4, 7, 8, 9, 10, 11, 12
Elephantopus carolinianus – 13, 15
Elymus hystrix – 2, 4, 5, 13, 15
E. riparius – 8, 13
E. villosus – 2, 4, 5, 12
E. virginicus – 3, 4, 5, 6, 8, 11, 12, 13, 15
Epifagus virginiana – 2, 3, 5, 14
Epigaea repens – 2
Equisetum hyemale – 13
Erichtites hieracifolia – 3
Erigeron annuus – 3, 5, 13
E. philadelphicus – 2, 4, 5, 13
E. pulchellus – 13
E. strigosus – 3, 4, 5
Erythronium americanum – 9, 10, 11, 12
Euonymus alatus – X – 8
E. americanus – 1, 2, 3, 5, 6, 11
E. fortunei – X – 6
Eupatorium purpureum – 1, 2, 3, 4, 6, 7, 11, 14
E. serotinum – 6, 11
Euphorbia corallata – 13, 15
Eurybia divaricata – 1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 14, 15
Fagus grandifolia – 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15
Festuca subverticillata – 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Fragaria viriginiana – 2, 4, 7, 11
Fraxinus americana – 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
F. quadrangulata – 13
Galearis spectabilis – 5
Galium aparine – 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15
G. circaezans – 1, 3, 5, 7, 8, 10, 13, 14
G. pilosum – 6
G. triflorum – all
Geranium maculatum – 1, 2, 3, 4, 7, 8, 9, 10, 14
Geum canadense – 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15
G. vernum – 4, 5
Glechoma hederacea – X – 6, 9, 13
Glyceria striata – 4, 5
Goodyera pubescens – 2
Hamamelis virginiana – 1, 2, 3, 4, 5, 7, 9, 10, 11, 13, 14
Helianthus decapetalus – 3, 4, 6, 7, 10, 11, 13, 15
H. microcephalus – 2, 3, 6, 7, 11, 13, 15
H. tuberosus – 13

Hepatica acutiloba – 4, 6, 7, 10, 11
H. americana – 1, 2, 11, 14
Heuchera americana – 1, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15
H. x *hirsuticaulis* – 7
H. x *hispida* – 11
H. villosa – 2, 7, 8, 11, 12
Hexastylis arifolia var. *ruthii* – 1, 2, 3, 4, 5, 13, 14
H. shuttleworthii – 1, 2, 3, 10, 11, 12, 14, 15
Houstonia purpurea – 1, 3, 13
Hybanthus concolor – 4
Hydrangea arborescens – all
Hydrophyllum canadense – 8, 9
H. macrophyllum – 7, 8
Hypericum punctatum – 2, 5, 7, 8, 10, 13, 15
Ilex opaca – 3
Impatiens capensis – 1, 2, 3, 4, 6, 7, 10, 11, 12, 14, 15
I. pallida – 2, 6, 8, 9, 10, 11, 12, 15
Ipomoea pandurata – 4, 13, 15
Iris cristata – 1, 2, 3, 5, 6, 7, 10, 14
Jeffersonia diphylla – 6, 8, 9, 10, 11
Juglans nigra – 3, 5, 6, 7, 8, 9, 10, 11, 13, 15
Juniperus virginiana – 5, 6, 7, 13, 14, 15
Kalmia latifolia – 2
Lactuca floridana – 1, 2, 4, 5, 6, 7, 10, 13, 15
Laportea canadensis – 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15
Leersia virginica – 1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 13, 14
Ligustrum sinense – X – 2, 4, 6, 9
Lindera benzoin – all
Liquidambar styraciflua – 13
Liridendron tulipifera – all
Lobelia cardinalis – 5
L. inflata – 2, 3, 4, 5, 8, 10, 13, 15
L. puberula – 13
L. siphilitica – 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Lonicera japonica – X – 1, 3, 5, 6, 7, 8, 10, 11, 12, 14, 15
Luzula acuminata – 1
L. bulbosa – 3, 13
Lysimachia ciliata – 8, 10, 13
Magnolia acuminata – 1, 3, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15
M. tripetala – 1, 2, 3, 9
Maianthemum racemosum – 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
Melica mutica – 13, 14
Menispermum canadense – 1, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15
Mertensia virginica – 13
Microstegium vimineum – 1, 2, 7, 8
Mitchella repens – 1, 2, 3, 9, 14
Mitella diphylla – 6, 7, 8, 9, 10, 11, 12
Monarda dinopodia—1, 3, 4, 7, 9, 10, 11, 12
Morus rubra – 1, 4, 5
Muhlenbergia frondosa – 2, 13
M. schreberi – 15
M. sobolifera – 2, 13
M. sylvatica – 13
M. tenuiflora – 1, 13
Nyssa sylvatica – 1, 2, 3, 4, 5, 8, 11, 13, 14, 15
Ornithogalum umbellatum – X – 4
Osmorhiza claytonii – 1, 2, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14
O. longistylis – 2
Osmunda cinnamomea – 2, 8
Ostrya virginiana – 1, 2, 5, 8, 13
Oxalis dillenii – 5, 9, 10
O. stricta – 6, 7, 8, 11
Oxydendrum arboreum – 1, 2, 3, 4, 10, 13
Packera anonyma – 13, 15
P. aurea – 2, 6, 7, 8, 9, 10, 12, 13
Parthenocissus quinquefolia – all
Passiflora lutea – 13
Pedicularis canadensis – 1
Pellaea atropurpurea – 6, 8, 11
Penstemon laevigatus – 7, 13, 15
Phacelia bipinnatifida – 4, 6, 8, 9, 11, 12, 14
Phegopteris hexagonoptera – 2, 3, 14
Phlox divaricata – 4, 6, 7, 11, 13, 15
P. paniculata – 13, 15
Phryma leptostachya – 3, 4, 5, 7, 10, 13, 14
Physalis heterophylla – 14
Pilea pumila – 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14
Platanus occidentalis – 2, 4, 5
Poa cuspidata – 1, 3, 4, 7, 8, 9, 13, 14
P. languida – 2, 6, 7, 13
P. pretensis – X – 7
P. sylvestris – 2, 4, 5, 6, 7, 11
P. wolfii – 2
Podophyllum peltatum – 4, 5, 9, 10, 12, 14
Polygonatum biflorum – all
Polygonum scandens – 1, 8
P. virginianum – 1, 2, 3, 4, 5, 7, 8, 11, 13, 14, 15
Polymnia canadensis – 7, 8, 9, 10, 12, 13, 15
Polystichum acrosticoides – 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15
Porteranthus trifoliatus – 6, 11
Potentilla canadensis – 14
Prenanthes altissima – 1, 2, 3, 4, 5, 7, 9, 10, 11, 14
Prunella vulgaris – 1, 2, 3, 5, 11, 13, 14
Prunus serotina – 3, 4, 5, 11, 13, 14, 15
Ptelea trifoliata – 8
Pycnanthemum pycnanthemoides – 13
Pyrularia pubera – 2
Quercus alba – 1, 3, 4, 7, 13, 15
Q. montana – 3
Q. muhlenbergii – 1, 6, 8, 9, 10, 11, 12, 13, 14, 15
Q. rubra – 1, 2, 3, 4, 6, 7, 10, 11, 12, 13, 14
Q. shumardii – 10, 11, 13
Q. velutina – 1, 2, 4
Ranunculus abortivus – 1, 3, 4, 5, 6, 7, 9, 12, 13
R. hispidus – 1, 3, 4, 5, 6, 8, 9, 10, 12, 14
R. recuvatus – 4, 5, 6, 8, 9, 11, 12
Rhamnus caroliniana – 1, 3, 4, 13
Rhododendron bakeri – 14
R. maximum – 1, 2, 3
Rhus aromatica – 13
Ribes cynosbati – 8
Robinia pseudoacacia – 2, 4, 7, 9, 14, 15
Rosa multiflora – X – 4, 6, 7, 8, 9, 12, 13, 15

R. setigera – 7
Rubus phoenicolasius – X – 6
Rubus spp. – 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15
Rudbeckia fulgida – 13, 15
R. hirta – 6
R. laciniata – 1, 2, 3, 8, 9, 10, 13
R. triloba – 15
Ruellia caroliniana – 13
R. purshiana – 15
R. strepens – 13
Salvia lyrata – 13, 15
Sambucus canadensis – 1, 2, 3, 4, 5, 10, 11, 12, 14, 15
Sanguinaria canadensis – 1, 4, 6, 7, 8, 10, 11, 12, 13, 15
Sanicula canadensis – 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Sassafras albidum – 2, 4, 7, 13, 14
Saxifraga careyana – 8
Scrophularia marilandica – 6, 7, 11
Scutellaria elliptica – 2, 5
S. incana – 2
Sedum ternatum – all
Sicyos angulatus – 7, 9
Silene stellata – 13
S. virginica – 7, 8, 13, 15
Silphium perfoliatum – 8, 15
Sisyrinchium angustifolium – 2
Smallianthus uvedalium – 8
Smilax bona-nox – 13, 15
S. glauca – 3, 4, 5, 13
S. herbacea – 1, 3, 4, 5, 9, 10, 14
S. hispida – 7, 10
S. rotundifolia – 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15
Solidago caesia – 1, 3, 4, 5, 7, 10, 13, 14
S. canadensis var. *scabra* – 2, 7, 8, 11
S. curtisii – 2, 6, 11
S. faucibus – 2
S. flexicaulis – 1, 2, 6, 7, 8, 9. 10, 11, 12, 13, 14, 15
S. gigantea – 4, 6, 13
S. sphacelata – 13, 15
Sphenophilis obtusata – 2, 3, 7, 10, 13, 14
Staphylea trifolia – 6, 13
Stellaria corei – 12
S. pubera – 1, 2, 3, 4, 7, 8, 9, 10, 11
Stylophorum diphyllum – 4, 6, 8, 9, 12
Symphoricarpos orbiculatus – 13
Symphyotrichum cordifolius – 3, 8
S. lateriflorus – 1, 2, 3, 4, 5, 6, 7, 11, 13, 14, 15
S. lowrieanus – 1, 4, 7, 8, 9, 13, 15
S. novae-angliae – 13
S. ontarione – 8, 11
S. patens – 13
S. prenanthoides – 12, 15
S. priceae – 4
S. urophyllum – 1, 2, 4, 6, 7, 8, 10, 11, 15
Teucrium canadense – 7, 8
Thalictrum dioicum – 7, 8, 10, 13
T. revolutum – 12, 13
Thaspium barbinode – 1, 4, 7, 10, 12, 13, 14
T. pinnatifidum – 4
T. trifoliatum – 13
Thelypteris noveboracensis – 3, 12
Tiarella cordifolia – 1, 2, 3, 8, 9, 10, 11, 12
Tilia americana – 2, 3, 4, 6, 7, 8, 9, 11, 12, 14
Tipularia discolor – 2, 5
Toxicodendron radicans – all
Tradescantia subaspera – 7
Trillium erectum – 2, 8, 9, 10, 12
T. erectum var. *album* – 9
T. sulcatum – 1, 3, 9, 10, 12
Tsuga canadensis – 1, 2, 3
Ulmus alata – 4, 5, 15
U. americana – 5, 7, 13
U. rubra – 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14
Uvularia grandiflora – 1, 2, 6, 7, 10, 11, 12
U. perfoliata – 2, 4, 5, 7, 10, 12
Valerianella radiata – 13
Verbena urticifolia – 2, 6
Verbesina alternifolia – 6, 7, 8, 10, 11, 12, 15
Vernonia gigantea – 2
Viburnum acerifolium – 1, 3, 14
V. rufidulum – 5, 10, 13
Vicia caroliniana – 4, 13
Viola blanda – 2
V. canadensis – 1, 3, 4, 5, 7, 9, 10, 12, 14
V. cucullata – 4
V. pallens – 1, 3
V. palmata – 3
V. rostrata – 10
V. sororia – 2, 6, 7, 8, 9, 10, 11, 12, 13
Viola spp. – 1, 2, 3, 5, 7, 8, 9, 10, 12, 14
V. striata – 8, 9, 10
Vitis rotundifolia – 5, 7
V. vulpina – 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 15
Woodsia obtusa – 4, 6
Yucca filamentosa – 13

AN ECOLOGICAL STUDY OF THE AMERICAN CHESTNUT IN KENTUCKY AND TENNESSEE

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ABSTRACT. From 2002 to 2004, 2068 native American chestnut trees were inventoried in 42 Kentucky and Tennessee counties. For each specimen, GPS coordinates, diameter at breast height (dbh), height, flowering status, presence or absence of blight, associated tree species, elevation, and topographic position were recorded. The data were stored and analyzed with Excel, and ArcView was used to map chestnut sites and to show physiographic and geological associations. Five percent of the trees were blighted and 2% were flowering. On the Highland Rim, 74% of the trees occurred on dry sites--mostly south or west-facing slopes, while on the Cumberland Plateau and at Mammoth Cave National Park, 91% and 55% respectively were on mesic sites--mainly north to east-facing slopes. Chestnut trees were usually on sloping, well-drained, acidic, upland soils. On the Highland Rim, chestnut trees were primarily on cherty, limestone soils. On the Coastal Plain, chestnut was associated with sandy soils. At Mammoth Cave and on the Cumberland Plateau, chestnut trees were mostly on sandstone-derived soils. Typical associated species included *Acer rubrum*, *Carya glabra*, *Liridodendron tulipifera*, *Oxydendrum arboreum*, *Quercus prinus*, *Q. velutina*, and *Vaccinium spp*. Of the largest live chestnut trees (those > 35 cm), 7 of 10 were on the eastern Highland Rim. A total of 112 dead chestnut stems ≥2.5 cm were examined; their average longevity was 15.9 years, average diameter was 6.4 cm, and average growth rate was 0.5 cm per year.

INTRODUCTION

The American chestnut (*Castanea dentata*) was an abundant, tall canopy tree in many of the forests of Kentucky and Tennessee prior to the blight which swept westward through the region from the late 1920s to the early 1940s (Cochran, 1990). By the late 1940s, nearly all large chestnut trees in Kentucky and Tennessee were dead. In 2005, due to repeated sprouting from the root collar, chestnut sprouts continue to survive in this region, but rarely reach the canopy.

Rhoades and Park (2001) reviewed the historical information on the pre-blight distribution and abundance of American chestnut in Kentucky and concluded that it was most abundant in the Cumberland Mountain region of southeastern Kentucky, while chestnut abundance on the Cumberland Plateau and Knobs of eastern Kentucky was roughly one-third of that for the Cumberland Mountains. On the Mississippian Plateau (Highland Rim) and the western Knobs of central Kentucky, they determined chestnut abundance was similar or slightly less than that for the Cumberland Plateau. They concluded that chestnut was scarce, less than one percent of the forest resources, in the Bluegrass region of northern Kentucky as well as the Western Coalfields (Shawnee Hills) and Mississippi Embayment (Coastal Plain) in western Kentucky.

Ashe (1911) described the abundance and distribution of chestnut in Tennessee. He noted that it was most abundant on the slopes of the Unaka (Blue Ridge) Mountains in east Tennessee at elevations between 550 m and 1670 m, where it formed as much as 25% of the forest over tracts thousand of hectares in extent. In the Ridge and Valley Region between the Unaka Mountains and the Cumberland Plateau, he stated that chestnut occurred mostly in the hollows and on north-facing slopes, and that it formed less than 15% of the timber. Ashe indicated that chestnut was common on the slopes of the Cumberland Plateau, where the sandstone-derived soils were relatively deep and not too rocky; on the thin-soiled and stony portions of the Plateau, he judged chestnut to be nearly absent. On the Cumberland Plateau in Claiborne, Campbell, Anderson, Morgan, and Cumberland Counties, he claimed that it formed possibly 15% of the timber. Ashe indicated that chestnut was rare in the Central (Nashville) Basin, but considered it to be one of the chief trees on the surrounding Highland Rim; in portions of Hickman County on the western Highland Rim, he stated that chestnut comprised 10% of the forests. He added that on the sandier soils of the Highland Rim, chestnut constituted up to 20% of the forest. He noted that on the Coastal Plain region of Tennessee, chestnut was comparatively unimportant.

The primary objectives of this study were to: (1) construct a database of live and dead American chestnut trees in Kentucky and Tennessee, including data on location, size, health, fruiting, site conditions, and associated tree species; (2) from the database of live specimens, determine geographic distribution, preferred habitat conditions, size class distribution, incidence of blight, ratio of fruiting to non-fruiting trees, and seedling production; (3) from the dead stem database, determine average growth rates, diameters, and longevity; (4) find flowering American chestnut trees which may be used in The American Chestnut Foundation's backcross breeding program.".

METHODS

Botany professors, foresters, students, and others helped us locate chestnut in Kentucky and Tennessee. From October 2001 to October 2004, we ranged from the Highland Rim eastward to the Cumberland Plateau and westward to the Coastal Plain. A Global Positioning System instrument was used to determine coordinates for each chestnut tree which allowed the pinpointing of specimens on topographic maps and elevation determinations at Topozone.com. Using ArcView, chestnut site positions were plotted on county, physiographic, and geological maps. Stem diameter at 1.4 m above ground (diameter breast height or dbh) and estimated height for live specimens were recorded; if stems were in a cluster (clone), the number of stems per cluster was recorded and only the largest stem was measured. Associated tree and shrub species within a 15 m radius of each chestnut specimen were recorded. A hand-held compass was used to determine slope aspect. Notes on signs of blight, flowering or fruiting, and soil conditions were made. The diameters of 112 dead chestnut stems ≥2.5 cm dbh were measured and recorded; if more than one dead stem was in a cluster, only the largest was recorded. A small section of each dead stem was cut at 1.4 m above the ground and stored at VSCC for tree ring examination. The data were entered into an Excel database for storage and analyses.

Digital photos were made of the investigators, their operations, and the largest chestnut trees encountered; selected photos along with information about the ongoing research were placed on Schibig's VSCC-sponsored chestnut website: (*http://www2.volstate.edu/jschibig/resurrectingthechestnut.htm*).

RESULTS AND DISCUSSION

We recorded data on 2068 chestnut trees in 42 counties of Kentucky and Tennessee (Fig.1). Most of the work was done on the Highland Rim region and at Mammoth Cave National Park (Mammoth Cave N.P.) which is located in Kentucky in a transition zone between the Western Coalfields and the Highland Rim. At Mammoth Cave N.P. in Edmonson and Hart counties, 1201 chestnut specimens were recorded. Most (289) of our Cumberland Plateau specimens were found in Cumberland County, Tennessee. In Trigg County, Kentucky and Stewart County, Tennessee within Land Between The Lakes, located on the northwestern Highland Rim, we recorded data for 230 specimens. On the Coastal Plain of Kentucky and Tennessee, 36 chestnut trees were recorded. We found only one chestnut tree in the Western Coalfields region of western Kentucky, but it was a large one. We did not do field work in the Ridge and Valley region and mountains of eastern Kentucky and Tennessee, but Wood (2003) provided ecological data on chestnut trees in the Great Smoky Mountains National Park in Tennessee and North Carolina.

As was the case in the past, chestnut still is very abundant in the mountains of eastern Kentucky and Tennessee, and in some places on the Cumberland Plateau; however, as one goes westward, they are generally more scarce. On the Highland Rim and the Coastal Plain, they occur as small, widely spaced populations usually on hilly land growing on acidic, nutrient-poor, gravelly and/or sandy soils. American chestnut remains absent from the inner Nashville Basin, although a few trees have been found on the periphery of the outer Basin on upper slopes and ridges which are outliers of the Highland Rim.

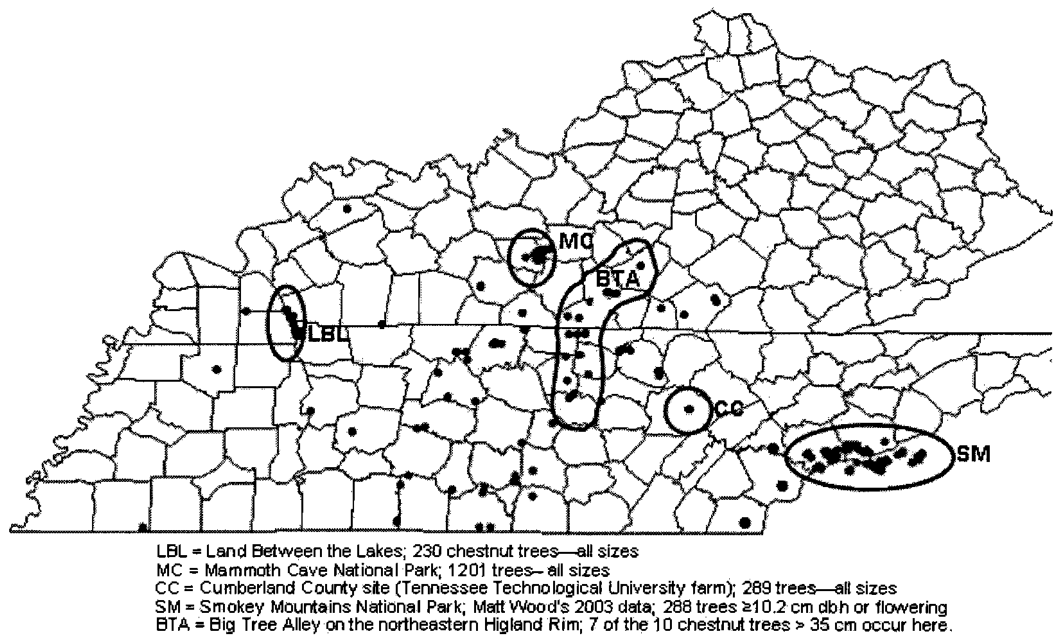

Figure 1. Sites of recorded American chestnut trees (Oct. 2001-Oct 2004) in Kentucky and Tennessee

Chestnut sprouts have been found in diverse habitats at elevations exceeding 1525 m in the Great Smoky Mountains (Stupka, 1964) to elevations under 115 m in southwestern Kentucky. On the Coastal Plain, chestnut specimens were found at an average elevation of 134 m, on the western Highland Rim--164 m, at Mammoth Cave N.P.--226 m, on the eastern Highland Rim--288 m, on the Cumberland Plateau--552 m, and in the Great Smoky Mountains, the data from Wood (2003) puts chestnut at an average of 1213 m.

Eight percent of the 441 trees on the Highland Rim were flowering. Elsewhere, the total number of trees and the percent which flowered were: Coastal Plain, 6% of 36; Cumberland Plateau, 1% of 390; and Mammoth Cave N.P., 0.08% of 1201. Overall, of the 2068 chestnut specimens we examined, only 2% were flowering.

We noted only four recent chestnut seedlings on three sites which had obviously resulted from natural cross pollination. Paillet (1984) found no recent seedlings in his study of 353 chestnut trees (sprout clones) in northeastern Massachusetts. This rareness of sexual reproduction which requires two flowering chestnut trees in close proximity, a very rare situation these days, makes natural evolution toward blight resistance very difficult. Paillet (2002) concluded that many of the surviving sprouts in New England forests were from old seedlings that have continued to re-sprout since establishment before the blight approximately 100 years ago.

The ability of chestnut to reproduce asexually by repeatedly sprouting from the root collar has allowed it to survive as a subcanopy species in many places throughout its former range. It reaches the canopy only rarely--20 trees, less than 1% in our study, were over 15 m tall. Only a small number (<5%) of the sprouts were found adjacent to the remains of an old pre-blight stump. Paillet (1984) also observed that <5% of the chestnut trees in his northeastern Massachusetts study showed any stump connection to pre-blight trees. Although resistant to decay, many of the >60 year old stumps have decomposed, but some still persist, especially on the drier sites. Interestingly, the largest known surviving American chestnut in Tennessee, the Jackson County tree, appears to have sprouted from a pre-blight stump. Ashe (1911) claimed that the sprouting capacity of chestnut was far superior to that of any other important hardwood species growing in Tennessee. He noted that on the north slope of Roan Mountain, above Burbank, at an altitude of about 915 m, 99% of the stumps of lumbered trees one to 1.3 m in diameter, and varying in age from 150 to 300 years, sprouted, and the sprouts from most of the stumps were both numerous and vigorous.

We observed 10 chestnut sprouts a few months after they had been unintentionally burned by a controlled fire at Mammoth Cave N.P. in 2004. Two were saplings (dbh--8 and 13 cm) which suffered scorched bark but appeared not to have been damaged by the fire. The other eight were smaller stems which had been killed, but all of them had produced new sprouts from the root collar. Although Ashe (1911) stated "young chestnut is so subject to fire damage that it is of first importance to protect young stands", based on our limited observations, it appears that controlled burns, if not too hot, do kill the smaller stems, but not the root collars which continue to send up new sprouts. The park commenced controlled burning in selected areas in 2002.

There was a greater occurrence of blight among chestnut trees (all sizes) on the Highland Rim (17% blighted) and the Coastal Plain (25% blighted) than on trees at Mammoth Cave N.P. (1% blighted) and on the Cumberland Plateau (1% blighted). Overall, we found signs of blight on 5% of the chestnut trees in Kentucky and Tennessee. Of the larger chestnut trees (≥10.2 cm dbh), 63% (42 of 67) were blighted, while 83% (35 of 42) of the flowering chestnut trees had the blight. Wood (2003) reported that 51% (147 of 288) of the chestnut trees (flowering and/or ≥10.2 cm dbh) in the Great Smoky Mountains N.P. were blighted. Larger sprouts are blighted more because they are usually older than the smaller sprouts, thus they have had more time to become infected, and larger trees tend to have splitting bark which makes spore entry easier, and having a larger bark surface naturally increases the likelihood of infection. Larger chestnut trees are also pecked on more than smaller ones by woodpeckers, which no doubt, are agents of blight (*Cryphonectria parasitica*) spore dispersal.

Carey (1985) isolated *Cryphonectria parasitica* from all 18 of the large chestnuts in his study in North Carolina; ten of them had abnormal isolates indicating hypovirulence. Of the 19 chestnut "mother" trees that have been used in The American Chestnut Foundation's breeding program in Kentucky and Tennessee, only two were blight free. Eight of the 17 blighted Kentucky-Tennessee mother trees exhibited swollen cankers. Such cankers indicate that the blight fungus is superficial and slow growing. Trees with these cankers usually live longer than those that develop the fast-growing sunken cankers. The largest chestnut in Kentucky, the Adair County tree, and the largest one in Tennessee, the Jackson County tree, both have many swollen cankers, yet they are vigorous trees which have lived with the blight for many years. Such rare large survivors may have lived so long because of a combination of these factors: (1) the attacking blight pathogens are hypovirulent (the fungus is weakened by a virus); (2) the trees have at least a small level of resistance to the blight; and (3) the trees are growing on sites conducive to chestnut growth and survival. Griffin (1986) believed such factors explained the survival of the large long-lived American chestnut in Amherst County, Virginia. Fred Hebard informed me (email correspondence in 2003) that he has tested many American chestnut trees for blight resistance and has found some that showed a low level of resistance to the blight, but none that displayed a high level of resistance, as is the case in some of the Asian chestnuts.

In addition to blight, other diseases, browsing by deer and cattle, insect attacks, anthropogenic disturbances, and competition from other vegetation continue to reduce the number of chestnut trees. On many of the chestnut sites in middle Tennessee and south central Kentucky, deer heavily browse chestnut sprouts; at Edgar Evins State Park in middle Tennessee, the deer population is so high that successful sprout regeneration is seldom possible. We noted five occurrences of gall wasps (*Dryocosmus kuriphilus*) on chestnut trees in middle Tennessee and one in south central Kentucky, but most of the afflicted trees seemed to be making good growth despite the wasp infestation. We observed two chestnut saplings at Land Between The Lakes which were severely attacked by Japanese beetles (*Popillia japonica*) in 2003, but they made good growth in 2004.

We found a higher percentage of relatively large (dbh ≥10.2 cm) chestnut trees on the Highland Rim (12.7%) than at Mammoth Cave N.P. (only 0.6%). This may be partly due to the fact that most of the chestnut trees at Mammoth Cave N.P. were growing in protected, but usually more shaded areas than those on the Highland Rim. The largest chestnut trees were found on the northeastern Highland Rim of north central Tennessee and south central Kentucky. Of the 10 chestnut trees with a dbh >35 cm, seven were clustered in this region. The largest chestnut tree recorded in the Great Smoky Mountains N.P. by Wood (2003) had a dbh of only 31 cm. There are many small chestnut sprouts still surviving in the Great Smoky Mountains N.P. and at Mammoth Cave N.P., but it is surprising that no surviving chestnut trees with a dbh >31 cm have been found in either of these parks. Perhaps chestnut grows faster and larger on the limestone-derived soils of the northeastern Highland Rim because they are generally deeper and more fertile than the Smoky mountains soils or the sandstone-derived soils of Mammoth

Cave N.P. We know the Highland Rim area has been logged intensively, thus releasing chestnut for faster growth, while little human disturbance has occurred in the parks. The chestnut with the greatest dbh in our study area is found on the northeastern Highland Rim; the huge (dbh of 100 cm) Adair County, Kentucky chestnut has lived with the blight, a lighting strike, and a large bulldozer scrape for many years. It has the distinction of being one of the very few surviving chestnut trees that was a mature tree (about 20 cm dbh) when the blight struck in the 1930s and which remained healthy while millions of other chestnut trees perished. The two largest chestnut trees in Tennessee are also on the northeastern Highland Rim, and both are in Jackson County--they have dbhs of 61 and 48 cm.

Most of the 1201 chestnut trees at Mammoth Cave N.P. were quite small and slow-growing--85.8% of them were <2.5 cm dbh while only 7 of 1201 were ≥10.2 cm. In the other regions, the percent of chestnut trees with a dbh ≥10.2 cm were: Cumberland Plateau, 1% of 390 trees; Land Between The Lakes (LBL) on the northwestern Highland Rim, 3.4% of 230 trees; for all of the Highland Rim, 12.7% of 441 trees; and Coastal Plain, 5.6% of the 36 trees. There was no bias for finding the larger trees at Mammoth Cave N.P., the Cumberland Plateau, and LBL; chestnut trees of all sizes were sought and recorded, so we think their sizes are representative of these regions. On other parts of the Highland Rim and on the Coastal Plain, there was some tendency to find and document the larger trees, because some of the reported trees came from foresters and loggers who tended to report mainly the larger specimens.

Most of the tallest chestnut trees were found on the northeastern Highland Rim where 20 of the trees were in the 15 to 24 m class, but the tallest chestnut (known to us) in the southeastern U.S. was found on sandstone soil in Webster County, Kentucky, in the Western Coalfields region. It towered to 27 m and had a dbh of 51 cm.

We found chestnut trees on a wide range of soils, but they were almost always on well-drained soils. On the Highland Rim, we observed them on mostly deep, acidic, cherty soils derived from the Fort Payne limestone formation. On the Coastal Plain, chestnut trees were found on sandy and/or gravelly soils (mostly Tertiary deposits). At Mammoth Cave N.P., they were most often on rocky, acidic, sandstone soils. On the Cumberland Plateau, they were on the sandy, acidic soils derived from sandstone. Currently, we have very few records of chestnut trees in the Ridge and Valley (Great Valley) Province, but there is a very productive "mother" tree in Blount County. Martin (1989) stated that chestnut was an important species in the Great Valley, particularly on the ridges; he described the ridge soils as usually deep, well-drained, acidic, and cherty. We have documented very few chestnut specimens in the Unaka mountains of eastern Tennessee because that region is so distant from us, but we suspect there are many small sprouts there today on a variety of well-drained, acidic, soils derived from a mixture of igneous, metamorphic, and sedimentary bedrocks.

By referring to county soil survey maps, we determined the following soil series for sites occupied by chestnut in Trigg County, Kentucky and Stewart County, Tennessee within Land Between the Lakes: Baxter-Hammock soils derived from cherty limestone (28.3% of the chestnut sites); Bodine Cherty Silt Loam derived from cherty limestone (23.5%); Saffel and Brandon-Saffel derived mostly from Cretaceous gravel (32.2%); Brandon Silt Loam from loess and Cretaceous gravel (8.3%); Guin Gravelly Loam mostly from Cretaceous gravel (5.2%); Nixa Cherty Silt Loam derived from cherty limestone (1.7%); Hammack-Baxter soil derived from cherty limestone (0.9%). All of these soils were acidic, well-drained, and most were deep.

At Mammoth Cave N.P., the following soil series associated with chestnut were in Hart and Edmonson Counties, Kentucky: Bledsoe-Wallen Rock Outcrop (at 39% of the chestnut sites)--rocky sandstone soils on steep slopes; Riney Loam (28%)--loamy sandstone soils on gentle to steep slopes; Wellston Silt Loam (21%)--gentle to moderately steep ridge and upper slope soils derived mostly from loess and sandstone-siltstone residuum; Lily Loam (6%)--soils on steep slopes derived from sandstone, shale, and siltstone; Jefferson Lily Rock Outcrop (4%)--rocky sandstone soils on moderately steep slopes; Caneyville Rock Outcrop (1%)--soil with limestone outcrops; Tiltsit Silt Loam (1%)--sandstone-based soils on gentle slopes.

On the Highland Rim, chestnut was found more often on the drier sites (ridges and mostly south to west-facing slopes) than on the more mesic sites (ravines and mostly north to east-facing slopes); 74% were on dry sites, while 26% were on relatively mesic sites. At LBL on the northwestern Highland Rim, chestnut trees were found primarily on the west-facing bluffs adjacent to Kentucky Lake. On the Cumberland Plateau, only 9% were on the drier sites while 91% occurred on the more mesic sites. It should be pointed out that the sandy Cumberland Plateau soils are usually very well-drained and tend to be somewhat dry even on ravine and north-facing slope sites. Hinkle (1989), studied forest communities on the Cumberland Plateau of Tennessee and reported that living chestnut sprouts were in 4.8% of his ravine sample plots, and 14% of the ravine plots had evidence (old stumps and logs) of chestnut. On his drier upland plots, chestnut sprouts were recorded in only 1.8% of them. On the mostly sandstone soils at Mammoth Cave N.P., 45% of the chestnut sprouts were on the dry sites, while 55% were on the more mesic sites. Many of these were found in an old-growth forest called the "Big Woods." In this 120-hectare tract, chestnut sprouts had a density of approximately 10 trees per hectare. Lucy Braun (1950) reported her observations in the "Big Woods" that she made in the 1930s. She noted that chestnut was the fourth most abundant tree species in the white oak-black oak-tulip tree forest of the upland slopes in the "Big Woods." Today, white oak, black oak, and tulip tree (tulip poplar) still dominate this area, and chestnut remains plentiful in the understory as small, slow-growing sprouts. We also found chestnut on the rocky slopes of large sandstone-capped sinkholes in the southern portion of Mammoth Cave N.P.

In our study, 83% of the 41 flowering chestnut trees were found on dry sites. In the Great Smoky Mountains N.P., Wood (2003) obtained similar results with 74% of the 157 flowering chestnut trees occurring on dry sites. This can be explained by the fact that chestnut trees only flower when they receive direct sunlight for much of the day. The drier sites are the ridges and the upper south to west-facing slopes where the canopy usually is more open admitting more sunlight than on the more mesic sites (ravines and north to east-facing slopes).

On the northern Highland Rim of south central Kentucky and northern middle Tennessee, Schibig et al. (2003) sampled the tree species (dbh ≥10.2 cm dbh) associated with chestnut on dry and mesic sites. On four dry sites, the five most dominant tree species were, in order of descending importance value, chestnut oak, red maple, black oak, sourwood, and blackgum. The shrubs/small trees most often found with chestnut on dry sites were wild blueberry, greenbriar, and serviceberry. Although generally rare on the Highland Rim, mountain laurel occasionally occurred with chestnut on dry upper slopes. On relatively mesic sites, the five most ecologically important tree species were tulip poplar, white oak, sugar maple, red maple, and sourwood. Spicebush and strawberry bush often occurred on these mesic sites.

For each chestnut tree recorded in Kentucky and Tennessee, we noted the associated tree species within a 15 m radius (Table 1). By far, red maple was the chief chestnut associate; like chestnut, it is adapted to acidic, well drained soils, but unlike chestnut, it is also found on poorly drained soils.

In the Great Smoky Mountains N.P., Wood (2003) reported that the chief overstory trees associated with chestnut included northern red oak, chestnut oak, red maple, white oak, and scarlet oak. He also listed the understory trees and shrubs most often occurring with chestnut; they included red maple, northern red oak, mountain laurel, and Allegheny serviceberry.

Overall, a total of 112 dead chestnut stems ≥2.5 cm were examined; their average longevity was 15.9 years, average diameter was 6.4 cm, and average growth rate was 0.5 cm per year. Thirty-five of the 112 dead chestnut stems were Mammoth Cave N.P. specimens; these averaged 3.3 cm in diameter, had and average growth rate of 0.2 cm per year, and their average longevity was 20 years. Chestnut stems at Mammoth Cave N.P., on average, are living longer than chestnut stems elsewhere in our study area, because most of them have smooth, non-splitting bark, and are relatively small targets for *Cryphonectria* spores. They are growing more slowly, because many of them are heavily shaded.

We will continue to inventory native chestnut trees in Kentucky and Tennessee to gain a better understanding of their ecology. The baseline data we are obtaining will be useful in monitoring future changes in the native chestnut populations. Knowing the habitat preferences of chestnut will be helpful in determining the best sites for restoration when regionally adapted, blight-resistant American chestnut trees become available.

Table 1. The twenty tree species most often associated with 2032 chestnut trees at Mammoth Cave National Park (1201 chestnut trees), on the Highland Rim (441 trees) and the Cumberland Plateau (390 trees) of Kentucky and Tennessee.

Common name	Scientific name	No. of times found within a 15 m radius of a chestnut tree	Percent of 2032 possible associations
Red maple	*Acer rubrum*	1336	65.8
Tulip poplar	*Liriodendron tulipifera*	932	45.9
Sourwood	*Oxydendrum arboretum*	927	45.7
Blackgum	*Nyssa sylvatica*	854	42.1
Dogwood	*Cornus florida*	808	39.8
White oak	*Quercus alba*	617	30.4
Pignut hickory	*Carya glabra*	585	28.8
Sassafras	*Sassafras albidum*	555	27.3
Black oak	*Quercus velutina*	552	27.2
Chestnut oak	*Quercus prinus*	442	21.8
American beech	*Fagus grandifolia*	418	20.6
Serviceberry	*Amelanchier arborea*	313	15.4
Scarlet oak	*Quercus coccinea*	296	14.6
Mockernut hickory	*Carya tomentosa*	235	11.6
Virginia pine	*Pinus virginiana*	163	8.0
Post oak	*Quercus stellata*	144	7.1
Sugar maple	*Acer saccharum*	121	6.0
Red hickory	*Carya ovalis*	104	5.1
Northern red oak	*Quercus rubra*	85	4.2
Shagbark hickory	*Carya ovata*	64	3.2

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THE BLACK BELT PRAIRIE OF MISSISSIPPI AND ALABAMA

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ABSTRACT. The Black Belt Prairie is a crescent shaped region that extends southward from McNary County in southern Tennessee, through east-central Mississippi and east to Russell County, Alabama, near the Georgia border. The Black Belt is underlain by Cretaceous Selma chalk, that is composed of fossiliferous, soft, white-gray limestone that weathers into fertile black soil, for which the region is named.

The Black Belt contains three major plant communities: open prairie, chalk outcrop, and forest. The open prairie habitat includes many species that are disjunct from Great Plains as well endemic and rare species. This suggests that a grassland corridor may have historically connected the Black Belt and the Great Plains. Although no pollen cores studies have been conducted in the Black Belt, a study of the macro-vertebrate fossil assemblage reveals a community of grazers, dominated by six species of *Equis*, three of which are only know from the Black Belt and the Great Plains.

It is estimated that less than 1% of the Black Belt's open prairie habitat remains intact. Threats include agriculture, development, and the incursion of eastern red cedar, *Juniperus virginiana* L. A group of concerned citizens, Friends of the Black Belt, currently lease sixty acres of land in the Black Belt in an effort to conserve one of the better examples of Black Belt habitat. This land has been used as a teaching tool by a local high school and also as a study site for several graduate students from Mississippi State University.

TREE REGENERATION STATUS OF UPLAND FORESTS IN THE ILLINOIS HILLS

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ABSTRACT. Oak and hickory species have historically been the predominant species in much of the publicly owned forests of the Illinois Ozark Hills. Over the past several decades, this forest type has been in decline relative to mesophytic species. This transition has occurred along with, or in response to, changing forest management practices, fire suppression and, most recently, a suspension of all silvicultural activities. Preliminary observations have suggested that forest vegetation responses to these forces have differed in response to topographic position within this sharply dissected landscape. The objectives of this study were to evaluate the relationships between past silvicultural activities and landscape position on present forest tree species composition.

Long-term partial cutting at Trail of Tears State Forest. without subsequent control of midstory vegetation, has failed to produce a new cohort of oak and hickory species. The transformation toward mixed mesophytes has occurred across this landscape, but with greater rapidity on productive landscape positions. In the absence of severe canopy disturbance or remedial silvicultural activities, species composition will become increasingly homogeneous across this landscape.

At Atwood Ridge on the Shawnee National Forest, clearcutting, with or without herbicidal control of residual stems, maintained an oak component. The herbicide treatment maintained sugar maple at pre-treatment density, but increased the density of American beech, in the cove position. In the midslope and ridge positions, herbicidal control produced inconsistent results.

These studies suggest that maintenance of oak-hickory forests through past management practices have produced varying results. Based on experience elsewhere in oak-hickory forests, silvicultural interventions have fallen short of addressing all regeneration goals at least in part due to the long-term absence of fire on the landscape. Meaningful restoration of a fire regime to replicate pre-exclusion forest processes will likely require complimentary cutting and or herbiciding to remove trees that have grown beyond the influence of fire.

JUSTIFICATION FOR REESTABLISHING FIRE IN OAK ECOSYSTEMS OF THE CENTRAL HARDWOODS

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ABSTRACT. The historic role of fire in the development and maintenance of oak forests has been well established across much of the eastern deciduous biome. Twentieth century fire suppression has resulted in decreased oak regeneration and portends the loss of keystone species across many landscapes. In the central hardwoods, cultural burning and harvesting fostered consistent oak recruitment until the 1950s when cutting declined and fires were widely suppressed. Now, many mature oak stands are in jeopardy of being replaced en masse by species previously confined to mesic sites. We review evidence for fire as an ecosystem process across this region and discuss an emerging strategy for the widespread reintegration of fire management across the midwestern landscape against the backdrop of media-driven public perceptions.

RELATIONSHIPS BETWEEN WHITE OAK SITE INDEX AND SOIL, TOPOGRAPHIC, AND STAND FACTORS AT LAND BETWEEN THE LAKES, KENTUCKY AND TENNESSEE.

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ABSTRACT. Tree and stand data from 74 permanent plots at Land Between The Lakes, Kentucky and Tennessee, were used to evaluate the influence of soil, topographic, and stand factors on white oak growth as indicated by site index. In each stand, height and age data were obtained from four to six healthy white oak (*Quercus alba*) or post oak (*Quercus stellata*) dominant or codominant trees. Data from five stands were withheld from the data set and used to test the models. Scattergrams of site index plotted over various independent soil, topographic, and stand variables were examined for linear and curvilinear relationships. Independent soil variables tested included percent sand, silt, clay, and percent rock in the B_2 horizon. Also tested were available water holding capacity (AWC), potassium (K), magnesium (Mg), and calcium (Ca) to a 100 cm depth or to depth of rooting if restricted by a pan or bedrock (effective soil depth, ESD). Topographic variables included slope position (SLOPOS), aspect (TRASP), elevation (ELEVATN), percent slope, distance to opposing slope and distance to the opposing slope or lake shore water (DTOPSWA). Stand variables included stand tree basal area and seedling and sapling density. Subsequently, natural log transforms were applied to effective soil depth, available water holding capacity (lnAWC), basal area (lnBA), and calcium (lnCA) to produce more linear relationships. In the soil group, site index was correlated with ESD ($r = 0.41$), lnESD ($r = 0.38$), AWC ($R = 0.50$), lnAWC ($r = 0.49$) K (0.36), lnK ($r = 0.37$), Mg ($r = 0.25$), CA ($r = 0.47$), and lnCA ($r = 0.59$). For the topographic variables, site index was related to SLOPOS ($r = 0.76$), TRASP ($r = 0.70$), ELEVATN, and DISLOPWA ($r = 0.76$). Of the individual stand variables, white oak site index was strongly related to BA ($r = 0.60$) and lnBA (0.61) and was not related to seedling and sapling density. Subsequently, all variables were included in a forward stepwise multiple regression analysis. The most parsimonious predictive model included the following variables in the order in which they entered the model: DSTOPWA ($p = .0000$), lnCA ($p = .0000$), SLOPOS ($p = .0002$), TASP ($p = .0000$), lnAWC ($p = .0000$), and K ($p = .0007$) accounted for 89% of the variation (Adjusted $R2 = 0.88$).

ECOLOGY OF AMERICAN CHESTNUT AT MAMMOTH CAVE NATIONAL PARK

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ABSTRACT. From 2003 to 2004, 1201 native American chestnut trees were studied at Mammoth Cave National Park. For each tree, GPS coordinates, diameter breast height (dbh), height, flowering status, presence or absence of blight, associated tree species, elevation, and topographic position were recorded. Excel was used to record and analyze the data while ArcView was used to map chestnut sites to show physiographic and geological correlations. Only one of the chestnut trees was flowering, but it died of blight in 2004. Most specimens were small, but seven chestnut trees had a dbh ≥10.2 cm. The largest one had a dbh of 20 cm, was 13.7 m tall, and was blight-free. Only 14 (1%) of the trees definitely had the blight. The average elevation for chestnut trees was 226 m. Eighty-eight percent of the chestnut trees were found on these sandstone-based soils: Bledsoe-Wallen rock outcrop, Riney loam, and Wellston silt loam. Only 1% of the trees were on limestone soil (Caneyville-rock outcrop). Fifty-five percent of the chestnut trees were on mesic sites (mostly ravines and north to east-facing slopes) while 45% were on drier sites (ridges and south to west-facing slopes). The species most often associated with chestnut included *Acer rubrum*, *Carya glabra, C. tomentosa*, *Cornus florida*, *Fagus grandifolia*, *Liriodendron tulipifera*, *Nyssa sylvatica*, *Quercus alba*, *Q. velutina*, and *Vaccinium spp*. The richest area of the park for chestnut was an old growth forest called the "Big Woods"; in this 121-hectare tract, chestnut had a density of approximately 8 trees per hectare. The age, diameter, and growth rate of 35 dead chestnut stems ≥2.5 cm were determined. These averaged 3.3 cm in diameter, had an average growth rate of 0.2 cm per year, and their average longevity was 20 years.

ECOLOGY OF AMERICAN CHESTNUT AT LAND BETWEEN THE LAKES

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ABSTRACT. A study of native *Castanea dentata* specimens was conducted at Land Between the Lakes (Trigg County, Kentucky and Stewart County, Tennessee) from May, 2002 to October, 2003. For each specimen, GPS coordinates, size, flowering status, presence of blight, elevation, soil series, geological formation, openness of canopy, associated tree species, and other notations were recorded in an Excel spreadsheet. ArcView was used to map chestnut sites and to correlate them with geological formations. A total of 230 live specimens were located, all on the western edge of Land Between the Lakes. Eight had diameters at breast height (dbh) ≥10.2 cm; the largest was 28 cm (dbh) and 14 m tall. Six chestnut trees (2.6%) were flowering. Twenty-six specimens (11.3%) showed signs of blight. Growth ring examination of 40 dead chestnut stems ≥2.5 cm dbh revealed an average growth rate of only 0.2 cm per year; this reflected the dry and infertile soil conditions of most chestnut sites. The elevation range for chestnuts was 110 to 189 m (average elevation, 140 m). All specimens were found on well-drained, gravelly, acidic soils (28.3% on Baxter-Hammock; 23.5% on Bodine Cherty Silt Loam; 18.3% on Brandon-Saffel; 13.9% on Saffel; 8.3% on Brandon Silt Loam; 5.2% on Guin Gravelly Loam; 1.7% on Nixa Cherty Silt Loam and 0.9% on Hammack-Baxter). These soils were derived primarily from the cherty Mississippian limestones of the Fort Payne Formation or from Cretaceous gravels. Most (75%) chestnuts were found on very xeric sites (ridges and south to west-facing slopes) and 86 percent of the specimens were in woods with a somewhat open canopy. The species most often associated with *C. dentata* were *Quercus prinus*, *Q. velutina*, *Q. coccinea*, *Acer rubrum*, *Oxydendrum arboreum*, *Vitis rotundifolia*, and *Vaccinium spp*.

DISJUNCT TENNESSEE POPULATIONS OF AN UNDESCRIBED *EUPHORBIA* (EUPHORBIACEAE) FROM THE MIDDLE CUMBERLAND RIVER REGION (TENNESSEE)

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ABSTRACT. An undescribed species of *Euphorbia* has been primarily documented from the Ouachita Moutain region of eastern Oklahoma and west-central Arkansas where it is known from less than 15 separate localities. Outside of the Ouachita Mountain region, it is known only in the upper Roaring River Valley in Barry County, Missouri, and from four localities in Trousdale County in Tennessee. The Tennessee populations present an intriguing trans-Mississippi River disjunction most similar to that of *Calamovilfa arcuata* (Cumberland Sandreed), and *Carex ouachitana* (Ouachita Sedge). We present morphological, distributional, and ecological details of the undescribed species of *Euphorbia*, and provide a detailed comparison to similar *Euphorbia* species in the southeastern US. Insights into the phylogenetic relationships of this and related *Euphorbia* species based on DNA sequence data (the Internal Transcribed Spacer region, or ITS, or nuclear ribosomal DNA; and the chloroplast spacer *trn*S-*trn*G) are also discussed.

THE HISTORIC DISTRIBUTION AND PRESENT STATUS OF *DESMODIUM OCHROLEUCUM* (CREAMFLOWERED TICK-TREFOIL) IN TENNESSEE

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ABSTRACT. In 2004, the U.S. Fish and Wildlife Service funded a survey for *Desmodium ochroleucum* (creamflowered tick-trefoil) in Tennessee. The survey conducted over the summer of 2004 led to the discovery of a new population of *D. ochroleucum* from a successional cedar barren in Perry County, Tennessee. The current historical range of *D. ochroleucum* includes 12 eastern states, but is documented as extant in only seven, with less than 15 known rangewide occurrences. Within Tennessee it has been historically recorded from three counties and had not been collected or observed since 1965. It is currently legally listed as an endangered species in Tennessee. The global rarity and recent relocation of this species in Tennessee makes *D. ochroleucum* a species of high conservation concern.

THE STATUS, MANAGEMENT, AND MONITORING OF EGGERT'S SUNFLOWER (*HELIANTHUS EGGERTII*) ON ARNOLD AIRFORCE BASE, TENNESSEE

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ABSTRACT. Eggert's sunflower (*Helianthus eggertii* Small) is the only Federally listed "threatened" plant species known from Arnold AFB, TN (AAFB). Management actions for the species are integrated with other aspects of the AAFB ecosystem management program by employing a coarse filter-fine filter approach (Leslie et al. 1996). The coarse filter approach is to restore and maintain vegetation structure and ecological processes in suitable habitats for Eggert's sunflower. Such process-oriented management supports mission flexibility by working at multiple spatial and temporal scales to conserve biological diversity. Fine filter protective measures are also taken to ensure that localized destruction of the species or its habitat do not encroach on mission flexibility by violating provisions of the Endangered Species Act. Management is coupled with monitoring to help track impacts to the plant. The AAFB Conservation program implements management and develops projects to further the recovery objectives outlined by the United States Fish and Wildlife Service (USFWS). This presentation summarizes the management and monitoring conducted in support of the recovery objectives and ultimate delisting of the species as outlined by the USFWS.

PROPAGATION AND SUBSEQUENT SURVIVAL AND GROWTH OF GIANT CANE (*ARUNDINARIA GIGANTEA*) RHIZOMES FOUR YEARS AFTER FIELD PLANTING IN SOUTHERN ILLINOIS

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ABSTRACT. This study was conducted to determine factors important for rhizome cutting propagation and subsequent survival and growth of giant cane (*Arundinaria gigantea*) propagules for use in canebreak restoration. Initial greenhouse studies determined that greater numbers of culm shoots were produced from rhizomes with more internodes, especially when surface planted and exposed to light rather than buried. A mean of 7.9 nodes per rhizome was needed to produce one culm shoot. In early 2001, rhizomes were planted slightly off-vertical in pots with 3 cm of the distal portion left unburied and exposed to light. Of the 435 rhizomes planted, 76% produced at least one culm shoot and 28% had produced two or more culms shoots. Culm shoot production varied by date of collection and site (putative genotype). Rhizomes that produced at least 1 culm were field planted in May 2001 at two sites in southern Illinois. One planting site, off of Thunderstorm Road in Jackson County, was established adjacent to an impoundment on a former upland farm within a fescue sod. The Rose Farms site in Johnson County, was formerly a bottomland forest converted to farming and cultivated up to the time of planting. Results after four growing seasons of the survival, height, number of culms, and the distance of spread of the cane patches that grew from the original planted propagule will be presented.

ALL TAXA BIODIVERSITY INDEX UPDATE AT EDGAR EVINS STATE PARK

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ABSTRACT. Tennessee Department of Environment and Conservation (TDEC), supported by other organizations such as Tennessee Natural Heritage, Natural and Cultural Resource Management (NCRM), Discover Life in America (DLIA), et al., are sponsoring a Tennessee State Parks All Taxa Biodiversity Inventory (ATBI). A weekend conference in August, 2004, initiated and began organizing the project, and included representatives from Tennessee State Parks and higher academic institutions, as well as the previous mentioned groups. We decided to basically follow the methodologies of the North Carolina Vegetation Survey with some modifications. Traditional and structured observation, collecting, and documenting are encouraged. Traditional surveys include chance discoveries of species as well as random or systematic accepted survey methods. Structured sampling will involve permanent plots and long term monitoring, and will be a uniformed protocol in all parks. Details of the structured methodologies are still being discussed by the Tennessee State Parks ATBI Steering Committee, but 20 x 50 meter traditional permanent plots will be utilized. Protocol details as finalized are being reported. A research team from Volunteer State Community College (VSCC), Gallatin, Tennessee, is participating in a traditional dendrology survey on the 2,600 ha (6,500 acre) Edgar Evins State Park. Five study areas are initially being systematically surveyed utilizing the quarter-point method, and data will be analyzed with traditional Importance Value (IV) statistics. Although some of the park is relatively recently disturbed and anthropogenic factors are apparent and being documented, the research team has discovered several diverse, relatively natural deciduous forest ecosystems and communities. The primary objective of this traditional preliminary research is to delineate existing forest communities, which will help designate randomly chosen permanent plot locations. Despite anthropogenic influences, preliminary analysis of the quarter-point survey data collected so far shows deciduous diversity is apparent, although in certain segregates *Juniperus virginiana* is dominant. Details of this traditional survey and updates of establishing permanent plots, as well as aspect, topographic, and edaphic correlations, will be reported.

CONTRIBUTED PAPERS

SESSION II: AQUATIC BIOLOGY AND ZOOLOGY

Saturday, April 2, 2005

Moderated by:

Mack T. Finley
Austin Peay State University

GEOTUBE USES AND LESSONS LEARNED BY THE CORPS OF ENGINEERS

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ABSTRACT. The Corps of Engineers has experimented with geotubes since 1991. Geotubes are constructed from a variety of geotextile fabrics and are designed to trap and filter solids, even fine silts and clays. Geotubes can be filled on dry land, partially submerged, or even fully submerged. They can be used for a number of purposes including sediment disposal, containment of contaminated sediments, dike creation, and water filtration. Items to consider when using geotubes include the type of dredge material, the type of geotextile material, the goal or intended use, cost, project schedule, public perception, and finished product. Geotubes can be temporary or can become a permanent fixture. They can be stacked to achieve additional height or to conserve horizontal space and can be planted to appear as a natural part of the landscape. Geotubes can eliminate sediment plumes from dredge disposal or dewaterings. A variety of plants will naturally try to colonize the tubes, but they can also be sprigged or seeded to establish desired plant cover.

MULTIVARIATE NONPARAMETRIC STATISTICS (ANOSIM) USED TO MONITOR CHANGES IN THE MUSSEL COMMUNITY DOWNSTREAM FROM KENTUCKY LOCK AND DAM

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ABSTRACT. The U.S. Army Corps of Engineers is adding a 366-m long navigation lock at Kentucky Lock and Dam, located at Tennessee River Mile 22.4 in Marshall and Livingston counties, Kentucky. Downstream from the dam, there is an extensive mussel community that may be influenced by changes in flow patterns and river navigation traffic. A mussel monitoring program was initiated in 2003 to assess the current condition of the mussel community and to establish a baseline for monitoring changes that may occur during construction and later operation of the new lock. Mussels were collected from four sites downstream from the dam. Within each site, eighty 0.25 m^2 quadrats were sampled by excavation and screening of sediment. Twenty-eight species and 4496 individuals were collected from the total sample area of 80 m^2, aged, weighed, measured, and returned to their original locations. Nonparametric multivariate statistical techniques: Bray-Curtis ordination, cluster analysis, non-metric multidimensional scaling, and analysis of similarity (ANOSIM, a permutation procedure), were used to compare sites. These multivariate tests, which do not require the assumptions of multivariate normality and homogeneity of variances, provide sensitive methods for detecting changes in the mussel community over time, whether changes result from natural mortality and fluctuations in reproductive success or environmental perturbations. Only long-term monitoring of the mussel community can provide the information needed to document change if it occurs. Although other statistical procedures, such as the Shannon diversity index, are useful for comparing communities to assess habitat support of diverse assemblages of species, the index does not reveal differences in species composition between sample areas or sample times. Nonparametric statistical procedures such as ANOSIM (analysis of similarities) using permutations of Bray-Curtis ordination of similarity coefficients allows communities to be compared species by species, and provides sensitive inference tests for detecting differences in community structure between sample sites or within sample sites at different times. Habitat characteristics are also being studied including depth, bottom profile, and sediment grain size. This information will be analyzed using GIS spatial analysis procedures to determine if species composition can be related to habitat characteristics. This project was funded by the Nashville District Army Corps of Engineers.

MUSSEL RELOCATION IN ASSOCIATION WITH THE NAVIGATION LOCK REPLACEMENT AT CHICKAMAUGA LOCK AND DAM ON THE TENNESSEE RIVER IN CHATTANOOGA, TENNESSEE

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ABSTRACT. Chickamauga Lock and Dam is located at Tennessee River Mile (TRM) 470.9, near Chattanooga, Tennessee in Hamilton County. The existing lock has been in service since 1940 and has deteriorated throughout its life span due to a chemical Alkali-Aggregate Reaction that causes concrete to swell or grow. Construction of the new navigation lock will involve construction of a cofferdam on the downstream side of the dam located between Chickamauga Dam (TRM 470.9) and approximately river mile 470.7. The existing sailing line approach to the old lock is not expected to change, except that it will shift into the new lock. The action footprint of the new sailing line approach, cofferdam, new lock, and skirted guide walls is located approximately between Tennessee River Mile 470.6 and 470.9. The project also includes construction of a new dock facility for barges. The action footprint for the dock facility is located on the right descending bank in the area of TRM 470.1 - 470.2. The purpose of the mussel relocation was to remove as many native freshwater mussels as possible from within the two proposed action footprints prior to construction activities at Chickamauga Lock and Dam. The footprints are located within a Tennessee State mussel sanctuary. The total estimated area of the action footprints totaled approximately 20 acres. To minimize impact to the mussel population, and specifically to federally listed species, the Chickamauga Environmental Impact Statement (EIS) and the Biological Opinion from the U.S. Fish and Wildlife Service required that mussels found within the impact areas should be relocated to an area of suitable habitat within the state mussel sanctuary. Commercially certified divers were used during the mussel relocation effort performed between July 19, 2004 and August 26, 2004. A total of 24 days were dedicated to performing the work involved with the initial survey and the mussel relocation. Overall approximately eight acres of river bottom, mainly where mussels was concentrated, were searched and a combined total of 44,858 mussels from 22 species were relocated during the initial survey and relocation. Mussel species included *Amblema plicata*, *Cyclonaias tuberculata*, *Ellipsaria lineolata*, *Elliptio crassidens*, *Elliptio dilatata*, *Lampsilis abrupta* (endangered), *Lampsilis ovata*, *Leptodea fragilis*, *Ligumia recta*, *Megalonaias nervosa*, *Obliquaria reflexa*, *Plethobasus cooperianus* (endangered), *Pleurobema cordatum*, *Pleurobema plenum* (endangered), *Pleurobema sintoxia*, *Potamilus alatus*, *Potamilus ohiensis*, *Pyganodon grandis*, *Quadrula pustulosa*, *Quadrula metanevra*, *Tritogonia verrucosa*, and *Villosa vanuxemensis*. Six *Lampsilis abrupta*, one *Plethobasus cooperianus*, and one *Pleurobema plenum* were found during the relocation. The majority of the mussels remaining within the action footprints are located within the downstream half of the cofferdam and new lock footprint. Three acres were searched using qualitative methods within the cofferdam and new lock footprint (approximately 11 acres total) and 3,830 mussels were removed. The habitat within the cofferdam area was evaluated during a geotechnical survey and it was noted that many areas within the cofferdam did not provide suitable habitat for mussels. Much of the area was characterized by exposed bedrock with multiple fractures and rock ledges. Significant mussel concentrations occur within the sand and gravel filled fractures and in the overburden areas located within the downstream half of the cofferdam and new lock footprint.

The portion of Relocation Area A that was utilized during the mussel relocation encompassed approximately 16,500 square meters. The relocation area had an original density estimate of 0.42 mussels per square meter. During the initial survey and mussel relocation more than 44,800 mussels were placed in this area resulting in a new density estimate of approximately three mussels per square meter.

IMPLEMENTATION OF BIOTIC INTEGRITY METRICS TO IDENTIFY THE EFFECTS OF LAND USE ON THE DIVERSITY OF WETLANDS

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ABSTRACT. To identify critical biological measures of wetland health, we studied twelve wetlands in north-central Tennessee and south-central Kentucky, six impacted by row crop agriculture and six unimpacted. Aquatic macroinvertebrates were collected using 10.2-cm clear PVC pipe funnel traps and wire minnow traps. Seven samples were collected from each site between May 19 and August 8, 2004. Qualitative samples (one man-hour) were collected with dip nets from each wetland to correspond with the early July trap samples. Water quality parameters measured included dissolved oxygen, pH, temperature, specific conductance, and turbidity with multiparameter aquatic probe and nephlometer. Macroinvertebrates from three sets of samples for each site were identified, when possible, to genus. The number of organism collected per trap-period per site ranged from 43 to 2224. Fifty-six taxa were identified. Generally, natural areas showed greater species richness, diversity and evenness than agricultural sites. Dipterans, primarily chironomids, were the most dominant assemblages. The three most abundant predatory orders, Coleoptera, Odonata and Hemiptera, showed alternating patterns of dominance. Habitat stability and greater vegetative complexity, which are impacted by surrounding agricultural practices, appear to be strongly related to higher species diversity.

USING LONG-TERM MONITORING OF MUSSEL COMMUNITIES AS A TOOL FOR RESOURCE MANAGEMENT IN THE TENNESSEE RIVER

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ABSTRACT. In conjunction with the U.S. Army Corps of Engineer's construction of a new navigation lock at Kentucky Dam in Livingston County, Kentucky, Tennessee River Mile 22.4, a long-term mussel monitoring program was initiated in 2003. The purpose of the study was to establish a set of baseline data so that changes in the mussel community downstream from the dam could be monitored before and after any potential impacts that could be caused by construction and future operation of the new lock. Mussels were collected from two experimental sites and two control sites. The "experimental" sites could be impacted (positively or negatively) by the new lock and the "control" sites were far enough out of the channel and downstream to be unaffected directly by lock operations or increased barge traffic when the lock is completed. Within each site, eighty 0.25 m^2 quadrats were sampled by excavating to a depth of 15 cm. Substrate samples were washed through sieves down to 0.64 cm, and all mussels were identified, weighed (0.1g), measured (shell length to 0.1 mm), and aged (by ring count). A baseline of habitat conditions was documented by accurately mapping the substrate topography using survey quality hydrographic equipment that was sufficient so that future scour or deposition could be defined in terms meaningful to the mussel community and the maintenance of high quality habitat. In addition to the hydrographic survey, six substrate samples were collected within each of the four mussel sampling sites to document the initial sediment composition in terms of grain size and organic content. The combination of the baseline mussel and habitat data will be used for future comparisons to document positive or negative changes in the mussel community and habitat conditions, whether the changes occur naturally or as a result of environmental disturbance. Future comparisons will be based on whole- community analysis using multivariate-analysis techniques, such as multi-dimensional scaling, analysis of similarity, and cluster analysis through Bray-Curtis Ordination. Other statistical methods that evaluate only mussel density or species diversity do not always show changes that occur to the mussel community. This project provides a unique opportunity to examine mussel community structure in a large river environment and help in the conservation of this unique assemblage of animals by using methods to analyze the entire mussel community rather than individual components. This project was funded by the Nashville District Army Corps of Engineers.

A REEVALUATION OF NORTH AMERICAN PHOXININ (ACTINOPTERYGII: CYPRINIDAE) SYSTEMATICS USING NUCLEAR GENE SEQUENCE DATA

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ABSTRACT. The phoxinins (Actinopterygii: Cyprinidae) dominate North American (NA) cyprinid diversity. Out of approximately 300 cyprinid species found within NA, the golden shiner (*Notemigonus crysoleucas*) is the sole representative of the leuciscins. Historically, this has been a challenging group for systematists and current hypotheses of relationships have been inferred from various morphological and mitochondrial DNA (mtDNA) sequence data sets. Among these data sets, certain hypothesized groups are congruent, whereas other groups are considerably inconsistent. Current systematic studies of NA phoxinins focus on generating multiple data sets across several character classes (morphological, mtDNA, and nuclear DNA (nDNA) sequence data). This study introduces data from a new character class, nDNA sequence data, into the systematic evaluation of NA phoxinins. Sequence data from intron 1 of the ribosomal protein gene S7 and from exon 3 of the recombination activating gene RAG1 are used to evaluate NA phoxinin systematics with maximum parsimony (MP) and Bayesian analyses. Systematic hypotheses generated from nDNA data will be compared to hypotheses derived from previous morphological and mtDNA data sets.

HERPETOFAUNA OF FORT DONELSON NATIONAL BATTLEFIELD, STEWART COUNTY, TENNESSEE: A PRELIMINARY REPORT

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ABSTRACT. Fort Donelson National Battlefield is a 600-acre national park situated on the Cumberland River at Dover in Stewart County, Tennessee. Located on the western edge of the Western Highland Rim, it is a highly dissected area of ridges and ravines covered mainly by oak-hickory forest. Prior to this study, despite much work in surrounding areas, no data were available on the herpetofauna of the park. To remedy this, the following objectives were established: 1) document at least 90% of the species expected to occur in the park, 2) describe the distribution and relative abundance of species of special concern, and 3) provide baseline information for developing a general herpetofaunal monitoring strategy. Sampling techniques being employed include cover board arrays and area searches in randomly selected plots, time-constrained searches along stream stretches, drift fences with pit and funnel traps at a vernal pond, night and day road cruising, and hand capture upon incidental encounters. During the first year of the study, 37 species of herpetofauna (17 amphibians and 20 reptiles) were documented. This represents 66% of the 56 species considered possible for the area. None of the species found so far are considered rare, endangered or of special concern by federal or state authorities. The study is ongoing and will continue through the summer of 2005. Voucher specimens will be housed in the APSU Museum of Zoology along with a Microsoft Excel file containing the raw data from the study. Funding for this study is being provided by Austin Peay State University's Center for Field Biology and the National Park Service.

PAEDOMORPHOSIS IN *AMBYSTOMA TALPOIDEUM*: EFFECTS OF INITIAL BODY SIZE VARIATION AND DENSITY

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ABSTRACT. Environmentally cued polymorphisms are useful models for understanding the evolutionary ecology of phenotypic plasticity. One such polyphenism is facultative paedomorphosis, in which individuals either metamorphose into a terrestrial, metamorphic adult or retain a larval morphology to become a sexually mature paedomorphic adult. It is hypothesized that density and initial body size variation within populations are instrumental in cueing metamorphosis or retention of larval characteristics in salamanders, yet few studies have adequately addressed these questions using long-term experiments. Beginning in the spring of 2004, 36 experimental ponds were used to manipulate three body size variation levels (low, medium, high) and two density levels (low, high) of salamander larvae. Larvae were individually marked using visible implant elastomers, and collected every two weeks in order to measure snout-to-vent length and mass. Nightly sampling was used to collect new metamorphs as they appeared. Initial analysis revealed significant effects of density, size variation and morph on body size of individuals. Metamorphs were significantly larger than paedomorphs across all treatments, as were individuals from medium size variation and low density treatments. Further analysis should provide insight into the proximate and ultimate factors affecting this polymorphism.

WINTER OVIPOSITION BY THE SOUTHERN TWO-LINED SALAMANDER (*EURYCEA CIRRIGERA*) IN A HIGHLAND RIM CAVE, CANNON COUNTY, TENNESSEE

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ABSTRACT. On January 26, 2005, while surveying the amphibian community of a privately owned cave near the base of Short Mountain in Cannon County, Tennessee, we found six nests of *Eurycea cirrigera*. Nests were located past the twilight zone, but within the first 300' of cave passage, and were attached to the underside of submerged rocks in the cave stream. Adult females were found attending two of these nests. We returned on 9 February and located four of the original and one new nest. Females were again found attending two of the nests. On both dates, nests were photographed and analyzed digitally to determine diameter of eggs and length of embryos. Clutch size ranged from 31-65 eggs (x = 55.29 +/- 4.12). Developmental stages ranged from Harrison stage 12 to Harrison stage 43. Eggs and early stage embryos were white and ranged from 2.5-3.5 mm in diameter. Although still pale, pigmentation was noticeable in late stage embryos, particularly in the iris. The advanced stages of some of the clutches found on 26 January and the slow rate of development determined in the clutches observed twice, indicates that some clutches were oviposited during December. This observation documents the first use of subterranean aquatic habitats for oviposition by *E. cirrigera* and one of the earliest occurrences of oviposition in Tennessee.

DISTRIBUTION AND RELATIVE ABUNDANCE OF CAVE-DWELLING SALAMANDERS OF THE GENUS *GYRINOPHILUS* IN TENNESSEE

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ABSTRACT. **Three species of salamanders of the genus *Gyrinophilus* are known to inhabit subterranean streams of central and east Tennessee. The Tennessee Cave Salamander complex consists of two troglobitic species, the Tennessee Cave Salamander (*G. palleucus*) and Berry Cave Salamander (*G. gulolineatus*). The Spring Salamander (*G. porphyriticus*) inhabits subterranean waters as well as surface springs and streams. As part of an ongoing project to determine the status and relative abundance of populations of the Tennessee Cave Salamander complex in Tennessee, historic and potential localities were surveyed from June 2004 through February 2005. Three hundred thirty *Gyrinophilus* were observed in 19 out of 42 caves surveyed in Cannon, Coffee, DeKalb, Franklin, Grundy, Knox, Putnam, Roane, Rutherford, and Warren Counties. *Gyrinophilus porphyriticus* was observed in 4 caves while members of the *G. palleucus* complex were observed in 16 caves. Metamorphosed *Gyrinophilus* tentatively identified as *G. porphyriticus* and large (>75 mm SVL) larval *Gyrinophilus* were found syntopically at one cave in Knox County. However, the relationship between these two forms has yet to be resolved. Extant populations of the Tennessee Cave Salamander complex were confirmed at two caves in the Central Basin, two caves on the Eastern Escarpment of the Cumberland Plateau, one cave on the Western Escarpment of the Cumberland Plateau, and four caves in the Ridge and Valley Physiographic Province. New populations were located on the Eastern Highland Rim of Warren County (3 caves) and Western Escarpment (3 caves, one in Grundy County and two in Coffee County). Four or fewer salamanders were observed in most caves. However, 19 or more individuals were observed in six caves. Of the 310 Tennessee Cave Salamanders observed, 207 were captured yielding a 67% capture rate. Adults (> 70 mm SVL) dominated each of the populations, but larvae and juveniles were found at most caves, indicating that reproduction was occurring.**

THE IMPACT OF AGE AND SEX ON THE CHEMICAL EXPOSURE AND DEVELOPMENTAL STABILITY IN *RANA CATESBEIANA*

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ABSTRACT. **In recent times, there has been alarm over amphibian declines and malformations around the world, as well as the possible cause for such drastic events. This issue is further exacerbated when considering that the health of amphibians may also indicate the health of the ecosystem that they are a part of, as well as the other organisms that share their habitat and resources. Two of the many tasks that biologists and wildlife managers face when confronting declining populations is identifying stressed populations before they undergo drastic changes and identifying the stressor(s) affecting the populations. However, developing an early warning system to identify stressed populations without understanding the basic life history potential stressors may prove to be unsuccessful for creating management plans. Thus, a multivariable approach to examining stress and its effects on populations is needed.**

In this study, I compared the responses and susceptibility of male, female, and immature bullfrogs, *Rana catesbeiana*, at two different developmental stages (adults and tadpoles), to anthropogenic stress occurring in their natural habitats in southwestern Kentucky. Developmental stability (DS), was used to investigate the developmental stress that bullfrogs have incurred from their habitats. DS was also evaluated for its potential to serve as an early warning system for amphibian declines and malformations. To examine the relationship between age and stress, skeletochronological analysis was used to estimate the age of each individual, metamorphosed bullfrog. Results from these analyses were then compared to organic, organometallic, and trace element tissue assays, as well as to habitat variables. The data obtained from this study will aid in forming the baseline for future studies of stress in amphibian populations, and it will allow future explorations in the applicability and reliability of DS as an early warning biomonitoring system.

MOVEMENTS AND DIEL BEHAVIOR OF *STERNOTHERUS MINOR PELTIFER* IN WHITEOAK CREEK, HOUSTON AND HUMPHREYS COUNTIES, TENNESSEE: A PRELIMINARY REPORT

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ABSTRACT. **Little information is available on the movement behavior of any of the subspecies of** *Sternotherus minor.* **Most published studies on the species focus on other aspects of its life history and phylogeny. This paper presents the preliminary findings of an on-going investigation begun in May 2004 of movements and diel activity of a population of** *S. minor peltifer* **in Whiteoak Creek, a tributary to Kentucky Lake (impounded Tennessee River) in Houston and Humphreys counties, Tennessee. Using radiotelemetry and Geographic Information System (GIS) technologies, 14 individuals (6 males, 8 females) were relocated once weekly for periods ranging from 9 to 39 weeks, and their movements plotted in relation to assorted physical and biological features in and along the stream. Movements over the 24-hour cycle were also monitored on seven occasions. Data obtained to date suggests a linear-shaped home range (mean 341.4 m) extending along stream stretches with ample shoreline cover. Of the initial capture plus relocation points documented, 225 (62%) involved limestone bluffs, 70 (19%) fallen trees, 36 (10%) vegetated limestone outcrops, 27 (7%) banks with exposed tree roots, and 4 (2%) other features. Mean length of home ranges was 341 m, with no significant difference between that for males (335 m) and females (346 m). Data on movements during the 24-hour cycle suggests a nocturnal pattern of behavior.** **Funding for this project is being provided by Austin Peay State University's Center for Field Biology.**