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

HELD AT BRANDON SPRING GROUP CAMP
LAND BETWEEN THE LAKES
MARCH 9 AND 10, 2001

Sponsored by:

The Center 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
Golden Pond, Kentucky

****

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Published by and available from:
The Center for Field Biology,
Austin Peay State University, Clarksville, Tennessee 37044

Price: $5.00

SUGGESTED CITATION

Chester, E.W., and A.F. Scott. 2001. Proceedings of the Ninth Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Published
October 2001

PREFACE

The Ninth Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys was held at Brandon Spring Group Camp in Land Between The Lakes on 9 and 10 March 2001. This biennial gathering of naturalists and field biologists was sponsored by The Center for Field Biology at Austin Peay State University, The Center for Reservoir Research at Murray State University, and the U.S. Department of Agriculture, Forest Service, Land Between The Lakes. A total of 95 people representing 24 institutions registered at this symposium.

The symposium began Friday afternoon with welcoming comments from representatives of sponsoring institutions. Dr. Benjamin P. Stone, Director of the Center for Field Biology at Austin Peay State University, welcomed all participants. Additional comments were offered by Dr. David S. White, Director of the Hancock Biological Station at Murray State University, and William Lisowsky, Area Supervisor, Land Between The Lakes.

Two invited speakers presented papers addressing the afternoon theme of "Land Between the Lakes: Four Decades of Tennessee Valley Authority Stewardship." The first speaker, Rick Lowe, Deputy Area Supervisor, Land Between The Lakes, reviewed various Tennessee Valley Authority programs in wildlife management, forestry, environmental education, and others. The second speaker, William Lisowsky, Area Supervisor, Land Between The Lakes, discussed tentative plans for management of Land Between The Lakes, now under management of the U.S. Department of Agriculture, Forest Service.

The Friday evening presentation was by Drs. Jerry and Carol Baskin, The University of Kentucky. They gave a well-illustrated talk on plants and plant communities of the Negev Desert, Israel, based on a recent visit there.

Three sessions of contributed papers were presented Saturday morning. Session I included 15 botany papers; this session was moderated by Dr. Edward W. Chester, Austin Peay State University. Session II was moderated by Dr. Susan Hendricks, Murray State University, and included 11 papers in the areas of aquatic biology and water quality. Dr. Floyd Scott, Austin Peay State University, moderated the eight papers in Session III, Zoology. All contributors were invited to publish an abstract, short communication, or full manuscript in the 2001 proceedings.

The style and format of these proceedings follow that established in proceedings of previous symposia. Dr. Edward W. Chester organized and edited the Invited Papers and edited abstracts and papers from Session I (Botany). Dr. Floyd Scott edited abstracts and papers from Sessions II (Aquatic Biology and Water Quality) and III (Zoology).

ACKNOWLEDGMENTS

The editors thank Marilyn Griffy for her assistance in organizing and coordinating activities leading up to and throughout the symposium. We also recognize the participation of current APSU Center for Field Biology undergraduate and graduate research assistants for their help before and during this biennial event. Many abstracts and manuscripts were typed and corrected by Griffy, who also saw to details of the proceedings organization. The help of these individuals and others was critical to the success of this symposium and completion of these proceedings. All complete manuscripts were reviewed fully. We appreciate the comments of all reviewers as this process greatly enhances the quality of these proceedings. While we (the editors) would wish this publication to be error free, most likely it is not and for this we assume responsibility.

SYMPOSIUM REGISTRANTS

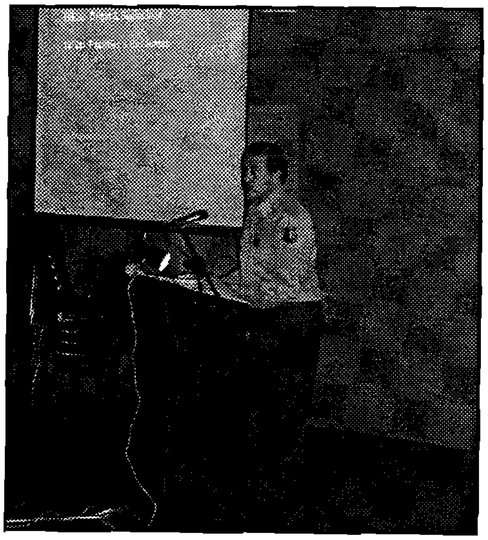
Following, in alphabetical order, is a list of those individuals who registered at the 2001 symposium. Institutional affiliation (when available), city (of the person's institution or home), and state are also given.

Christopher Adams, University of Kentucky, Lexington, KY; **Jason Albritton**, Murray State University, Murray, KY; **Devon Anderson**, Austin Peay State University, Clarksville, TN; **Bill Atkinson**, Hopkinsville Community College, Hopkinsville, KY; **Heather Bagwell**, Austin Peay State University, Clarksville, TN; **Rex Barber**, Volunteer State Community College, Lebanon, TN; **Carol Baskin**, University of Kentucky, Lexington, KY; **Jerry Baskin**, University of Kentucky, Lexington, KY; **Amy Benson**, Murray State University, Murray, KY; **Steve Bloemer**, USDA Forest Service - LBL, Golden Pond, KY; **Crockett Bone**, Austin Peay State University, Clarksville, TN; **Robert Brinkman**, Austin Peay State University, Clarksville, TN; **William Bryant**, Thomas More College, Crestview Hills, KY; **Angelo Bufalino**, St. Louis University, Richmond Hgts., MO; **Willodean Burton**, Austin Peay State University, Clarksville, TN; **Brian Canada**, Austin Peay State University, Clarksville, TN; **Edward Chester**, Austin Peay State University, Clarksville, TN; **Matt Cole**, Murray State University, Hazel, KY; **Michele Cox**, Austin Peay State University, Clarksville, TN; **Amanda Crook**, Murray State University, Murray, KY; **James Davis**, Western Kentucky University, Portland, TN; **Terry Derting**, Murray State University, Murray, KY; **Hal DeSelm**, UT- Knoxville, Knoxville, TN; **William Ellis**, Austin Peay State University, Clarksville, TN; **Larry Estes**, Columbia State Community College, Columbia, TN; **Rhonda Finch**, Murray State University, Murray, KY; **Mack Finley**, Austin Peay State University, Clarksville, TN; **Kevin Fitch**, ACS Conservation, Arnold AFB, TN; **Susan Fletcher**, Austin Peay State University, Clarksville, TN; **Alex Flynt**, Austin Peay State University, Clarksville, TN; **Thomas Forsythe**, TVA, Abingdon, MD; **Kari Foster**, Murray State University, Murray, KY; **Kenny Fralicx**, Between The Rivers, Eddyville, KY; **James Fralish**, Southern Illinois University, Carbondale, IL; **Marilyn Griffy**, Austin Peay State University, Clarksville, TN; **Debbie Hamilton**, Clarksville Academy, Clarksville, TN; **Steven Hamilton**, Austin Peay State University, Clarksville, TN; **Suzan Hamrick**, Murray State University, Murray, KY; **Greg Harris**, Austin Peay State University, Clarksville, TN; **Tracy Hawkins**, University of Kentucky, Jackson, KY; **Janice Helton**, Austin Peay State University, Pleasant View, TN; **Paula Helton**, Austin Peay State University, Pleasant View, TN; **Susan Hendricks**, Murray State University, Murray, KY; **Siti Nur Hidayati**, Middle Tennessee State University, Murfreesboro, TN; **Heather Hollis**, Austin Peay State University, Clarksville, TN; **Rebecca Houtman**, Austin Peay State University, Clarksville, TN; **Robert Hoyt**, Western Kentucky University, Bowling Green, KY; **Ted Ives**, Austin Peay State University, Clarksville, TN; **Richard Jensen**, Saint Mary's College, Notre Dame, IN; **Timothy Johnston**, Murray State University, Murray, KY; **Elizabeth Jones**, Kentucky Wesleyan College, Owensboro, KY; **Joanna Kind**, Murray State University, Murray, KY; **Rob Kingsolver**, Kentucky Wesleyan College, Owensboro, KY; **George Kipphut**, Murray State University, Murray, KY; **John Koons**, Jackson State Community College, Jackson, TN; **Jill Kruper**, Murray State University, Murray, KY; **Shelley Ladd**, Kentucky Wesleyan College, Owensboro, KY; **Larry Latson**, David Lipscomb, Nashville, TN; **Joanna Lau**, University of Illinois, Urbana, IL; **Jeff Lebkuecher**, Austin Peay State University, Clarksville, TN; **William Lisowsky**, USDA Forest Service - LBL, Golden Pond, KY; **Bommanna Loganathan**, Murray State University, Murray, KY; **Rick Lowe**, USDA Forest Service - LBL, Golden Pond, KY; **Laurina Lyle**, Austin Peay State University, Clarksville, TN; **Bill Martin**, Eastern Kentucky University, Richmond, KY; **Eric Meyer**, Kentucky Wesleyan College, Owensboro, KY; **Lorna Morris**, Middle Tennessee State University, Murfreesboro, TN; **Robert O'Daniel**, Western Kentucky University, Bowling Green, KY; **William Oliver**, Western Kentucky University, Bowling Green, KY; **Nathan**

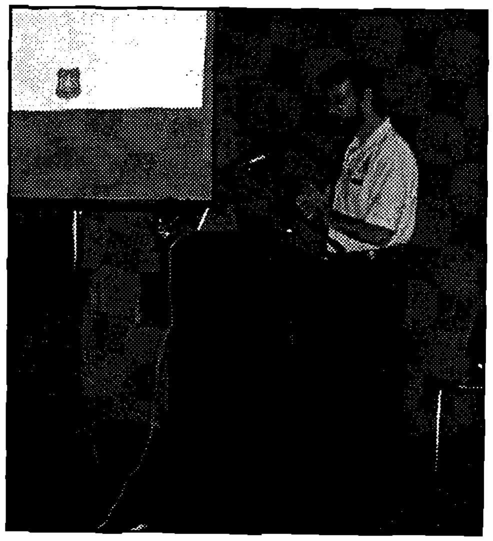
Parker, Austin Peay State University, Clarksville, TN; **Cathy Petty**, Clarksville Academy, Clarksville, TN; **Monica Pope**, Murray State University, Murray, KY; **Erin Rastede**, Kentucky Wesleyan College, Owensboro, KY; **Terry Ray**, Murray State University, Murray, KY; **Dan Reimers**, Memphis City Schools, Memphis, TN; **David Robinson**, Bellarmine University, Louisville, KY; **Baki Sadi**, Murray State University, Murray, KY; **Joe Schibig**, Volunteer State Community College, Portland, TN; **Joe Schiller**, Austin Peay State University, Clarksville, TN; **Floyd Scott**, Austin Peay State University, Clarksville, TN; **Kosta Seaford**, Murray State University, Murray, KY; **Adam Smith**, Murray State University, Murray, KY; **David Snyder**, Austin Peay State University, Clarksville, TN; **Logan Snyder**, Clarksville Academy, Clarksville, TN; **Wheeler Stephens**, Kentucky Wesleyan College, Owensboro, KY; **Ben Stone**, Austin Peay State University, Clarksville, TN; **Cindy Taylor**, Austin Peay State University, Clarksville, TN; **Jeffrey Walck**, Middle Tennessee State University, Murfreesboro, TN; **David White**, Murray State University, Murray, KY; **Howard Whiteman**, Murray State University, Murray, KY; **Amanda Wilding**, Austin Peay State University, Clarksville, TN; **Scott Williamson**, Austin Peay State University, Clarksville, TN; **Ashley Woods**, Austin Peay State University, Clarksville, TN; **Paul Yambert**, Murray State University, Murray, KY.

SYMPOSIUM SPEAKERS

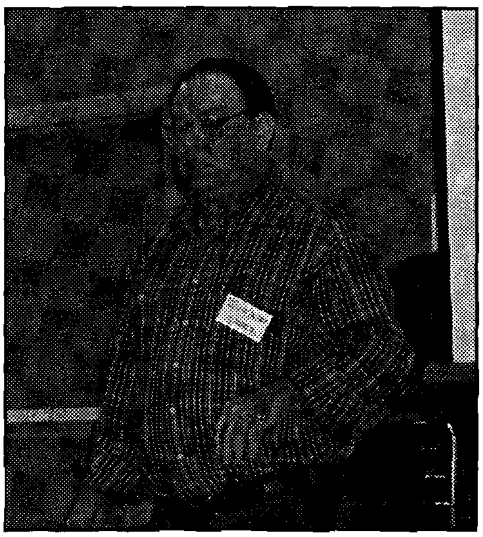
Invited Papers



Rick Lowe

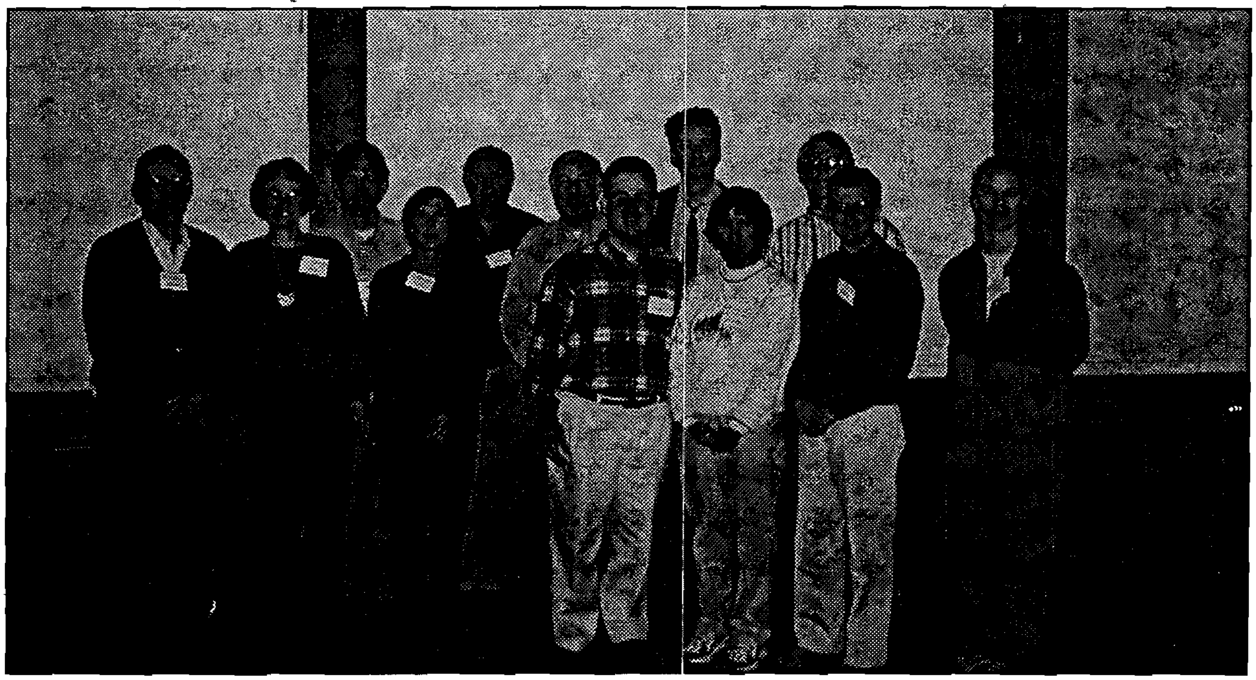


William Lisowsky

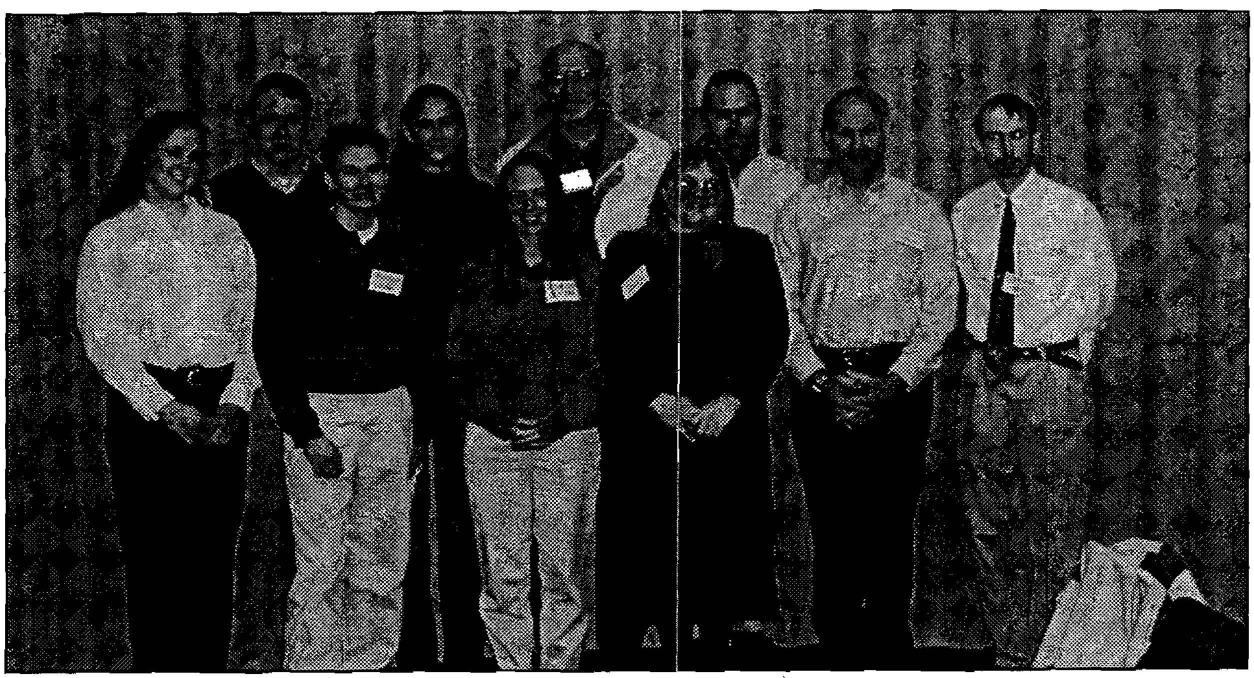


Dr. Jerry Baskin

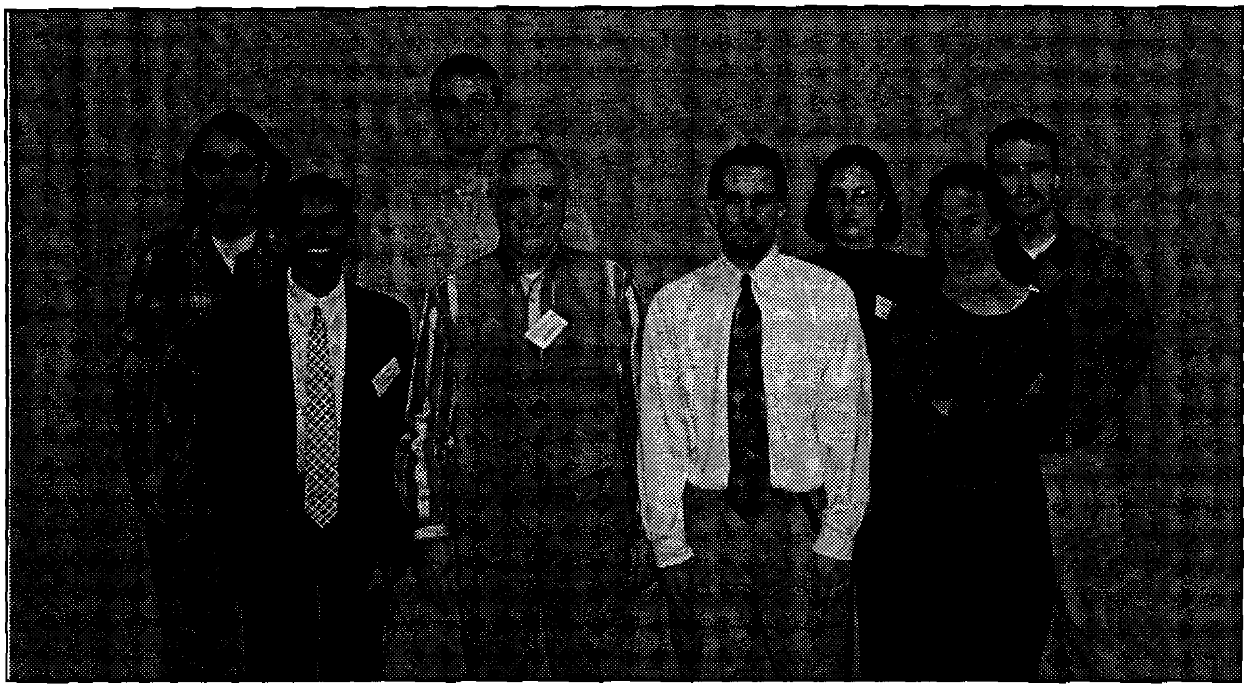
Contributed Papers



Session I: Botany - (from left) H.R. DeSelm, C.C. Baskin, K.C. Fitch, T.S. Hawkins, E.W. Chester, W.S. Bryant, C.A. Adams, D.L. Robinson, S.N. Hidayati, R.J. Jensen, J.L. Walck, and L.L. Morris.



Session II: Aquatic Biology and Water Quality - (from left) S. Barton, C. J. Albritton, A. Crook, J. Kind, R. Houtman, R.D. Hoyt, S. Hendricks, K. Davenport, G. Kipphut, and G. Harris.



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1. Friday Afternoon

Land Between The Lakes: A Review of the Past - Rick Lowe (oral presentation only)

Land Between The Lakes: A Look to the Future Under Forest Service Management, March 9, 2001 - William Lisowsky

2. Friday Evening

Wildflowers and Plant Communities of the Negev Desert, Israel (ABSTRACT)
J. M. Baskin and C. C. Baskin

Moderator and Editor

Edward W. Chester
Austin Peay State University

LAND BETWEEN THE LAKES – A LOOK TO THE FUTURE UNDER FOREST SERVICE MANAGEMENT, MARCH 9, 2001

WILLIAM LISOWSKY

United States Department of Agriculture, Forest Service
Land Between The Lakes National Recreation Area
Golden Pond, KY 42211

EXECUTIVE SUMMARY

The key objectives of the presentation were to provide an overview of the Forest Service, a short review of the legislation that brought Land Between The Lakes (LBL) to the Forest Service—(The Land Between The Lakes Protection Act of 1998) and our assessment of the future management challenges we face. A period of questions and answers followed.

The Forest Service appreciates and respects the outstanding research and resource management that has been accomplished at LBL over the past 30-plus years. We are anxious to work with members of the educational community and other members of the public, to learn from those efforts, and develop goals, objectives, and strategies that will guide us to even greater heights. The desire of the Forest Service to develop relationships with universities, researchers, academicians and the scientific community is sincere. In addition to working with us in the daily challenges of LBL, the soon-to-be-revised (again) planning regulations are expected to identify additional significant opportunities for interested parties to get involved.

Specific answers to what will occur in the future will not be available until the new Plan is completed. Sustainability of uses, services or resources will be one of the tests each proposed action must pass. Many members of the general public are supportive of management strategies already in place. Likewise, there are many supporters of the management goals of the Biosphere Reserve, although use of this term sometimes creates misunderstandings and apprehension as well. It would be inappropriate and premature for the Forest Service to discuss future land allocations although it is likely that ecologically sensitive areas will be identified and appropriately protected in the planning process. The Forest Service needs to validate and/or add to these comments through our public participation process.

PRESENTATION OUTLINE

1. Forest Service Mission and Applicable Laws
2. LBL Protection Act
3. Looking to the Future

1. FOREST SERVICE MISSION AND APPLICABLE LAWS

Organic Act of 1897:

- Created the National Forest System to "improve and protect" federal forests;
- Forest Service "...is vested with broad authority to make rules to regulate occupancy and use and to preserve the forests from destruction";
- Reaffirmed congressional intent to improve and protect the forests, secure water flows and to furnish a continuous supply of products.

Multiple Use/Sustained Yield Act of 1960:

- Confirms FS management responsibility for outdoor recreation, range, timber, watershed,

wildlife and fish purposes;
- Gives each unit discretion to set levels and mix of uses.

National Environmental Policy Act of 1969:

- Promote efforts to prevent damage to the environment;
- Stimulate health and welfare of humans;
- Improve understanding of effects and proposal alternatives.

Endangered Species Act of 1973:

- Conservation of ecosystems upon which threatened and endangered species depend;
- Utilize Forest Service authorities in consultation with US Fish and Wildlife Service.

National Forest Management Act of 1976:

- Manage NF lands using a plan;
- Process and analyses described;
- Provide for multiple use and sustained yield;
- Integrate science with action;
- Provide and preserve diversity and communities from a biological, social and economic perspective.

Forest Service Mission Statement:

- "...sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations";
- Motto of the FS: "Caring for the Land and Serving People."

USDA Forest Service Strategic Plan 2000 Goals:

- Promote ecosystem health and conservation to sustain forests;
- Provide a variety of uses, values, products and services within capability of sustainable ecosystems;
- Forest Service is the leading provider of recreation in the US;
- Develop and use the best scientific information to support ecological, economic and social sustainability;
- Ensure infrastructure to enable delivery of variety of uses and effective public services.

In Management of a "Typical" National Forest Unit There Are Several Scales to Consider:

- Land and Resource Management Plan (LRMP) covers 10-15 years. The Plan guides future management by articulating priorities, standards and desired conditions to be achieved;
- Strategic Plan (3-5 yrs) with tiers to the Plan. Shorter-term implementation strategies are created to reach milestones and monitor progress towards long range goals of LRMP;
- Annual Plans and decisions are made to match intent of Congress, emerging issues, available objectives, funds and people;
- Decisions move in direction of Goals and Desired Future Conditions identified in the Plan.

2. LBL PROTECTION ACT OF 1998

Four Key Purposes:

1. Transfer jurisdiction of LBL from TVA to the Forest Service;

2. Protect and manage resources for optimum yield of outdoor recreation and environmental education through multiple use management;

3. Authorize, research, test, and demonstrate cost-effective and innovative government management;
4. Cooperate between and among agencies, organizations, corporations and individuals; help stimulate development of surrounding region; extend results as widely as practicable.

Emphases:

- Provide for public recreation opportunities;
- Conserve fish and wildlife and habitat;
- Provide for diversity of plants, animals, opportunities for hunting and fishing, and environmental education.

LBL Advisory Board:

- Created by the Protection Act with two purposes:

  1. Means of promoting public participation for the land and resource management plan for the recreation area;
  2. Environmental education.

LBL Land and Resources Management Plan:

- Protection Act anticipated need to develop Plan;
- Recognized crucial role of public in the process, including the Advisory Board-collaboration is crucial to success;
- Allows use, as appropriate, of existing 1994 Natural Resources Management Plan, until Plan is in place.

Other Provisions of Act:

- Ensures cemetery access;
- Trust fund created to support regional promotion and public education, grants, and internships;
- Counties eligible for Payment in Lieu of Taxes;
- No general entrance fee may be charged.

3. LOOKING TO THE FUTURE

Transition Priorities:

- Overall goal of seamless transition to avoid disruption to public;
- Difficult summer for employees required great sensitivity;
- Building relationships and trust a primary objective and a cornerstone of future interactions;
- Important to get to know the resources, public, and the area in which we live and work.

Strategies We're Using While The Plan is Being Developed:

- Now that transition is mostly complete, this is the current phase for LBL;
- We are not making significant changes for the foreseeable future. There are plenty of examples of "We made some changes, what do you think"? LBL needs to demonstrate

integrity and build trust first. The Plan will be the place to make such changes if warranted, with the owners and the public, clearly communicating what they want from their public land.

- We are striving to meet intent of Protection Act and moving towards goals of sustainability.
- We are also keeping future management options open by avoiding irretrievable commitments or investments.
- We intend to continue existing programs and activities and focus our energy on developing long-term goals and objectives for LBL, with public input.
- We must find ways to engage and truly collaborate with the public. Part of this will relate to the role of the Advisory Board.
- It takes information to do Planning. We are observing, monitoring, and gathering data needed to assess condition, and find ways to make information understandable for discussions.
- We will identify resource protection issues and respond accordingly. There are places that need specific actions taken to protect them.
- We are moving forward with re-establishing past relationships. LBL has a long history of university involvement and research that we wish to continue.
- Every visitor should receive an environmental education message when they visit. We'll be moving ahead on some environmental education efforts, again with the help of the Advisory Board.
- Backlog maintenance is a major issue. Many facilities are nearing the end of their design life. It will be a priority to deal with health and safety issues as they arise.

WILDFLOWERS AND PLANT COMMUNITIES OF THE NEGEV DESERT, ISRAEL

JERRY M. BASKIN[1] AND CAROL C. BASKIN[1,2]

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[2]Department of Agronomy, University of Kentucky, Lexington, KY 40546

ABSTRACT. In late March-early April 1998, the authors spent about 10 days in the central Negev Desert, Sede Boqer, Israel. The Negev is a hot, winter-rainfall desert with a highly-variable annual precipitation that averages less than 100 mm (4 inches); annual temperature at Sede Boqer is about 19-20°C. The shrubs *Zygophyllum dumosum* and *Artemisia herba-alba* are important components of the vegetation in the central Negev, and in spring 1998 many annuals and herbaceous perennials were in bloom following the winter rainy season. Several botanical excursions were made into the Negev with our host Professor Yitzchak Gutterman, a plant ecologist. This talk primarily will be a short survey of the plants photographed on these excursions. In addition, brief accounts will be given of (1) the exotic ornamental woody plants (*e.g., Acacia, Cupressus, Eucalyptus*) of Sede Boqer; (2) the collection of succulents (*e.g., Aloe,* Cactaceae, Euphorbiaceae) in the botanical garden at the Desert Research Institute, Sede Boqer; (3) the shrub (*Thymelaea*)-annual grass (*Stipa*) community on löess in the northern Negev (200-300 mm annual precipitation) just south of the Mediterranean Region; and (4) a sacred grove of matorral vegetation in the Mediterranean Region south of Jerusalem (about 400 mm annual precipitation) dominated by *Pinus halepensis* and *Quercus calliprinos*. Our biggest "taxonomic surprise" was that 82% of the families and 25% of the genera in our photographic survey are indigenous to the Kentucky-Tennessee area. The five largest families are Asteraceae, Brassicaceae, Leguminosae, Liliaceae, and Poaceae. Genera quite familiar to Kentucky and Tennessee botanists include *Allium, Convolvulus, Iris, Pinus* (matorral), *Plantago, Populus* (along a canyon stream), *Quercus* (matorral), *Rumex,* and *Senecio*. Our biggest "botanical thrill" was seeing a desert species of tulip (*Tulipa systola*) with its velvet-red flowers.

CONTRIBUTED PAPERS

SESSION I: BOTANY

Saturday, March 1, 2001

Moderator and Editor:

Edward W. Chester
Austin Peay State University

AN ORDINATION OF THE PLANT COMMUNITIES OF THE JACKSON PURCHASE REGION OF KENTUCKY

WILLIAM S. BRYANT[1] AND MICHAEL E. HELD[2]

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[2]Department of Biology, Saint Peter's College, Jersey City, NJ 07306

ABSTRACT. Plant communities of the Jackson Purchase Region of Kentucky were subjected to ordination (indirect gradient analysis) using Principal Components Analysis (PCA). Axis-l was interpreted to be a moisture gradient and Axis-2 a topographic, and to a lesser degree, soils, gradient. *Taxodium distichum* and/or *Nyssa aquatica* swamps and a complex of bottomland hardwoods clustered at the wet end of the moisture gradient while upland oak-hickory was at the drier end. Microtopographic differences on the alluvial plain were not of sufficient magnitude to further segregate the bottomland community types; however, species of *Celtis-Fraxinus-Liquidambar-Quercus-Acer-Carya* were most prominent there. Flatwoods dominated by *Q. stellata, Q. pagodaefolia,* or *Q. falcata* were confined to Henry silt loam soils near the flat end of the topographic gradient and mixed mesophytic communities on the highly dissected loess bluffs were at the opposite end. Two oak hickory groupings were recognized--one on the flat to gently rolling uplands in which *Q. stellata* and/or *Q. falcata* were indicator species (but not dominants), and one on the more rolling to sloping topography dominated by *Q. alba* and/or *Q. velutina* with *Carya* spp. Successional (disturbed) communities were clustered around the point of intersect of the two gradients thus indicating their transitional character. Former barrens clustered in the flat to gently rolling lands and in the dry-mesic portion of the moisture gradient.

INTRODUCTION

DeFriese (1880) noted that topography, especially the "change in height above drainage," was a major factor in determining the distribution and general character of the forests in the Jackson Purchase Region of Kentucky (JPR). He also considered exposed gravel beds, either where loess deposits were thin or where erosion had removed the loess, as influencing vegetation patterns. Over 40 years later, Davis (1923) identified seven geographic subdivisions of the JPR (Figure 1) on the basis of differences in topography, soil, vegetation, and other factors or combinations of these.

Since that time, follow-up studies to determine whether the early observations of DeFriese (1880) and Davis (1923) were correct have not been undertaken. Analyses of specific ecological communities, e.g., bottomland hardwoods (Bryant 1990), mixed mesophytic forests (Bryant 1993), swamps (Bryant 1997), and flatwoods (Bryant 1999), and numerous floristic surveys, e.g., Bryan (1977), Fuller (1980), Funk and Fuller (1978, 1980), Grubbs and Fuller (1991), Wilson (1976), and Woods (1983) have revealed much about vegetation structure and composition in the JPR. However, these studies were subjective and communities based primarily on leading dominants; we believe that a more objective means is needed when considering vegetation or community patterns for the entire JPR.

Ordination methods may represent an improvement on vegetation description based on dominants (Dooley and Collins 1984) and perhaps reveal some of the underlying relationships between vegetation and environment. The specific objective of this study was to elucidate vegetational gradients in the JPR and their possible environmental bases by the use of ordination. In particular, we were interested to see whether topographic or soil related gradients occur that might explain vegetation patterns.

THE STUDY AREA

The JPR, 6144 km^2 in size, is that portion of Kentucky west of the Tennessee River. This area is bounded by three large rivers, the Tennessee on the east, the Ohio on the north, and the Mississippi

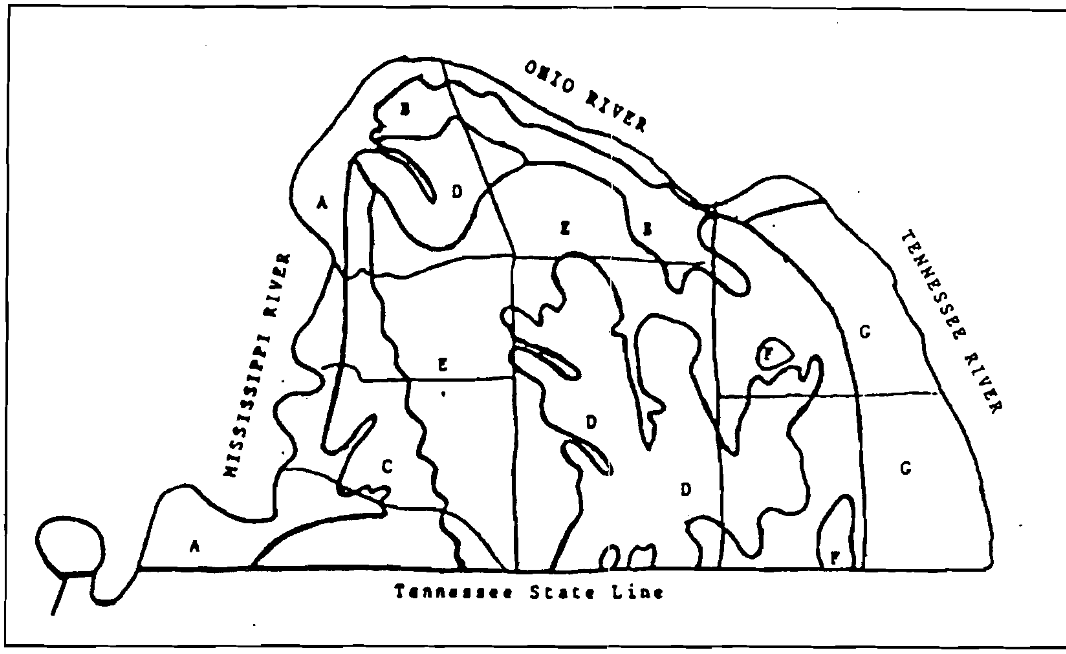

Figure 1. Map of the Jackson Purchase Region of Kentucky with subdivisions after Davis (1923): A. The Big Bottoms; B. The Second Bottoms; C. The Cane Hills; D. The Barrens; E. The Oak and Hickory Uplands; F. The Flatwoods; G. The Breaks of the Tennessee River.

on the west. The state of Tennessee forms the southern boundary at 36°30' north latitude. The JPR was purchased from the Chickasaw Indians in 1818 and was the last area added to the state of Kentucky. This was the only region of Kentucky to be surveyed in sections using General Land Office methods (Bryant and Martin 1988).

For the most part, the JPR is an undulating plain with elevations usually between 100-125 m. Local relief is not much in excess of 15 m except in the vicinity of major streams (McFarlan 1950). There are three general patterns of relief in the JPR: nearly level to hilly uplands; gently sloping to steep uplands; and nearly level to gently sloping bottomlands (Forsythe 1997).

The JPR differs from the rest of Kentucky geologically since it is located in the Gulf (or Mississippi) Embayment, a Coastal Plain region. This region is the area of outcrop of the unconsolidated and only semi-consolidated sediments of the Cretaceous and Tertiary (McFarlan 1950). Cherty residuum and limestone of the Mississippian formation are exposed in a narrow strip along the Tennessee River where erosion has removed the Coastal Plain sediments. A thick mantle of loess covers much of the coastal plain sediments, except where removed by erosion. This loess cover thins across the JPR from west to east. Loess deposits may exceed 30 m along the Mississippi River.

Soils and Climate

Soil surveys have been produced for each of the eight counties of the JPR: Ballard and McCracken (Humphrey 1976), Calloway (Leighty et al. 1945), Calloway and Marshall (Humphrey, et al. 1973), Carlisle and Hickman (Forsythe 1997), Fulton (Newton and Sims 1987), and Graves (Leighty 1953). Soils in the region differ widely in physical characteristics and primarily have formed from deep or thin loess, coastal plain sediments, river alluvium, alluvium washed from loessal uplands, and cherty limestone. Soils are seldom completely dry and are frozen for only short periods. Nearly continual leaching has moved many of the soluble bases and clay minerals from upper to lower horizons (Forsythe 1997). Fragipan development is typical for many of the soils on level to gently rolling topography. Upland soils are mature and floodplain soils are young.

Climate for the JPR is temperate with hot humid summers and occasional cold spells in winter. Rainfall averages 120 cm annually (Newton and Sims 1987) and the mean annual temperature is 15° C (Forsythe 1997).

METHODS

Field Sampling

Sixty-seven sites were visited and sampled and these data were used in the ordination. A minimum of five plots/stands was sampled, but more than five plots were sampled in most stands. Plots were 0.04 ha in size and spaced at 30 m intervals through the stands. All woody stems >10 cm diameter-breast-height (dbh) were measured in plots. Collected data were analyzed to relative density (RD), relative dominance or basal area (RDo), and importance value (IV=RD+RDo). Density (trees/ha), H' (species diversity) and other variables such as percentage canopy vs. subcanopy also were determined.

At each sampling site, soils and topography were recorded. Sites were selected by the senior author and by field personnel of the Natural Resource Conservation Service to reflect habitats and topographic diversity for each county. Only stands with no obvious major disturbance and that were large enough to allow a minimum of five sampling plots were considered. The location of sampling sites is shown in Figure 2. A total of 5871 trees was measured.

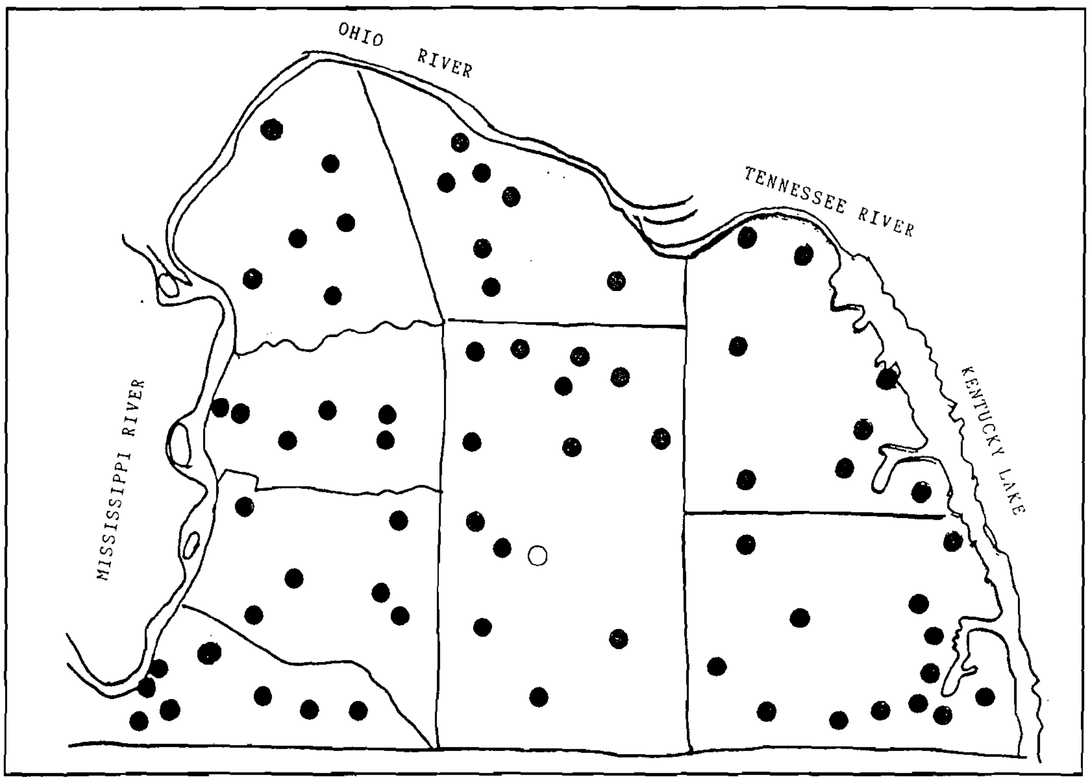

Figure 2. Location of sampling sites in the Jackson Purchase Region of Kentucky. Closed circles are forest sites and the open circle represents a prairie site.

Ordination Methods

Stand relationships were summarized as scores on the first and second axes of the Principal Components Analysis (Kovach 1998) based on square root transformed importance value data, which included all species in each stand. Scores on the second axis did not show "arching" (Pielou,

1984) and thus the ordination was considered a satisfactory description of the relationship between the stands sampled and environmental variables.

RESULTS

Axis-1 of the ordination was interpreted to be a moisture gradient and Axis-2 a topographic gradient. Nine broad vegetation types segregated out on the two gradients: swamps, bottomland hardwoods, two types of flatwoods, two types of oak-hickory, mixed mesophytic forest, transitional (successional-disturbed), and former barrens (Figure 3).

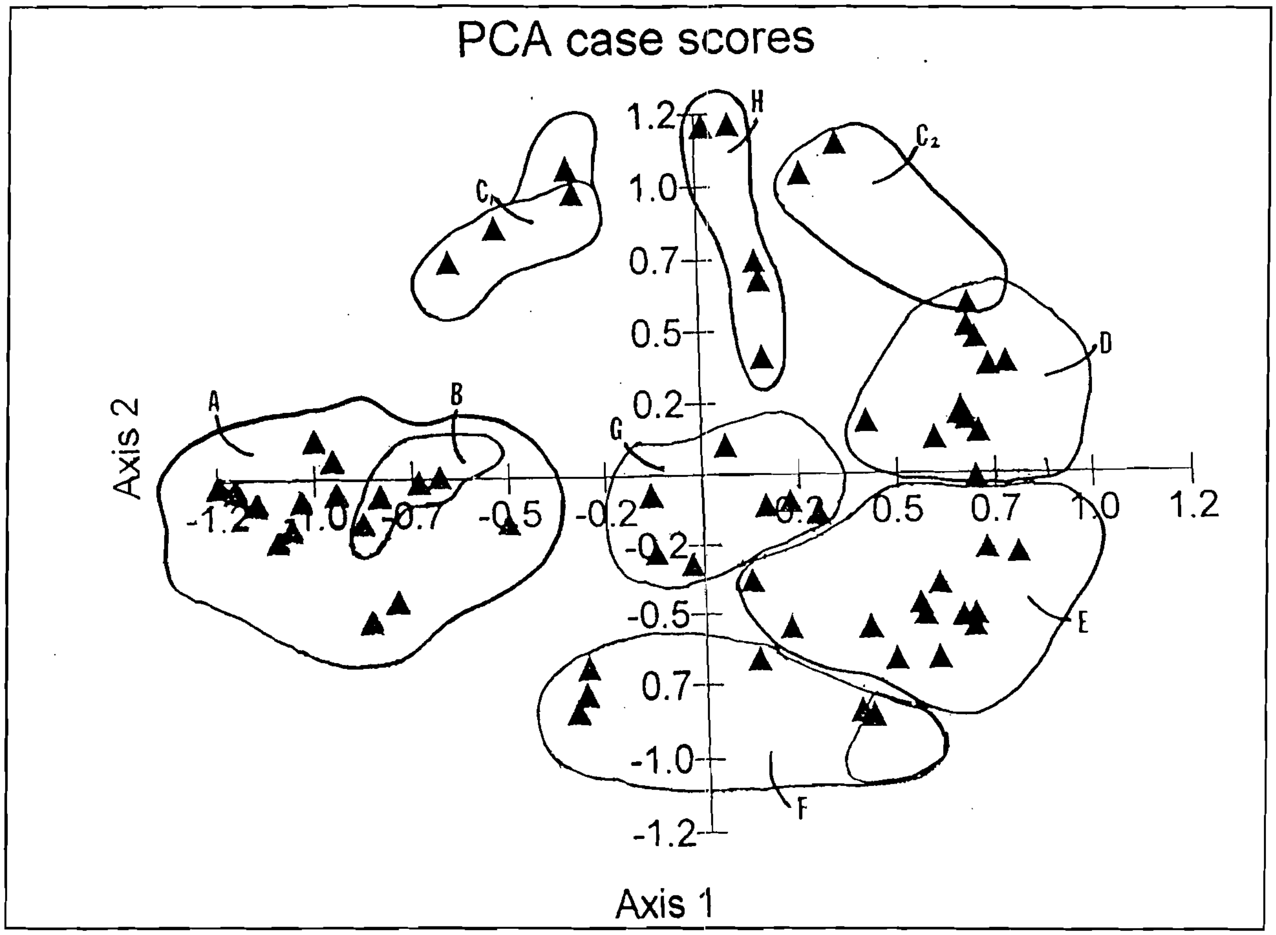

Figure 3. Ordination of plant communities of the Jackson Purchase Region of Kentucky: A. Bottomland Hardwoods; B. Swamps; C_1. Flatwoods-Wet Phase; C_2. Flatwoods-Dry Phase; D. Oak-Hickory (Open or Savanna-Like); E. Oak-Hickory (White Oak and/or Black Oak); F. Mixed Mesophytic; G. Transitional (disturbed or successional); H. Former Barrens.

Swamps and bottomland hardwood forests clustered together at the wet end of the moisture gradient. However, microtopographical differences on the floodplain were not of sufficient magnitude to further separate the various community types (Figure 4). Swamps were nearly monospecific stands dominated by *Taxodium distichum* and/or *Nyssa sylvatica*. These stands were generally located on first bottoms and were covered by water throughout much of the year. Swamps were of low tree species diversity, but had high basal area values and high density (Bryant 1997). Bottomland hardwood communities, which occupied the alluvial plains of the major rivers and, in the interior of the JPR, were present along streams that have nearly reached grade and flowed sluggishly in wide, flat floodplains. These are on first and second bottoms. The floodplains are microtopographically complex and here species sort out individualistically (Robertson et al. 1978)

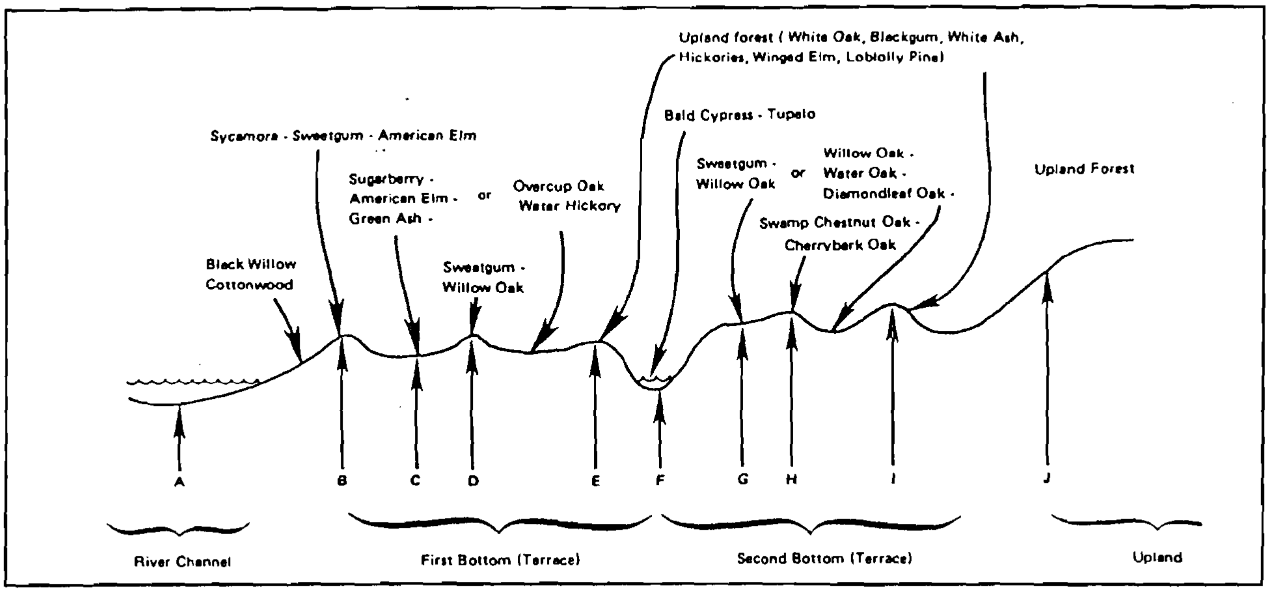

Figure 4. The correspondence between alluvial floodplain microtopography and forest cover types. A = river channel; B = natural levee (front); C = backswamp or first terrace flat; D = low first terrace ridge; E = high first terrace ridge; F = oxbow; G = second terrace flats; H = low second terrace ridge; I = high second terrace ridge; J = upland. The vertical scale is exaggerated. After Wharton et al. (1982).

indicating that flooding frequency and duration of flooding are important factors. *Celtis-Fraxinus-Liquidambar-Quercus-Acer-Carya* are the important genera that sort out on the alluvial floodplains. Sandbar communities that form along the Mississippi River were not sampled.

The two types of flatwoods that Bryant (1999) suggested for the JPR segregated out at the flat end of the topographic gradient. The two types appeared to be a wet phase and a dry phase. Both flatwoods types were found on level to slightly concave surfaces that appeared to be old lake beds (Leighty et al. 1945). The wet phase was characterized by *Q. pagodaefolia* and Q. *stellata* and the dry phase by *Q. falcata* and *Q. stellata*. Both types were on Henry silt loam; however, there was one stand on Routon silt loam on the wet phase. Because of alternating wet and dry periods due to the underlying fragipan on Henry and Routon soils, the flatwoods communities tend to be clustered around the mesic portion of the moisture gradient.

Two types of oak-hickory forest sorted out toward the dry end of the moisture gradient, but one was on flat to rolling topography and the other on more rolling to rough, sloping topography. *Quercus stellata* and *Q. falcata* were indicator species, but not community dominants on the flat to rolling lands; *Q. alba* and/or *Q. velutina* and *Carya ovata* and *C. glabra* were characteristic of the rougher lands. Loess is generally thin or absent where *Q. alba* and *Q. velutina* are most prominent.

Mixed mesophytic forests were nearly confined to the highly dissected loess bluffs although one mixed mesophytic stand in the Sand Hill section of Graves County clustered with those of the bluffs. Braun (1950) and Delcourt and Delcourt (1975) considered these highly diverse communities to be refugial in nature. Their dominants include *Acer saccharum, Fagus grandifolia, Liquidambar styraciflua, Q. alba*, and *Liriodendron tulipifera* (Bryant 1993). As expected, the mixed mesophytic communities sorted out near the middle of the moisture gradient.

Although efforts were made not to sample recently disturbed stands, communities that showed evidence of past disturbances clustered near the intersection of the moisture and topographic gradients. Species in disturbed stands varied; however, the shade intolerant *Liquidambar styraciflua* (Burns and Honkala 1990) was generally abundant. Their location on the gradients point to their transitional character.

The last grouping that we recognized was not nearly as distinct as some of the others. We recognize it as perhaps the former barrens of the JPR. *Quercus stellata, Q. falcata, Sassafras albidum*, and *Diospyros virginiana* were generally present in the stands sampled, which were located in those portions of Ballard, Graves and Calloway counties mapped as barrens by Davis (1923). *Andropogon gerardi, Schizachyrium scoparium*, and *Sorgastrum nutans*, characteristic prairie grasses, and several scrub oaks were located together in Graves County near the stands sampled. The former barrens were on flat to gently rolling lands just to the dry side of the moisture gradient.

DISCUSSION

The JPR has had a long history of agriculture. Even though forests have been fragmented, swamps have been drained, woodlands have been grazed, and fires suppressed, most of the plant assemblages recognized in the 1820 GLO Survey of the JPR (Bryant and Martin 1988) were still recognizable, although perhaps modified. These communities generally segregated out in response to moisture and topographic gradients.

According to Braun (1950), the vegetation of the Mississippi Embayment section of her Western Mesophytic Forest Region in which the JPR lies is a mosaic of unlike types including prairies, oak hickory forest, swamp forest, and mixed mesophytic communities. In general, these were present in our study. Braun (1950) further noted that oak-hickory communities occupied a considerable part of the rolling uplands and that their composition varied in relation to topography and soils. The importance of oaks and hickories as a group in the JPR was shown in the ordination. Flatwoods were dominated by oaks and hickories, as were former barrens. The two upland oak-hickory forest types also reflect the importance and broad areal extent of oak-hickory in the JPR. Braun (1950) wrote that if it were not for the mixed mesophytic communities of the loess bluffs, she would have included the JPR in her Oak-Hickory Forest Region rather than the Western Mesophytic. The fact that the various community types including those dominated by oaks and hickories sorted out along moisture and topographic gradients is of significance since these environmental factors can now be used to determine if other factors might also underlie vegetation patterns in the JPR. Heineke (1987) considered flatwoods to have been largely eliminated from the JPR; however, not only were they present, they were of two types that segregated in response to topography, soil moisture, and especially soil type.

Other gradients, i.e. an anaerobic gradient (Wharton et al. 1982) may be operational in sorting out species and communities on the alluvial plain. There the interaction of flooding depth and duration with microtopographic differences on the alluvial plain exercise influence on species patterns. Former barrens were now more similar to oak-hickory than to original prairie. Remnant populations of prairie grasses that formerly characterized the barrens at the time of settlement added evidence to our interpretation. However, historic accounts written in the 1880s (e.g. DeFriese 1880, Loughridge 1888) mentioned that 30, 40, or even 60 years earlier, prairies were abundant in portions of the JPR and that these prairies were fire-maintained. Leighty (1945) wrote, "Beginning about 1863, after the removal of the Indians and the increase in white settlers, fires decreased, the forests extended in area, and the prairies became more restricted." This is similar to Baskin and Baskin's (1978) conclusion that the Big Barrens of Kentucky were not part of the Prairie Peninsula, but were fire maintained. In Williamson County, Illinois, Anderson and Anderson (1975) found that oak-hickory was the dominant vegetation type during presettlement times. There prairies or barrens occurred on level tracts of land where fire beat back forests. Rugged landscapes do not carry fires as well as level or rolling ones (Anderson and Anderson 1975) and these maintain oak-hickory. In a similar way, the more rolling and rough lands supported oak-hickory in the JPR. Fire also may have had an influence on the oak-hickory of the level to gently rolling topography. These lands may have formerly been more open and savanna-like, but with fire cessation returned to oak-hickory. The fire tolerant *Q. stellata* and *Q. falcata* were considered to be indicator species of this oak-hickory type. Anderson and Anderson (1975) found much of the rolling land in Williamson County, Illinois, to support savanna-like vegetation during presettlement times. The lower importance of *Q. marilandica* today as compared to 1820 (Bryant and Martin 1988) also may be a result of fire suppression.

Factors other than fire, soils, moisture and topography may also influence vegetation patterns. DeFriese (1880) did not feel that geology had as much influence on plant distributions in the JPR as in other parts of Kentucky. However, *Acer saccharum* appears to be somewhat influenced by geology in its distribution in the JPR. It is found along the Tennessee River where Mississippian limestone is exposed and on the deep loess, but is rare in the interior of the JPR where loess is thin and Coastal Plain deposits are predominant.

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A FLORISTIC STUDY OF THE HAYNES BOTTOM WILDLIFE MANAGEMENT AREA, MONTGOMERY COUNTY, TENNESSEE

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ABSTRACT. The Tennessee Wildlife Resources Agency purchased approximately 393 ha (971 acres) in Montgomery County, Tennessee, in 1996 for development of a wildlife management area. At that time the land was in agricultural production (corn, wheat, soybeans, tobacco, pasture) with some secondary woodlands and both upland and Cumberland River bottomland fields. Wetland habitats included bottomland hardwood forests, riverside forests, an apparently abandoned river meander channel (slough), marshes, a first-order stream, wet meadows, drainage ditches, and upland ponds. The entire area shows the results of extensive anthropogenic usage since settlement. Conversion into the Haynes Bottom WMA, named in commemoration of early setters and their ancestors who still live in the area, began in the summer of 1999 and the area was officially opened in November 1999. Construction included dikes, pools, and other wetland enhancement projects to attract waterfowl. A study of the vascular flora during 1997-1999 documented 550 species representing 108 families and 327 genera. The Asteraceae and Poaceae are the major families, accounting for nearly 25% of taxa. Major genera are *Carex* (18 taxa), *Quercus* (13), *Polygonum* (9), and *Cyperus, Desmodium*, and *Panicum* (8 each). Four taxa are state-listed and 121 taxa (22%) are introduced.

INTRODUCTION

The Tennessee Wildlife Resources Agency (TWRA) manages 87 Wildlife Management Areas (WMA's) across the state, ranging in size from 88 to 624,000 acres (TWRA website, 2000). Many WMA's serve as important preserves for significant habitats, community types, and rare taxa. In most cases botanical inventories are lacking, especially for pre-management conditions. Haynes Bottom is one of the most recent WMA additions (purchased 1996). A floristic inventory of the vascular plants of the WMA was made over two growing seasons (1998 and 1999) with special attention given to locating state and/or federally-listed, and exotic species. The resulting data base will: (1) add to existing information on the flora and vegetation of northwestern Tennessee; (2) provide information that TWRA may use as they develop the site into a wildlife management area, especially in the conservation of rare species and elimination of exotic-invasive taxa; and (3) allow for monitoring as existing vegetation matures, as landscape changes are facilitated in the construction process, and as hydrologic changes occur due to wetland enhancements.

THE STUDY AREA

Montgomery County is within the Western Highland Rim Subsection, Highland Rim Section, Interior Low Plateau Physiographic Province (Fenneman 1938). This Subsection is a dissected plateau bordered on the east by the Central Basin and on the west by the Tennessee River; the Southern Highland Rim Subsection is to the south and the Pennyroyal Plain Subsection to the north. Numerous stream valleys, ravines with steep slopes, narrow ridges, springs, perpendicular bluffs, and some karst features are characteristic. Uplands have developed primarily on St. Louis and Warsaw limestones with some Fort Payne cherty limestone, all of Mississippian age. Silurian and Ordovician strata are exposed in a few valleys, and Quaternary alluvium occupies larger stream valleys, such as that of the Cumberland River, which provides primary drainage. Eight major soil Associations occur in the county (U.S.D.A. 1975), with parts of three Associations within the WMA, including: (1) Pembroke-Crider (gently rolling, well-drained soils on uplands); (2) Baxter-Mountview (rolling to steep, well-drained soils that may include much chert); and (3) Arrington-Lindside-Beason (level, well-drained to somewhat poorly drained soils on bottomlands of the Cumberland River). The climate is warm-temperate with mild winters and warm summers. The average annual precipitation is about 122 cm (48 inches). Temperature extremes have been -22 to 110 degrees F; the average is 60 degrees F. The average growing season is 207 days and extends from 4 April to 29 October. The soil freezes to a depth of a few cm several times each year, but rarely remains frozen for more than a few days. Several cm of snow usually occur each year. Gentle to moderately strong prevailing winds are from the west and southwest (U.S.D.A.1975).

Vegetationally, Montgomery County is within the Deciduous Forest Formation, Western Mesophytic Forest Region, of Braun (1950), where the vegetation is a mosaic of types determined by local climatic, edaphic, and topographic features. Typically, it is transitional between the more mesic Mixed Mesophytic Region to the east and the more xeric Oak-Hickory Region to the west. Oak and oak-hickory phases dominate but more mesophytic types occur on some slopes. Chester, Jensen, and Schibig (1995) found that four genera (*Acer, Carya, Quercus, Ulmus*) account for more than 50 percent of existing tree stems. Barrens and upland wetlands and flatwoods also contribute to area diversity (Baskin, Baskin, and Chester 1999; Baskin, Chester, and Baskin 1997).

HAYNES BOTTOM WILDLIFE MANAGEMENT AREA

Haynes Bottom Wildlife Management Area (HB) is a 393-ha (971-acre) tract adjacent to and on the north side of the Cumberland River in southwestern Montgomery County, Tennessee. It is on the Palmyra, TENN,1958, photorevised 1983, U.S. Geol. Survey Quadrangle, and Map 43 of the Montgomery County Soil Survey (U.S.D.A. 1975). The site is mostly between river miles 114 and 116 and is directly north of the small town of Palmyra, Tennessee, which is on the south side of the Cumberland River. The area is accessed from Chester Harris Road off Dotsonville Road, which intersects U.S. Highway 79 west of Clarksville. The old Palmyra Ferry Road (also called River Road) leads from Chester Harris Road to the Cumberland River. Elevations range from 356 feet (normal summer pool of the Cumberland River) to about 500 feet above sea level.

From European settlement until TWRA purchase, the site was in private ownership and mostly agricultural (corn, wheat, tobacco, soybeans, pastures). The productive bottomlands especially were intensively cultivated and there were at least three farmsteads with dwellings and outbuilding. The vast canebrakes and bottomland forests seen by the first settlers in the late 1700s had been mostly removed by the late 1800s (Sudworth 1897). An iron industry once thrived in the area and included blast furnaces directly opposite the WMA in Palmyra. Hematite ore was surfaced-mined in the region and a few test pits and surface mines were located on the property; these are evident today (this fact also observed in communication with older residents of the area), and at least two of the old surface mines have permanent water.

The site supports a variety of habitat types, including the Cumberland River and an adjacent strip of riparian forest, broad alluvial bottomlands with drainage ditches, old fence rows, and an apparent abandoned river meander channel (Harrison Slough) with associated marshes and meadows, a first-order stream (Hog Creek) with adjacent riparian forest, upland successional fields, old homesites (one now occupied), several small, mostly upland ponds, and upland forests. The upland wooded areas are on landscapes that mostly were too steep, rocky, or otherwise unsuitable for crops; they have been pastured constantly and high-graded for timber on numerous occasions. The alluvial bottomlands are cultivated in corn, soybeans, and wheat. The upland fields suitable for tilth had undergone succession from the time of TWRA purchase until spring 1999, when many were burned and planted in corn, using both tillage and no-till methods.

The TWRA is converting the area into a wildlife management area, especially for migratory waterfowl, by enhancing and expanding existing wetlands and constructing new ones, by wildlife food plantings, and by other habitat construction-manipulation, including varying water-levels in wetlands. Construction of dikes, ponds, and other waterfowl habitat enhancements began in August 1999. Pumps were used to flood several of the ponds with water from the Cumberland River. The area was officially opened as a WMU in November 1999. The results reported herein preceded the construction work.

METHODS

Descriptive data were obtained from (1) the U.S.G.S. topographic quadrangle, (2) the U.S.D.A. soil survey for Montgomery County, (3) aerial photographs from the Montgomery County Office of the U.S.D.A. Natural Resources Conservation Service, (4) current aerial photograph from the U.S.D.A. Aerial Photography Field Office (Salt Lake City), and (5) computer generated maps from the Tennessee Wildlife Resources Agency. Several long-time local residents were interviewed and the site was flown for photographs. Field data were collected in more than 100 trips made to the area from March 1998 to March 2000; 49 trips were made in 1998, 52 in 1999, and 12 in 2000. S. Joy Stephens, former graduate student at Austin Peay State University, accompanied the author on 11 trips, collecting data on riparian forests, wetlands, and flora. Several undergraduate students at APSU also contributed to the field work. During each data-collecting trip, voucher specimens were taken and notes accumulated. More than 600 specimens were accessioned into the Austin Peay State University Herbarium. Broad plant community types were subjectively determined and these types used in preparation of the annotated checklist. Floristic analyses include the determination of major categories of species found, dominant families and genera (based on number of taxa), listed taxa, and exotic/introduced taxa. The taxonomic treatment and designation of introduced species follows Wofford and Kral (1993); listed taxa were taken from the Tennessee Department of Environment and Conservation (1999).

RESULTS AND DISCUSSION

The know vascular flora of HB consists of 550 species representing 108 families and 327 genera. A summary is given in Table 1 and an annotated checklist in Appendix 1.

Table 1. Statistical Summary of the Haynes Bottom Wildlife Management Area Flora.

Group	No. Families	No. Genera	No. Introd. Taxa	No. Native Taxa	Total No. Taxa
Pteridophytes	7	9	-	11	11
Gymnosperms	2	2	1	1	2
Angiosperms: Monocots	15	67	35	98	133
Angiosperms: Dicots	84	249	85	319	404
TOTALS	108	327	121	429	550

Floristic Analyses

Table 2 gives the major families and shows clear dominance by the Asteraceae (composites) and Poaceae (grasses); these two families account for nearly 25 percent of taxa. The families listed in Table 2 amount to 17.6 percent of families but account for 65.5 percent of species. In addition to the families listed in Table 2, there are eight families with five taxa, ten with four, nine with three, 21 with two, and 41 with one.

The major genera (Table 3) are those that include both xeric and wetland species, e.g., *Carex* (sedges) and *Quercus* (oaks). The 26 listed genera (8 percent of the genera) account for 153 taxa (27.8 percent of all taxa). In addition, 21 genera have three species each, 53 have two species each, and 228 genera are monotypic. The major woody genera are *Quercus* (13 taxa), *Acer, Carya,* and *Prunus* (4 each), and *Ulmus* (3). Major woody vine genera are *Smilax* (4 taxa) and *Ampelopsis* and *Vitis* (2 each). The pteridophyte flora is relatively small (11 taxa) and consists of expected species. Only *Juniperus virginiana* and *Pinus taeda* are gymnosperms, and the latter is introduced.

Table 2. Major Vascular Plant Families of the Haynes Bottom Wildlife Management Area.

Family	Number of Genera	Number of Species
Asteraceae	37	68
Poaceae	41	68
Fabaceae	16	33
Cyperaceae	4	29
Brassicaceae	15	19
Rosaceae	8	17
Polygonaceae	4	15
Scrophulariaceae	13	15
Fagaceae	2	14
Lamiaceae	11	14
Rubiaceae	5	11
Euphorbiaceae	5	9
Solanaceae	3	8
Apiaceae	7	7
Caryophyllaceae	5	7
Liliaceae	6	7
Ranunculaceae	5	7
Asclepiadaceae	3	6
Onagraceae	4	6

Four taxa are Tennessee-listed; no federally listed taxa were found.

(1) *Arabis shortii* (Fernald) Gleason, Short's Rock Cress. This mustard ranges from New York to Virginia, Tennessee, and Alabama, west to Arkansas, Kansas, and Nebraska, north to Minnesota. The typical habitat is rocky woods, stream banks, lake shores, steep wooded slopes, limestone bluffs and cliffs, river flood plains, and shaded bottomlands (Rollins 1993). It is a special concern species in Tennessee. Several plants, regularly flowering and fruiting, grow on the floodplain of the Cumberland River (including U.S. Army Corps of Engineers property).

(2) *Phacelia ranunculacea* (Nuttall) Constance, Blue Scorpion Weed. This annual species has a tricentric distribution pattern with centers on the Atlantic Coastal Plan of Virginia and Maryland, the piedmont of North Carolina, and along the Mississippi Embayment and adjacent provinces of Indiana, Illinois, Missouri, Kentucky, Arkansas, and Tennessee. Low, moist woods and floodplains are typical habitats (Chuang and Constance 1977). It is a special concern species in Tennessee. Several plants were observed along the floodplain of the Cumberland River.

(3) *Sagittaria brevirostra* Mack. & Bush, Midwestern/Short-Beaked Arrowhead. This perennial is wide ranging in middle North America from Saskatchewan to Texas. It is a wetland species and often grows in muck or shallow water (Haynes and Hellquist 2000). Threatened in Tennessee, relatively large populations grow around Harrison Slough.

(4) *Solidago rupestris* Rafinesque, Rock Goldenrod. Cronquist (1980) notes that this species grows from Pennsylvania and Maryland to southern Indiana, Kentucky, and Tennessee. River banks and bluffy woods are typical habitats. It is an endangered species in Tennessee. Specimens were observed along the banks of the Cumberland River, usually bending outward toward the water.

As now known, 121 species (22 percent of the known flora) are not indigenous. This number is slightly higher than the approximately 20 percent of introductions in the Tennessee flora as a whole. The majority of these 12 woody taxa and 115 herbs are from Europe and the Old World (68 species, or 56.2 percent of introduced species). Other origins include Asia/Eurasia (29 species, 24 percent), tropical America (11 species, 9.1 percent), other parts of the United States (11 species, 9.1 percent), India (1 species, <1 percent, and South America (1 species, <1 percent). Families with large numbers of introduced taxa are the Poaceae (25), Fabaceae (14), Asteraceae (14), Brassicaceae (8), Scrophulariaceae (6), Lamiaceae (5), Liliaceae, Polygonaceae, and Rosaceae (4 each), and Amaranthaceae, Caryophyllaceae, Malvaceae, and Moraceae (3 each). Three families have two introduced taxa and 19 have one.

Table 3. Major Genera of the Haynes Bottom Wildlife Management Area.

Genera	Number of Taxa	Genera	Number of Taxa
Carex	18	*Acer*	4
Quercus	13	*Amaranthus*	4
Polygonum	9	*Asclepias*	4
Cyperus	8	*Bromus*	4
Desmodium	8	*Carya*	4
Panicum	8	*Commelina*	4
Eupatorium	6	*Lespedeza*	4
Solidago	6	*Physalis*	4
Aster	5	*Plantago*	4
Bidens	5	*Prunus*	4
Eragrostis	5	*Rumex*	4
Galium	5	*Smilax*	4
Hypericum	5	*Viola*	4

Many of the introduction have little effect upon native vegetation. Some, e.g. *Iris germanica*, (see annotated list for common names), *Narcissus* spp., and *Prunus persica* persist from former plantings or appear around old trash dumps. Others (e.g., *Abutilon theophrastii, Lactuca saligna, Sisymbrium officinale*) are roadside and barnyard weeds of little consequence. Still others are agronomic weeds (e.g., *Amaranthus* spp., *Digitaria* spp., *Senna obtusifolia*), while others are former agricultural crops-mostly pastures/hay (e.g., *Kummerowia* spp., *Phleum pratense, Trifolium pratense*). Species of most concern are *Lonicera japonica* (Japanese honeysuckle), and *Eulalia vimenia* (Nepal or Japanese grass). These taxa are highly invasive in woodlands and thickets, mostly to the detriment of native vegetation. *Festuca pratensis* (tall fescue), planted for hay and pasture, is a common species of open fields. Also significant, but to a lesser extent, are *Ligustrum vulgare* (privet)-spreading into woodland borders and thickets, and *Sorghum halepense* (Johnson grass)-a weed of cultivated fields, especially bottomlands.

Plant Communities

1. Upland forests. All forests are secondary and show the results of recent logging. Most are dominated by a young growth of various oaks, hickories, hackberry, maples, and other hardwood species. Invasion by such woody taxa as tree-of-Heaven, empress tree, black locust, and by such exotic herbs and woody vines/shrubs as Japanese grass, Japanese honeysuckle, and privet is commonplace. The bluffy woods adjoining the bottomlands on the east side has the potential of becoming a good habitat for herbaceous flora, but is now over-run by exotics.

2. Upland successional and cultivated fields. These formerly (or presently) cultivated fields add to diversity by supporting innumerable weedy taxa. Fencerows, thickets, old farm ponds, barnyards, pastures, garden sites, lawns, and other remnants of farms and homes, add to species lists, but include mostly expected flora. Exotics contributed heavily to these areas.

3. Low forests. The former bottomland forests are represented a few successional sites that have been historically too wet for tilth but in which high-grading of timber has been on-going. These remnants are dominated by dense stands of black willow and green ash. However, two riparian forests, the Hog Creek site (woodland in the bottomland adjacent to Hog Creek) and the Cumberland River woods (a narrow strip adjacent to the river)are somewhat older and have potential of developing into types perhaps representative of previous bottomland forests of the area. These forests were quantitatively sampled in 1998 and the results presented by Stephens and Chester (1999).

4. Bottomland fields. These alluvial, rich, fields (including low bottoms and terraces) are agriculturally productive and have been in tilth since settlement. Corn, soybeans, wheat, and tobacco have been the major crops. Numerous agronomic weeds contribute to diversity. Several drainage ditches and old fence rows also are floristically rich. This is the area in which dikes, pools, and other management techniques are being used to enhance/provide habitat/food for migratory waterfowl.

5. Wetlands. Several upland and lowland ponds, at least two dating to strip-mining days, provide floristic diversity. The major wetland area is Harrison Slough on the west side of the site. This slough appears to be an old meander channel and apparently is fed by underground springs. It is large enough to support a surrounding strip of wetland habitat ranging from mudflats as water levels drop during autumn to shrub (mostly black willow and buttonbush) thickets. Enhancement of this site would add significantly to the area and preserve the habitat where the state listed short-beaked arrowhead now grows.

Annotated List

The appended annotated list is divided into major categories following Wofford and Kral (1993): Pteridophyta (ferns/fern allies); Gymnosperms (non-flowering seed plants); Angiosperms (flowering plants), divided into Monocotyledoneae and Dicotyledoneae. Within each group families, genera, and species are arranged alphabetically. Non-native taxa are indicated by an asterisk. Community type(s) where the taxon most often occurs is given next, followed by subjective observations of abundance: abundant (found throughout, often in large numbers); occasional (often present but rarely in large numbers), infrequent (not always encountered in a community type); locally abundant (only occasionally found but then in large numbers); and rare (found fewer than five times in the WMA).

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Appendix 1. Annotated Checklist of Vascular Taxa Known from the Haynes Bottom Wildlife Management Area, Montgomery County, Tennessee.

PTERIDOPHYTA: FERNS AND FERN ALLIES

ASPLENIACEAE, Spleenwort Family

Asplenium platyneuron (L.) BSP., Ebony Spleenwort. Scattered in woodlands throughout [EWC-13387].

AZOLLACEAE, Water-Fern Family

Azolla caroliniana Willd., Mosquito Fern. Old farm ponds on Tobacco Barn Road and Connector Road; locally abundant [EWC-13683].

DRYOPTERIDACEAE, Wood-Fern Family

Polystichum acrostichoides (Michx.) Schott, Christmas Fern. Slope woods, especially on gully banks; probably the most abundant fern [EWC-13629].

EQUISETACEAE, Horsetail Family

Equisetum arvense L., Field Horsetail. Swampy woodlands around seeps in Hog Branch bottomland forest; locally abundant [EWC-13456].

LYCOPODIACEAE, Club-Moss Family

Lycopodium digitatum A. Braun [*L. flabelliforme* (Fern.) Blanch.], Ground-Pine, Running-Cedar. Dry woods by power lines running north of Cook House; very rare [EWC-13824].

OPHIOGLOSSACEAE, Adder's-Tongue Family

Botrychium biternatum (Savigny) Underwood [*B. tenuifolium* Underwood, *B. dissectum* Sprengel var. *tenuifolium* (Underwood) Farwell], Southern Grapefern. Low woods near the Cumberland River; very rare [EWC-13666].

Botrychium dissectum Sprengel [*B. obliquum* Muhl. ex Willd., *B. dissectum* Spreng. var. *obliquum* (Muhl.) Clute], Dissected Grapefern. Slope woods west of Hog Creek; infrequent to rare [EWC-13633].

Botrychium virginianum (L.) Swartz, Rattlesnake Fern. Mesic slope, ravine and riparian forests; infrequent [EWC-13441; EWC-13761].

WOODSIACEAE, Cliff-Fern Family

Athyrium pycnocarpon (Spreng.) Tidestrom, Glade Fern. Hog Creek bottomland forest; rare [EWC-13439].

Woodsia obtusa (Sprengel) Torrey, Common Woodsia. Mesic to dry woods, especially bluffy woods west of Hog Creek; infrequent [EWC-13388].

Onoclea sensibilis L., Sensitive Fern. Bottomland forests and wet thickets; rare [EWC-13500].

SPERMATOPHYTA: GYMNOSPERMAE

CUPRESSACEAE, Cedar Family

Juniperus virginiana L., Red Cedar. Old fields, fencerows, bluffs and open forests; throughout, often in large numbers [EWC-13465].

PINACEAE, Pine Family

**Pinus taeda* L., Loblolly Pine. Several large "seed trees" just south of the Connector Road are enabling this species to spread into adjacent fields and woodlands [EWC-13783].

SPERMATOPHYTA: ANGIOSPERMAE-MONOCOTYLEDONEAE

ALISMATACEAE, Water-Plantain Family

Alisma subcordatum Raf., Water-Plaintain. Pond margins, Harrison Slough wetlands, ditches, wet woods along Hog Creek and other wet-swampy areas throughout; frequent [EWC-13427].

Sagittaria brevirostra Mack.& Bush, Short-Beaked Arrowhead. Marshy areas around Harrison Slough, bottomland ditches, wet woods by Hog Branch; locally abundant [EWC-13594].

AMARYLLIDACEAE, Amaryllis Family

Hymenocallis occidentalis (Le Conte) Kunth, Spider-Lily. Wet woodlands and thickets; rare [EWC-13499].

**Narcissus poeticus* L., Poets' Narcissus. Persisting and slightly spreading around homesites and at old dump sites [EWC-13240].

**Narcissus pseudonarcissus* L., Buttercup, Daffodil. Persisting and slightly spreading around homesites and at old dump sites [EWC-13239].

ARACEAE, Arum Family

Arisaema dracontium (L.) Schott, Green Dragon. Mesic forests and thickets; occasional [EWC-13310].

Arisaema triphyllum (L.) Schott, Jack-in-the-Pulpit. Mesic woods and thickets; rather rare [EWC-13546].

COMMELINACEAE, Spiderwort Family

**Commelina communis* L., Dayflower. Mesic thickets, fields and old barnlots; locally abundant [EWC-13406].

Commelina diffusa Burm. f., Diffuse Dayflower. Weedy sites, mostly in disturbed soils; rare [EWC-13631].

Commelina erecta L., Erect Dayflower. Roadsides, bottomland thickets and ditch lines; locally abundant [EWC-13354].

Commelina virginica L., Virginia Dayflower. Marshes, low woods and thickets; locally abundant; [EWC-13429].

Tradescantia subaspera KerGawl, Harsh Spiderwort. Riparian forests by the Cumberland River; locally abundant [EWC-13776]

CYPERACEAE, Sedge Family

Carex abscondita Mack., Concealed Sedge. Mesic woods in ravine east of River Road; rare [EWC-13768; ! Dr.Vern McNeilus, TENN].

Carex amphibola Steud., Ambiguous Sedge. Low wet woods, riparian forests; occasional to rare [EWC-13753].

Carex cephalophora Muhl., Headed Sedge. Old barnlot at Harrison House; rare [EWC-13755 ! Dr. Vern McNeilus, TENN].

Carex conjuncta Boott., Joined Sedge. Wet woods in Hog Branch riparian forest; rare [EWC-13759; ! Dr. Vern McNeilus, TENN].

Carex crus-corvi Shuttlw. Crow-Spur Sedge. Low woods along west edge of site; locally abundant [EWC-13519].

Carex frankii Kunth, Frank's Sedge. Marshy soils throughout, often in stands [EWC13325; ! Dr. Vern McNeilus, TENN].

Carex grayi Carey, Gray's Sedge. Mesic to swampy woodlands and thickets; infrequent [EWC-13342; ! Dr. Vern McNeilus, TENN].

Carex hirsutella (Bailey) Gleason, Hairy Sedge. Old fields, dry roadsides and thickets; occasional [EWC-13787].

Carex jamesii Schw., James' Sedge. Mesic woods in ravine east of River Road; rare [EWC-13769 ! Dr. Vern McNeilus, TENN].

Carex leavenworthii Dewey, Leavenworth's Sedge. Old lawns, fields and barnlots; rare [EWC-13747 ! Dr. Vern McNeilus, TENN].

Carex lupulina Muhl., Hop-Like Sedge. Open wet areas throughout, often in large stands [EWC-13334; ! Dr. Vern McNeilus, TENN].

Carex muhlenbergii Schkuhr [including var. *enervis* Boott], Muhlenberg's Sedge. Dry woods and fields; rather rare

[EWC-13788].

Carex pensylvanica Lam., Pennsylvania Sedge. Mesic woods in ravine east of River Road; rare [EWC-13770 ! Dr. Vern McNeilus, TENN].

Carex retroflexa Willd. [including the var. *texensis* (Torr.) Fern. = *C. texensis* (Torr.) Bailey], Reflexed Sedge. Dry woods, rocky slopes, fields, old logging roads; frequent [EWC-13748 ! Dr. Vern McNeilus, TENN; EWC-13752; EWC-13754].

Carex shortiana Dewey, Short' Sedge. Dry to mesic fields and thickets; rather rare [EWC-13779; EWC-13806 - both identified by Dr. Vern McNeilus, TENN].

Carex squarrosa L., Spreading Sedge. Wet woods, ditches, marshes; frequent, often in large stands [EWC-13332; ! Dr. Vern McNeilus, TENN].

Carex tribuloides Wahlenb., Tribulus-Like Sedge. Marshes and wet woods; frequent and often in large numbers [EWC-13333; ! Dr. Vern McNeilus, TENN].

Carex vulpinoidea Michx., Fox-Tail Sedge. Marshy areas, wet fields, ditches and pond margins; throughout, often in large numbers [EWC-13327, EWC-13331; ! Dr. Vern McNeilus, TENN].

Cyperus echinatus (L.) Wood [*C. ovularis* (Michx.) Torr.], Egg-Shaped Sedge. Fields and disturbed sites; occasional [EWC-13371].

Cyperus erythrorhizos Muhl., Red-Rooted Sedge. Marshes and wet fields; frequent [EWC-13661].

Cyperus esculentus L., Yellow Nut-Grass. A characteristic species of bottomland fields; abundant [EWC-13675].

Cyperus ferruginescens Boeckl., Rusty Sedge. Fields, ditches and pond margins; scattered throughout [EWC-13565].

**Cyperus iria* L., Iris-Like Sedge. Bottomland fields and upland ditches; locally abundant [EWC-13316; EWC-13592].

Cyperus lancastriensis Porter, Lancaster's Sedge. Fields and disturbed sites; occasional [EWC-13372].

Cyperus squarrosus L. [*C. aristatus* Rottb.], Aristate Sedge. Open wet sites in bottomlands and flats along the Cumberland River as dewatering occurs in autumn; rare [EWC-13574; EWC-13655].

Cyperus strigosus L., Strigose Sedge. Ditches, pond margins, swampy fields; throughout, [EWC-13438].

Eleocharis obtusa (Willd.) Schultes, Blount Spike-Rush. Pond margins, ditches, marshes and other wet areas; frequent, often in large stands [EWC-13353].

Scirpus atrovirens Willd., Dark-Green Bulrush. Marshy fields, ditches, swamp borders, pond margins and similar sites; frequent, often in large clumps [EWC-13436; EWC-13543].

Scirpus cyperinus (L.) Kunth [*S. rubricosus* Fern.]. Red Bulrush. Marshy sites in bottomland fields and around Harrison Slough; locally abundant [EWC-13573].

DIOSCOREACEAE, Yam Family

**Dioscorea batatas* Dcne. [*D. oppositifolia* L.], Chinese Yam or Cinnamon Vine. Thickets and weedy roadsides; occasional [EWC-13627].

Dioscorea villosa L. [*D. quaternata* (Walt.) J. F. Gmelin], Wild Yam. Mesic woods, thickets and fencerows; rare [EWC-13651].

IRIDACEAE, Iris Family

**Iris* x *germanica* L., Garden Iris. Persisting and vegetatively spreading around homesites; rare [EWC-13728].

Sisyrinchium angustifolium Mill., Narrow-Leaf Blue-Eyed Grass. Mesic woods, fields, thickets and roadsides in bottomlands; occasional [EWC-13278; EWC-13756].

JUNCACEAE, Rush Family

Juncus acuminatus Michx., Sharp-Sepaled Rush. Pond margins, drainage ditches, and around Harrison Slough; frequent [EWC-13424; EWC-13804].

Juncus effusus L., Soft Rush. Pond edges, swamps, ditches and other areas with standing water; frequent [EWC-13797].

Juncus tenuis Willd., Path Rush. Homesites, trails, old roads and other disturbed sites; frequent [EWC-13798; EWC-13805].

LEMNACEAE, Duckweed Family

Lemna perpusilla Torr. [*L. minor* L.], Duckweed. Ponds, ditches, Harrison Slough; locally abundant [EWC-13442].

Wolffia brasiliensis Wedd. [*W. papulifera* Thompson], Water-Meal. Ponds, Harrison Slough; locally abundant [EWC-13441].

LILIACEAE, Lily Family

Allium canadense L., Wild Onion. Mesic fields and meadows, low woods; frequent [EWC-13741; EWC-13780].

**Allium vineale* L., Field Garlic. Roadsides, lawns, fields and meadows; weedy [EWC-13293].

Camassia scilloides (Raf.) Cory, Wild Hyacinth. Bluffy woods east of Hog Branch; rare [EWC-13251].

**Hemerocallis fulva* L., Orange Day-Lily. Persisting and vegetatively spreading from old plantings around homesites and old trash dumps [EWC-13811].

**Muscari racemosum* L., Racemose Grape-Hyacinth. Fallow bottomland fields in early spring; locally abundant [EWC-13726].

**Ornithogalum umbellatum* L., Star-of-Bethlehem. Fallow bottomland fields in early spring; locally abundant [EWC-13722].

Trillium recurvatum Beck, Recurved or Prairie Trillium. Scattered in rich woods; quite rare [EWC-13715].

ORCHIDACEAE, Orchid Family

Spiranthes vernalis Engel, & Gray, Ladies'-Tresses. Old field by pond on River Road; very rare [EWC-13813].

POACEAE, Grass Family

**Agrostis gigantea* Roth [*A. alba* L., *A. stolonifera* L.], Redtop. Roadsides, fields, disturbed lands; frequent [EWC-13304].

Agrostis perennans (Walt.) Tuckerman, Upland Bent. Mesic to dry woodlands, fields and roadsides; infrequent [EWC-13617].

**Aira elegantossima* Schur [*A. elegans* Willd.], Elegant Hairgrass. Fields and dry roadsides; rare [EWC-13301].

Alopecurus carolinianus Walt., Carolina Foxtail. Fallow bottomlands in early spring; abundant [EWC-13277].

Andropogon gyrans Ashe [*A. elliottii* Chapman], Elliott's Broom Sedge. Upland weedy fields; generally rare [EWC-13697].

Andropogon virginicus L., Broom Sedge. Old fields, thickets, cut-over woods; abundant and one of the most conspicuous grasses [EWC-13603].

Aristida oligantha Michx., Few-Flowered Needlegrass. Dry fields and eroded lands; infrequent but sometimes conspicuous [EWC-13586].

**Arthraxon hispidus* (Thunb.) Makino, Joint-Grass. Mesic to wet fields, thickets and ditches; abundant when found [EWC-13674].

Arundinaria gigantea (Walt.) Muhl., Cane. Thin woods on streambanks and in bottomlands, usually in dense stands; locally abundant [EWC-13591].

Brachiaria platyphylla (Griseb.) Nash., No Common Name. Bottomland fields; locally abundant [EWC-13595].

Brachyelytrum erectum (Schreb.) Beauv., Short Huskgrass. Wooded slopes; locally abundant but generally rare [EWC-13502].

**Bromus commutatus* Schrad., Racemose Brome Grass. Fallow and cultivated fields in spring, especially in bottomlands; common [EWC-13799].

**Bromus japonicus* Thunb. ex Murray, Japanese Brome. Fallow and cultivated fields, roadsides, more upland than the previous species [EWC-13795].

Bromus pubescens Muhl. ex Willd. [*B. purgans* L.], Woodland Brome Grass. Mesic woodlands and thickets; infrequent [EWC-13482].

**Bromus tectorum* L., Brome Grass. Roadsides and fields; generally rare [EWC-13800].

Chasmanthium latifolium (Michx.) Yates [*Uniola latifolia* Michx.], Wild Oats. Mesic to wet fields and woods; frequent [EWC-13392].

Cinna arundinacea L., Wood Reedgrass. Swampy woods along Hog Branch; occasional [EWC-13457].

**Cynodon dactylon* (L.) Pers., Bermuda Grass. A lawn grass spreading vegetatively to roadsides, around old homes, often in both upland and low fields; common [EWC-13812].

**Dactylis glomerata* L., Orchard Grass. A forage and hay crop, self-seeding onto roadsides, in fields and disturbed sites; frequent [EWC-13318].

Danthonia spicata (L.) Beauv., Poverty Grass. Dry woods, banks, eroded fields and other dry open areas; occasional [EWC-13781].

Diarrhena americana Beauv., Diarrhena. Shaded river banks and bluffy woods; rare [EWC-13621].

**Digitaria ischaemum* (Schreb.) Muhl., Smooth Crab Grass. Cultivated fields and other disturbed sites; frequent, often in dense stands [EWC-13632].

**Digitaria sanguinalis* (L.) Scop., Hairy Crab Grass. Disturbed sites and cultivated fields; throughout, often in dense stands [EWC-13829].

**Echinochloa crusgalli* (L.) Beauv., Barnyard Grass. Wet fields, ditches, swamp borders, around ponds; locally abundant [EWC-13317].

**Echinochloa frumentacea* (Roxb.) Link, Japanese Millet. A common species of bottomland fields and weedy sites [EWC-13579].

**Eleusine indica* (L.) Gaertn., Goose Grass, Yard Grass. Fields, roadsides, old barnyards and other disturbed soils; locally abundant [EWC-13405].

Elymus virginicus L. Wild Rye. Woodlands and thickets throughout, especially abundant in riparian woods [EWC-13774].

Eragrostis capillaris (L.) Nees, Lace Grass. Dry fields and roadsides; locally abundant [EWC-13282].

**Eragrostis cilianensis* (All.) Mosher [*E. megastachya* (Koel.) Link], Stink-Grass. Open wet fields and roadsides; infrequent [EWC-13600].

Eragrostis frankii Meyer, Frank's Love Grass. Dewatered flats by the Cumberland River in autumn; occasional [EWC-13692].

Eragrostis hypnoides (Lam.) BSP., Creeping Love Grass. Dewatered flats by the Cumberland River in autumn; abundant [EWC-13654].

Eragrostis spectabilis (Pursh) Steud., Tumble Grass. Dry upland fields; rather rare [EWC-13820].

Erianthus gigantea (Walt.) Muhl., Giant Beardgrass. Successional fields; infrequent [EWC-13634; EWC-13635].

**Eulalia viminea* (Trin.) Ktze. [*Microstegium vimineum* (Trin.) Cam.], Japanese Grass. Weedy throughout in almost all habitats but most abundant in bottomlands [EWC-13673].

Festuca obtusa Biehler, Obtuse Fescue. Mesic woods throughout, often in dense stands [EWC-13775].

**Festuca pratensis* Huds. [*F. elatior* L.], Tall or Meadow Fescue. Naturalized throughout in fields, meadows, on roadsides and in disturbed soils [EWC-13794].

Glyceria striata (Lam.) Hitchc., Manna-Grass. Wet woods, swamps and ditches; scattered throughout [EWC-13486].

Hordeum pusillum Nutt., Little Barley. Fallow bottomlands in early spring (abundant) and upland disturbed sites (rare); [EWC-13276].

Hystrix patula Moench [*Elymus hystrix* L. in Wofford and Kral (1993)], Bottlebrush Grass. Bluffy woods; infrequent to rare [EWC-13547].

Leersia oryzoides (L.) Swartz, Rice Cutgrass. Marshes, swamps, wet meadows and ditches; frequent and often very abundant [EWC-13580].

Leersia virginica Willd., Virginia Cutgrass. Mesic to wet woods, fields, roadsides and thickets; frequent [EWC-13497].

Leptochloa filiformis (Lam.) Beauv., Feathergrass. Dewatered sites along banks and flats of the Cumberland River in autumn; rare [EWC-13691].

**Lolium multiflorum* Lam., Italian Ryegrass. An introduced and weedy grass of disturbed sites throughout [EWC-13796].

Melica mutica Walter, Melic Grass. Bluffy woods west of Hog Branch; infrequent to rare [EWC-13718].

Muhlenbergia frondosa (Poir.) Fernald, Leafy Muhly. Eroded banks along the Cumberland River; rare [EWC-13657].

Muhlenbergia schreberi Gmel., Nimble-Will. Mesic and disturbed weedy sites throughout; locally abundant [EWC-13664].

Muhlenbergia sobolifera (Muhl.) Trin., Sprouting Muhly. Bluffy woods; infrequent [EWC-13618].

Panicum acuminatum Swartz var. *acuminatum* [*P. lanuginosum* Ell.], Woolly Panic Grass. Old fields and thickets; occasional [EWC-13402; EWC-13789].

Panicum capillare L., Witch-Grass. Fields and thickets, especially in bottomlands; infrequent [EWC-13682].

Panicum clandestinum L., Hidden Panic Grass. Mesic to dry woods, thickets and fields; infrequent [EWC-13326].

Panicum commutatum L., Changeable Panic Grass. Open woods, thickets and fields; occasional [EWC-13389].

Panicum dichotomiflorum Michx., Forked-Flowered Panic Grass. Bottomland and mesic upland fields; often abundant [EWC-13520].

Panicum dichotomum L., Forking Panic Grass. Dry thin woods, thickets and fields; abundant [EWC-13403].

Panicum rigidulum Bosc ex Nees var. *rigidulum* [*P. agrostoides* Spreng.], Agrostis-Like Panic Grass. Bottomland and mesic upland fields; locally abundant [EWC-13503].

Panicum virgatum L., Switchgrass. Old field off Harris Road west of Hog Creek; abundant in one large stand [EWC-13474].

**Paspalum dilatatum* Poir., Dallis-Grass. Moist meadows and fields, especially in bottomlands; locally abundant [EWC-13688].

Paspalum laeve Michx. [including *P. circulare* Nash], Smooth Knotgrass. Mesic fields, meadows, thickets and disturbed sites; scattered throughout [EWC-13622].

Paspalum repens Berg. [*P. fluitans* (Ell.) Kunth], Repent Knotgrass. Dewatered flats along the Cumberland River in autumn; occasional [EWC-13656].

**Phleum pratense* L., Timothy. Naturalized on roadsides and in other disturbed sites; infrequent [EWC-13802].

**Poa annua* L., Low Speargrass, Annual Bluegrass. Fallow bottomlands and disturbed uplands; locally abundant [EWC-13258].

**Poa pratensis* L., Kentucky Bluegrass. Roadsides, fields, old lawns, other disturbed sites; frequent, but rarely abundant [EWC-13757].

Poa sylvestris Gray, Woodland Bluegrass. Slope, ravine, and riparian forests throughout; often abundant [EWC-13767; EWC-13777].

**Setaria faberii* Herrm., Tall Foxtail. An agronomic weed and also common in successional fields; abundant [EWC-13365].

Setaria parviflora (Poir.) Kerg. [*S. geniculata* (Lam.) Beauv.], Bent Bristly Foxtail. Fields and roadsides; frequent, often in large stands [EWC-13359; EWC-13640].

**Sorghum halepense* (L.) Pers., Johnson Grass. A noxious weed, especially in bottomland fields; abundant [EWC-13360].

Tridens flavus (L.) Hitchc. [*Triodia flava* (L.) Smyth], Purple-Top. Meadows, fields, roadsides; frequent, often in large numbers [EWC-13452].

**Triticum aestivum* L., Common Wheat. Commonly planted and self-seeding in bottomland fields and on roadsides; abundant [EWC-13739].

**Zea mays* L., Corn. Commonly planted and sometimes self-seeding on roadsides and in disturbed sites [EWC-13818].

POTAMOGETONACEAE, Pondweed Family

Potamogeton diversifolius Raf., Diverse-Leaved Pondweed. Connector Road Pond behind old tool shed; abundant [EWC-13425].

Potamogeton foliosus Raf., Leafy Pondweed. North pond on River Road; abundant [EWC-13448].

SMILACACEAE, Catbrier Family

Smilax bona-nox L., China-Brier. Mesic thickets and fencerows, mostly in bottomlands; occasional [EWC-13648].

Smilax glauca Walt., Sawbrier. Old fields, thickets and fencerows; infrequent [EWC-13808].

Smilax hispida Muhl. [*S. tamnoides* L.], Bristly Greenbrier. Low woods, thickets and fencerows; frequent, especially along the Cumberland River [EWC-13652].

Smilax rotundifolia L., Common Greenbrier. Mesic thickets, fencerows and woodlands; frequent [EWC-13589].

TYPHACEAE, Cat-Tail Family

Typha latifolia L., Common Cat-Tail. Swamp margins and bottomland ditches; scattered, usually in large colonies when found [EWC-13582].

SPERMATOPHYTA: ANGIOSPERMAE-DICOTYLEDONAE

ACANTHACEAE, Acanthus Family

Dicliptera brachiata (Pursh) Spreng., Dicliptera. Bottomland woods along Hog Creek and the Cumberland River; locally abundant [EWC-13613].

Ruellia strepens L., Smooth Wild Petunia. Mesic woodlands, fields and thickets; occasional [EWC-13296].

ACERACEAE, Maple Family

Acer negundo L., Box Elder. Moist woods, fields and thickets, especially in bottomlands; frequent [EWC-13481].

Acer rubrum L., Red Maple. Successsional sites, especially in mesic situations; scattered throughout [EWC-13384].

Acer saccharinum L., Silver or Water Maple. A characteristic and often dominant species of bottomland and streambank forests [EWC-13352].

Acer saccharum Marsh., Sugar Maple. General in mesic woodlands and persisting from plantings around homesites [EWC-13396].

AIZOACEAE, Sea-Purslane Family

**Mollugo verticillata* L., Carpetweed. Fields and other recently disturbed sites; locally abundant [EWC-13356].

AMARANTHACEAE, Amaranth Family

**Amaranthus hybridus* L., Pigweed, Wild Beet. A weed of cultivated ground and waste places; locally abundant [EWC-13540].

**Amaranthus palmeri* S. Watson, Palmer's Pigweed. A weed in bottomland soybean fields; infrequent [EWC-13641 ! Dr. Vern McNeilus, TENN].

**Amaranthus spinosus* L., Spiny Amaranth. A weed of old barnlots and fields; occasional [EWC-13404].

Amaranthus tuberculatus (Moq.) Sauer, Water Hemp. Dewatered flats along the Cumberland River after late-summer drawdown; occasional [EWC-13658; EWC-13694].

ANACARDIACEAE, Cashew Family

Rhus copallina L., Shining or Winged Sumac. A characteristic species of old fields, thickets and fencerows; abundant [EWC-13464].

Rhus glabra L., Smooth Sumac. In the same habitats and often with the previous species; abundant [EWC-13492].

Toxicodendron radicans (L.) Kuntze [*Rhus radicans* L.], Poison Ivy. In various habitats from fields to forests and disturbed sites; abundant [not collected].

ANNONACEAE, Custard-Apple Family

Asimina triloba (L.) Dunal, Pawpaw. A constant and often abundant understory member of mesic woods, especially in Hog Branch and Cumberland River bottomlands [EWC-13386].

APIACEAE, Parsley Family

Chaerophyllum tainturieri Hook., Rough Chervil. Low woods, roadsides, thickets, disturbed sites throughout [EWC-13699].

Cicuta maculata L., Water Hemlock. Wet fields and thickets, along bottomland ditches and other open, wet bottomland sites; frequent [EWC-13339].

Cryptotaenia canadensis (L.) DC., Honewort. Fields, roadsides and mesic woods; occasional [EWC-13312].

**Daucus carota* L., Wild Carrot, Queen Anne's Lace. Upland fields, roadsides, cultural sites; frequent and often abundant [EWC-13286].

Sanicula canadensis L., Canada Black Snakeroot. Mesic to dry woodlands; infrequent [EWC-13391].

Thaspium pinnatifidum (Buckl.) Gray, Meadow Parsnip. Riparian woods by Cumberland River; rare [EWC-13760].

Zizia aurea (L.) Koch, Golden Alexanders. Riparian woods by Cumberland River; occasional to rare [EWC-13724].

APOCYNACEAE, Dogbane Family

Amsonia tabernaemontana Walt., Bluestar, Blue Dogbane. Mesic thickets and bluffy woods; occasional [EWC-13264].

Apocynum cannabinum L., Indian Hemp. Roadsides, fields, thickets, other disturbed lands; frequent and often in dense stands [EWC-13383].

AQUIFOLIACEAE, Holly Family

Ilex decidua Walt., Deciduous Holly. Frequent in bottomland woods of Hog Branch and the Cumberland River, rare elsewhere [EWC-13476].

ARALIACEAE, Ginseng Family

Aralia spinosa L., Devil's Walking Stick. A species of dry woods, forest borders, road and trailsides; infrequent to rare [EWC-13601].

ARISTOLOCHIACEAE, Birthwort Family

Aristolochia tomentosa Sims, Dutchman's Pipe Vine. A high climbing vine in thickets and woods along or near the Cumberland river; frequent and often abundant [EWC-13279].

Asarum canadense L., Wild Ginger. Rich mesic woods and bluffs, especially along Hog Branch; locally abundant [EWC-13249].

ASCLEPIADACEAE, Milkweed Family

Asclepias incarnata L., Swamp Milkweed. Open wet fields, swamps, marshes and ditches; abundant [EWC-13506].

Asclepias syriaca L., Common Milkweed. Mesic fields and roadsides; often abundant [EWC-13300].

Asclepias tuberosa L., Butterfly Weed. Upland fields and roadsides; frequent and often abundant [EWC-13311].

Asclepias viridiflora Raf., Green Milkweed. Weedy upland fields; rare [EWC-13473].

Cynanchum laeve (Michx.) Pers. [*Ampelamus albidus* (Nutt.) Britton], Honeyvine. Fencerows and thickets; occasional [EWC-13530].

Matelea gonocarpa (Walt.) Shinners [*Gonolobus gonocarpos* (Walt.) Perry], Climbing Milkweed, Angle-Pod. Bottomland thickets and fencerows; occasional [EWC-13653].

ASTERACEAE, Composite Family

Achillea millefolium L., Common Yarrow. Fields, roadsides and other disturbed sites; infrequent [EWC-13792].

Ambrosia artemesiifolia L., Common Ragweed. Fields, roadsides and thickets; frequent [EWC-13508].

Ambrosia trifida L., Great Ragweed, Buffalo Weed. Bottomland fields and thickets, mesic disturbed sites; locally abundant [EWC-13509].

**Anthemis cotula* L., Mayweed. Roadsides, fields, old barnyards; occasional [EWC-13314].

**Arctium minus* (Hill) Bernh., Common Burdock. Fields and thickets, especially around old homes and barnyards; rare [EWC-13826].

**Artemesia annua* L., Wormwood. Fields, thickets and disturbed sites; occasional [EWC-13557].

Aster dumosus L., Bushy Aster. Upland dry fields, woods and roadsides; infrequent [EWC-13475; EWC-13624].

Aster lateriflorus (L.) Britt., Lateral-Flowered Aster. Bluffy woods west of Hog Branch; rare [EWC-13686].

Aster pilosus Willd., Pilose Aster. Old fields, thickets, dry woods and banks; frequent [EWC-13623].

Aster shortii Lindl., Short's Aster. Bluffy woods west of Hog Branch; occasional [EWC-13685].

Aster simplex Willd., Simple Aster. Low woods and thickets throughout; abundant [EWC-13626].

Bidens bipinnata L., Spanish-Needles. Disturbed sites, roadsides and thickets; infrequent [EWC-13587].

Bidens cernua L., Nodding Sticktights. Mudflats, swampy fields and thickets; occasional, mostly around Harrison Slough [EWC-13659].

Bidens frondosa L. [including *B. vulgata* Greene], Leafy Sticktights. Marshes, wet fields, woods and thickets; infrequent [EWC-13611; EWC-13660].

Bidens polylepis Blake, Scaled Sticktights. Mesic fields and thickets, especially in bottomlands; locally abundant [EWC-13516].

Bidens tripartita L. [*B. comosa* (Gray) Wieg.], Three-Parted Sticktights. Dewatered zone along the Cumberland River, swampy fields, pond margins; occasional [EWC-13665].

Boltonia diffusa Ell., Diffuse Boltonia [incl. *B. asteroides* (L.) L'Her.]. Wet fields, reservoir margins, mudflats, swampy thickets; infrequent [EWC-13507].

**Carduus nutans* L., Nodding or Musk Thistle. Roadsides and fields; rare but a potentially troublesome weed [EWC-13313].

**Centaurea cyanus* L., Bachelor's-Button, Cornflower. Fallow bottomlands in early spring; locally abundant [EWC-13746].

**Chrysanthemum leucanthemum* L., Oxeye Daisy. Fields and roadsides; abundant [EWC-13287].

Cirsium discolor (Muhl.) Spreng., Two-Colored Thistle. Upland fields and roadsides; frequent, sometimes abundant [EWC-13680].

**Cirsium vulgare* (Savi) Tenore, Bull or Common Thistle. Upland fields and roadsides; frequent, sometimes abundant [EWC-13496].

Conyza canadensis (L.) Cronquist [*Erigeron canadensis* L.], Horseweed. Mesic fields, thickets and cultural sites; locally abundant [EWC-13524].

Coreopsis tinctoria Nutt., Tickseed. Mesic fields, especially in bottomlands; locally abundant [EWC-13377].

**Eclipta alba* (L.) Hassk., Yerba-De-Tago. Wet thickets and ditches, swampy areas, pond margins; locally abundant [EWC-13445].

Elephantopus carolinianus Willd., Carolina Elephant's Foot. Mesic fields, disturbed and cultural sites; locally abundant [EWC-13461].

Erechtites hieracifolia (L.) Raf. ex DC., Fireweed. Fields and disturbed woodlands; locally abundant [EWC-13539].

Erigeron annuus (L.) Pers., Daisy Fleabane. Fields, roadsides and disturbed sites; abundant [EWC-13320].

Erigeron philadelphicus L., Philadelphia Fleabane. Fields, roadsides, other disturbed sites; frequent, often abundant [EWC-13712].

Erigeron strigosus Muhl. ex Willd., Daisy Fleabane. Fields and roadsides; abundant [EWC-13290].

Eupatorium coelestinum L., Mist Flower, Wild Ageratum. Mesic fields, ditches, disturbed sites; abundant [EWC-13605, EWC-13537].

Eupatorium fistulosum Barratt, Joe Pye Weed. Mesic fields and thickets; rare [EWC-13538].

Eupatorium hyssopifolium L., Hyssop-Leaved Thoroughwort. Dry fields; locally abundant [EWC-13466].

Eupatorium incarnatum Walt., Flesh-Colored Thoroughwort. Ditches, wet fields and woods; rare [EWC-13604].

Eupatorium rugosum Houtt., White Snakeroot. Low woods, streambanks and ravines; abundant throughout [EWC-13616].

Eupatorium serotinum Michx., Late-Flowering Thoroughwort. Upland and lowland fields throughout; frequent [EWC-13518].

**Galinsoga quadriradiata* Ruiz & Pavon [*G. ciliata* (Raf.) Blake], Ciliate Galinsoga. Weedy in some bottomland soybean fields [EWC-13620].

Gnaphalium obtusifolium L., Fall Catfoot. Upland fields and open woods; frequent [EWC-13584].

Gnaphalium purpureum L., Purple Catfoot. Fields, dry woods and thickets; frequent [EWC-13778].

Helenium amarum (Raf.) Rock [*H. tenuifolium* Nutt.], Slender-Leaved Sneezeweed. Roadsides, homesteads, old barnyards and pastures; locally abundant [EWC-13370].

Helenium autumnale L., Autumnal Sneezeweed. Swampy fields, meadows and thickets; rare [EWC-13570].

**Helianthus annuus* L., Common Sunflower. Rarely appearing in bottomlands, apparently spreading from upstream plantings [EWC-13572].

Helianthus maximiliani Schrad., Maximilian's Sunflower. Large stands occur in upland fields on River Road [EWC-13609].

Helianthus tuberosus L., Jerusalem Artichoke. Bottomland fields, especially along drainage ditches; locally abundant [EWC-13571].

**Iva annua* L. [*I. ciliata* Willd.], Marsh Elder. Fields, especially around cultivated bottomlands; frequent and often in dense stands [EWC-13559].

Krigia dandelion (L.) Nutt., Potato Dandelion. Fields, disturbed sites, roadsides; occasional [EWC-13731].

Krigia oppositifolia Raf. [*Serinia oppositifolia* (Raf.) Ktze.], Opposite-Leaved Dwarf Dandelion. Fallow bottomlands; locally abundant [EWC-13256, EWC-13284].

Lactuca canadensis L., Canadian Wild Lettuce. Fields, roadsides and open woods; infrequent [EWC-13382].

Lactuca floridana (L.) Gaertn., Florida Wild Lettuce. Mesic fields and low woods; occasional [EWC-13541].

Lactuca saligna L., Willow-Leaved Wild Lettuce. Weedy roadsides; rare [EWC-13827].

Polymnia uvedalia. Bear's-foot. Mesic woods and bluffs west of Hog Creek; infrequent [EWC-13458].

Prenanthes altissima L., Tall Rattlesnake Root. Mesic woods, fields and thickets; rare [EWC-13822].

Pyrrhopappus carolinianus (Walt.) DC., False Dandelion. Mesic fields, thickets, ditches and roadsides; frequent [EWC-13364].

Rudbeckia hirta L., Black-Eyed Susan. Upland fields and roadsides; abundant [EWC-13367].

Rudbeckia triloba L., Trilobed Black-Eyed Susan. Low fields and thickets; locally abundant [EWC-13471].

Senecio glabellus Poir., Butterweed. Fallow bottomlands, wet fields and meadows; abundant [EWC-13257].

Silphium perfoliatum L., Cup-Leaved Rosinweed. Low woods by Cumberland River; locally abundant [EWC-13625].

Solidago altissima L. [*S. canadensis* L.], Tall Goldenrod. Upland fields and roadsides; very abundant and weedy [EWC-13608].

Solidago gigantea Ait., Large Goldenrod. Mesic fields, especially in bottomlands; often in large stands [EWC-13567].

Solidago juncea Ait., Stiff Goldenrod. Fields and roadsides; frequent, sometimes plentiful [EWC-13477].

Solidago nemoralis Ait., Woodland Goldenrod. Upland fields and roadbanks; locally abundant [EWC-13614].

Solidago rupestris Raf., Rock Goldenrod. Along banks of the Cumberland River, often sprawling outward toward water; occasional [EWC-13627].

Solidago ulmifolia Muhl. ex Willd., Elm-Leaved Goldenrod. Dry woods and forest borders; occasional [EWC-13615].

Taraxacum officinale Weber, Common Dandelion. Lawns, fields, roadsides and other disturbed areas; frequent [EWC-13727].

Verbesina alternifolia (L.) Britt. [*Actinomeris alternifolia* (L.) DC.], Wing-Stem. Bottomland thickets and streambanks; frequent [EWC-13535].

Verbesina virginica L., Tickweed or Frostweed. Low fields, thickets and forest borders; abundant [EWC-13531].

Vernonia gigantea (Walt.) Trel., Tall Ironweed. Mesic fields and thickets; locally abundant [EWC-13517].

Xanthium strumarium L., Cocklebur. A weedy pest, especially in cultivated bottomlands; abundant [EWC-13510].

BALSAMINACEAE, Touch-Me-Not Family

Impatiens capensis Meerb., Spotted Touch-Me-Not. Creekbanks, wet woods and thickets; locally abundant [EWC-13485].

BERBERIDACEAE, Barberry Family

Podophyllum peltatum L., Mayapple. Ridge and slope forests throughout; often plentiful [EWC-13716].

BETULACEAE, Birch Family

Carpinus caroliniana Walt., Blue Beech. A rather infrequent understory species of mesic forests [EWC-13419].

Ostrya virginiana (Mill.) K. Koch, Hop Hornbeam. Understory tree in ridge and slope forests; infrequent [EWC-13764].

BIGNONIACEAE, Bignonia Family

Bignonia capreolata L., Cross-Vine. Mesic woodlands, thickets and fencerows, especially in bottomlands; occasional [EWC-13263].

**Catalpa speciosa* (Ward.) Engelm., Catalpa, Cigar-Tree. Mesic thickets and woods along the Cumberland River; rare [EWC-13619].

Campsis radicans (L.) Seem., Trumpet Creeper. Often weedy in fields, fencerows and thickets, especially in bottomlands; frequent [EWC-13291].

BORAGINACEAE, Borage Family

Cynoglossum virginianum L., Wild Comfrey. Dry to mesic wooded slopes; occasional [EWC-13463].

Hackelia virginiana (L.) Johnston, Stickweed. Wooded slopes and bluffs west of Hog Branch; occasional to rare [EWC-13480].

Myosotis macrosperma Engelm., Large-Seeded Scorpion Grass. Fields, roadsides and other disturbed sites; frequent [EWC-13744].

Myosotis verna L., Scorpion Grass. Fields, roadsides and other disturbed sites; often abundant, especially in fallow bottomlands [EWC-13267].

BRASSICACEAE, Mustard Family

**Arabidopsis thaliana* (L.) Heynh., Mouse-Ear Cress. Fields, roadsides, disturbed sites; occasional but sometimes abundant, especially in early-spring fallow fields [EWC-13234].

Arabis laevigata (Muhl.) Poir., Smooth Rock Cress. Mesic woodlands, especially around outcrops and bluffs; occasional [EWC-13253; EWC-13723].

Arabis shortii (Fernald) Gleason, Short's Rock Cress. Sandy alluvium in riparian woods by Cumberland River; occasional to rare [EWC-13725].

**Barbarea vulgaris* R. Browne, Yellow Rocket, Winter Cress. Mesic fields, meadows and roadsides; occasional [EWC-13713].

**Brassica rapa* L., Common Turnip. Old barnlots and roadsides; occasional to rare [EWC-13734].

**Capsella bursa-pastoris* (L.) Medic., Shepherd's Purse. Fields, meadows, roadsides and disturbed soils, especially fallow bottomlands; often abundant [EWC-13244].

**Cardamine hirsuta* L., Bitter Cress. Lawns, fields, meadows and disturbed soils; frequent, often abundant [EWC-13230].

Cardamine pensylvanica Muhl., Pennsylvania Bitter Cress. Bottomlands, often in shallow water of ditches [EWC-13269].

Cardamine rhomboidea (Pers.) DC. [*C. bulbosa* (Schreb.) BSP.], Spring Cress. Springy woods, wet meadows and streambanks; locally abundant, especially around Harrison Slough [EWC-13742].

Dentaria laciniata Muhl.]. Lacinate Toothwort, Crowtoes. Wooded ravines, slopes and bluffs; frequent [EWC-13236].

Draba brachycarpa Nutt., Short-Fruited Whitlow Grass. Roadsides, lawns, fields and disturbed soil; locally abundant [EWC-13235].

**Draba verna* L., Whitlow Grass. Same habitats and often with the previous species [EWC-13232].

Iodanthus pinnatifidus (Michx.) Steud., Purple Rocket. Low mesic woodlands and footslopes, bottomland thickets; occasional [EWC-13266; EWC-13740].

Lepidium virginicum L., Peppergrass, Poor-Man's Pepper. Fields, roadsides, old barnyards and other disturbed sites; occasional [EWC-13308].

Lesquerella lescurii (Gray) Watson, Nashville Mustard. Fallow bottomlands in early spring; abundant [EWC-13246].

**Nasturtium officinale* R. Browne, Water Cress. Known only from Hog Branch in shallow water; rare [EWC-13809].

Rorippa sessiliflora (Nutt.) Hitchc., Sessile-Flowered Yellow Cress. Wet fields and meadows, dewatered zone along the Cumberland River, around ponds; occasional [EWC-13578; EWC-13729].

Sibara virginica (L.) Rollins, Arabis-Spelled-Backward. Fallow bottomlands; abundant [EWC-13233].

**Sisymbrium officinale* (L.) Scop., Hedge Mustard. Thickets, old barnyards, and other disturbed sites; locally abundant [EWC-13319].

CALLITRICHACEAE, Water-Starwort Family

Callitriche deflexa A. Browne, Deflexed Water-Starwort. Clumped on moist soil, especially in bottomlands; occasional [EWC-13730].

CAMPANULACEAE, Bluebell Family

Campanula americana L., American Bellflower. Mesic bluffy woods and thickets; occasional [EWC-13394].

Lobelia cardinalis L., Cardinal Flower. Wet fields, thickets and woods in bottomlands; frequent [EWC-13498].

Lobelia inflata L., Indian Tobacco. Fields, open woods and disturbed sites; occasional [EWC-13447].

Lobelia siphilitica L., Great Blue Lobelia. Mesic to wet fields and thickets; generally rare [EWC-13528].

Triodanis perfoliata (L.) Nieuwl., Venus' Looking Glass. Mesic fields, roadsides and disturbed sites; frequent [EWC-13294].

CAPRIFOLIACEAE, Honeysuckle Family

**Lonicera japonica* Thunb., Japanese Honeysuckle. Thickets, fencerows, fields and disturbed sites; a noxious weed throughout [EWC-13390].

Sambucus canadensis L., Elderberry. Mesic thickets, fields, fencerows and disturbed sites; frequent, often in large stands [EWC-13292].

Symphoricarpos orbiculatus Moench, Coralberry, Buckbush. Fields, thickets, disturbed sites; frequent, often in stands [EWC-13521].

Viburnum rufidulum Raf., Rusty Blackhaw. Rocky woods, bluffs and thickets; generally rare [EWC-13607].

CARYOPHYLLACEAE, Pink Family

**Cerastium glomeratum* Thuillier [*C. viscosum* L.], Sticky Mouse-Ear Chickweed. Mat-forming in lawns, fallow fields and disturbed sites; abundant, especially in bottomlands in early spring [EWC-13698].

Cerastium nutans Raf., Nodding Mouse-Ear Chickweed. Fallow bottomlands; infrequent (EWC-13245)

**Dianthus armeria* L., Deptford Pink. Dry fields and roadsides; occasional to rare [EWC-13297].

Saponaria officinalis L., Soapwort or Bouncing Bet. Gravelly roadsides in bottomlands; generally rare [EWC-13329].

Silene antirrhina L., Sleepy Catchfly. Fields, roadsides, disturbed areas; frequent [EWC-13801].

Silene virginica L., Fire Pink. Rich woods and thickets west of Hog Branch; infrequent [EWC-13252].

**Stellaria media* (L.) Cyrillo, Common Chickweed. Disturbed soils throughout, often forming dense mats [EWC-13717].

CELASTRACEAE, Staff-Tree Family

Euonymus americanus L., Strawberry Bush. Mesic woodlands, especially in ravines and on streambanks; rare, heavily browsed by deer [EWC-13821].

Euonymus atropurpureus Jacq., Wahoo. Bluffy woods west of Hog Branch; very rare [EWC-12684].

CHENOPODIACEAE, Goosefoot Family

Chenopodium album L., Lamb's Quarters. Disturbed lands such as old homesites, barnyards and eroded river banks; occasional [EWC-13525].

Chenopodium ambrosioides L., Mexican Tea. Distrubed areas, especially around old barnlots and on eroded river banks; occasional [EWC-13433].

CISTACEAE, Rockrose Family

Lechea tenuifolia Michx., Narrow-Leaved Pinweed. Eroded upland fields; rare [EWC-13414].

CLUSIACEAE, St. John's-Wort Family

Hypericum drummondii (Grev. & Hook.) Torr. & Gray, Nits-and Lice. Sandy roadsides and fields; frequent, often in stands [EWC-13379].

Hypericum frondosum Michx., Leafy St. John's-Wort. Top of river banks along the Cumberland River; very rare [EWC-13670].

Hypericum mutilum L., Slender St. John's-Wort. Marshes, wet meadows, ditches, pond margins; frequent, often weedy [EWC-13423].

Hypericum punctatum Lam., Dotted St. John's-Wort. Roadsides, fields, thickets and disturbed areas throughout; frequent [EWC-13368].

Hypericum stragulum Adams & Robson [*Ascyrum hypericoides* L. var. *multicaule* (Michx.) Fernald], Decumbent St. Andrew's Cross. A common species of dry open woods and sandy roadsides and eroded soils [EWC-13415].

CONVOLVULACEAE, Morning-Glory Family

Calstegia sepium (L.) R. Browne [*Convolvulus sepium* L.], Hedge-Bindweed. Fencerows, thickets, fields; frequent, often in large stands [EWC-13348].

Cuscuta campestris Yuncker, Field Dodder. Fields, meadows and thickets throughout, often in large stands [EWC-13814].

Ipomoea hederacea L., Ivy-Like Morning-Glory. Fields and thickets, most often in and around areas of cultivation; frequent [EWC-13513].

Ipomoea lacunosa L., White Morning-Glory. Mesic fields and thickets, especially in bottomlands; locally abundant [EWC-13533].

Ipomoea pandurata (L.) Meyer, Wild Potato-Vine, Man of the Earth. Mesic fields, roadsides and thickets; frequent, often in large stands [EWC-13544].

CORNACEAE, Dogwood Family

Cornus florida L., Flowering Dogwood. An understory component of some slope and ridge forests, also in fields, thickets and fencerows; occasional [EWC-13735].

CRASSULACEAE, Orpine Family

Sedum pulchellum Michx., Stonecrop. Sandy road shoulders and fields in bottomlands; rare [EWC-13280].

CUCURBITACEAE, Gourd Family

Melothria pendula L., Creeping Cucumber. Thickets and fencerows, especially in moist soil; locally abundant [EWC-13453]

Sicyos angulatus L., Bur Cucumber. Mesic thickets, especially in bottomlands, often covering large areas; frequent [EWC-13575].

EBENACEAE, Ebony Family

Diospyros virginiana L., Common Persimmon. Fields, woodlands, fencerows and shorelines of the Cumberland River; frequent [EWC-13460].

ERICACEAE, Heath Family

Chimaphila maculata (L.) Pursh, Spotted Wintergreen. Upland woods; rare [EWC-13823].

EUPHORBIACEAE, Spurge Family

Acalypha ostryaefolia Ridd., Three-Seeded Mercury. Cultivated fields and other disturbed sites; occasional, sometimes in large numbers [EWC-13678].

Acalypha virginica L., Virginia Three-Seeded Mercury. Fields, roadsides, dry woods, and disturbed sites; frequent [EWC-13409].

Croton capitatus Michx., Hogwort, Wooly Croton. Sandy roadsides in bottomlands; rare [EWC-13831].

Croton glandulosus L., Sand Croton. Bottomland roadsides and thickets; occasional [EWC-13529].

Croton monanthogynus Michx., Prairie Tea. Fields, roadsides, other disturbed sites; frequent [EWC-13376].

Euphorbia dentata Michx., Spurge, Wild Poinsettia. Roadsides and fields; rare [EWC-13583].

Euphorbia maculata L., Eyebane. Fields, cultivated grounds, other disturbed sites; frequent [EWC-13514].

Phyllanthus caroliniensis Walt., Phyllanthus. Open places in bottomlands, especially around and in cultivated fields; rare [EWC-13569].

Tragia cordata Michx., Cordate-Leaved Tragia. Dry woods; very rare [EWC-13821].

FABACEAE, Legume or Pulse Family

Apios americana Medic., American Potato Bean. Thickets along roadsides and drainage ditches in bottomlands; abundant [EWC-13532].

Cercis canadensis L., Redbud. A characteristic understory species of many slope and forests, often in old fields; occasional [EWC-13758].

Chamaecrista fasciculata (Michx.) Greene [*Cassia fasciculata* Michx.], Patridge Pea. A weedy species of meadows, fields and roadsides; abundant [EWC-13478].

Chamaecrista nictitans (L.) Moench [*Cassia nictitans* L.], Wild Sensitive Senna. Mesic roadbanks, fields and meadows; infrequent to rare [EWC-13536].

Desmodium canescens (L.) DC., Hoary Tick Clover. Weedy fields and thickets; occasional [EWC-13550].

Desmodium ciliare (Muhl. ex Willd.) DC., Ciliate Tick Clover. Weedy upland fields; occasional [EWC-13469].

Desmodium marilandicum (L.) DC., Maryland Tick Clover. Weedy upland fields; occasional [EWC-13637].

Desmodium paniculatum (L.) DC., Panicled Tick Clover. Weedy fields and thickets; occasional [EWC-13548].

Desmodium pauciflorum (Nutt.) DC., Few-Flowered Tick Clover. Mesic woodlands above Hog Branch; rare [EWC-13550].

Desmodium perplexum Schub. [*D. paniculatum* (L.) DC. var. *dillenii* (Darl.) Isely], Perplexing Tick Clover. Fields, thickets and roadsides throughout; frequent [EWC-13545].

Desmodium sessilifolium (Torr.) Torr. & Gray, Sessile-Leaved Tick Clover. Dry upland fields; rare [EWC-13470].

Desmodium viridiflorum (L.) EC., Velvety Tick Clover. Weedy upland fields; occasional [EWC-13638].

Gleditsia triacanthos L., Honey-Locust. Woodlands, fencerows and fields throughout; frequent [EWC-13413].

**Glycine max* (L.) Merrill, Soybean. Cultivated and frequently appearing in fields and on roadsides [EWC-13830].

**Kummerowia stipulacea* (Maxim.) Schind. [*Lespedeza stipulacea* Maxim.], Korean Lespedeza. A former pasture and hay crop now naturalized in fields, old lawns, on roadsides and in other disturbed sites; locally abundant [EWC-13552].

**Kummerowia striata* (Thunb.) Schind. [*Lespedeza striata* (Thunb.) H. & A.], Japanese Lespedeza. Like the previous species and in the same habitats; locally abundant [EWC-13551].

Lathyrus hirsutus L., Hairy Sweet Pea. Fallow bottomlands, especially in weedy sites by Harrison Slough; rare [EWC-13345].

**Lespedeza bicolor* Turcz., Bicolor Lespedeza. A shrub planted in plantations in fields east of River Road and sometimes spreading; [EWC-13483].

**Lespedeza cuneata* (Dumont) G. Don, Sericea Lespedeza. Spreading from plantings, especially on roadsides; abundant [EWC-13484].

Lespedeza procumbens Michx., Trailing Bush Clover. Dry fields and roadsides; locally abundant [EWC-13467].

Lespedeza virginica (L.) Britt., Virginia or Slender Bush Clover. Dry upland fields and open woods; occasional [EWC-13553].

**Medicago lupulina* L., Black Medic. Roadsides, fields, other disturbed sites; locally abundant [EWC-13299].

**Melilotus alba* Medic., White Sweetclover. Roadsides, fields, meadows, disturbed sites; frequent [EWC-13289].

Robinia pseudoacacia L., Black Locust. Fields, fencerows, disturbed woods; locally abundant [EWC-13262].

Senna marilandica (L.) Link [*Cassia marilandica* L.], Wild Senna. Mesic fields and thickets occasional to rare [EWC-13522].

**Senna obtusifolia* (L.) Irwin & Barneby [*Cassia obtusifolia* L.; *C. tora* L.], Sicklepod. Often weedy in cultivated bottomlands and sometimes in other disturbed sites [EWC-13560].

Strophostyles helvula (L.) Ell., Yellow Wild Bean. Bottomland thickets, especially near the Cumberland River; locally abundant [EWC-13564].

**Trifolium campestre* Schreb. [*T. procumbens* L.], Hop Clover. Fields, roadsides, other disturbed sites; frequent [EWC-13298].

**Trifolium pratense* L., Red Clover. Fields, roadsides, homesteads, disturbed sites; frequent [EWC-13749].

**Trifolium repens* L., White Clover. Fields, roadsides, homesteads, disturbed sites; often abundant [EWC-13737].

**Vicia dasycarpa* Tenore (*V. villosa* Roth. ssp. *varia* (Host) Corbin), Winter Vetch. In field by old Haynes homestead; rare [EWC-13772].

Vicia minutiflora Dietrich, Minute-Flowered Vetch. Riparian woods by Cumberland River; abundant on east end of unit [EWC-13732].

**Vivia sativa* L. ssp. *nigra* (L.) Ehrend. [*V. angustifolia* (Bauhin) L.], Narrow-Leaved Vetch. Fields, roadsides, thickets; locally abundant [EWC-13270].

FAGACEAE, Beech Family

Fagus grandifolia Ehrh., American Beech. Mesic woodlands, barnlots and roadsides; locally abundant where hollow trees have been left by timber cutters [EWC-13491].

Quercus alba L., White Oak. Slope and ridge forests throughout; probably the most abundant oak species [EWC-13494].

Quercus falcata Michx., Southern Red Oak, Spanish Oak. A characteristic species of dry woods, fencerows and fields; abundant [EWC-13411].

Quercus imbricaria Michx., Shingle Oak. Mesic gully banks, bottomland woods; rare [EWC-13606].

Quercus lyrata Walt., Overcup Oak. Fencerows in bottomlands; rare [EWC-13643].

Quercus macrocarpa Michx., Mossycup or Bur Oak. Bottomland woods, especially along Hog Branch and along the Cumberland River; rare [EWC-13449].

Quercus michauxii Nutt., Swamp Chestnut, Basket, or Cow Oak. Fencerows in bottomlands; very rare [EWC-13646].

Quercus muehlenbergii Engelm., Chinqapin Oak. Bluffy woods and riverbank forests; frequent [EWC-13350; EWC-13669].

Quercus pagoda Raf. [*Q. falcata* Michx. var *pagodaefolia* Ell.], Cherrybark Oak. Low woods, especially in old fencelines; frequent [EWC-13590].

Quercus palustris Muenchh., Pin Oak. Bottomland fencerows and woods along the Cumberland River; occasional [EWC-13645].

Quercus phellos L., Willow Oak. Bottomland fencerow on the western edge of the unit; rare [EWC-13337; EWC-13642].

Quercus shumardii Buckl., Shumard Red Oak. Mostly in bottomland forests, especially in old fencelines; frequent [EWC-13602].

Quercus stellata Wang., Post Oak. Dry ridge and slope forests, fencerows; infrequent [EWC-13369].

Quercus velutina L., Black Oak. Dry ridge and slope woodlands and fencerows throughout; usually abundant [EWC-13380].

FUMARIACEAE, Fumitory Family

Corydalis flavula (Raf.) DC., Yellow Corydalis. Ravine and streambank woods, especially along Hog Branch and the Cumberland River; often abundant [EWC-13237].

GENTIANACEAE, Gentian Family

Sabatia angularis (L.) Pursh, Rose Pink. Open roadsides and fields; frequent, sometimes abundant [EWC-13416].

GERANIACEAE, Geranium Family

Geranium carolinianum L., Wild Cranesbill. Roadsides, fields and disturbed sites; occasional, sometimes abundant [EWC-13719].

**Geranium dissectum* L., Dissected-Leaf Cranesbill. Fallow bottomlands in early spring; rare [EWC-13268].

HAMAMELIDACEAE, Witch-Hazel Family

Liquidambar styraciflua L., Sweetgum. Low woodlands, streambanks, upland fields; frequent [EWC-13417].

HIPPOCASTANACEAE, Buckeye Family

Aesculus glabra Willd., Ohio Buckeye. Lower slope forests along Hog Branch; rare [EWC-13451]

HYDROPHYLLACEAE, Waterleaf Family

Phacelia ranunculacea (Nutt.) Const., Blue Scorpion Weed. Sandy alluvium in riparian woods along the Cumberland River; occasional to rare [EWC-13707].

JUGLANDACEAE, Walnut Family

Carya cordiformis (Wang.) K. Koch, Bitternut Hickory. Mesic and low woods, especially along the Cumberland River; occasional [EWC-13636].

Carya laciniosa (Michx. f.) Loud., Big Shellbark Hickory, Kingnut. Bottomland forests near the Cumberland River; rare [EWC-13676].

Carya ovata (Mill.) K. Koch, Shagbark, Scalybark, or Shellbark Hickory. Slope and low forests, fields, fencerows; frequent [EWC-13493; EWC-13681].

Carya tomentosa Nutt., Mockernut or White-Heart Hickory. Dry woodlands, fencerows and fields; infrequent [EWC-13816].

Juglans nigra L., Black Walnut. Mesic slope, bottomland and ravine forests; frequent. [EWC-13771].

LAMIACEAE, Mint Family

Agastache nepetoides (L.) Kuntze, Giant Hyssop. Mesic thickets, roadsides and along forest borders; rare [EWC-13599].

Blephilia hirsuta (Pursh) Benth., Hairy Wood-Mint. Mesic woods and thickets; occasional [EWC-13440].

**Glechoma hederacea* L., Ground Ivy. Riparian woods along the Cumberland River; infrequent but mat-forming when found [EWC-13738].

**Lamium amplexicaule* L., Henbit. Homesites, meadows and roadsides, fallow bottomlands; frequent, often very abundant in early spring [EWC-13243].

**Lamium purpureum* L., Dead Nettle. Same habitats and often with the previous species [EWC-13231].

Lycopus americanus Muhl., Water Horehound. Swamp margins, streambanks, ditches, wet meadows and woods; occasional [EWC-13512; EWC-13598].

Lycopus virginicus L., Bugleweed. Wet woods, swampy fields and meadows; locally abundant [EWC-13597].

**Perilla frutescens* (L.) Britt., Beefsteak Plant. Disturbed woods, thickets and fields; frequent and often in large numbers [EWC-13630].

**Prunella vulgaris* L., Heal-All. Fields, meadows, and roadsides; frequent and sometimes abundant [EWC-13455].

Pycnanthemum incanum (L.) Michx., Gray Mountain Mint. Fields, roadsides, forest borders; infrequent [EWC-13817].

Pycnanthemum tenuifolium Schrad., Slender Mountain Mint. Old fields and thickets; occasional [EWC-13556].

Salvia lyrata L., Lyre-Leaved Sage. Fields, meadows, old lawns; locally abundant [EWC-13265].

Scutellaria lateriflora L., Mad-Dog Skullcap. Swampy fields, ditches, and pond margins; locally abundant [EWC-13437].

Teucrium canadense L., American Germander. Wet soil of ditches, fields and disturbed sites; often abundant [EWC-13307].

LAURACEAE, Laurel Family

Lindera benzoin (L.) Blume, Spicebush. Ravine, lower slope and bottomland forests; frequent and often abundant [EWC-13487].

Sassafras albidum (Nutt.) Nees, Sassafras. Fields, roadsides, fencerows, disturbed forests; abundant [EWC-13462].

LOGANIACEAE, Logania Family

Polypremum procumbens L., Prostrate Polypremum. Old fields and roadsides; very rare [EWC-13561].

Spigelia marilandica L., Indian-Pink. Bluffy woods west of Hog Branch; infrequent [EWC-13762].

LYTHRACEAE, Loosestrife Family

Ammannia coccinea Rothb., Long-Leaved Ammannia. Open wetlands throughout; often abundant [EWC-13426].

Rotala ramosior (L.) Koehne, Tooth-Cup. Open wetlands throughout; often in large numbers [EWC-13576].

MAGNOLIACEAE, Magnolia Family

Liriodendron tulipifera L., Tulip Tree or Yellow Poplar. Once an important timber tree of mesic slopes and ravines; also frequently found in successional fields [EWC-13766].

MALVACEAE, Mallow Family

**Abutilon theophrasti* Medic., Velvet-Leaf, Buttermold Plant. A weed in bottomland fields and ruderal areas; locally abundant [EWC-13689].

Hibiscus laevis All. [*H. militaris* Cav.], Halberd-Leaved Rose Mallow. Around Harrison Slough and in bottomland ditches; abundant [EWC-13428].

Hibiscus moscheutos L., Swamp Rose Mallow, Swamp Cotton. Around Harrison Slough and in bottomland ditches; occasional [EWC-13505].

**Hibiscus syriacus* L., Rose-of-Sharon. Persisting and spreading around the old Cook homesite; rare [EWC-13398].

Sida spinosa L., Prickly Sida. Cultivated fields, roadsides, disturbed sites; frequent and sometimes abundant [EWC-13523].

MENISPERMACEAE, Moonseed Family

Calycocarpum lyoni (Pursh) Gray, Cupseed. Alluvial woods along the Cumberland River; rare [EWC-13649].

Cocculus carolinus (L.) DC., Red-Berried Moonseed, Snailseed. Low fencerows, thickets, mesic woodlands; infrequent [EWC-13687].

Menispermum canadense L., Moonseed, Yellow Parilla. Alluvial woods along the Cumberland River; occasional [EWC-13650].

MORACEAE, Mulberry Family

Broussonetia papyrifera (L.) Vent., Paper Mulberry. Several shrubs and small trees near old dump south of Harrison house [EWC-13785].

Maclura pomifera (Raf.) Schneid., Osage Orange, Bois D'Arc. Fencerows, thickets, and in woods along the Cumberland River; occasional [EWC-13628].

Morus alba L., White Mulberry. Persisting at homesites and in bottomland woods along the Cumberland river; frequent [EWC-13349].

Morus rubra L., Red Mulberry. An understory shrub or small tree in mesic woodlands; infrequent [EWC-13366].

NYSSACEAE, Sour-Gum Family

Nyssa sylvatica Marsh., Black-Gum. Throughout in almost all woodlands and often in fields, fencerows and thickets [EWC-13803].

OLEACEAE, Olive Family

Forestiera acuminata (Michx.) Poir, Swamp-Privet. Banks of the Cumberland River near east property line; very rare [EWC-13671].

Fraxinus americana L., American or White Ash. Mesic woodlands, fields and fencerows; frequent [EWC-13418].

Fraxinus pennsylvanica Marsh., Green Ash. Streambank and bottomland forests and fencerows [EWC-13338; EWC-13647].

Ligustrum vulgare L. [*L. sinense* Lour.], Privet. Persisting and sometimes spreading around homesites, especially in fencerows; occasional [EWC-13401].

ONAGRACEAE, Evening Primrose Family

Epilobium coloratum Biehler, Willow-Herb. Weedy bottomland fields; occasional [EWC-13588].

Jussiaea decurrens (Walt.) DC. [*Lugwigia decurrens* Walt.], Decurrent Primrose-Willow. Wet fields, marshes, pond margins; frequent [EWC-13593].

Ludwigia alternifolia L., Seedbox. Wet fields, ditches, pond margins and swampy thickets; frequent, sometimes in large stands [EWC-13446].

Ludwigia palustris (L.) Elliott, Marsh Purslane. In mud around ponds, swamps and marshes; locally abundant [EWC-13568].

Ludwigia peploides (Humb., Bonpl. & Kunth) Raven ssp. *glabrescens* (Kuntze) Raven [*Jussiaea repens* L. var. *glabrescens* Kuntze]. Some ponds, Harrison Slough, bottomland ditches; often abundant [EWC-13422]

Oenothera biennis L., Biennal Evening Primrose. Fields, roadsides, open woods, other disturbed sites; frequent [EWC-13479].

Oenothera laciniata Hill, Ragged Evening Primrose. Fields and other disturbed sites; locally abundant [EWC-13362].

OXALIDACEAE, Wood-Sorrel Family

Oxalis stricta L., Yellow Wood Sorrel. Fields, meadows, old lawns, disturbed sites; abundant [EWC-13639].

Oxalis violacea L., Violet Wood Sorrel. Dry woods and thickets; rare [EWC-13714].

PASSIFLORACEAE, Passion-Flower Family

Passiflora incarnata L., Passion-Flower, Maypops. Thickets, fencerows and fields; frequent and often abundant [EWC-13344].

PHYTOLACCACEAE, Pokeweed Family

Phytolacca americana L., Pokeweed. Roadsides, fields, fencerows, disturbed woodlands; occasional and sometimes abundant [EWC-13361].

PLANTAGINACEAE, Plantain Family

Plantago aristata Michx., Bracted Plantain. Fields, roadsides, disturbed sites; often abundant [EWC-13378].

**Plantago lanceolata* L., Buckhorn, Lance-Leaved Plantain. Old lawns, fields and disturbed sites; often abundant [EWC-13793].

Plantago rugelii Dcne., Rugel's Plantain. Mesic fields, old barnlots, roadsides and other disturbed sites; often abundant [EWC-13444].

Plantago virginica L., Virginia or Hoary Plantain. Fields, especially fallow bottomlands, disturbed open lands; occasional [EWC-13736].

PLATANACEAE, Plane-Tree Family

Platanus occidentalis L., Sycamore. General along streams, around ponds and in moist to wet woodlands and fields; frequent [EWC-13773].

POLEMONIACEAE, Phlox Family

Phlox divaricata L., Blue or Common Phlox. Alluvial and lower-slope woods; frequent, sometimes in large stands [EWC-13248].

Phlox paniculata L., Fall or Garden Phlox. Low fields and thickets and riverside forests; rare [EWC-13488].

POLYGONACEAE, Buckwheat Family

Brunnichia cirrhosa Gaertn., Ladies' Eardrops. Thickets along the Cumberland River; rare [EWC-13566].

Polygonum amphibium L., Scarlet Smartweed. Bottomland ditches and around Harrison Slough; locally abundant [EWC-13435].

**Polygonum cespitosum* Blume var. *longisetum* (DeBry.) Stewart, Bristled Smartweed. Mesic or wet fields, ditches, thickets and woodlands; abundant [EWC-13407].

Polygonum erectum L., Erect Knotweed. Mesic disturbed sites, especially in bottomlands; occasional [EWC-13662].

Polygonum hydropiperoides Michx., Mild Water Pepper. Swamps, marshes, wet woods and fields, often in shallow water; abundant [EWC-13504].

Polygonum lapathifolium L., Dock-Leaved Smartweed. Mesic fields, roadsides and disturbed sites, mostly in bottomlands; infrequent [EWC-13526].

Polygonum pensylvanicum L., Pinkweed. Mesic fields and thickets, ditches and shorelines; occasional [EWC-13511].

**Polygonum persicaria* L., Lady's Thumb. Fields, roadsides, mesic disturbed sites such as old barnlots; occasional [EWC-13408].

Polygonum punctatum Ell., Water Smartweed. Wet fields, woods, swamps and marshes, roadside ditches; frequent [EWC-13495].

Polygonum scandens L., Climbing False Buckwheat. Old fencerows, thickets, disturbed sites, most often in mesic places; locally abundant [EWC-13577].

**Rumex acetosella* L., Sheep Sorrel. Fields, meadows, and disturbed open sites; often abundant and weedy [EWC-13288].

Rumex altissima Wood, Pale Dock. Upland ditches such as at the old barnlot on Tobacco Barn Road, and lowland swampy sites; rare [EWC-13322].

**Rumex crispus* L., Curly or Yellow Dock. Fields, meadows, other disturbed sites; frequent, often weedy [EWC-13321].

Rumex verticillatus L., Swamp Dock. Around Harrison Slough, often in shallow water; rare [EWC-13341].

Tovara virginiana (L.) Raf., Jumpseed. Mesic slope and ravine woodlands; frequent [EWC-13468].

PORTULACACEAE, Purslane Family

Claytonia virginica L., Spring Beauty. Mesic woodlands and thickets, especially along Hog Branch and the river; locally abundant [EWC-13238].

PRIMULACEAE, Primrose Family

Lysimachia ciliata L., Fringed Loosestrife. Thickets around Harrison Slough; occasional; [EWC-13335].

**Lysimachia nummularia* L., Moneywort. Wet woods and ditches; generally rare but sometimes forming an extensive ground-cover [EWC-13459].

Samolus parviflorus Raf., Brookweed, Water Pimpernel. Seeps in bottomland forests along Hog Creek; rare [EWC-13610].

RANUNCULACEAE, Crowfoot Family

Clematis virginiana L., Virgin's Bower. Thickets and weedy fields, especially in low ground; occasional [EWC-13555].

Delphinium tricorne Michx., Dwarf Larkspur. Bluff woods east of Hog Branch; rather rare [EWC-13255].

Myosurus minimus L., Mousetail. Fallow bottomlands in early spring; locally abundant [EWC-13721].

Ranunculus abortivus L., Small-Flowered Crowfoot. Idle fields, especially bottomlands, and disturbed sites; locally abundant [EWC-13242].

Ranunculus carolinianus DC., Carolina Buttercup. Swampy woods on west end of property at drain from Harrison Slough; locally abundant [EWC-13743].

**Ranunculus sardous* Crantz, European Crowfoot. Mesic or wet fields, meadows, ditches; locally abundant, especially in bottomlands [EWC-13261].

Thalictrum revolutum DC., Waxy Meadow-Rue. Thickets at footslopes of bluffy woods; rare [EWC-13395].

RHAMNACEAE, Buckthorn Family

Rhamnus caroliniana Walt., Carolina Buckthorn, Indian Cherry. Mesic woodlands and thickets; rare [EWC-13782].

ROSACEAE, Rose Family

Agrimonia parviflora Ait., Small-Flowered Harvest Lice. Low thickets, weedy fields and woods; occasional to rare [EWC-13542].

Agrimonia pubescens Wallr., Hairy Harvest Lice. Mesic woodlands and thickets; occasional to rare [EWC-13549].

Crataegus viridis L., Green Haw. Low woods near the Cumberland River and upland thickets; rare [EWC-13677].

**Duchesnea indica* (Andr.) Focke, Indian Strawberry. On alluvium in riparian woods by the Cumberland River, occasional, locally abundant [EWC-13705].

Geum canadense Jacq., Canada or White Avens. Mesic fields, thickets and woods; frequent [EWC-13328].

Geum vernum (Raf.) Torr. & Gray, Vernal Avens. Mesic fields, thickets and weedy disturbed sites; infrequent [EWC-13254].

**Potentilla recta* L., Upright Five-Finger. Weedy fields and roadsides; occasional to rare [EWC-13784].

Potentilla simplex Michx., Old-Field Cinquefoil. Fields, thickets and weedy disturbed sites; frequent [EWC-13745].

Prunus americana Marsh., American Plum. Small tree in mesic woodlands; rare [EWC-13700; EWC-13810].

Prunus angustifolia Marsh., Chickasaw Plum. Forming dense thickets in some fields, fence rows; occasional [EWC-13400; EWC-13700].

**Prunus persica* (L.) Batsch, Common Peach. Roadside waif on lower River Road; very rare [EWC-13363].

Prunus serotina Ehrh., Wild Black Cherry. A constant member of mesic to dry slope forests and in fencerows and fields; frequent [EWC-13397].

**Rosa multiflora* Thunb., Multiflora Rose. Widely spreading from old plantings; a locally abundant and often noxious weed in fields, thickets and fencerows [EWC-13751].

Rosa setigera Michx., Prairie Rose. Fields, thickets and roadsides; frequent and often abundant [EWC-13285].

Rubus argutus L., Common Blackberry. Fields and roadsides, often forming dense stands; frequent [EWC-13430].

Rubus flagellaris Willd., Dewberry. Fields, roadbanks and open disturbed woods; occasional to rare [EWC-13733].

Rubus occidentalis L., Black Raspberry. Spreading in fields, thickets, and cut-over woods; generally rare [EWC-13765].

RUBIACEAE, Madder Family

Cephalanthus occidentalis L., Buttonbush. Swampy thickets, especially around Harrison Slough, often in dense stands [EWC-13336].

Diodia teres L., Poor-Joe, Buttonweed. Dry fields, old pastures, disturbed sites; locally abundant [EWC-13373].

Diodia virginiana L., Virginia Buttonweed. Wet fields, meadows, ditches; locally abundant [EWC-13358].

Galium aparine L., Cleavers, Bedstraw. Fields, thickets, and disturbed sites throughout; weedy [EWC-13720].

Galium circaezans Michx., Wild Licorice. Mesic to dry woods; infrequent [EWC-13819].

**Galium pedemontanum* Ell., Piedmont Bedstraw. Barnyard weed; locally abundant [EWC-13346].

Galium pilosum Ait., Hairy Bedstraw. Fields and cut-over woods; locally abundant [EWC-13472].

Galium tinctorium L., Swamp Bedstraw. Marshes, swampy fields and thickets, pond margins; locally abundant [EWC13324, EWC-13330].

Houstonia purpurea L., Purple Bluets. Dry woodlands, roadbanks, disturbed sites; frequent [EWC-13303].

Houstonia pusilla Schoepf [*H. patens* Ell.], Small Bluets. Fields, meadows, lawns, and roadsides, frequent in early spring [EWC-13702].

Spermacoce glabra Michx., Buttonweed. Wet meadows, fields, swampy places; occasional [EWC-13663].

RUTACEAE, Rue Family

Ptelea trifoliata L., Wafer-Ash. Frequent in bluffy woods west of Hog Branch [EWC-13295].

SALICACEAE, Willow Family

Populus deltoides Bartr., Cottonweed. Bottomland forests and ditches, sometimes in mesic upland fields; frequent [EWC-13351].

Salix nigra Marsh., Black Willow. Pond margins and low woods throughout; frequent [EWC-13432].

SAPINDACEAE, Soapberry Family

**Cardiospermum halicacabum* L., Balloon Vine. Mesic thickets, mostly in bottomlands; frequent and sometimes weedy [EWC-13515].

SAPOTACEAE, Sapodilla Family

Bumelia lycioides (L.) Gaertn., Southern Buckthorn. Slope woods; very rare [EWC-13786].

SAURURACEAE, Lizard's-Tail Family

Saururus cernuus L., Lizard's-Tail. Marshes, swamps, bottomland woods and thickets; locally abundant [EWC-13340].

SAXIFRAGACEAE, Saxifrage Family

Penthorum sedoides L., Ditch Stonecrop. Swamps, wet fields, pond margins, ditches; occasional [EWC-13534].

Philadelphus pubescens Loisel., Hairy Mock-Orange. Shrub in bluffy woods west of Hog Branch; rare [EWC-13283].

SCROPHULARIACEAE, Figwort Family

Agalinis fasciculata Ell. [*Gerardia fasciculata* Ell.] Fascicled Foxglove. Weedy upland fields; generally rare [EWC-13585].

Bacopa rotundifolia (Michx.) Wettst., Round-Leaved Water-Hyssop. Ponds and ditches; locally abundant [EWC-13421].

Conobea multifida (Michx.) Benth. [*Leucospora multifida* (Michx.) Nutt.], Clefted Conobea. Dewatered river banks in autumn, pond margins, wet sites in bottomlands; locally abundant [EWC-13562].

Dasytoma macrophylla (Nutt.) Raf. [*Seymeria macrophylla* Nutt.], Mullein-Foxglove. Scattered in bluffy woods and riparian forest by Cumberland River; infrequent [EWC-13393].

Gratiola neglecta Torr., Hedge-Hyssop. Pond margins, wet fields, ditches; locally abundant [EWC-13315].

Lindernia dubia (L.) Penn. [*L. anagallidea* (Michx.) Penn.], False Pimpernell. Dewatered river banks in autumn, pond margins, wet fields and ditches; frequent, often in large numbers [EWC-13355].

**Mazus pumilis* (Burm.f.) Stennis, Japanese Mazus. Dewatered flats along the Cumberland River in autumn; very rare [EWC-13693].

Mimulus alatus Ait., Winged Monkey Flower. Marshes, wet meadows, bottomland ditches and low woods; infrequent [EWC-13434].

**Paulownia tomentosa* (Thunb.) Steud., Princess or Empress Tree. Spreading into woodlands and on roadsides; occcasional [EWC-13750].

Penstemon calycosus Small, Large-Calyxed Beard-Tongue. Mesic bluffy woods, meadows and roadsides; infrequent [EWC-13281].

Scrophularia marilandica L., Carpenter's-Square. Mesic to wet woods and thickets, bluffy woods; infrequent [EWC-13501].

**Verbascum blattaria* L., Moth-Mullein. Fields and roadsides; frequent [EWC-13374].

**Verbascum thapsus* L., Common Mullein. Fields and roadsides; frequent [EWC-13375].

**Veronica arvensis* L., Common Speedwell. Open fields and roadsides; abundant throughout, especially in bottomlands [EWC-13260].

**Veronica peregrina* L., Neckweed. Fallow bottomland fields; Frequent but not abundant [EWC-13259].

SIMAROUBACEAE, Quassia Family

**Ailanthus altissima* (Mill.) Swingle, Tree-of-Heaven. Adventive in cut-over woodlands and fields; often weedy [EWC-13763].

SOLANACEAE, Nightshade Family

**Datura stramonium* L., Jimsonweed. Edges of cultivated fields, cultural sites, open disturbed areas such as eroded river banks; occasional to rare [EWC-13679].

Physalis angulata L., Angled Ground Cherry. Cultivated fields, especially bottomlands, and disturbed sites; frequent

[EWC-13596].

Physalis heterophylla Nees, Variable-Leaved Ground Cherry. Weedy fields, especially in bottomlands; infrequent [EWC-13527].

Physalis longifolia Nutt. var. *subglabrata* (Mack. & Bush) Cronquist [*P. subglabrata* Mack. & Bush; *P. virginiana* var. *subglabrata* (Mack. & Bush) Waterfall], Glabrous Ground Cherry. Fields, roadsides and other open disturbed sites; frequent [EWC-13420].

Physalis pubescens L., Pubescent Ground Cherry. Dewatered flats along the Cumberland River in autumn; occasional [EWC-13690].

Solanum carolinense L., Horse-Nettle. Fields, meadows and other such disturbed sites; frequent, often in large numbers [EWC-13381].

Solanum ptycanthum Dunal [*S. americanum* Mill., *S. nigrum* L.], American Nightshade. Fields and other open disturbed sites; frequent [EWC-13357].

**Solanum rostratum* Dunal, Buffalo-Bur. Gravelly roadsides and parking lot at the former Cook house; rare [EWC-13454].

TILIACEAE, Linden Family

Tilia heterophylla Vent, White Basswood. Banks of the Cumberland River; very rare [EWC-13668].

ULMACEAE, Elm Family

Celtis laevigata Willd., Sugarberry. Low woodlands, fencerows, fields, cultural sites; frequent [EWC-13412].

Celtis occidentalis L., Hackberry. Mostly in alluvium along the Cumberland river; infrequent [EWC-13347].

Ulmus alata Michx., Winged Elm. Dry woods, old fields, fencerows and roadsides; abundant [EWC-13410].

Ulmus americana L., American Elm. Fencerows in bottomlands; generally rare [EWC-13563].

Ulmus rubra Muhl., Red or Slippery Elm. Mesic woodlands, especially in bottomlands, also in fencerows and fields; frequent [EWC-13385].

URTICACEAE, Nettle Family

Boehmeria cylindrica (L.) Sw., False Nettle, Bog-Hemp. Swamps, wet fields and woods; frequent [EWC-13490].

Laportea canadensis (L.) Wedd., Wood-Nettle. Wet woods and thickets, especially in the Hog Creek bottomlands; locally abundant [EWC-13489].

Pilea pumila (L.) Gray, Clearweed. Mesic to wet woods, epecially in the Hog Creek area; occasional [EWC-13612].

Urtica chamaedryoides Pursh, Stinging Nettle. Alluvial woods, mostly along Hog Creek and the Cumberland River; occasional [EWC-13695].

VALERIANACEAE, Valerian Family

Valerianella radiata (L.) Dufr., Corn-Salad. Fields, roadsides, thickets; very abundant in fallow bottomland fields [EWC-13706].

VERBENACEAE, Vervain Family

Phyla lanceolata (Michx.) Greene [*Lippa lanceolata* Michx.], Fog-Fruit. Wet fields, bottomland ditches, pond margins; locally abundant [EWC-13431].

**Verbena brasiliensis* Vellozo, Brazilian Vervain. Upland fields throughout; often in large stands [EWC-13306, EWC-13399].

Verbena simplex Lehm., Narrow-Leaved Vervain. Road shoulders, fields and disturbed sites; frequent [EWC-13309].

Verbena urticifolia L., White Vervain. Mesic thickets, fields and woodlands; frequent [EWC-13343].

VIOLACEAE, Violet Family

Viola priceana Pollard, Confederate Violet. Riparian forest along the Cumberland River; rare [EWC-13704].

Viola pubescens Ait. var. *eriocarpa* (Schwein.) Russell [*V. pensylvanica* Michx., *V. eriocarpa* Schwein.], Yellow Violet. Rich slope and ravine forests; locally abundant, especially along Hog Branch [EWC-13250].

**Viola rafinesquii* Greene, Field Pansy. Lawns, meadows, roadbanks and other open disturbed sites; frequent, often in large numbers [EWC-13241].

Viola sororia Willd. [*V. papilionacea* Pursh], Meadow Violet. Low woods, meadows, old lawns, fields; frequent, often abundant [EWC-13701].

VISCACEAE, Mistletoe Family

Phoradendron serotinum (Raf.) M.C. Johnson [*P. flavescens* (Pursh) Nuttall], Mistletoe. Epiphytic on various hardwood species, most often in low woods; occasional [observed but not collected].

VITACEAE, Grape Family

**Ampelopsis arborea* (L.) Koehne, Peppervine. Persisting from cultivation around the former Cook house [EWC-13554].

Ampelopsis cordata Michx., Heart-Leaf Ampelopsis. Mesic fencerows and thickets, especially in bottomlands; locally abundant [EWC-13581].

Parthenocissus quinquefolia (L.) Planch., Virginia Creeper. Woodlands, fencerows, thickets and disturbed sites throughout; abundant [EWC-13672].

Vitis aestivalis Michx., Summer Grape. Dry, upland woods and thickets; rather rare [EWC-13815].

Vitis vulpina L., Frost Grape. Mesic woods, fencerows and thickets, especially in bottomlands; frequent, forming thickets or high-climbing [EWC-13644].

VEGETATION RESULTS FROM LAND SURVEYS IN THREE EAST TENNESSEE COUNTIES, 1807-1887

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ABSTRACT. Metes and bounds surveys of property ownership boundaries for the period 1807-1887 have been used to characterize forest composition in three Tennessee counties. The counties (dates, numbers of surveys, numbers of corner trees) were: Blount, 1824-1826, 336, 1071; Roane, 1807-1808, 141, 519; Rhea, 1824-1889, 260, 1625. Trees most often used as corners were oaks and hickories, but pine, poplar, and chestnut were also much used. Comparison of percent composition of the surveys with modern inventories reveals that some species/species groups have remained relatively constant over time, some taxa have increased in relative importance (*e.g.*, *Pinus, Juniperus*), and some have decreased (*e.g.*, mesophytes as *Fagus grandifolia*). Changes in land use, modern forest "management" and disease are probably responsible for percentage shifts. Plant communities known from modern studies are no more than suggested by survey percentages or species co-occurrences. Survey records provide valuable information about Tennessee's forest landscape near the time of settlement and a few decades thereafter.

INTRODUCTION

The vegetation cover of the whole landscape at or near the time of settlement by European-Americans is of interest to field scientists. Such information is relevant to the research of historians (Williams 1989), paleoecologists (Delcourt *et al.* 1993), pedologists (Jenny 1980), anthropologists (Chapman and Shea 1981), and vegetation biomass modelers (Waring and Schlesinger 1985). Vegetation ecologists (as DeSelm 1994) use past vegetation patterns to interpret the effects of historical, cultural, and environmental factors on present vegetation (Mueller-Dombois and Ellenbereg 1974). Congressional land survey records and similar rectilinear surveys (cf. DeSelm 1994) and metes and bounds surveys have been used to interpret early settlement vegetation (DeSelm 1995, 1997, 1999; DeSelm and Rose 1995).

This paper reports vegetation results obtained from metes and bounds surveys of the period in Blount, Rhea and Roane counties (Fig. 1). I report percent forest composition as seen by surveyors and compare that with modern forest inventory composition.

CHARACTER OF THE SURVEYED AREAS

The surveyed parts of Blount County lie in the Ridge and Valley Physiographic Province and a few surveys were made in coves in the Blue Ridge Province. The surveyed part of Roane County also is in the Ridge and Valley while almost all surveys in Rhea County are in the Appalachian Plateaus (Cumberland Plateau) part of the county (Fenneman 1938). These areas (including only low elevation Blount County) have a tropical humid climatic type. Precipitation varies from 122 to 132 cm per year, rather well distributed, but floods and late-season droughts are common (Trewartha 1968, Dickson 1960). January mean maximum temperatures are in the 10-11°C range, mean minima are in the -1-0°C range. July mean maximum temperatures range from about 31-32°C, mean minima range from about 18-20°C (Dickson 1960).

Blount County of 1820, near the beginning of the survey period, included small parts of the present Sevier and Loudon counties (Fig. 1). Parallel southwest-northeast trending ridges and valleys characterize most of the county landscape. These areas are underlain by Paleozoic sandstones, dolomites, limestones and shales (Rodgers 1953, Luther 1977, Hardeman 1966). Major rivers, the Tennessee and the Little Tennessee, border the county. Elevations range from about 300 m on the Tennessee River to 2026 m but surveying was done between about 300 and 450 m. Topography is

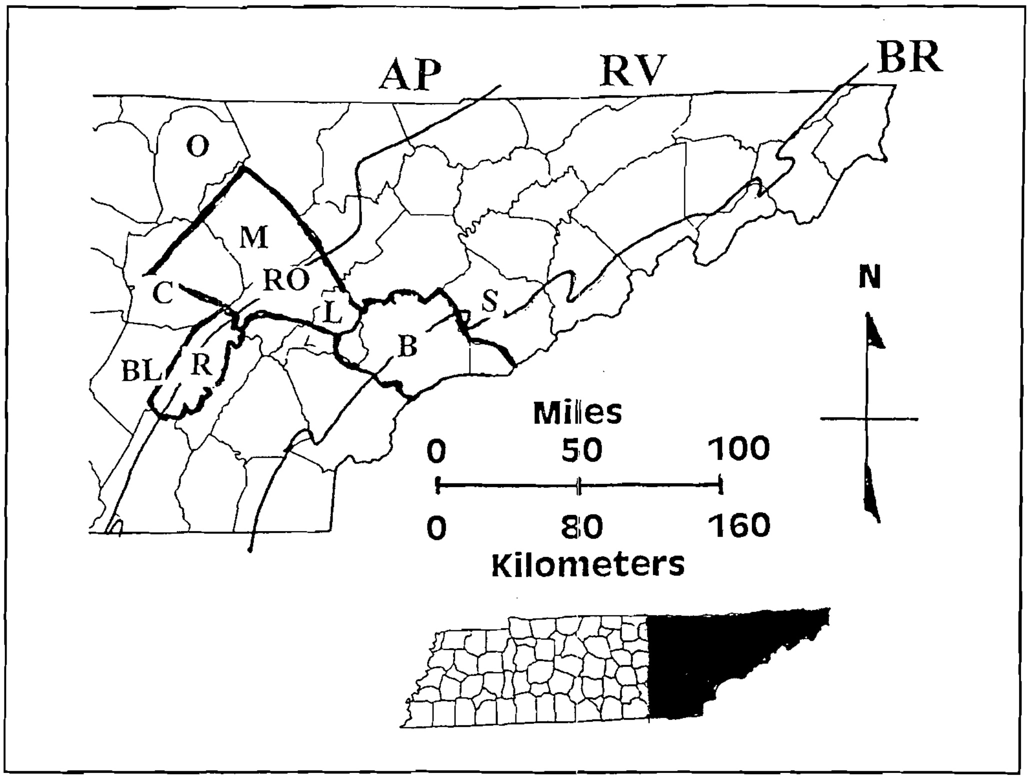

Figure 1. Map of eastern Tennessee showing approximate boundaries of Blount County, 1820 (B), Roane County 1810 (RO), and Rhea County 1840 (R) (from Foster 1922). Other counties from the text with modern boundaries are Bledsoe (BL), Cumberland (C), Loudon (L), Morgan (M), Overton (O), and Sevier (S). Also shown are Blue Ridge (BR), and eastern Appalachian Plateaus (AP) boundaries with the Ridge and Valley (RV) between.

undulating to steep. Soils are mostly well drained, shallow to deep, and loamy to clayey–some have chert in the profile or have limestone outcrops. Soils are classed as Alfisols, Inceptisols and Ultisols (Springer and Elder 1980).

Of the 239 Blount County surveys located by place, 205 were in the Ridge and Valley on the Holston and Tennessee rivers or on tributaries of these and on tributaries of the Little Tennessee River; locations were: Elijoy, Crooked, Nine Mile, Nails, Six Mile creeks and the Little River. The other 34 surveys were on 14 other creeks or at other places including four at unknown places (not in the Tennessee Gazeteer, Fullerton, 1974). All of these were in the Ridge and Valley except 12 surveys in Tuckaleechee and Millers coves–calcareous valleys of the Blue Ridge (Hardeman 1966).

Roane County of 1810, at the end of the survey period, included parts of the present Loudon, a large part of Cumberland, most of Morgan, as well as most of Roane counties (Fig. 1). Surveys were in the eastern, the Ridge and Valley part of the county. The Tennessee, Clinch, and Emory rivers bisect the area. Elevations range from about 220 to 620 m on the plateau escarpment (Walden Ridge) just beyond the west edge of the survey area. The topography is undulating to steep. Soils are shallow to deep, well drained to excessively drained, clayey, cherty or stony and are classed as in Blount County (Springer and Elder 1980).

Rhea County of 1840 (Fig. 1), near the middle of the survey period, lies both in the Ridge and Valley and on the Cumberland Plateau. The county is bordered on the east by the Tennessee River and, in the west, it extends beyond the Plateau escarpment 4-8 km. Elevations vary from about 208 to 600 m. The topography is undulating to steep. On the Plateau, bedrock is sandstone and shale, with limestone on the lower slope of the escarpment and in the bottom of deep valleys (Hardeman

1966). Soils are loamy, often stony, well drained, moderately deep, and rock outcrops may occur. They are mapped as Ultisols and Inceptisols (Springer and Elder 1980).

The floras of these areas are rather well known (Wofford and Kral 1993, Chester *et al.* 1993, Chester *et al.* 1997). Known floras (native plants) range in numbers of species from 570 in Rhea to 1050 in Blount County (Univ. of Tennessee Herbarium 1998). The forest vegetation is discussed by Stephenson *et al.* (1993) and Hinkle *et al.* (1993), the barrens by DeSelm and Murdock (1993) and the sandstone outcrops (flatrocks) by Perkins (1981). Generally, the forests fall into upland oak, oak-hickory, oak-pine or oak-cedar types; lower slopes and coves exhibit mesic hardwood or hemlock-hardwood types and flooded areas exhibit wetland types. Forest vegetation class composition or average forest composition by site have been published in the Ridge and Valley and on the Plateau (Anonymous 1953, 1954, Cowan 1958, Parr and Pounds 1987, and Thor and Summers 1971). Plant community classes are mapped in these counties (Tennessee Valley Authority 1941).

More than 10,000 years ago, people of Native American cultures began visiting the surveyed areas (Paleoindian and Archaic cultures). The major stream valleys were used by later cultures for village and field sites, uplands were hunted for game animals and wild plant food. Fire was commonly used in the forest to clear the understory (Hudson 1976, Lewis and Kneberg 1958). European-American settlement occurred following treaties with Native Americans over the period 1780-1819 (Mathews 1960, Folmsbee *et al.* 1969). Forests on low-slope topography were cleared and row crops cultivated. Slopes were logged for farm, or in some cases export timber, and forests were grazed and often burned using spring surface fires (Killebrew *et al.* 1874).

METHODS

Land Entry Books (Entry Takers Books) were available from Blount, Roane, and Rhea counties. Land transfers are described from the periods: Blount 1824-1826, Rhea 1824-1887, 1902-1929, and Roane 1807-1808. The Blount and Roan data were handwritten records from the State Archives in Nashville, typed in the 1930s (1938 Blount County, no date Roane County), as part of the Works Progress Administration Historical Records Project. They are available from Mountain Press in book form. The Rhea County Land Entry Book (Surveyors Book No. 1) is a publication of the Rhea County Historical and Geneological Society. The numbers of surveys used and (usually) trees cited were: Blount: 336-1118, Rhea: 260-1621 and Roane: 141-526. Surveys came from parts of the county areas of the period (Fig. 1). Blount surveys were all by Robert Wear. Rhea County surveys were apparently all from the Cumberland Plateau area except for two tracts of I. T. Lockes on the Tennessee River. In this county no records after 1889 were used. Roane County records include a few entries from nearby (Cumberland, Bledsoe and Overton counties–all part of the Fourth Survey District) (Crouch 1968).

The original records were typed, or copied as they were found. Plant and topographic spellings and other nomenclature is preserved here (plant names used have been repeated in the tables). The surveys usually recorded a tree (or stump) at each survey corner, sometimes more than one tree, or topographic feature, or a stake was recorded instead. (In Blount County more stake corners were used than tree corners.) The botanical qualifications of the surveyors is not known. Surveyors used a compass and measured distances in poles or chains and links. No attempt is made to find the survey lines on the ground. No diameters or point-to-tree distances are given. Specific locations are not known.

In a few surveys, only stakes were used. Some of these are at town lots as in Kingston. The early surveys passed through wild, little modified forest land but all started from known corners of existing property lines. Some surveys crossed roads or paths or recorded fields. Some surveys duplicated corners, apparently representing resale of lands earlier described by the same corners. This tree data has been eliminated when recognized.

RESULTS

General

Tree names, tree-form descriptors and landscape descriptors were similar to those used in other, mainly nineteenth century, surveys (DeSelm 1995, 1997, 1999, DeSelm and Rose 1995). Most place names could be found in modern gazetteers (Fullerton 1974, United States Geological Survey 1991).

Blount County

Two unusual natural-cultural features in the county were ore banks and ironworks. The people considered the latter so important to their success there, that ore bank land was condemned for use only by the ironworks (company). Table 1 contains the percentages of "species" of survey stems; 40 taxa were named, in addition was Frenchwood which is unknown. See also the modern inventories in the table. The oak proportion in the Survey data is notable--they exceed proportions of pines and hickories by a factor of more than three. The high percentages of black and post oaks suggest that there may have been communities of these types there--in fact, types dominated by white, black and post oaks are known (Martin 1971, 1978, Martin and DeSelm 1976). The black and post oak percentages are nearly as high as those from northern Sevier County (DeSelm and Rose 1995) where

Table 1. Percent occurrences in Surveys from Blount County. Cowan (1946) data is percent board feet. TVA (1971) DEN is for stems ≥5 inches; TVA (1971) VOL is for stems ≥9 inches.

TAXA	Survey	Cowan 1946	TVA 1956	TVA 1971 DEN	TVA 1971 VOL
	PERCENT				
Acer spp., maple	0.3	1.2[a]			
A. saccharum, sugar tree	0.8				
Aesculus sp., buckeye	0.2				
Alnus serrulata, alder	0.1				
Betula spp., burch	0.2				
Carpinus caroliniana, horn beam	1.0				
Carya spp., hickory	13.5	4.1	9.5	10.1	6.8
Castanea dentata, chestnut	2.1				
C. pumila, chestnut brush	0.1				
Cercis canadensis, redbud	0.5				
Cornus florida, dogwood	1.3				
Diospyros virginiana, persimmon, symin	0.3				
Fagus grandifolia, beech	2.5				
Fraxinus spp., ash	2.1				
French wood	0.1				
Gleditsia triacanthos/Robinia pseudoacacia, locust	0.5			3.0	0.9
Juglans cinerea, white walnut	0.3				
J. nigra, black walnut	0.2			0.8	0.6
J. spp., walnut	0.9				
Juniperus virginiana, cedar	0.1	0.6			
Liquidambar/Nyssa, gum	0.5				
Liquidambar styraciflua, sweetgum	0.4				
Liriodendron tulipifera, poplar	2.6	5.2	3.5	4.3	4.7
Morus rubra, mulberry	0.2				
Nyssa sylvatica, black gum	0.7	1.2	2.5		
Ostrya caroliniana, ironwood	0.4				

Table 1, continued.

	Survey	Cowan 1946	TVA 1956	TVA 1971 DEN	TVA 1971 VOL
Oxydendron arboreum, sowerwood	0.8				
Pinus spp., pine	13.5	41.0	42.2	41.7	36.0
Platanus occidentalis, sycamore	0.4				
Prunus spp., plumb tree	0.1				
Quercus alba, white oak	10.5		5.0	3.3	5.0
Q. falcata, Spanish oak	2.8				
Q. rubra, Q. coccinea, red oak	1.0				
Q. marilandica, blackjack	1.1				
Q. nigra, water oak	0.1				
Q. prinus, chestnut oak	0.7		9.4	10.3	12.5
Q. stellata, post oak	18.0		2.2	1.5	1.0
Q. velutina, black oak	18.8				
Q. spp., all oaks	53.0	41.1			
Q. spp., red oaks	23.6	27.2			
Q. spp., white oaks	29.3	13.9	7.2		
Q. spp. (*Q. velutina, rubra, falcata*)	19.8		6.3	6.1	13.0
Q. coccinea			6.8	4.0	5.7
Sassafras albidum, sassafras	0.5				
Tsuga canadensis, spruce pine	0.3				
Ulmus spp., elm	0.6				

[a]Includes sugar maple.

most of the data came from the "slate" knobs. The sum of percents from nine mesophytes including beech, sugar maple and poplar suggests that some lower slope and cove communities were sampled (and then cleared for agriculture). The paucity of wetland taxa, as sycamore, suggests that few bottoms were sampled. Mesic and wetland forests are well known in the area (Martin 1971).

Comparison of Survey with inventory data (which excludes the Great Smoky Mountains National Park) reveals the existence of species which are modern increasers. These are locust (probably mostly *Robinia pseudoacacia*, which is an invader [Burns and Honkala 1990] and is planted), walnut (planted and saved to grow because of the value of the wood), poplar (an increaser with disturbance, Martin 1971, Smith 1968, Burns and Honkala 1990), cedar, the pines (disturbance invader and increasers), and black gum, and chestnut oak. The apparent increases in the last two may be a sampling area phenomenon. Surveys were done on deep soils, the best potentially agricultural soils of the period, but few forests available to be inventoried occur there now. Thus modern inventories are more likely placed on stony slopes where chestnut oak and black gum are typical.

Decreasers include hickories, white oak and post oak. This may again be that the lands of these survey species are now in agriculture and modern samples come from poorer sites. Comparing percent number of stems versus volume of stem wood allows comparing tree numbers versus size. Hickory, locust (largely *Robinia*), pines and post oak have higher relative density than volume suggesting small tree size and overall modern management for pulp, poles, ties, and posts. Other oaks (white, chestnut and mixed oak including black and southern red) have larger relative volume than density suggesting current management for saw timber.

Roane County

The surveys reported plant observations among 33 taxa. Surveys were in the Ridge and Valley part of the county though some stream bottoms of the Emory River are included (which may have been in the Plateau). Features seen include a fish trap, coal, a mill seat, a saltpeter cave and a sucking spring or pond. Apparently the Fourth District (Crouch 1968) had been previously surveyed at the section level since repeated references are made to section lines, section miles and such trees as ". . . the two mile tree of the section line. . . ."

Percentages among taxa (Table 2) are less than five percent each except for hickories, pines, poplar and three oak taxa. The sum of all oaks exceeds the sum of hickories, pines, or poplar by X5 to X8. The oak percent exceeds that of chestnut by more than X24. The relatively high percentages of white, post, and black oaks suggests that communities dominated by these taxa may have occurred in Roane County of that period. In fact, several white oak types, a black oak type, and a post oak type occur in modern forests (Martin 1971, 1978, Martin and DeSelm 1976, Stephenson *et al.* 1993). Several white oak types contain black and post oaks and the post oak type contains black oak (Martin 1971). Pines, poplar, hickories, and chestnut are common constituents of the white, post, and black oak types; indeed pines or poplar are dominant among other types (Martin 1971).

Percentages of mesic taxa, including poplar, beech and sugar maple sum to 25 percent of the total indicating a good representative of moist sites and mesic forests in the area. On the other hand, percentages of wetland taxa, as sycamore, total only 4.1 although some survey lines crossed streams and some paralleled rivers.

On Yellow Creek in Bledsoe County, surveyors Richard Hodson and John Hunt surveyed ". . . 200 poles to a stake in a gease near to four blazed black oaks . . ." (gease ? = geason, meaning producing scantily, barren or unproductive; Oxford English Dictionary, Simpson and Weiners 1989). This might have been a barren which vegetation types are well known on the Plateau (DeSelm 1992).

Increasers between Survey and modern times are black gum (X6 – nearly X10), Spanish oak (X4), red (and scarlet) oaks (X1.8), chestnut oak (nearly X30-43.5), and pines (X5.8-11.2). These increases are again probably due to modern sample location. Survey samples came from the Ridge and Valley where few forests now remain whereas modern inventory data comes from the Plateau part of the county where forests abound. The pine increases are due to forest disturbance, where it is an invader, and due to planting. No cedar was mentioned in the Survey–it is now a successional invader (Smith 1968) and is common enough to appear in the 1973 inventory (Tennessee Valley Authority 1973).

Decreasers include the mesophytes sugar maple, buckeye, beech, ash, poplar and hemlock–their sites now mostly in cultivation. Similarly the inventory use of the well-drained to tight soils of oak forests with white, post, and black oak, and dogwood have declined. Swamp taxa, boxelder and sycamore have declined with drainage and conversion of their sites to agriculture. The loss of chestnut and elm are due to disease (Hepting 1971).

A table of 156 co-occurrences was prepared (not shown) where more than one tree was recorded at the same corner. Most commonly a species name was repeated on a single corner (as white oak with white oak); however, white oak also occurred at three or more corners with hickory, dogwood, and black oak. Post oak occurred most commonly with black oak and hickory. Sugar maple and beech were commonly associated. The co-occurrence of the oaks, hickories and dogwood suggest the existence of white oak, post oak, and black oak forests, or these together or with hickory as a dominant. These are reported by Martin (1971) along with a beech-sugar maple type (Martin 1971).

Rhea County

Surveying in Rhea County was done on the Plateau surfaces, and also on the slopes of the escarpment, at its base, and in Cranmore Cove. Surveyors were chiefly Jesse Thompson and Alfred

Collins but 12 other surveyors worked for short periods. They reported a tar kiln in operation and

Table 2. Percent occurrences in surveys from Roane County. The Cowan (1946) data is percent board feet.

TAXA	Survey	Cowan 1946	TVA 1960	TVA 1973
	PERCENT			
Acer spp., maple	2.9			2.0
A. negundo, boxelder	0.6			0.1
A. saccharum, sugar tree	4.4			0.6
Aesculus spp., buckeye	1.5			
Carya spp., hickory	9.3	7.3	8.2	6.7
Castanea dentata, chestnut	1.9			
Celtis spp., hackberry	0.4			
Cornus florida, dogwood	3.9			0.7
Fagus grandifolia, beech, beach	3.5	1.7		
Fraxinus spp., ash	2.5			1.0
Ilex spp., holly	0.4			
Juglans spp., walnut	0.4			
J. cinerea, white walnut	1.3			
J. nigra, black walnut	0.4			0.2
Liquidambar styraciflua/Nyssa sylvatica, gum	1.2			
Liriodendron tulipifera, poplar	5.7	1.1	4.8	3.9
Magnolia acuminata, cucumber	0.4			0.1
Nyssa sylvatica, black gum	0.2	1.1	2.5	2.9
Pinus spp., pine	5.8	64.9	45.2	32.9
Platanus occidentalis, sycamore	1.5			0.1
Quercus spp., oak	0.4			
Q. alba, white oak	16.6		7.9	6.8
Q. falcata, Spanish oak	0.8			3.2
Q. coccinea, Q. rubra, red oak	2.7			4.9
Q. marilandica, blackjack	0.4			0.3
Q. prinus, chestnut oak	0.2		5.9	8.7
Q. stellata, post oak	16.5		2.2	1.3
Q. sp., swamp oak	0.2			
Q. velutina, black oak	10.6			6.0
Q. spp., red oaks	14.5	14.7	13.2	
Q. spp., white oaks	13.3	6.2	16.0	
Q. spp., *Q. falcata, Q. rubra, Q. velutina*			6.9	
Q. coccinea			6.3	
Sassafras albidum, sassafras	0.2			0.3
Tilia spp., lyn, linn	2.0			
Tsuga canadensis, hemlock	0.4			
Ulmus spp., elm	1.4			0.6

such land features as coal banks, flatrock, rockhouse, calybeate spring (also as cylebriate spring), chinquepin plain, ponds, a swamp, canebrakes, and "Gaze's hickory flat."

The Surveys reported 38 taxa (Table 3). Percentage representation reported among taxa are all less than five except for certain oaks, chestnut, and hickory. The oak total exceeds that of chestnut or hickory by ratios of 6.7 and 4.5. The high percentages of white, black and post oaks suggest that communities dominated by these taxa occurred. Modern communities dominated by white oak, mixed oaks (high in black oak), and post oak occur on the Plateau (Hinkle 1978, 1989). These xeric

Table 3. Percent occurrences in surveys from Rhea County. Cowan (1946) data is percent board feet. Peterson (1931) data from Woolrich and Neeley (1934).

TAXA	Survey	Peterson 1931	Cowan 1946	TVA 1959
	PERCENT			
Acer rubrum, red maple				2.0
A.rubrum, A. saccharum, maple	2.3		1.6	
Amelanchier spp., service tree	<0.1			
Arundinaria gigantea, cane	0.2			
Betula spp. birch	<0.1			
Carya spp., hickory	14.8	1.0	4.0	10.1
Castanea dentata, chestnut, chesnut	9.8			
Castanea pumila, chinquepin	<0.1			
Celtis, spp., hackberry	<0.1			
Cercis canadensis, redbud	0.1			
Cornus spp., dogwood	2.3			
Diospyros virginiana, persimmon	0.1			
Fagus grandifolia, beech, beach	0.2	5.6		
Fraxinus spp., ash	0.2			
Hamamelis virginiana, witch hazel	<0.4			
Ilex spp., holly	0.1			
Juglans nigra, black walnut	<0.1			
Juglans sp., walnut	0.1			
Juniperus virginiana, cedar	<0.1			
Kalmia latifolia, laurel	0.2			
Liquidambar styraciflua, sweet gum, red gum	0.1	1.0		
Liquidambar/Nyssa, gum	0.4			
Liriodendron tulipifera, poplar	1.4	1.0		2.3
Magnolia acuminata, cucumber	0.1			
Nyssa sylvatica, black gum	5.4	4.8		
Oxydendron arboreum, sowerwood	1.4			
Pinus spp., pine	3.1	30.0	55.6	36.9
P. spp., yellow pine	<0.1	30.0	51.6	36.2
P. strobus, white pine	0.9		4.0	0.7
Platanus occidentalis	0.2			
Quercus alba, white oak	15.0			6.7
Q. falcata, Spanish oak	2.7			
Q. coccinea, Q. rubra, red oak	1.9			
Q. marilandica, blackjack	1.4			
Q. cf. *nigra*, water oak	<0.1			
Q. prinus, chestnut oak	3.4			6.7
Q. spp., oak	0.3			
Q. stellata, post oak	11.5			4.2
Q. velutina, black oak, spotted oak	17.3			

Table 3, continued.

TAXA	Survey	Peterson 1931	Cowan 1946	TVA 1959
	PERCENT			
Q. falcata, rubra, velutina, Southern red, Northern red, black oaks				13.0
Q. coccinea, scarlet oak				8.4
Q. spp., all red oaks	20.8		17.8	21.4
Q. spp., white oaks	29.9		3.2	17.6
Q. spp., all oaks	53.6	66.2	21.0	39.0
Q. spp. /*Carya* spp., oaks and hickories	68.3	67.2	25.0	49.1
Q. spp./*Castanea dentata*, oaks and chestnut	63.4	66.2		
Q. spp./*Pinus* spp., oaks and pines	57.7	96.2	76.6	75.9
Sassafras albidum, sassafras	0.2			
Tsuga canadensis, spruce pine	0.7			0.6

types all contain some pine and hickory, in fact, Hinkle (1978) reports both Virginia and shortleaf pine types. In the Surveys, pine on ridges and cliffs is reported repeatedly. Oak, oak-pine, oak-chestnut and oak-hickory percentages (Table 3) sum to half to two-thirds of the total. The sum of mesic taxa as poplar, beech, maple and others indicates that only a few coves were sampled. The totals of sycamore, sweet gum, water oak and hackberry indicate that few wetlands were seen although a swamp and two ponds were crossed. Fields and old fields were seen but percentages of invaders as cedar, persimmon and sassafras are low; potential invaders there as poplar and pine cannot be distinguished from individuals in natural forests.

Of the 32 tree taxa, only about 12 names can be used with modern inventory names; others are understory plants or are included in combined species categories. Useable taxa include those which are constants (holding their percentages with time) as maple, black gum and hemlock. Decreasers include those cut heavily for lumber, post and white oaks. Chestnut was decimated by disease (Hepting 1978).

Apparent increasers include taxa such as sweetgum, poplar, and pine (increases vary from about X2 to X18). The increase in beech may simply be that beech is often left in the forest after logging. Chestnut oak may be less accessible among the oaks and so also less frequently cut.

A table of co-occurrences of taxa, mentioned together at the same corner was prepared (not shown); they total 888 including 260 duplicates of a single species reported more than once at the same corner. White oak occurred mainly with black oak, hickory and chestnut. Black oak was recorded most with post oak, white oak, hickory, and chestnut. Blackjack was most often with post oak. Red oak (some were doubtless scarlet oak) was most often with post oak. The pines grew mostly with chestnut, black and chestnut oaks and black gum. Dogwood grew mainly with white oaks and hickory.

DISCUSSION AND CONCLUSIONS

Between the three surveyed areas, 43 taxa were named, 25 to the species level, 12 to the genus level and two were unknown. The intergeneric terms gum and locust were used, in *Pinus*, yellow pine was cited (subgenus *Pinus*, Little and Critchfield 1969), and the term red oak probably included northern red and scarlet oaks. The forests were mainly hardwood–percentages totaled 86.1-94.7 and softwoods only <4.9-13.9. The proportions of post, black, and white oaks and the hickories were large. Importance trends among genera were in Blount County oak > hickory = pine > poplar > chestnut (and beech exceeds chestnut); Roane County oak > hickory > pine = poplar > chestnut (six other taxa exceed chestnut); Rhea County oak > hickory > chestnut > pine (black gum exceeds pine). The first two (easternmost) of these counties lie in the Appalachian Oak Forest (Stephenson *et al.*

1993) where Survey data support this classification. Rhea County lies in the Mixed Mesophytic Forest of Hinkle *et al.* (1993) who make it clear that uplands are chiefly oak, oak-hickory and oak-pine forests as are indicated in the surveys.

Increasers in two of the three county areas are pine, black gum and chestnut oak. The first is an opportunistic invaders, spreading with disturbance (Burns and Honkala 1990), the last two now remain in areas difficult to log. Decreasers in two areas are white and post oak, hickory, and maple (chiefly red maple). The decreasers are probably due to the loss of moist soil oak sites by their conversion to agriculture. Poplar seems to be an increaser with pine and cedar in Blount County but a slight decreaser in Roane County which lost other mesophytes such as sugar maple and beech (mentioned previously) during land use conversion to agriculture.

Metes and bounds survey records are not without deficiencies of field methods which make interpretations in terms of vegetation cover less than conclusive. Included are lack of precise location of survey starting points and survey lines, surveying through or near disturbed areas as roads, fields, and other already-in-use properties, the naming of small plants at corners, the possible non-random choice of corners, and the possible limited taxonomic expertise of surveyors as evidenced by the few species seen and their grouping of species. In spite of these deficiencies, the surveys constitute nearly the only record of vegetation present near the time of settlement. Thus, their contribution to our historical botanical geographic knowledge is great.

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A NEW ISOHYETAL MAP OF TENNESSEE AND ADJACENT AREA

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ABSTRACT. The availability of 1961-1990 precipitation data and the average increase in precipitation from the 1925-1960 data stimulated preparation of a new isohyetal map for Tennessee and adjacent area. Most of West and Middle Tennessee and the Sequatchie Valley receive 130-150 cm; the central and southern Cumberland Plateau receives over 150 cm annually. The Ridge and Valley receives 110-140 cm. Mountainous regions of East Tennessee and western North Carolina receive 110-over 200 cm annually but the paucity of measurement stations from these areas has abrogated accurate mapping of isohyates there.

INTRODUCTION

No external factors influence the human condition more than those of weather and climate, and those factors related to them. The world's human populations are clustered in relation to the equitibility of climate and its food and shelter provision. Similarly the terrestrial biotic elements, flora and fauna are arranged in a general pattern responsive to the types of climate (Walter 1984, Trewartha 1961). Biotic units, as biomes, are arrayed around areas of unique climate (Vankat 1979, Barbour and Billings 1988). The occurrences of drought and flood focus attention on the water regime as a climatic element. Precipitation lows producing drought may change human history (Bryson and Murray 1977, Rosenberg 1978). The grasslands in particular have been examined for effects of drought stress (Weaver 1954). Floods, normal in river valley topography, may cause severe devastation to societal infrastructure (Tennessee Valley Authority 1949), and damage vegetation normally upslope from the flood zone (Lindsay *et al.* 1961).

Average precipitation, as shown on isohyetal maps, is the baseline for understanding drastic variation resulting in droughts and floods. Past isohyetal maps for Tennessee have been based on 1925-1955 data (Dickson 1960) and 1931-1960 data (United States Department of Commerce 1968, Baldwin 1973). The new map included here chiefly uses data from 1961-1990. The need for this is occasioned by higher precipitation averages in recent decades. Thirty-four Tennessee stations with 1925-1955 data (Dickson 1960) show an average increase of 5.5 cm in the more recent data; 16 western North Carolina stations show an average 3.6 cm increase when comparing 1925-1955 (Carney 1960) and modern data. The 1925-1955 data includes the droughts of the 1930s and 1950s (Vaiksnoras and Palmer 1973.)

METHODS

Average total annual precipitation, for 1961-1990, for Tennessee and an adjacent area for 165 stations was obtained on the Internet by Schmidt from, *i.e.*, Owenby and Ezell (1992) and United States Department of Commerce (1992). Station data were placed on a map display of stations and isohyetal lines were drawn freehand (Figure 1). Lines ("contours") are with variable rather than constant intervals of centimeters. These lines were then compared to those adjacent states in Climatography of the United States (United States Department of Commerce 1960). Agreement was fairly good except for the mountainous eastern edge of Tennessee and western North Carolina and northwestern South Carolina. In the new data set there are only 14 stations with precipitation over 158 cm. In this mountainous area, the map was compared with that by the Tennessee Valley Authority (1959), using data from the years 1935-1955. For these data, the precipitation gauge network was about one per 199 square kilometers versus one per more than twice that many square kilometers in Middle Tennessee. This network includes a few stations on mountains of high precipi-

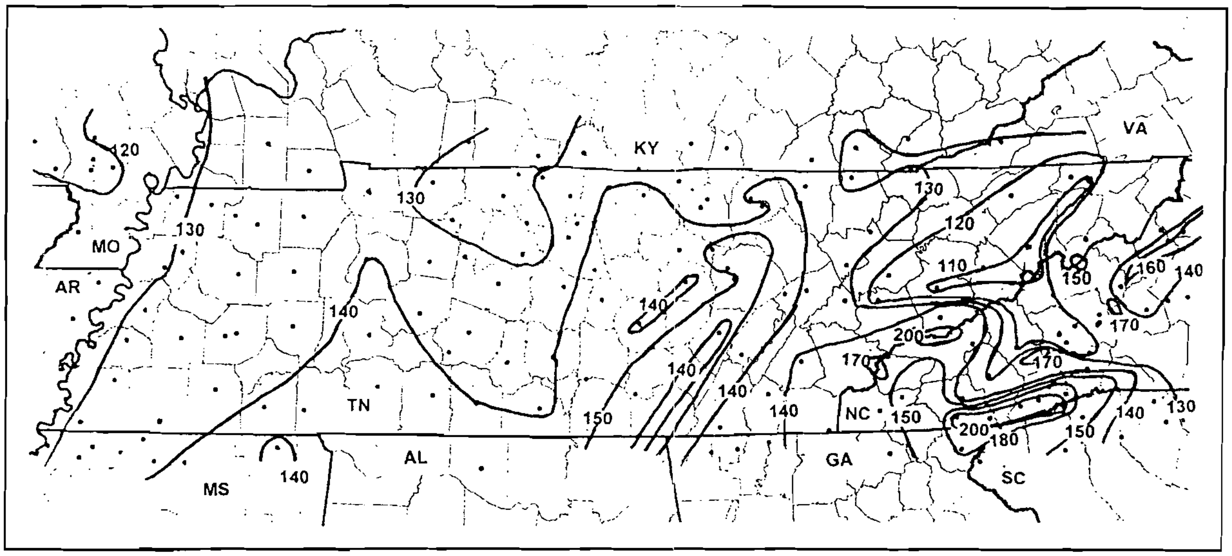

Figure 1. Map of Tennessee and adjacent regions showing state and county boundaries, weather station locations, and isohyetal lines (cm).

tation (there are 44 peaks over 1830 meters in Tennessee and North Carolina). Precipitation data from a few peaks have been added to Figure 1 using Tennessee Valley Authority (1959) data:

Graham County, NC (Hawk Knob, Haywood Gap)
Sevier County, TN (Clingman's Dome, Great Smoky Mountains National Park)
Carter County, TN and Madison County, NC (McKinley Gap, Roan Mountain area)
Yancey County, NC (Mt. Mitchell)
Buncombe County, NC (Mt. Pisgah)

RESULTS

An irregular precipitation trend between southeastern Missouri and eastern Middle Tennessee (120-150 cm) reflects part of the mid-continental trend of increasing precipitation from the eastern foot of the Rocky Mountains eastward (United States Department of Commerce 1968, 1992). A less well-defined trend from southern to northern Middle Tennessee reflects part of the Gulf of Mexico to central southeastern decreasing trend (United States Department of Commerce 1968, 1992). The westernmost 130 cm line marks the loess bluffs area of West Tennessee with over 31-meter bluffs over the Mississippi River alluvial plain (Springer and Elder 1980). The elevated central and southern Cumberland Plateau exhibit precipitation of 150 cm and above. However, the Sequatchie Valley (Pikeville) and that valley in northeastern Alabama, lower topographically, exhibit lower precipitation than the Plateau surface (also see Long 1959).

The Ridge and Valley, lying in the rain shadow of the Appalachian (Cumberland) Plateaus to the north and west, and also being sheltered by the Blue Ridge Mountains from the moist winds blowing from the south, include areas of lower precipitation (110-140 cm) and the isohyates extend into North Carolina in the French Broad and Pigeon River valleys (also seen on the map by Carney 1960).

Since few precipitation measurements are made on the little-accessible mountain peaks and ridges, mountainous areas do not show precipitation corresponding to the intricacies of the topography. In Figure 1, no precipitation increase is shown for the Cumberland Mountains, with ridges over 1068 meters in Tennessee; nor is one shown for the Cumberland Mountains of Kentucky with peaks over 300 meters higher (Anderson 1959). Blue Ridge precipitation varies from <110 to >200 cm.

The addition of Tennessee Valley Authority data from five isolated areas of high precipitation of earlier decades only slightly improves the map quality. These data do not suffice for the generally inadequate high elevation data. Expected annual precipitation can be predicted from precipitation/ elevation relationships (Dickson 1959), but great seasonal annual and topographic variability is to be expected (Smallshaw 1953). Perhaps in the future, a new, cheap instrumental unit will become available to place in usually inaccessible areas to provide routine precipitation data.

SUMMARY AND CONCLUSIONS

A map of annual precipitation levels is one useful descriptor of a geographic area as are those of other climatic descriptors (as temperature). This hybrid map uses precipitation chiefly from the 1961-90 period but five stations are included with data from earlier decades. However, no averages predict annual conditions, variability is great and is to be expected (see data in Martin 1930). The paucity of measurements on uplands in mountainous topography make assessment of the true pattern of mountain precipitation nearly impossible. The probability that our climate is undergoing at least partly man-induced changes means that known averages (and extremes) of precipitation measures may be expected to continue to change (Budyo and Izrael 1991, Gates 1993, Lashot and Tirpak 1990, Schneider and Temkin 1977).

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JAMES SAFFORD AND HIS RESPONDENTS' PLANTS OF WEST AND MIDDLE TENNESSEE IN 1880

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ABSTRACT. In the 1880 United States Census report, published in 1884, the culture of cotton crops in the United States was described by the census agents and by their respondents. They describe cotton cultivation and the lands, soils on which it grew, and the native plants there. The lands of West Tennessee, the western Tennessee River valley, the Highland Rim and Central Basin are included. Dozens of respondents are cited. Sixty-seven plant taxa are reported, including 54 species and 13 other genera; there were also two intergeneric categories. Certain genera and species are reported throughout or nearly throughout the area. Oaks, hickories, and tulip poplars are the most mentioned upland trees; hydrophytic taxa are mentioned chiefly in the Bottoms; mesophytes and calciphiles are mentioned, especially in the Basin.

INTRODUCTION

The natural vegetation cover on the landscape is of interest to a variety of field scientists including historians (as Williams 1989), paleoecologists (Delcourt *et al.* 1993), pedologists (Jenny 1980), anthropologists (Chapman and Shea 1981), and vegetation biomass modelers (Waring and Schlesinger 1985). Vegetation ecologists (Mueller-Dombois and Ellenberg 1974) use past vegetation to interpret impacts of environmental factors on existing vegetation and subsequent emerging vegetation patterns.

Rectangular survey records (DeSelm 1994) and metes and bounds survey records (DeSelm 1999) have been used in the study of vegetation present at or near the time of European-American land settlement. However, studies of later vegetation, such as this one, show snapshots of vegetation to be compared with both the early records and with modern inventories.

This paper reports the compilation of observation-reports of plants present in West and Middle Tennessee on and near cotton cropland at the time of the Tenth Census in 1880 (Safford 1884). I report plant composition in seven physiographic (sub)divisions (Figure 1). Chronologically, these observations lie between the land survey period near the time of settlement (DeSelm 1999) and the brief descriptions of Tennessee forests by Hall (1910). The Census reports are one of a group of three Safford reports made during this period which describe geology, soils, and note native plants; the other two are Safford (1869, Geology of Tennessee) and Killebrew, Safford and others (1874, Introduction to the Resources of Tennessee).

CHARACTER OF THE SURVEYED AREAS

The western two-thirds of Tennessee has a subtropic humid climatic type. Precipitation, chiefly rainfall, varies from 122-132 cm per year but late summer and fall droughts and winter and spring floods are common (Trewartha 1968, Dickson 1960). January mean maximum temperatures vary from about 8.8-11.1°C and mean minima are in the –2.2 -1.1°C range. Mean maximum temperature in July range from 31.1-33.3°C and mean minima range from 17.8-22.2°C (Dickson 1960).

The Mississippi Alluvial Plain, Bluff Region, Tableland and Summit Region lie within the Mississippi Alluvial Plain and Eastern Gulf Coastal Plain sections of the Coastal Plain Physiographic Province. The Western Valley of the Tennessee River, Highland Rim, and Central Basin lie within the Interior Low Plateau Physiographic Province (Figure 1, Fenneman 1938).

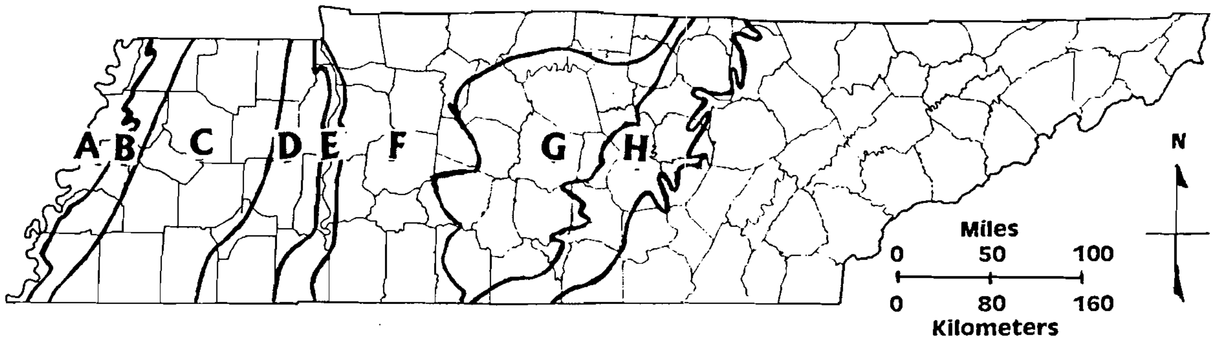

Figure 1. Natural Regions of West and Middle Tennessee. Safford's 1884 agricultural map of Kentucky and Tennessee and his great natural divisions map are used as the basis for boundaries in this figure. The regions are: A – Mississippi River Alluvium, B – Bluff Loam, C – Tablelands, D – Summit, E – Western Valley of the Tennessee River, F – Western and Northern Highland Rims, G – Central Basin, H – Eastern Highland Rim. On the eastern border of H is the Cumberland Plateau Tableland. Safford's Sandy Pine Uplands, Black Prairie Belt and Flatwoods of the agricultural map comprise the Summit region. The Central Basin boundary here is simplified from the agricultural map. The eastern edge of the eastern Highland Rim here is simplified slightly from the agricultural map. Safford's maps of the eastern Highland Rim include the western limestone edge of the Cumberland Plateau.

Topography of the Alluvial Plain is a flat to undulating surface deposited by the Holocene and Pleistocene Mississippi River (Saucier 1974). Elevations at water's edge vary from only about 55 m near the Mississippi State line to only 73 m near the Kentucky border. Elevations rise to ca. 92 m at the foot of the Bluff. Soils are sandy, silty or clayey, well drained to poorly drained, and very fertile. They are mapped as Entisols, Inceptisols, Mollisols, Alfisols, and Utisols (Luther 1977, Springer and Elder 1980).

Topography of the Bluff Region is one of rolling topography cut by floodplains and terraces of the Mississippi River tributaries, and characterized by some high steep bluffs bordering the Alluvial Plain. Elevations exceed 122 m. Underlying Tertiary deposits are covered by the deep loess mantle. Soils are well drained to moderately so, are fertile, and are classed as Alfisols, Entisols and Ultisols (Hardeman 1966, Luther 1977, Springer and Elder 1980).

The Tableland Region of West Tennessee is a level to rolling surface again cut by tributary stream valleys. Upland soils are chiefly well drained to moderately so. Above floodplains with poorly drained soils are terraces with somewhat poorly drained to poorly drained soils. All soils are classed as Alfisols, Entisols, and Ultisols (Hardeman 1966, Luther 1977, Springer and Elder 1980).

Safford's Summit Region is an undulating to hilly area with elevations from about 122 m to over 183 m. His underlying three geologic beds are now expanded into 12 units and mapped in detail (Hardeman 1966). Some surface sediments are capped by thin loess. Soils are sandy, silty or clayey, well drained to somewhat poorly drained, some are cherty, some calcareous. They are classed as Ultisols, Alfisols and Entisols (Hardeman 1966, Luther 1977, Springer and Elder 1980).

The Western Valley of the Tennessee River is an area of undulating to hilly and steep topography varying in elevation from less than 120 m to a little more than 180 m. It includes uplands and flood plains and terraces of the Tennessee River. Soils are underlain by, and on uplands developed from, limestone more characteristic of the Rim. Several Devonian limestone and cherts and several Silurian limestones and shales outcrop. Level upland sites may have a loess cap. Cretaceons formations also appear, as do extensive beds of Quaternary-Tertiary high level terraces. Soils are cherty or silty, loamy, excessively to somewhat poorly drained developed chiefly for limestone, shale, alluvium and loess. They are classed as Ultisols, Alfisols and Entisols (Hardeman 1966, Luther 1977, Springer and Elder 1980).

The Highland Rim is a large area in Middle Tennessee with elevations of about 120 m along the Tennessee River near its western border to about 300 m at the edge of the Cumberland Plateau. It is an undulating to rolling surface punctuated by entrenched stream valleys; the Rim encircles the Central Basin. The Rim surface is underlain by nearly flat-lying limestones (rarely Cretaceous gravel on top); the valleys expose Siluvian or Ordovician limestones and shales, some partly covered by alluvium. Sites vary from hilly and steep to rolling and to undulating; they are excessively drained to poorly drained. The soils may be cherty, shaley, gravelly, loamy, or clayey derived from rocks noted above or from loess on undulating sites. Upland soils are acid and infertile. Soils are classed as Ultisols, Inceptisols and Alfisols (Hardeman 1966, Luther 1977, Springer and Elder 1980).

The Central Basin is an elliptic saucer-shaped depression cut near the middle of the Highland Rim. Its elevations fall from Rim level to about 180 m. The rolling Outer Basin is underlain by massive to shaley limestones of which several are high in phosphate and calcium. Sites are undulating to rolling and hilly, soils are loamy or clayey, deep or moderately deep, and well drained from phosphatic limestone, or alluvium, or loess. They are classed as Alfisols, Ultisols, Mollisols and Inceptisols (Edwards *et al.* 1974, Luther 1977, Hardeman 1966). Sites of the Inner Basin are level to rolling, with shallow to deep silty or clayey soils which are poorly drained to well drained underlain by thin to thick bedded nearly horizontal limestone strata (Edwards *et al.* 1974, Luther 1977).

The flora of the study area is relatively well known (Wofford and Kral 1993). Collections of native plants vary in number from 1056 (Montgomery County) to 110 (Crockett County) (University of Tennessee Herbarium 1998). Bottomland forests of West Tennessee are described by Sharitz and Mitsch (1993) and Patterson and DeSelm (1989). Upland forests of West and Middle Tennessee are described by Bryant *et al.* (1993). A small area of oak-hickory-pine forest is mapped in southwestern Middle and southeastern West Tennessee (Skeen *et al.* 1993). Cedar glade communities of the Basin are described by Quarterman *et al.* (1993) and barrens of the study area are described by DeSelm and Murdock (1993). Generally the forest vegetation falls into bottomland types, mesic lower slope and cove types and upland oak, oak-hickory, oak-pine, oak-cedar or cedar types. Some of these are mapped in part of the study area (Tennessee Valley Authority 1941).

The study area was occupied or at least visited by Native Americans beginning at least 10,000 years before present (Paleoindian and Archaic cultures). Later cultures built villages along streams and uplands were used for hunting and the gathering of wild plant food. The use of fire in the forests was common (Hudson 1976). European-American settlement occurred following a series of treaties with the Native Americans over the period 1770 to 1818 (Folmsbee *et al.* 1969). Forests were cleared, some valley lands drained, and much land was put into row crops. Slopes were logged for building timbers, the forests were grazed and spring surface fires were used to facilitate early growth of the understory (Killebrew *et al.* 1874).

METHODS

Using his extensive knowledge of Tennessee geology, soils, and plants, John M. Safford describes again these characteristics of the West and Middle Tennessee landscape. In this version, he concentrates on those areas west of the Cumberland Plateau with deeper, more fertile soils used in the cultivation of cotton. He also selected cotton farmers from each of the various physiographic areas and asked them to send him written descriptions of the cotton land and cotton culture. Some descriptions seem to be quoted verbatim and some are edited (they are called "Abstracts"). Virtually all references to the native vegetation of the crop soil are prefaced by, "The growth is . . . ," or rarely . . . "and formerly with cane." Safford used 126 respondents who either wrote generally about a county or specifically about their locales.

Safford and his respondents report 67 taxa in 1375 "species noted" reports; these are divided among the seven physiographic areas and separated herein as overstory versus understory taxa. This tabular data has been converted to percent by area and provide the basis for conclusions in this paper. The plant sample being small, the writer has not tried to divide data by Safford's (let alone modern) geologic nor soil units smaller than those stated. My opinion of modern plant name versus common name used appears in the tables. Nothing is known of the geologic, soils, nor botanical expertise of the respondents. Within-county locations are only generally known.

Reported plant observations were biased toward the objectives of the study plants of cotton soils although nearby shallow-soil cedar glades and "flint lands" of ridges are occasionally mentioned. The reports followed by several decades settlement, and conversion of much of the land to crop use, forest logging, increases in forests of opportunistic, less shade-tolerant invader species, grazing by stock, and perhaps annual spring surface fires.

RESULTS

In Table 1, note concentrations of observations of taxa (higher percentages) and geographic trends in taxa. However, many taxa well known in the various areas (Chester *et al.* 1993, Chester *et al.* 1997, Little 1971, 1977) may, or, disconcertingly, may not appear in the data. Sample size is the likely factor here. The focus of soils of cotton cultures, the virtual elimination of native plants from the most valuable soils, growth of increaser species in disturbed woodlots, stock grazing, and surface fires all effect species survival and availability to be seen and reported.

Table 1. Numbers of overstory "species" observations by "species" (taxa) and area.

TAXA	WEST				MIDDLE		
	Bottom	Bluff	Table-land	Summit	Western Valley	Rim	Basin
	PERCENT						
Acer spp. (maple)		5	2	3			1
Acer negunda (boxelder), H	3	1		1	1	1	2
A. rubrum (red maple)	3	4					
A. saccharum/nigrum (sugar), M				1	3	4	6
Aesculus spp. (buckeye) M			1	1			<1
Betula cf. *nigra* (birch), H			<1		1		
Carya spp. (hickory)	6	10	12	13	13	8	7
C. illinoensis (pecan), H	6	1		1			
C. laciniosa (shellbark)			<1				
C. spp. (scaly bark)					1		
Castanea dentata (chestnut)		1	3	2	5	6	1
Celtis spp. (hackberry), C, H	6	2	1	0	2	3	3
Cladastris kentuckea (yellow wood)							<1
Diospyros virginiana (persimmon)			<1			2	<1
Fagus grandifolia (beech), M	3	5	6	6	5	4	7
Fraxinus spp. (ash)	6	7	6	3	5	5	8
F. americana (white ash)							<1
Gleditsia triacanthos (honey locust)		1					2
Gleditsia/Robinia (locust)						1	<1
Gymnocladus dioica (coffeenut)	3						<1
Julgans spp. (walnut), C	8	7	7	4	5	3	5
J. cinerea (white walnut), C		1				1	1

Table 1, continued.

TAXA	WEST				MIDDLE		
	Bottom	Bluff	Table-land	Summit	Western Valley	Rim	Basin
	PERCENT						
J. nigra (black walnut), C		1	<1			4	3
Juniperus virginiana (cedar), C					2	1	3
Liquidambar/Nyssa (gum)	3	5	3	5	3	1	1
L. styraciflua (sweetgum), M	3	5	4	2	2	1	2
Liriodendron tulipifera (poplar), M		10	10	9	10	10	12
Magnolia acuminata (cucumber tree)							<1
Morus rubra (mulberry)	6	2	1	1	1		1
Nyssa aquatica (tupelo gum), H	3		<1				
N. sylvatica (blackgum)		2	3	1	3	3	1
Oxydendron arboreum (sourwood)					1	1	
Pinus spp. (pine, yellow pine)			2			1	
Platanus occidentalis (sycamore), H	6					1	1
Populus deltoides (cottonwood), H	11	2	1		1		<1
Prunus serotina (cherry), M				1			2
Quercus spp. (oak)	6	7	3	1	7	4	8
Q. alba (white oak)		6	7	10	7	6	3
Q. falcata (Spanish oak)			3	2	1	1	
Q. lyrata (overcup oak), H							2
Q. marilandica (blackjack oak)			4	6	2	4	
Q. nigra (water oak), H				1		1	
Q. palustris (pin oak), H							<1
Q. phellos (willow oak), H						1	
Q. prinus (chestnut oak)						2	
Q. rubra (red oak)		4	6	7	5	4	2
Q. stellata (post oak)		1	5	8	5	4	1
Q. spp. (swamp oak)							<1
Q. sp. (turkey oak)		1					
Q. velutina (black oak)		4	4	9	5	6	2
Robinia pseudoacacia (black locust)							2
Salix cf. *nigra* (willow), H	3					1	<1
Sassafras albidum (sassafras)	3	3	1			1	
Taxodium disticum (cypress), H	14			1	3		
Tilia spp. (linden), M		1			1	2	2
Ulmus spp. (elm), C	3	5	1	2	4	6	8
U. americana (white elm), H							<1
U. rubra (red elm)							1
Number overstory spp. observations	36	169	233	191	130	142	337

Overstory

In the following, genus/species reports are summarized (from Table 1):

Acer: Note concentration of box elder and red maple (including probably also silver maple (*A. saccharinum*) in the Bottoms; note the increase in abundance of sugar maple eastward from the Summit.

Carya: Hickories are abundant, pecan concentrated in the Bottoms.

Castanea: Chestnut is concentrated on acid soil highlands.

Celtis: Hackberries are distributed throughout but concentrated in Bottoms.

Fagus and *Fraxinus*: Beech and ashes are reported throughout.

Gymnocladus: Coffeenut (coffeetree) is reported in the Bottoms and Basin which is most of its range known today in Tennessee (Chester *et al.* 1997).

Juglans: Walnut is reported throughout. Most reports are probably black walnut but. respondents seldom separated the two walnut species. White walnut was reported only on clay loam upland in Tipton County, in valleys in Hickman County, and on brown loams in Williamson County. The large, chiefly black walnut percentages (3-8) contrasts sharply from modern West and Middle Tennessee forests where black walnut ranges from 0.20 to 0.78 percent of live trees (Schweitzer 1997, 1997). White walnut has been known in 27 counties (Chester *et al.* 1997) but is currently in decline from attack by the butternut canker believed to be an introduced fungus pathogen (Schlarbaum *et al.* no date).

Juniperus: Cedar (eastern red cedar) is known almost throughout the area but is mentioned only in Middle Tennessee where it occurs on shallow limestone soils (glades and limey glades of Safford). Low percentages are doubtless due to its concentration on non-cotton-culture soils.

Liquidambar styraciflua: Sweetgum, *Liquidambar* or *Nyssa*, gum, and *Liriodendron tulipifera* appear nearly throughout.

Magnolia acuminata: Cucumber tree is known today in the Basin from Sumner County; Safford reports it in the Basin on "mulatto lands of the Nashville Series" [bedrock].

Morus: Mulberry (red mulberry, *Morus rubra*) was reported nearly throughout. The high concentration in the Bottoms may be an artifact or local phenomenon as it is noted in the Mississippi River delta forests as, "Never prominent or of much importance" (Putnam and Bull 1932).

Nyssa: Tupelo gum is in the Bottoms, other species are throughout–*N. sylvatica* may include *N. biflora*.

Oxydendron and *Pinus*: Sourwood and the pines are uncommonly mentioned on acid soil uplands.

Platanus: Sycamore is mainly on Bottoms.

Populus: Cottonwood (*P. deltoides*) is concentrated in the Bottoms and may include *P. heterophylla*.

Quercus: The oaks collectively comprise a large proportion of the reports. *Q. alba*, *Q. velutina*, *Q. falcata*, *Q. stellata* are most important in that order. *Q. velutina*, black oak, may include northern red oak (*Q. rubra*), and shumard oak (*Q. shumardii*) on limestone and cherry bark oak (*Q. pagoda*) on loess bluffs. Pin oak of the Basin may include shumard oak which occurs in swamps there with pin. The identification of swamp oak and turkey oaks is unknown although turkey oak is a name sometimes given to *Q. falcata* (Britton and Brown 1913). *Q. falcata* may include *Q. pagoda* in the west.

Salix: Willow, presumably mostly *S. nigra*, in Bottoms.

Sassafras: An occasional forest tree and old field invader, its importance here is in the Bottoms and on Bluffs. According to Sargent (1884) its importance is greatest in "southwestern Arkansas and the Indian Territory [Oklahoma]."

Taxodium: Concentrated in Bottoms.

Tilia: Two species occur in Tennessee. Their increased importance eastward is mirrored in the trend shown here.

Ulmus: Seven species occur in Tennessee; in the west the higher importances are in the Bottoms and Bluffs (here *U. americana*) whereas eastward *U. alata* and *U. rubra* may be expected to increase. *U. serotina* may be included in Basin numbers. Mr. Samuel Perkins of eastern Williamson County was the only respondent who reported red elm and white (American) elm separately. He also distinguished the species black and white walnuts. (He distinguished white and yellow poplar but the basis for this is not known to the author.)

Understory

Taxa listed as understory include small trees, shrubs, vines and two herbs (Table 2). The species or genera occur widely over the study area (Chester *et al.* 1974, Chester *et al.* 1977).

Table 2. Numbers of understory "species" observations by "species" and area.

TAXA	WEST				MIDDLE		
	Bottom	Bluff	Table-land	Summit	Western Valley	Rim	Basin
	PERCENT						
Amphicarpa bracteata (peavine)			3				
Arundinaria gigantea (cane)	100	4	3				8
Asimina triloba (pawpaw)		13	21	17	14		8
Carpinus caroliniana (ironwood)			3			33	8
Cercis canadensis (redbud)		13	11	17	9	17	11
Cornus cf. *florida* (dogwood)		43	34	35	57	50	47
Corylus americana (hazelnut)		8	18	17			
Ilex opaca (holly)		4					3
Lindera benzoin (spicewood)				4			
Ostrya virginiana (horn beam)		13	3				8
Poa pretensis (bluegrass)							5
Rhus spp. (sumac)			3				
Smilax spp. (greenbrier)			3				
Viburnum cf. *rufidulum* (black haw)							3
Vitis spp. (grapevine)				8			
Number understory "species" observations	2	23	38	23	7	6	38
Total number "species" observations	38	192	271	214	137	148	375
Total number taxa	21	35	40	32	31	37	51

Arundinaria cf. *gigantea* was the only species noted specifically in the Bottoms. Earlier descriptions note cane's abundance in many forests in most parts of the State and its demise following grazing/browsing by stock in rural areas after settlement (Killebrew *et a*l. 1874).

Asimina (pawpaw), *Cercis* (redbud) and *Cornus* (dogwood): Their abundances across the area are noteworthy.

Corylus cf. *americana*: Abundance in West Tennessee upland is noted.

Special Sites, Species, or Communities

Carroll County: "The black sandy soil of the hickory barrens is our best cotton soil . . ."
Central Basin: "Cedar glades and great cedar forests . . ."
Hardeman County: some pine land
Hardin County, east of Savannah: "post oak flatwoods"
Hatchie Bottoms: cypress sloughs

Haywood County: greenbrier land and cypress swamps and "hazelnut plains" on chocolate-colored soils.
Henry County: "post oak glades in the eastern part of the 24th civil district," and "The black sandy loams of hazel-nut valleys . . . and ridges of the northwestern part of the county . . ."
Highland Rim: ". . . upland flat barrens . . ."
Lincoln County: ". . . high barrens to the south with half size oaks"
Madison County: ". . . swamp and greenbrier glades."
McNairy and Henderson counties where green sand comes to the surface: glades and bald places
McNairy County: ". . . with woodland and marly and glady places; bald knobs in some barrens with small oaks and hickories . . ."
Mississippi River: cypress swamps
Obion County: gray soil with ". . . a small amount of glade. . ."
Perry County: "some woodland with marly limestone glades"
Rutherford County: "poplar lands" [but with a variety of species]
Sumner County: "yellow poplar land" and "bluegrass land"
Weakley County: hickory-dogwood-black gum barrens, post oak barrens, blackjack barrens, white oak and hickory highlands and post oak ridges
Wilson County: "poplar ridge land" [also with oak and hickory]

DISCUSSION

Numbers of "species" observations per geographic area controls numbers of "species" seen. Each 100 "species" observation increases the number of taxa reported by 5.93 (between 21 and 51 species). The list of trees given by Safford or his respondents for any given area does not necessarily means they grow together in the same community. For example, respondent Z. Bryant, Sr., of Gibson County, on sandy soil, lists blackjack oak with poplar and beech–obviously not from the same site. In Tipton County alluvial soils are noted by respondent A. W. Smith with walnut, beech and others including cottonwood–again not from the same site. Individual plant communities are not suggested by the composition nor proportions of observations of the various levels of taxa in the physiographic areas. The Bottom taxa neither match the frequency of species in all bottomlands nor relative importance across communities (see Patterson and DeSelm 1989). The tabular list here from the Bluffs is only suggestive of the combined ridge and southwest facing and northeast facing slope communities described by Miller and Neiswender (1987). Similarly some of the communities described or listed for the Highland Rim and Central Basin seem to be averaged by the Tabular data in Table 1 (see DeSelm and Schmalzer 1982, McKinney and Hemmerly 1989, Pearsall *et al.* 1985, and Smith *et al.* 1983).

Classes of Taxa

Vegetational homogeneity is seen from the Bluffs eastward through the Rim: the sums of oak, hickory and poplar percentages is 44-71 among the areas. However, in the Bottoms these taxa total only 18 and in the Basin they totally only 37 indicating the different nature of the vegetation of the latter two areas. The uniqueness of the Bottoms (Table 1) may be seen in that 14 taxa chosen as hydrophytes (H) have percentages totaling 52 compared to only 2+ to 9 in the other geographic areas. In Table 1, eight taxa are shown as mesophytes (M). Percentages totals are six in the Bottoms, 25-27 in the Bluffs eastward through the Rim, and 33 in the Basin. Clearly the often flooded bottoms exceed stress levels for mesophytes. Most of the areas contain some soils which are fertile, but on the deep, fertile soils of the Basin, the mesophytes flourish best.

Six taxa have been designated calciphiles (C). Percentages of these total 6-18 in the Bottoms eastward through the Rim. In the Basin calciphile percentages total 23 suggesting the selective action on these high calcium soils on certain tree species abundance. Note also that the young, less leached, alluvial soils of the Bottoms and loess soils of the Bluffs harbor 17 and 16 total calciphile percentages respectively. Some woody plants (Shanks 1952) and a few grasses (as *Panicum malacophyllum*) occur both in the Basin and on the Bluffs (DeSelm *et al.* 1994).

Forest Region Designation

In Bryant *et al.* (1993) most of the upland of the study area is designated the Oak-Hickory Forest. This applies well to upland eastward through the Rim where oak and hickory percentages total 34 to 62. Oak-hickory-poplar percentages total 44 to 71. The "chestnut-chestnut oak-yellow poplar" designation of Zon (Shantz and Zon 1924) applies well to poplar here but inadequate sampling here of non-cotton-chestnut oak-chestnut landscape negates distinguishing such vegetation. Low chestnut percentage may be due to the particular lands sampled as suggested above, or due to logging prior to this study. Or perhaps chestnut dieback was occurring; Mohr (1901) reported dieback of chestnut during the previous three decades in Alabama.

Clearly the Bottom area fits into the Southern Floodplain Forest (Sharitz and Mitsch 1993). But what regional designation should be applied to the Basin? Its oak and hickory percentages total only 25 compared to 34-62 for the other upland areas. The higher mesophyte percent total of 33 versus 6-27, and higher calciphile percentage, 23 versus 6-18 elsewhere, suggests the discreteness of the Basin vegetation. Its contrast with the vegetation of the eastern Rim has been seen before in the 1807 survey records (DeSelm 1994) and its floristic uniqueness has been noted by others (Baskin and Baskin 1986, Bridges and Orzell 1986, Quarterman 1950, and Shanks 1958). The name given to the region by Braun (1950), Western Mesophytic Forest Region, applies best to the Basin.

CONCLUSIONS

There being little absolute geographic control, there being observations by probably unskilled scientific respondents, and there being relatively few data accumulated, conclusions warranted can only be few. The Mississippi River Bottoms are little related to the uplands and inclusion in Southern Floodplains Forest is supported. The land eastward to the Central Basin is more or less homogenous vegetationally and its inclusion in the Oak-Hickory Forest applies. The Central Basin, having lower oak and hickory percentages and higher mesophyte and calciphile percentages may fit better into Braun's Western Mesophytic Forest Region. Safford's separation of the Western Tennessee River valley from the western Rim does not seem justified on the basis of the vegetation of deeper, cotton-culture soils.

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ECOLOGICAL LIFE CYCLE OF *TREPOCARPUS AETHUSAE* (APIACEAE)

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ABSTRACT. In western Kentucky, seeds of the state-endangered species *Trepocarpus aethusae* mature in mid- to late August and early September and germinate from late September through November. Plants overwinter as rosettes and flower the following June and July. Vernalization was not required for flowering, and plants flowered faster under long days (night interruption) than under short days. Plants died after producing seeds, thus the species is a late-flowering winter annual. Seeds have underdeveloped (small, but differentiated) linear embryos that are physiologically dormant, thus they have morphophysiological dormancy. None of the freshly-matured seeds placed at 12 h/12 h alternating temperature regimes of 15/6, 20/10, 25/15, 30/15, or 35/20°C in light (14 h daily photoperiod) or in continuous darkness for 2 wk germinated. Experiments showed that embryos do not grow until after physiological dormancy is broken. Physiological dormancy was broken in a portion of the freshly-matured seeds by 4 to 6 wk of incubation on moist sand at the simulated September (30/15°C) temperature regime. After incubation for 6 wk at 30/15°C, embryo growth and germination occurred within 2 wk in 69, 73, and 56% of the seeds incubated in light at 15/6, 20/10, and 25/15°C, respectively, and in 40, 45, and 54% of those incubated in darkness, respectively. Few or no seeds germinated in light or in darkness at 30/15°C or at 35/20°C. Thus, physiological dormancy is broken in the field in Kentucky during the relatively warm days of September, and embryo growth and germination occur in October and November. Seeds sown on soil in a nonheated greenhouse in Lexington, Kentucky, in early September germinated from mid-October to early December, with the peak occurring in late October and early November. In spite of the lack of a light requirement for embryo growth and germination, seeds of *T. aethusae* have the potential to form a long-lived (≥5 yr) persistent seed bank. Germination of seeds sown on soil and of those in soil seed bank samples collected in a population site in Trigg County, Kentucky, was monitored for 10 years in the nonheated greenhouse. A few of the seeds sown on soil did not germinate until the 10th year, and the last seedlings to appear in the soil samples was in the 8th year. Six weeks of cold stratification at 5°C did not cause a significant number of seeds to re-enter physiological dormancy. Since seeds of *T. aethusae* do not have a light requirement for embryo growth and germination, those that come out of physiological dormancy in early autumn germinate that autumn; no seeds germinated in the nonheated greenhouse in spring. Thus, the persistent seed bank in this species is attributed to a delay (of several years in some seeds) in loss of physiological dormancy and not to dormancy cycling. The dormancy/germination strategy of *T. aethusae* differs from that of another native winter annual species of Apiaceae, *Chaerophyllum tainturieri,* whose seeds also have morphophysiological dormancy. In *C. tainturieri,* the seeds have a light requirement for embryo growth and germination, and they exhibit dormancy cycling (J. and C. Baskin. 1990. *Journal of Ecology* 78:993-1004).

TAXONOMIC AND ECOLOGICAL DIVERSITY OF THE OAKS OF LAND BETWEEN THE LAKES: A REVIEW

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ABSTRACT. At least 18 of the 22 species of oaks native to Kentucky and Tennessee are known to occur in the Land Between The Lakes (LBL). This taxonomic diversity is unusual for such a relatively small geographic area and is undoubtedly related to the diversity of ecological habitats documented for LBL. Oaks dominate the moderately mesic to dry forests in LBL, with as many as seven species co-occurring in a single community type, and are encountered regularly, albeit infrequently, in wetter habitats (e.g., ravines and bottomlands). The patterns of co-occurrence of species provide support for the hypothesis that co-occurring species are more likely to belong to different sections of the genus (red and black oaks versus white and chestnut oaks) than to the same section. Despite this, there is ample evidence of hybridization among a number of species. In particular, the xeric slope and ridge forests above Ginger Bay and the forests in and adjacent to Wrangler's Camp contain a high proportion of trees of apparent hybrid origin. These, and other, cases of putative hybridization involve species of red and black oaks. While no specimens of hybrids among the white and chestnut oaks have been recorded, there is every reason to believe that such hybrids also occur in LBL.

SEED DORMANCY IN *ARISTOLOCHIA TOMENTOSA* (ARISTOLOCHIACEAE)

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ABSTRACT. ***Aristolochia tomentosa*** **Sims (Aristolochiaceae) is a woody vine found primarily in riparian areas and wet alluvial woods from southern Indiana and Illinois, west to southern Kansas, south to eastern Texas, and east to southwest Georgia and the Florida panhandle. Flowering occurs from mid to late May through June, and seeds are dispersed from October to early November. The purpose of this study was to investigate the seed dormancy-breaking and germination requirements of *A. tomentosa*. This species is part of a comparative study of seed dormancy that also includes two of its close relatives, the California endemic *A. californica* and the Appalachian endemic *A. macrophylla*. These three species, along with the eastern Asian species *A. manshuriensis*, are part of a monophyletic group (subgenus *Siphisia*). The primary objective of the larger study is to determine if dormancy-breaking requirements have evolved (diverged) in different directions since these three closely-related species became geographically separated, presumably in the mid to late Tertiary. Efforts are underway to obtain seeds of *A. manshuriensis* so that this species can be included in the comparative study.**

Embryos of freshly-matured *A. tomentosa* seeds are 2.35 ± 0.5 mm (mean ± SE) long, and they must grow to more than twice this length before germination can occur. Thus, fresh seeds have morphological dormancy (MD). Seeds incubated in light (14 hr photoperiod) at five 12hr/12hr thermoperiods (35/20, 30/15, 25/15, 20/10, 15/6°C) germinated to 68, 54, 69, 35, and 2%, respectively, after 30 days, and to 84, 56, 74, 51, and 63%, respectively, after 90 days. Embryos in nongerminated seeds removed from each of the five thermoperiods did not grow during a 12-wk cold (5°C) stratification treatment. However, cumulative germination of these cold-stratified seeds after an additional incubation of 30 days was 95, 100, 90, 100, and 95%, respectively. Thus, a portion of these seeds also has a physiological component to dormancy; they have morphophysiological dormancy (MPD).

To determine length of cold period needed to break MPD, fresh seeds were given 4, 8, or 12 wk of cold stratification in light (simulating natural field conditions in winter) and then moved to the five thermoperiods. After 30 days, seeds cold-stratified for 4 wk germinated to 98, 100, 98, 99, and 76%, respectively, and those stratified for 8 wk germinated to 98, 100, 99, 99, and 96%, respectively. Seeds cold-stratified for 12 wk germinated to 97, 100, 100, 100, and 97%, respectively, after only 18 days. Seeds stratified for 12 wk germinated at a faster rate at all five thermoperiods than those stratified for 4 or 8 wk.

Fresh seeds incubated in darkness over the range of thermoperiods germinated to 64, 52, 42, 48, and 38%, respectively, after 30 days, and to 72, 63, 68, 53, and 42%, respectively, after 90 days. Cumulative germination increased to 86, 70, 72, 58, and 65%, respectively, after the seeds subsequently were incubated in light for 60 days. Thus, a portion of seeds in the population has a light requirement for germination. Seeds given 12 wk of cold stratification in dark and then incubated at the five thermoperiods in dark for 60 days germinated to 100, 96, 100, 98, and 94%, respectively. Thus, cold stratification overcomes the light requirement in seeds that initially will not germinate in darkness

Like seeds of *A. macrophylla* [Adams, C.A., J.M. Baskin, and C.C. Baskin. 2000. Amer. J. Bot. 87 (suppl. to No. 6): 38-39 (abstract).], those of *A. tomentosa* require a cold stratification pretreatment to germinate to highest percentages over the 35/20-15/6°C temperature range. In contrast, seeds of *A. californica* do not germinate at the higher (*e.g.* 30/15, 25/15°C) thermoperiods and, further, they require exposure to a period of warm-stratifying temperatures (e.g. 30/15, 25/15°C) to germinate at low (15/6°C) temperatures. Thus, preliminary results of this comparative study indicate that dormancy-breaking requirements in these three species have diverged since their separation, presumably from a common ancestor in the Tertiary.

A COMPARATIVE GERMINATION STUDY OF AN EASTERN AND A WESTERN NORTH AMERICAN *HEUCHERA* SPECIES (SAXIFRAGACEAE)

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ABSTRACT. *Heuchera parviflora* Bartl. var. *parviflora* **occurs primarily in southeastern North America and** *H. cylindrica* **Dougl. var.** *cylindrica* **in northwestern North America. Both species are herbaceous perennials that grow in rocky habitats. Seeds of** *H. parviflora*, **collected in eastern Kentucky in November 1995 and 1996, and those of** *H. cylindrica*, **collected in western Washington in August 1996, were used to test temperature and light requirements for dormancy-break and germination, and germination phenology. Fresh seeds of** *H. parviflora* **germinated to 2-64% during 2 wk of incubation in light at alternating temperature regimes of 15/6, 20/10, 25/15, 30/15, and 35/20°C, with highest germination at 25/15°C; none of them germinated in darkness. Dry storage under laboratory conditions for up to 52 wk was not effective in overcoming dormancy. However, seeds given a 12 wk cold stratification period at 5°C in light germinated to 76-96% in light and those given cold stratification in darkness germinated to only 0-1% in darkness over the range of thermoperiods. Peak germination of** *H. parviflora* **seeds sown in mid-November 1996 in a nonheated greenhouse occurred in early March 1997, when mean weekly maximum and minimum temperatures were 14.8 and 8.7°C, respectively. On the other hand, fresh seeds of** *H. cylindrica* **germinated to 0-37% during 2 wk of incubation in light at 15/6-35/20°C, with highest germination at 15/6 and 20/10°C, and none germinated in darkness. Seeds continued germinating to ≥76% at 15/6-20/10°C during 4-12 wk of incubation in light. Neither dry storage for up to 52 wk nor cold stratification at 5°C for 9 wk was effective in overcoming dormancy. Peak germination of seeds sown in the greenhouse in early September 1996 occurred in late October 1996, when mean weekly maximum and minimum temperatures were 20.7 and 11.9°C, respectively.**

GENETIC ALTERATION OF SEED GERMINATION TRAITS IN *EUPATORIUM RUGOSUM*

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ABSTRACT. We are attempting to examine the physiological basis of seed dormancy and germination in white snakeroot (*Eupatorium rugosum* Houtt [*Ageratina altissima* (L.) King & Robinson]) by carrying out a recurrent selection program for individual plants producing seeds with either high or low levels of dormancy.

In May 1998, 2000 seeds (achenes), collected from a single population of white snakeroot growing in Louisville, KY, were planted onto a single tray lined with moist germination paper. Most (77%) of the seed germinated within 17 d when kept at a 21°C. The first seeds to sprout (4 d after sowing) were transplanted into pots and grown to maturity in a nursery. At 17 d after sowing, the ungerminated seeds were given a cold treatment (56 h) followed by another long incubation at 21°C. Thirty-four seeds (2% of total) germinated after this stratification treatment and were transplanted. This procedure was continued ten additional cycles. In each cycle seeds were given adequate time to germinate after cold-treatment, and were transplanted upon germination, with unsprouted seeds receiving another cold-treatment. The last seed to germinate (Cycle 9) did so 83 d after imbibition. Transplanted seedlings were grown to maturity in the same environment, and allowed to set seed.

In the spring/summer of 1999, seed from these individual selections were planted onto separate Petri dishes lined with moist filter paper and allowed to germinate with the same alternating cycles of cold and warm. As a group, there were no statistical difference in rates of germination for the seed from the non-dormant lines when compared to seed from plants that had shown some dormancy. There were obvious differences between individual selections, however. Individual seedlings exhibiting the appropriate germination patterns were transplanted and grown up in the same nursery for the next round of seed production.

In the spring/summer of 2000, the seeds from plants that had undergone two cycles of recurrent selection were again compared. These progeny expressed the desired phenotype much more strongly than what was observed after the first cycle of selection. While 74% of the seed from the non-dormant population germinated during the first 10 d of the study, only 17% of the seed germinated from plants that had been selected for cold-requirement during the same period. This difference was statistically significant (P=0.001).

The constant-temperature population continued to show small amounts of germination after exposure to one, two, three, or four cycles of cold treatments, but the quantities declined steadily after each treatment. The dormancy-selected progeny, however, showed more germination after the first and second cold treatments than before. The differences in how these two populations responded to cold treatment was statistically significant (P=0.002).

Therefore, it appears that we have identified white snakeroot plants which produce seeds that respond to the environment in very different ways. It is hoped that this germplasm will be a valuable resource in examining the morphological and physiological features of seed dormancy and germination in this species.

THE ECOLOGICAL LIFE CYCLE OF *CRYPTOTAENIA CANADENSIS* (APIACEAE) WITH SPECIAL REFERENCE TO BIOMASS ALLOCATION

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ABSTRACT. *Cryptotaenia canadensis* is an herbaceous plant species of mesic and wet-mesic deciduous forests of eastern North America. This species reproduces sexually, flowering and fruiting during early to mid-summer, and asexually via monocarpic ramets produced at the base of the stem. Plants of *C. canadensis* growing in Robinson Forest, Breathitt County, Kentucky are being observed and sampled to construct a detailed life cycle model and document biomass allocation. Preliminary results of this research, which was initiated in August 1999, indicate that under field conditions, plants produced from seeds have a biennial life cycle, thus requiring two growing seasons to reproduce (sexually and asexually). Ramets behave as annuals and reproduce (sexually and asexually) after one growing season. Throughout the active growing stages of the asexual life cycle, relative percent biomass allocation to roots decreases, whereas total biomass of all plant parts (roots, stem, leaves, and umbels) increases throughout the annual growth cycle, until death of the entire parent plant following reproduction. Further, percent biomass (mean ± SE) allocated to sexual reproduction (19.7 ± 2.0) is less than that of the sympatric biennial Apiaceae *Sanicula canadensis* (32.7 ± 1.7) and *S. trifoliata* (26.8 ± 1.8) and greater than that of the sympatric perennial Apiaceae *Osmorhiza claytonii* (5.2 ± 0.7), *S. gregaria* (13.1 ± 1.5), and *Thaspium barbinode* (10.4 ± 1.2). Based on current results of this research, a graphical model of the ecological life cycle and pattern of biomass allocation for *C. canadensis* will be presented.

A COMPARISON OF GROWTH AND REPRODUCTIVE CHARACTERISTICS OF THE INVASIVE *LIGUSTRUM SINENSE* AND THE NATIVE *FORESTIERA LIGUSTRINA* (OLEACEAE)

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ABSTRACT. *Ligustrum sinense* Lour. is an invasive shrub in southeastern United States that was introduced from China. In middle Tennessee, the species grows with the shrub *Forestiera ligustrina* (Michx.) Pour., native to southeastern United States, in the redcedar and/or hardwood forests surrounding cedar (limestone) glades. The goal of our research was to compare the growth and reproduction of the two species, and identify aspects that might influence the invasiveness of *L. sinense*. Plants of both species were sampled along the woodland edges of cedar glades (1362.0 ± 78.8 mmol m^{-2} s^{-1} on a clear day at noon in late August) and in the (primarily) redcedar forest (111.6 ± 12.9 mmol m^{-2} s^{-1}) at Stones River National Battlefield, Rutherford County, Tennessee between March 2000 and February 2001. Multivariate analyses of variances (MANOVAs, $P \leq 0.05$), analyzing all variables simultaneously, indicated significant differences between the species. Regardless of the habitat, *L. sinense* had higher stem elongation rate, leaf weight ratio (investment in leaf biomass), leaf area ratio (leafiness), and number of fruits per branch, and lower leaf abscission rate and percentage of damaged leaves (by insects) than *F. ligustrina*. Leaf area expansion rate, leaf area, and height of *L. sinense* plants growing in the woods were greater than those of *L. sinense* plants growing along the edge and were greater than those of *F. ligustrina* plants growing in both habitats. Branch architecture based on branch length and orientation and on bifurcation ratio was similar between the species. However, leaves of *L. sinense* were oriented at 98-107° from vertical in both the woods and edge, whereas those of *F. ligustrina* were oriented at 107° in the woods but at 132° along the edge. The results suggest that *L. sinense* has a competitive advantage due to its greater ability to spatially and temporally capture light, greater adjustment of growth responses to the light environment, and higher fruit production than *F. ligustrina*.

DORMANCY-BREAK AND GERMINATION REQUIREMENTS OF TWO EVENING PRIMROSES: *OENOTHERA MACROCARPA* AND *O. TRILOBA* (ONAGRACEAE)

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ABSTRACT. **Temperature and light requirements for dormancy-break and germination were determined for seeds of two *Oenothera* species collected in Rutherford County, Tennessee: *O. macrocarpa* Nutt. and *O. triloba* Nutt. *Oenothera macrocarpa* is a herbaceous perennial that occurs in central North America and is disjunct to middle Tennessee. *Oenothera triloba* is described as a winter annual, a biennial, or a short-lived perennial, and it grows in eastern and central North America. Fresh seeds of *O. macrocarpa* collected in mid-July 2000 germinated to 1-3% during 2 wk of incubation at alternating temperature regimes of 15/6, 20/10, 25/15, 30/15, and 35/20°C in light and in darkness. Seeds given a 12-wk warm stratification period at 25/15°C in light germinated to 4-11% over the range of thermoperiods in light, and those given warm stratification in darkness germinated to 0-4% in darkness. On the other hand, seeds given a 12-wk cold stratification period at 5°C in light germinated to 6% at 15/6°C and 93-100% at 20/10-35/20°C in light, and those given cold stratification in darkness germinated to 0-14% at 15/6-35/20°C in darkness. Seeds collected in mid-September 2000 and in mid-November 2000 germinated to 0-8% during 2 wk of incubation over the range of thermoperiods in light and in darkness, whereas those collected in mid-January 2001 germinated to 0% at 15/6°C and 83-100% at 20/10-35/20°C in light and to 0% at 15/6°C and 32-45% at 20/10-35/20°C in darkness. In contrast, fresh seeds of *O. triloba* collected in mid-July 2000 germinated to 1% at 15/6°C and 95-100% at 20/10-35/20°C in light and to 0-9% at 15/6-35/20°C in darkness during 2 wk of incubation. Seeds collected at monthly intervals between August 2000 and January 2001 germinated to 0-16% at 15/6°C and 61-100% at 20/10-35/20°C in light and to 0-16% at all thermoperiods in darkness during 2 wk of incubation. Thus, whereas seeds of *O. triloba* are nondormant at maturity, those of *O. macrocarpa* are dormant and require low (winter) temperatures to become nondormant.**

VEGETATION STRUCTURE MONITORING IN A MANAGEMENT CONTEXT, ARNOLD AIR FORCE BASE, TENNESSEE

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ABSTRACT. Vegetation monitoring is used to track management impacts in sites included in a Barrens Restoration Demonstration Project at Arnold Air Force Base, TN. The goal of the Barrens Restoration Demonstration Project is to assess the effectiveness of various management methods for restoring or maintaining a range of barrens habitats. The range of targeted Barrens habitats includes: grassland, shrub-grassland, oak savanna, and oak woodland. Management goals describing a range of desired vegetation structure, and monitoring objectives were designated for each demonstration site prior to management implementation. The management goal for grassland sites is to use biannual prescribed fire or annual mowing to maintain the grassland community (i.e., graminoid and forb cover) and minimize abundance of oaks and other woody species. The management goal for the shrub-grassland site is to use prescribed fire to convert shrublands to shrub-grasslands. The management goal for the oak savanna site and the oak woodland site is to use prescribed fire to change the vegetation structure from oak forest to a more open-canopy structure with a substantial ground cover dominated by graminoids and forbs. Monitoring objectives include estimating mean tree density, percent canopy cover, percent ground cover of functional groups (i.e., graminoids and forbs) below 1 meter, percent cover of woody species at 1-3 meters above the ground, and basal area.

Vegetation structure within the restoration sites has responded favorably to management. Biannual prescribed fire and annual mowing are adequate management tools for grassland maintenance. Prescribed fire is an adequate management tool for shrub-grassland restoration and has reduced tree density in some size classes within the oak savanna and oak woodland sites. However, the canopy cover management threshold has not been met. Continued management will likely decrease the canopy cover within the oak savanna and oak woodland sites to desirable levels. Mechanical thinning may be considered as a tool for reducing canopy and minimizing impacts from a high frequency fire regime.

THE ROLE OF DISTURBANCE AND STRESS ON SPECIES DISTRIBUTION ACROSS A KENTUCKY LAKE MUDFLAT

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ABSTRACT. Water-level fluctuations in Kentucky Lake create disturbed and stressed habitats within the mudflat community. Flooding destroys vegetation at lower elevations; water-saturated soils stress growth at upper elevations. Plant community parameters were measured at four zones, and seedbanks were germinated in a greenhouse under flooded or moist-soil treatments. Flowering date, population density, flower number, and seed number were determined. Plants (germinated from upper and lower elevation mudflat-collected seed) of *Rorippa sessiliflora* were grown under flooded or moist-soil treatments. Chlorophyll fluorescence, flowering date, and seedpod number estimated stress. At the lower elevation annuals composed 100% of species, while at higher elevations annuals were only 33%. Population density was 400/m^2 at higher elevations compared to 2,758/m^2 at lower elevations. Average height was 52.5 cm at higher elevations compared to 2.7 cm at lower elevations. Individuals from upper elevations initially exhibited greater stress (reduced photosynthetic yield) than individuals from lower elevations. Lower elevation individuals flowered sooner in both soil treatments than upper elevation individuals. Both low and high elevation individuals exhibited greater seedpod production under flooding. Disturbance appears to determine species composition at lower elevations. Levels of stress tolerance appear to vary among individuals within the same species.

CONTRIBUTED PAPERS

SESSION II: AQUATIC BIOLOGY AND WATER QUALITY

Saturday, March 1, 2001

Moderator:

Susan Hendricks
Murray State University

Editor:

A. Floyd Scott
Austin Peay State University

EFFECTS OF WATER QUALITY ON PHOTOAUTOTROPHIC PERIPHYTON PRODUCTION AND PHOTOCHEMICAL EFFICIENCY OF A POLLUTION-INTOLERANT ALGA WITHIN MILLER CREEK, ROBERTSON COUNTY, TENNESSEE

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ABSTRACT. Effects of water quality on growth and photochemical efficiency of a pollution-intolerant alga, photoautotrophic periphyton production, and periphyton photoautotrophic-heterotrophic biomass ratios were evaluated during the summer and fall of 2000 in the lower, middle and upper reaches of Miller Creek of Robertson County, Tennessee. The results were compared with effects of water quality in the lower reach of Buzzard Creek of Robertson County, Tennessee, known to have good water quality. Periphyton production was significantly greater in all three reaches of Miller Creek relative to Buzzard Creek during October of 2000. Photoautotrophic periphyton production, periphyton production, and rate of sediment accumulation were significantly greater in the upper reach of Miller Creek relative to the lower reach of Buzzard Creek during July and October of 2000. Photochemical efficiency of photosystem II and reproduction rate of the pollution-intolerant alga *Selenastrum capricornutum* following *in situ* growth during October of 2000 were significantly lower in *Selenastrum* grown in upper Miller Creek relative to Buzzard Creek. The results support conclusions from previous evaluations which indicate poor water quality in Miller Creek, especially in the upper reach of Miller Creek.

INTRODUCTION

Miller Creek is within the Sulphur Fork Creek watershed of Robertson County, Tennessee, and is targeted by the U.S. Natural Resource Conservation Service for implementation of best-management practices to improve water quality. Assessments of aquatic primary production were determined at selected sites within Miller Creek to provide data to evaluate the impact of planned-best management practices to improve water quality. This research is a supplement to other bio-monitoring studies being conducted in the watershed by The Center for Field Biology at Austin Peay State University.

The Sulphur Fork Creek watershed is located in the Western Pennyroyal Plain subsection of the Pennyroyal Karst ecoregion (Baskin *et al.* 1997). This subsection is characterized geologically by limestone, chert, shale, siltstone, sandstone, and dolomite. Soils are of the Pembroke, Crider, and Baxter series, forming a thin, loess mantle over limestone (Miller 1974). Vegetation is characterized as Western Mesophytic Forest consisting largely of *Quercus* and *Carya* species (Braun 1950). No single climax forest type occurs. Instead, a mosaic of types are present which are largely determined by edaphic factors and the diverse topography (Chester and Ellis 1989). The Sulphur Fork Creek watershed drains approximately 120,000 acres of the southern half of Robertson County and consists largely of highly erodible farmland supporting tobacco (planted using conventional tillage), numerous livestock operations, and suburban developments.

Metabolism and diversity in small streams are affected by changes in water quality that alter photoautotrophic components of the trophic base (Lebkuecher *et al.* 1998a). Autochthonous primary production is the major contributor to the trophic base of small streams, especially in those with decreased detritus input due to removal of riparian flora (Vannote *et al.* 1980, Lamberti and Steinman 1997). Because photoautotrophic periphyton are the most important photoautotrophic components of small lotic systems (Dodds 1991, Lambert and Steinman 1997), changes in water quality that affect photoautotrophic periphyton production in streams with little canopy cover may severely affect whole-stream ecological relationships.

Studying photoautotrophic production yields valuable information on the effects of water quality on the trophic relations of aquatic ecosystems (McIntire and Colby 1978, Naiman 1983). Nonpoint-source pollution (i.e., pollutants entering water bodies from surface runoff) is the most significant pollution problem in the watershed (M. T. Finley, APSU, personal communication). Different pollutants affect photoautotrophic production and physiological status of different genera in different ways (Lebkuecher *et al.* 2000). Thus, production of naturally occurring photoautotrophic periphyton as well as the status of the pollution-sensitive algae, *Selenastrum capricornutum*, grown *in situ* were evaluated during July and October of 2000.

MATERIALS AND METHODS

Sampling Site Locations

The lower Buzzard Creek sampling site is located approximately 6.4 km from Highway 41/11, off Buzzard Creek Road, 100 m upstream of its confluence with Little Buzzard Creek. The lower Miller Creek site is located 9.6 km northeast of I-24, approximately 0.4 km downstream of the Carr Road bridge. The middle Miller Creek site is located at the Turnersville bridge on Turnersville road. The upper Miller Creek site is on the west fork of upper Miller Creek along Henry Gower Road, 0.8 km from the intersection with Sandy Springs Road.

Periphyton Sampling

Periphyton was sampled between July 16 and 22, 2000, and between October 1 and 7, 2000. Periphyton sampling methods followed the recommendations of Morin and Cattaneo (1992). The sampling procedures were designed to provide the most consistent environmental conditions at all sites, a prerequisite to comparing aquatic primary productivity among different sites (Naiman 1983). Commercial periphytometers holding acid-washed slides, placed parallel to flow, were submerged 5 cm below the stream surface. The periphytometers were placed in areas of similar flow (Lebkuecher and Houtman, 1999) and sunlight exposure (full exposure during the photoperiod, maximum 2000 μmol photons$\cdot m^{-2} \cdot s^{-1}$). For all assays described below, periphyton was removed with a razor blade from both sides of the slides from each site.

Periphyton Ash-Free Dry Weight

Ash-free dry weight was determined following the methods of Clesceri *et al.* (1989). Periphyton from both sides of 12 slides from each site were scraped into preweighed, prefired, crucibles. Periphyton from three slides were combined to give four replicates. The periphyton was dried at 105°C for 24 h, cooled at 2% relative humidity, and weighed to the nearest 0.1 mg. The dried periphyton was ashed at 550°C for 2 h. Ash-free dry weight was determined following re-wetting the ash with deionized water to reintroduce water of hydration, drying at 105°C for 24 h, and cooling at 2% relative humidity.

Chlorophyll *a* Concentration

Chlorophyll *a* concentration was determined following the methods of Arnon (1949). Chlorophyll (chl) was extracted by grinding periphyton from four slides (1 slide per replicate) from each site with a mortar and pestle for 3 minutes in 80% acetone buffered with 2.5 mM NaPhosphate buffer, pH 7.8 at 25°C. The homogenate was filtered through Whatman no. 1 filter-paper circles. Optical density was determined at 663 nm and chl *a* concentrations calculated (Arnon 1949). Photoautotrophic periphyton biomass was calculated from the chl *a* concentrations using the equations of Clesceri *et al.* (1989).

Autotrophic Index

The heterotrophic nature of the periphyton community was evaluated by determining the autotrophic index (AI) and was calculated using the following equation (Crossey and La Point 1988):

$$AI = \frac{\text{Ash-free wt of organic matter (mg/m}^2\text{)}}{\text{chlorophyll } a \text{ (mg/m}^2\text{)}}$$

In Situ Sensitive Algal Assay

Selenastrum capricornutum, a pollution-sensitive green alga and a standard assay organism (Bartsch 1971, Shubert 1984), was used to perform *in situ* growth assays (Koltz *et al.* 1975, Shubert 1984). Axenic *Selenastrum capricornutum* (University of Texas Culture Collection, Austin Texas) was cultured in 25 ml of Bold's nutrient media with 0.15 $g \cdot L^{-1}$ penicillin for 3 d at 200 µmol $photons \cdot m^{-2} \cdot s^{-1}$ and 25°C to obtain cells in the exponential growth phase. *Selenastrum capricornutum* (2 X 10^5 cells) were suspended in 6 ml of one-twentieth strength nutrient solution in 16 clear, 1.5 nm-porous membrane bags which allow rapid passage of stream nutrients (Spectrum, Laguna Hills, CA., Spectra/Por Biotech membranes, molecular weight cut off = 3,500 daltons, 10-mm diameter, 10-cm length). The algae-containing bags were suspended 5 cm below the surface parallel to flow between bars of a metal frame attached to the periphytometers at each site. Cells were harvested after 6 d of *in situ* exposure. Cells were counted using a hemocytometer. Three replicate counts were used to obtain the mean number of cells in each bag to calculate the number of population doublings per day.

Physiological Status Following the *In Situ* Assay

The physiological status of *Selenastrum capricornutum* grown *in situ* was evaluated using chl *a* fluorescence transients measured with a Plant Efficiency Analyzer (PEA; Hansatech Limited, Kings Lynn, Norfolk, England). Cells suspended in stream water (0.4 ml) were placed inside the fluorescence chamber for 3 min to oxidize primary electron acceptors prior to fluorescence induction (Lebkuecher *et al.* 1999). Fluorescence transients were measured during a 2-s flash of red light (2000 µmol $photons \cdot m^{-2} \cdot s^{-1}$) provided by an array of six light-emitting diodes (peak at 650 nm). The fluorescence signals were detected using a PIN-photodiode after passing through a long filter (50% transmission at 720 nm). Origin fluorescence yield (F_O) was calculated by determining the line of best fit through the data points from the first 4-12 µs of fluorescence induction (Lebkuecher 1997). Relative concentration of photosystem II was determined as the variable fluorescence yield (F_V), obtained by subtracting F_O from the maximum fluorescence yield (F_M)(Lebkuecher *et al.* 1999). The photochemical efficiency of photosystem II was determined as F_V/F_M (Lebkuecher and Eickmeier 1991).

Statistical Methods

Statistical analyses followed the recommendations of Sokal and Rohlf (1981) and Day and Quinn (1989). The experimental design employed a model I analysis of variance with equal replication (Zar 1984). Means are determined to be significantly different if they were dissimilar at the experiment-wise error rate of alpha = 0.05 probability level using the Tukey-Kramer Honestly Significant Difference Test (Sokal and Rohlf 1981).

RESULTS AND DISCUSSION

Primary production is the rate at which inorganic carbon is assimilated into organic form and can be measured as the rate of photoautotrophic biomass accumulation (Lamberti and Steinman 1997, Lebkuecher *et al.* 1998b). Approximately 1.5% of the dry weight of algae is chl *a*, and the rate of chl *a* accumulation per unit area is widely used to determine aquatic primary production (Keithan and

Lowe 1985, Lamberti and Steinman 1997). Aquatic primary production is largely dependent on water quality and is most often increased by decreased water quality resulting from nutrient loading (Baxter 1977, Lebkuecher *et al.* 1996). Streams pick up dissolved and particulate pollutants from agricultural, silvicultural, and urban sources. This nonpoint source pollution is the major contributor to poor water quality in West Tennessee (Finley *et al.* 1992, Hupp 1992). The negative effect of nutrient loading from nonpoint-source pollution in upper Miller Creek is indicated by the high values of primary production, as determined by mg chl $a/m^2 \cdot d$ (Baxter 1977, Keithan and Lowe 1985), in upper Miller Creek relative to less disturbed Buzzard Creek during July and October (Table 1). Significantly increased ash-free dry weight of periphyton and sediment-accumulation rate in upper Miller Creek in July relative to Buzzard Creek also reveal that upper Miller Creek was more polluted relative to Lower Buzzard during the July sampling period.

Organic pollution of the waterway is indicated by high concentrations of heterotrophic biomass (Lowe and Pan 1996). The middle Miller Creek site is heavily impacted by animal access and this organic pollution is reflected by the high AI value during October relative to lower Buzzard Creek. Autotrophic index values typically increase downstream due to higher concentrations of organic matter in lower stream reaches which, in turn, support a larger biomass of heterotrophs (Vannote *et al.* 1980). The similar AI values of the upper and middle reaches of Miller Creek relative to the lower

Table 1. Periphyton characteristics, sediment weights (plus periphyton ash), and autotrophic indexes determined from artificial substrates in Miller and Buzzard creeks. Means ± SE represent four replicate determinations. Means followed by the same superscript letter are not significantly different at the experiment-wise error rate of alpha = 0.05 probability level.

Assay	Lower Buzzard	Lower Miller	Middle Miller	Upper Miller
July 2000				
Chlorophyll ($mg/m^2 \cdot d$)	0.31 ± 0.05^a	0.52 ± 0.06^{ab}	0.35 ± 0.02^a	0.64 ± 0.10^b
Photoautotrophic biomass ($mg/m^2 \cdot d$)	20.8 ± 3.5^a	35.2 ± 4.4^{ab}	23.7 ± 1.4^a	42.6 ± 6.4^b
Periphyton dry weight (ash-free) ($mg/m^2 \cdot d$)	102.2 ± 5.2^a	188.5 ± 16.9^b	107.4 ± 11.3^a	272.6 ± 19.3^c
Sediment weight (mg/m^2d)	1019 ± 66^a	1685 ± 147^a	1135 ± 377^a	3019 ± 233^b
Autotrophic index	361 ± 65^a	380 ± 78^a	310 ± 44^a	449 ± 48^a
October 2000				
Chlorophyll ($mg/m^2 \cdot d$)	0.05 ± 0.00^a	0.08 ± 0.01^{ab}	0.10 ± 0.01^b	0.16 ± 0.02^c
Photoautotrophic biomass ($mg/m^2 \cdot d$)	3.05 ± 0.16^a	5.67 ± 0.53^{ab}	6.77 ± 0.53^b	10.4 ± 1.1^c
Periphyton dry weight (ash-free) ($mg/m^2 \cdot d$)	15.6 ± 5.4^a	61.5 ± 3.6^b	43.0 ± 3.9^b	61.5 ± 5.8^b
Sediment weight ($mg/m^2 \cdot d$)	131 ± 12^a	664 ± 53^b	221 ± 24^a	470 ± 46^c
Autotrophic Index	356 ± 143^a	750 ± 94^b	438 ± 60^{ab}	403 ± 47^{ab}

reaches of Buzzard Creek during July and October (Table 1) indicate poor water quality at the upper and middle Miller sites.

Determination of the effects of water quality on the physiological status of primary producers is a prerequisite to understanding and monitoring changes in watershed ecosystems (Shubert 1984, Clesceri *et al.* 1989, Naiman 1983, de Madariaga and Joint 1992). The photochemical efficiency of photosystem II (PS II) is an indicator of the efficiency in which absorbed light energy is convertedinto initial electron flow (Lebkuecher and Eickmeier 1993) which, in turn, is used to convert inorganic carbon into organic molecules. This measurement is very accurate and is widely used as an indicator of photoautotroph physiological status (Powles 1984, Bjorkman and Demmig 1987). Significantly lower growth rate (cell doublings/d) and lower photosystem-II photochemical efficiency of the pollution-intolerant alga, *Selenastrum capricornutum,* grown in upper Miller Creek during October suggest poor water quality relative to the other sites (Table 2).

CONCLUSIONS

Our study provides information on the effects of water quality on periphyton primary production, periphyton autotrophic-heterotrophic relationships, and the growth and physiological status of a pollution-intolerant algae at different sites within Miller Creek. As a whole, the data indicate that Miller Creek has poor water quality relative to Buzzard Creek, especially the west fork of upper Miller Creek, and are consistent with earlier evaluations of water quality within Miller Creek (Lebkuecher and Houtman 1999). In conclusion, the rate of endogenous photoautotrophic-periphyton production was greatest in the west fork of upper Miller Creek during July and October which reveals the negative impact of nonpoint-source pollution. The low growth rate and low PS-II photochemical efficiency of pollution-intolerant *Selenastrum capricornutum* grown *in situ* during October support the conclusions from the periphyton characteristics which indicate poor water quality in the west fork of upper Miller Creek relative to the other sites.

Table 2. Growth and photochemical efficiency of photosystem II of *Selenastrum capricornutum* grown *in situ* in Miller and Buzzard creeks. Means ± SE represent four replicate determinations following 6 d of growth and if followed by the same superscript letter are not significantly different at the experiment-wise error rate of alpha = 0.05 level of probability.

Assay	Lower Buzzard	Lower Miller	Middle Miller	Upper Miller
July 2000				
Cell doublings/d	2.6 ± 0.1^{a}	5.5 ± 0.8^{b}	4.1 ± 0.3^{ab}	2.4 ± 0.5^{a}
Photochemical efficiency of PS II (F_V/F_M)	0.76 ± 0.01^{a}	0.73 ± 0.00^{b}	0.71 ± 0.01^{b}	0.72 ± 0.00^{b}
October 2000				
Cell doublings/d	2.7 ± 0.1^{a}	2.0 ± 0.1^{bc}	2.4 ± 0.2^{ab}	1.4 ± 0.5^{c}
Photochemical efficiency of PS II (F_V/F_M)	0.71 ± 0.01^{a}	0.72 ± 0.00^{a}	0.72 ± 0.01^{a}	0.53 ± 0.00^{b}

ACKNOWLEDGMENTS

The research was funded by the Tennessee Department of Agriculture (Environmental Protection Agency 319 Fund, contract ID nos. 98-06718-00 and Z-00-097944-00) and The Center for Field Biology of Austin Peay State University. We thank Drs. E. W. Chester, Mack Finley, and Floyd Scott for reviewing the manuscript and offering suggestions for improvement.

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SPATIO-TEMPORAL ASSESSMENT OF STREAM FISH COMMUNITIES ADJACENT TO AN AGRICULTURAL BEST-MANAGEMENT PRACTICES OPERATION

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ABSTRACT. **Buck Creek, an Order III tributary to the Trammel Fork of Drake's Creek, receives organic-waste irrigation water runoff along part of its watershed. Fish community samples were made in the fall and spring from 1992 to 2000, above and below the treated pasture area, using portable electro-fishing methods. A total of 17,734 fish representing 29 species and two hybrids were taken in the study. Except for two drought season collections at the upstream station (I), species occurrences were similar at both stations in both seasons, averaging 64% overlap. Significantly more fish were taken at the downstream Station II (68.3% vs 31.7%) and in the Fall (63.6% vs 36.4%). Small, short-lived fishes dominated the assemblages by station and season. The largescale stoneroller minnow, *Campostoma oligolepis*, was the only herbivore taken and represented 38.7% of the total; the bluntnose minnow, *Pimephales notatus*, striped shiner, *Luxilus chrysocephalus*, and creek chub, *Semotilus atromaculatus*, were major omnivores making up 8.9%, 5.7%, and 5.1%, respectively, of the total. The northern studfish, *Fundulus catenatus*, (13.2%) and orangethroat darter, *Etheostoma spectabile*, (9.6%) were the major insectivores, while the green sunfish, *Lepomis cyanellus*, (4.2%) was the major top carnivore. Seasonally, significantly greater numbers of herbivores occurred during the Fall ($P = 0.031$) while carnivores were more abundant in the Spring ($P = 0.023$). Insectivores were most abundant at Station I ($P = 0.006$) while omnivores ($P = 0.001$) and carnivores ($P = 0.002$) occurred in greater numbers at Station II. Principal component analyses indicated a clear site effect on patterns of species composition; PC I (15.68% of the total variation) was driven by variation in the rosefin shiner, *Lythrurus ardens*, orangefin darter, *Etheostoma bellum*, and bluntnose minnow, all more common in samples from the upstream site. PC II (12.87%) showed some separation of fall and spring samples; greenside darter, *Etheostoma blennioides*, rainbow darter, *Etheostoma caeruleum*, and splendid darter, *Etheostoma barrenense*, tended to be more abundant, and the largescale stoneroller less abundant, in spring samples. A reduced PCA excluding rarely-occurring taxa produced similar clusters, and patterns of loadings on the first two corresponding pairs of axes were highly correlated ($p < 0.00002$). However, the observed site effect did not appear to result from anthropogenic input; samples from two unimpacted sites in Mays Branch clustered with their spatial counterparts in Buck Creek in all analyses. As a result, community differences in Buck Creek were likely the result of habitat differences between the two sites rather than anthropogenic land-use practices.**

INTRODUCTION

Much has been written about stream fish assemblages since 1980 including works questioning contemporary ecological theory (Fisher 1983, Minshall *et al.* 1983, Schoener 1987) and the application of fresh analytical techniques (Felley and Hill 1983; Matthews 1985, 1990; Ross *et al.* 1987; Bianchi and Hoisaeter 1992; Hansen and Ramm 1994; Taylor *et al.* 1996; among others). Accompanying this renewed discussion has been considerable debate and divergent views regarding such topics as persistence and stability of stream fish communities (Hansen and Ramm 1994) and physical vs biological processes in regulating stream-fish community structure (Schlosser 1987, Freeman *et al.* 1988). From these studies and discussions has emerged a set of considerations to be used in conducting stream fish surveys; namely, simultaneous treatment of spatial and temporal features (Meador and Matthews 1992), long-term baseline data set acquisition (Ross *et al.* 1987, Taylor *et al.* 1996), identification of the influence of upstream-downstream environmental variation in lotic systems (Schlosser 1990, Capone and Kushlan 1991), and the recovery of fish populations and communities following natural and cultural disturbances (Detenbeck *et al.* 1992).

In 1992, an opportunity was realized to apply some of the above directives to an anthropogenic land-use practice on the fish community in a small stream in southern Kentucky. A Best Management Practice swine rearing production facility was established in south central Kentucky that has adopted the practice of irrigating concentrated animal waste effluents onto pasture lands at rates of 52 to 95 kg N/ha, 12 to 15 kg P/ha, and 91 to 95 kg K/ha per application, two times in the spring and two times in the summer. The wastes are taken from the second of a two cell, in-series lagoon system and applied to the pasture land. Buck Creek, an Order III tributary to the Trammel Fork of Drake's Creek, lies adjacent to the treated land and receives pasture land runoff via two effluent ditches.

The objective of this study was to compare the fish community in an unaffected reach of the stream, above the land-use plan, with that in a potentially affected stream reach, immediately below the most downstream land-use effluent over an eight-year sampling regime. The spatial separation between the two potential enrichment sites on the stream (1 km) was insufficient to consider the stream collecting sites to be representative of upstream versus downstream locales. On the basis of a different stream bed physiography at each locale, sampling the stream fishes above and below the inflows essentially compared the fish assemblages in an upper riffle/bedrock chute habitat with those in a lower riffle/pool habitat. Additional inferences were drawn regarding the stability of sampled communities in a small stream over an extended time frame. Interpretations were proposed to explain any differences that might occur within and between the fish communities.

STUDY AREA

Buck Creek is a small, Order III, perennial flow stream receiving spring inflows and groundwater runoff in Allen County, Kentucky. It is approximately 7.25 km long and empties into the Trammel Fork of Drake's Creek in south-central Kentucky (Figure 1). Buck Creek is canopied by riparian forest of varying width and drains land used mostly for cattle pasture.

Sampling stations were located in relation to groundwater inflows from an intensive swine rearing facility which utilizes animal waste, pasture fertilization-irrigation practices. Two sloping ravines from the treated pastures surrounding the rearing facility form intermittent effluents into Buck Creek less than 1.5 kilometer from the point of waste application. The most upstream station (Station I) was just above a gully-tributary draining one side of the watershed while the most downstream station (Station II) was just below a similar gully draining the other side of the property. The average stream gradient along the reach of both sampling stations was 4.5m/km.

Station I was a shallow water station (avg 0.1m), 35m long containing an upstream riffle and two, bedrock pool/chute areas separated by a small cataract with visible water movement. This station had a karstic, bedrock substrate with little gravel and represented an average 2,347 ft^2 (218.1 m^2) surface area. Station II was 87m long and consisted of two riffles and one large and one small pool representing an average 6,393 ft^2 (594.2 m^2) surface area. During the study period, Station II changed in size and configuration in response to several high-water episodes and the construction of a concrete, low-water bridge 100 m upstream from the head of the station. It's average depth was 0.3m with some bedrock but mostly gravel substrate. Station II was 1.04km downstream from Station I.

A second stream, Mays Branch, an Order III tributary of the Sulphur Fork of the Middle Fork of Drake's Creek, was sampled as a reference stream beginning in June 1995. Mays Branch was 10.5km west of Buck Creek and was not influenced by swine rearing practices. Two stations were

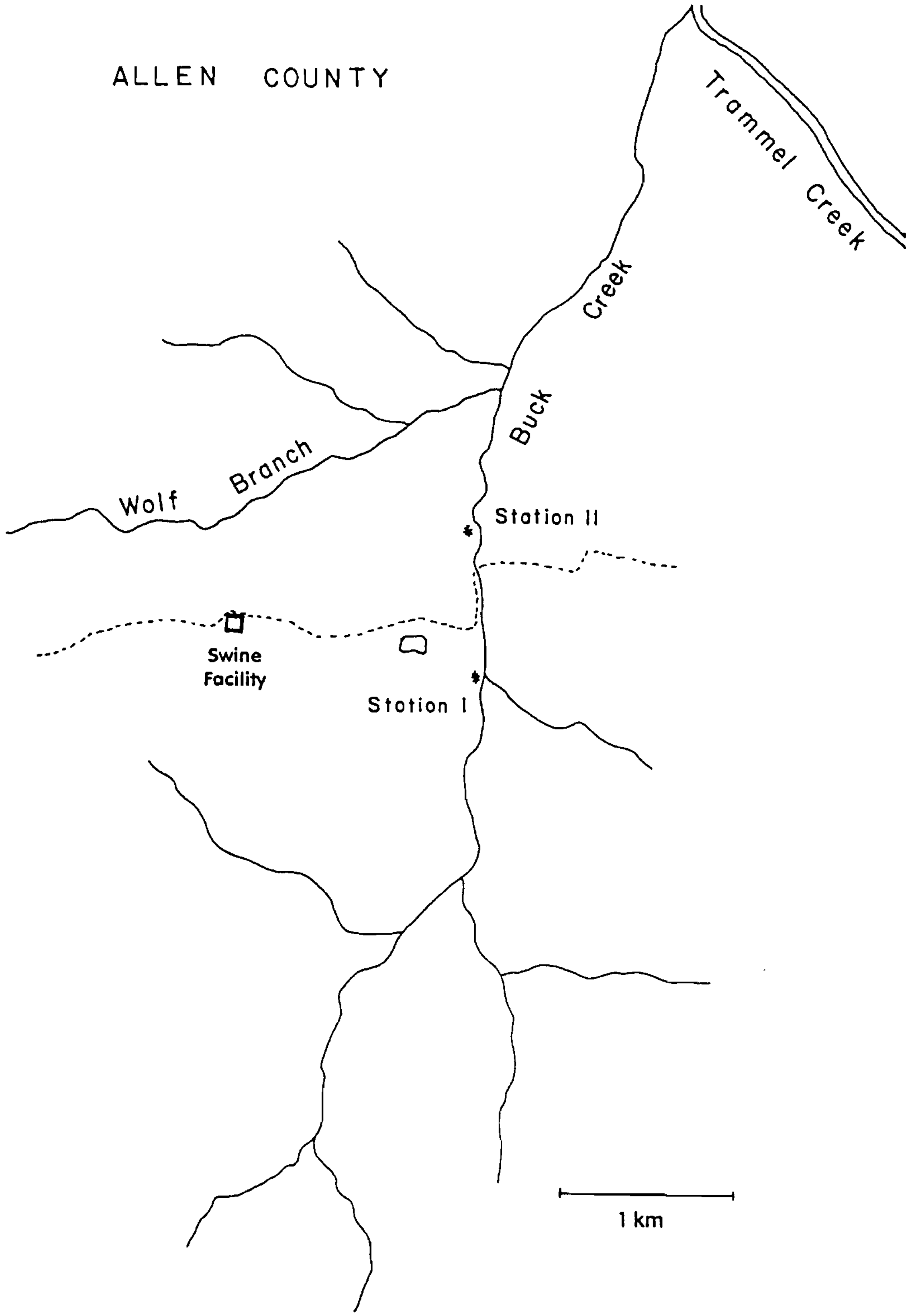

Figure 1. Map of Buck Creek, Allen County, Kentucky, showing fish collecting stations and proximity of swine rearing facility to the creek.

sampled on Mays Branch in order to compare station and stream effects on the fish communities in an affected and unaffected stream. Station I on Mays Branch was a shallow water station, 42m long, with mostly bedrock substrate. Mean depth was 0.1m and an average 2,314 ft^2 (215.1m^2) surface area were sampled. Station II was a larger station, 70m long, consisting of one long pool with entering and exiting riffle. Mean depth was 0.3m, the substrate was mixed bedrock and large rocks and gravel, and represented an average of 4,811 ft^2 (447.1 m^2) surface area. Station II was 0.75km downstream from Station I.

METHODS AND MATERIALS

Fish Sampling

Fish were collected from the Buck Creek stations in May-June and September-October from 1992 to 2000. Collections were made with electro-fishing gear consisting of portable electrodes powered by 120v AC current supplied by an industrial grade portable generator. Block nets were placed above and below the sampling stations and electrical current applied until fish were no longer observed. Fish were hand-picked from the substrate to maximize sampling effectiveness. Mean sampling time at each station was approximately 60 minutes. Fish were fixed in 10% formaldehyde upon capture, sorted, identified, measured, and weighed in the laboratory. All fish have been curated and reposited in the Biodiversity Center fish collection at Western Kentucky University.

Community Parameters

Various stream fish community metrics including the Shannon-Wiener diversity index (Brower and Zar 1984), index of biotic integrity (Karr 1981, Kentucky Division of Water 1993), biomass in pounds per acre, number of fish collected per sample, and species richness were determined for each collection.

Univariate Analyses

The Paired t-test was used to compare species richness, fish density, biomass, species diversity and Index of Biotic Integrity , for station and season effects. Because there were only single replications from each season/station, combined data were pooled across seasons in testing for station effects and vice-versa. This is a conservative approach as it increases the variance within groups. Significance was assessed using Bonferroni adjusted levels which were calculated separately for station and season tests. P_{critc} values were determined on the basis of .05/5 = .01.

Multivariate Analyses

All multivariate analyses were conducted using SYSTAT 9.0 (SPSS, Inc. 1999). Variation in species composition among samples from Buck Creek was summarized through principal components analysis (PCA) of the correlation matrix derived from species abundance data. For all analyses, the Fall 1999 Station I sample was excluded, as only 1 fish was captured in that sample). Use of the correlation rather than variance-covariance (VCV) matrix was deemed preferable given the two order of magnitude difference in abundance among the various taxa. In fact, while preliminary PCAs based on the variance-covariance matrix explained a higher proportion of the total variation in the data set (as expected), lower axes were all dominated by among-sample variation in the most abundant species and provided less evidence of among-sample structure.

The influence of rarely-occurring taxa on the relationships among samples was evaluated by comparing the PCA utilizing all Buck Creek taxa to one based on a reduced number of species. Here, species occurring in fewer than 40% of the samples were excluded; thirteen taxa were eliminated using this criterion: *Hypentelium nigricans*, *Catostomus commersoni*, *Cyprinella spiloptera*, *Notemigonus crysoleucas*, *Phoxinus erythrogaster* X *Semotilus atromaculatus* hybrid, *Ameiurus nebulosus, Noturus elegans, Chologaster agassizi, Ambloplites rupestris, Lepomis megalotis, Pomoxis annularis, Lepomis cyanellus* X *L. macrochirus* hybrid, *Etheostoma squamiceps* (Table 1). The correspondence in the ordinations resulting from the two analyses was qualitatively determined by comparing patterns of loadings on the first two principal axes. In addition, for each analogous pair of axes we computed the Pearson correlation coefficient of the loadings on those axes and evaluated their significance using Bonferroni-adjusted criteria.

To separate the possible impact of anthropogenic input into Buck Creek Station II from effects due to the more downstream position of that station, species abundance data from Mays Branch samples were projected onto the first two principal components derived from the Buck Creek complete data. Three taxa occurring only in Mays Branch were excluded. This approach allowed us to interpret the similarity of upstream and downstream stations in the two streams along the axes of variation important in Buck Creek.

RESULTS

A total of 17,734 fish representing 29 species and 2 hybrids was collected from Buck Creek during the study (Table 1). One cyprinid cross, probably *Semotilus* X *Phoxinus* (Burr and Warren 1986) represented by six individuals and a single centrarchid cross, probably *Lepomis cyanellus* X *L. macrochirus*, were taken at Station II (Table 1). Species occurrences were similar between stations and seasons during the study ranging from 5% to 93% overlap and averaging 64% (Table 2). Likewise, the numerical make-up of the assemblages by station and season consisted mostly of small, short-lived, minnow/darter type species, 87% and 94% in the Spring and Fall, respectively, and 93% and 91% at Station I and II, respectively (Table 1).

Station Effects

Twenty-one species were taken at Station I during the study while 28 species including both hybrids were taken at Station II (Table 1). With the exception of the northern hogsucker, spotfin shiner (*Cyprinella spiloptera*), and longear sunfish, which favored the deeper water of Station II, all other species not occurring at Station I were rare species represented by only 1 or 2 individuals at Station II (Table 1). Species richness was greater at the downstream station (17.6, SE 0.394) than at the upstream station (12.1, SE 1.02) ($P = 0.001$) (Table 2). Likewise, Shannon-Weiner species diversity was greater at Station II (2.764, SE 0.108) than at Station I (2.347, SE 0.209) ($P = 0.018$) (Table 2).

Although a greater total number of fish was collected at the downstream site than at the upstream station, when adjustments were made for the surface area difference between the two stations, slightly more fish occurred at the upstream station per unit area, 1.5 fish/m^2 (SE 0.202) vs.1.2 (SE 0.118) fish/m^2 ($P = 0.215$). Average biomass estimates at the two stations were similar for the entire study, 9.8 kg/ha (SE 1.13) for Station I and 10.3 kg/ha (SE 0.70) for Station II ($P = 0.63$). The Index of Biotic Integrity was not significantly different between the two stations, 43.9, SE 7.846 at Station I and 46.1, SE 0.98 at Station II ($P = 0.249$).

Season Effects

The total number of species collected in the study was similar in the Fall and Spring collections, 25 in the Spring and 28 in the Fall (Table 1). Average species richness per collection was similar in the Fall (14.2 spp, SE 1.234) and Spring (15.4 spp., SE 0.612), ($P = 0.357$). Greater seasonal variation in species richness was observed at Station I, 10.9, SE 1.83 in the Fall and 13.4, SE 0.532 in the Spring, although they were not significantly different ($P = 0.200$). Little variation in species richness was observed between seasons at Station II (17.25, SE 0.56 in Spring and 17.9, SE 0.56 in Fall) (Table 2).

Table 1. Scientific names and number of individuals of fishes collected from two stations in the Spring and Fall on Buck Creek, Kentucky, October 1992-October 2000, ordered by trophic category (Detenbeck *et al.* 1992, KY Division of Water 1993).

	Total		Spring Station		Fall Station		
	Spring	Fall	I	II	I	II	Total
HERBIVORE:							
Campostoma oligolepis	1881	4979	716	1165	997	3982	6860
OMNIVORE:							
Luxilus chrysocephalus	399	618	96	303	54	564	1017
Notemigonus crysoleucas	2	0	0	2	0	0	2
Phoxinus erythrogaster	157	299	107	50	168	131	456
Pimephales notatus	557	1027	112	445	92	935	1584
Semotilus atromaculatus	346	555	146	200	158	397	901
Semotilus X *Phoxinus*	2	4	0	2	0	4	6
Ameiurus natalis	26	29	1	25	13	16	55
Ameiurus melas	1	0	0	1	0	0	1
INSECTIVORE:							
Catostomus commersoni	0	1	0	0	0	1	1
Hypentelium nigricans	7	13	0	7	2	11	20
Lythrurus ardens	135	277	13	122	10	267	412
Cyprinella spilotera	0	14	0	0	0	14	14
Noturus elegans	0	1	0	0	1	0	1
Fundulus catenatus	579	1765	252	327	673	1092	2344
Chologaster agassizi	1	2	0	1	0	2	3
Lepomis macrochirus	183	122	33	150	20	102	305
Etheostoma barrenense	157	67	92	65	34	33	24
Etheostoma bellum	24	35	6	18	5	30	59
Etheostoma blennioides	38	15	3	35	1	14	53
Etheostoma caeruleum	263	205	93	170	128	77	468
Etheostoma flabellare	103	56	32	71	24	32	159
Etheostoma squamiceps	0	1	0	0	0	1	1
Etheostoma spectabile	972	722	683	289	534	188	1694
Cottus carolinae	230	73	106	124	27	46	303
CARNIVORE:							
Ambloplites rupestris	0	1	0	0	0	1	1
Lepomis cyanellus	370	372	83	287	96	276	742
Lepomis megalotis	15	16	0	15	3	13	31
Lepomis hybrid	1	0	0	1	0	0	1
Pomoxis annularis	0	1	0	0	0	1	1
Micropterus salmoides	1	14	0	1	5	9	15
Totals	6450	11284	2574	3876	3045	8239	17734

The total number of fish taken in Fall collections was significantly greater than in the Spring, 11,284 vs. 6,450, respectively (P = 006) (Table 1). When adjusted for area of stream sampled, however, only slightly more fish per square meter were taken in the Fall than Spring, 1.54 m^2 (SE 0.16) vs 1.14 m^2 (0.165), respectively (P = 0.188). Biomass estimates were also similar for the two season's collections, 10.0 kg/ha (SE 0.684) in the Fall and 9.34 (SE 1.134) kg/ha in the Spring (P=

Table 2. Number of fish/m^2 and species richness, estimated biomass in kilograms/hectare, Shannon-Weiner Diversity Index, and Index of Biotic Integrity for two stations on Buck Creek, Kentucky, 1992-2000.

	Buck Creek I					Buck Creek II					
Sample	No.Fish sq meter	Species Richness	Biomass Kg/ha	Diversity Index	IBI	No. Fish sq meter	Species Richness	Biomass Kg/ha	Diversity Index	IBI	% Species Similarity
Fall '92	1.87	14	9.72	2.75	46	1341	19	14.00	2.50	38	65
Spr '93	3.08	14	14.81	2.31	48	1.26	17	11.90	3.22	46	82
Fall '93	1.73	15	7.34	2.68	46	0.91	15	7.80	2.53	48	81
Spr '94	1.88	13	15.10	2.80	46	0.94	16	10.00	3.02	46	71
Fall '94	2.56	13	10.86	2.36	48	1.44	17	12.30	2.37	48	77
Spr '95	1.51	14	9.85	2.55	44	0.77	17	6.90	3.24	44	82
Fall '95	1.47	12	10.33	2.45	47	1.39	17	12.20	2.48	42	71
Spr '96	1.57	15	12.40	3.04	44	0.85	19	8.80	3.08	42	72
Fall '96	2.19	16	15.42	3.05	48	1.26	20	15.00	3.00	48	64
Spr '97	1.28	13	11.00	2.92	48	0.63	19	7.65	3.34	50	69
Fall '97	2.22	12	9.20	1.82	50	1.65	19	7.20	1.99	48	63
Spr '98	1.27	14	10.20	2.74	46	0.45	19	7.80	3.17	50	74
Fall '98	1.87	13	15.50	2.20	50	1.57	19	15.40	2.43	54	60
Spr '99	0.78	14	9.30	3.18	50	0.77	15	10.86	3.11	48	93
Fall '99	0.00	1	0.00	0.00	24	2.06	16	7.10	1.99	48	6
Spr '00	0.43	10	4.90	2.54	36	0.84	16	7.97	3.10	44	53
Fall'00	0.08	2	0.13	0.50	26	2.15	19	11.90	2.42	40	5
Mean	1.52	12.1	9.77	2.35	43.9	1.20	17.5	10.30	2.76	46.1	64

0.585). Seasonal biomass estimates within the two stations were trended during the study, although not significantly so; Station I estimates were greater in the Spring than those from Station II, (10.95 kg/ha (SE 1.16) and 8.99 kg/ha (0.622), respectively, $P = 0.087$), while in the Fall estimates were greater at Station II than Station I (11.43 kg/ha (1.096) and 8.72 kg/ha (SE 1.867), respectively, $P = 0.098$) (Table 2).

Shannon-Weiner species diversity was greater in the Spring than the Fall, 2.96 (SE 0.073) and 2.20 (SE 0.184), respectively (P = 0.002). Diversity indices were greater in the Spring than Fall at Station I, although not significantly so, 2.76 (SE 0.102) vs. 1.98 (SE 1.047), respectively, (P = 0.112), and also greater in the Spring than Fall at Station II, 3.16 (SE 0.088) vs. 2.41 (SE 0.114), respectively, (P = 0.001) (Table 2).

The Index of Biotic Integrity was similar for both seasons, 44.4 (SE 1.87) in the Fall and 45.8 (SE 0.892) in the Spring (P = 0.59).

Feeding Guilds

Herbivore and insectivore species were the dominant feeding types in Buck Creek (Table 3). Herbivores represented 38.7% of the total number of specimens collected followed by insectivores 34.2%, omnivores 22.6%, and top carnivores 4.5% (Table 3). The largescale stoneroller, *Campostoma oligolepis*, was the only true herbivore (Table 1). Omnivores included seven species and one hybrid but were mostly represented by the bluntnose minnow, *Pimephales notatus*, striped shiner, *Luxilus crysocephalus*, creek chub, *Semotilus atromaculatus*, and southern redbelly dace, *Phoxinus erythrogaster* (Table 1). Sixteen species were insectivores and included predominantly shiner and darter species, namely the rosefin shiner, *Lythrurus ardens*, orangethroat darter, *Etheostoma spectabile*, and rainbow darter, *Etheostoma caeruleum*, and most notably the northern studfish, *Fundulus catenatus*. Six species were top carnivores or piscivores and included mostly the green sunfish, *Lepomis cyanellus*.

Feeding preferences of fish in Buck Creek varied between stations and from season to season. Omnivores ($\bar{X}$ 25.4%, SE 2.77; P = 0.001) and top carnivores ($\bar{X}$ 5.0%, SE 1.418; P = 0.002) were significantly more common at Station II than Station I ($\bar{X}$ 16.9%, SE 2.77; and $\bar{X}$ 3.3%, SE 1.135, respectively) while insectivores were most characteristic of Station I ($\bar{X}$ 49.3%; SE 5.46) than Station II (27.1%; SE 2.85) (P = 0.006). Herbivores were more common in the Fall ($\bar{X}$ 44.2%; SE 5.74; P = 0.031) than Spring ($\bar{X}$ 29.2%, SE 2.907) while carnivores were more common in the Spring ($\bar{X}$ 6.0%, SE 1.663; P = 0.023) than Fall ($\bar{X}$ 3.6%, SE 0.829). Although not significantly supported in all cases, numerical trends suggested a strong herbivore presence in the Fall at Station II, insectivores in the Spring at Station I, and carnivores in the Spring at Station II (Table 3). An obvious *Cladophora* and filamentous algal mat was present on the substrate at the downstream station during the Fall collections that was not obvious in the spring. The biomass of the respective feeding groups followed basically the same trends as fish numbers.

PCA Results

Principal components analysis of fifteen samples from two stations along Buck Creek suggested the existence of station and season effects on patterns of variation in species composition among sites. The first three principal components accounted for 37.77 % of the total variation in the data set; 12 of 31 latent roots contained significant information (Reyment 1991). The first principal component (PC I - 15.68 % of the total variation) separated Station I and Station II samples (Fig. 2). Variation in abundance of *Lythrurus ardens, Etheostoma bellum, Pimephales notatus, Catostomus commersoni*, and *Ambloplites rupestris* loaded heavily on PC I (Table 4); these species were each more common at Station II (Table 1). Station I samples were also more variable than Station II samples, evidenced by the larger envelope encasing downstream sample scores (Figure 2). PC II (12.87 %) provided some separation of fall and spring samples; *Campostoma oligolepis, E. caeruleum*, and *E. barrenense* loaded heavily on this axis; *C. oligolepis* was more common in fall samples, while the other taxa were generally more abundant in spring samples (Table 1).

Patterns of variation in incidentally-occurring taxa did not strongly affect the relationships among samples. Reduced PCA excluding thirteen taxa generated ordinations qualitatively similar to those

Table 3. Number of fish by feeding guild as a percent of the total collected from Buck Creek, Kentucky, October 1992 to October 2000. Percentage fish weights by respective category in parentheses.

Category	Herbivore	Omnivore	Insectivore	Top Carnivore
Total	38.7 (37.3)	22.6 (26.1)	34.2 (27.0)	4.5 (9.6)
Station I	30.5 (32.1)	16.9 (21.5)	49.3 (39.4)	3.3 (7.0)
Station II	42.5 (39.1)	25.4 (27.6)	27.1 (22.7)	5.0 (10.6)
Spring	29.2 (30.4)	23.1 (27.5)	41.7 (30.4)	6.0 (11.7)
Fall	44.2 (42.6)	22.4 (25.0)	29.8 (24.3)	3.6 (8.1)

based on all 31 taxa. In addition, patterns of loadings on the first two corresponding pairs of principal components were each highly correlated ($P < 0.00002$).

Station I and Station II samples from Mays Branch clustered in principal component space with their spatial counterparts in Buck Creek (Fig. 2). As in Buck Creek, Station II samples from Mays Branch showed greater temporal variability than did Station I samples.

DISCUSSION

Species Richness

Species richness occurrences from Buck Creek in this study were consistent with those of other small streams in the southeastern U.S. (Ross *et al.* 1987, Freeman *et al.* 1988, Matthews 1990). In addition, the degree of temporal variation/overlap in species presence observed here agreed well with long-term sampling data from three Arkansas streams (Marsh-Matthews *et al.* unpubl.). In that study, individual samples contained 50-60% of the total number of species encountered, and approximately 70% of species observed in randomly-selected pairs of samples were common to both (E. Marsh-Matthews pers. comm.).

Similar to the observations of Schlosser (1987), and Taylor *et al.* (1996), the variation in abundance and distribution patterns of the assemblages observed in this study appeared to be primarily due to environmental variables such as habitat heterogeneity and the life histories of the fishes involved, rather than anthropogenic influences. The greater species richness and diversity indices at the Buck Creek downstream station was a reflection of greater availability of fish habitats in the pool setting. Schlosser (1987, 1990) and Capone and Kushlan (1991) reported that stream reaches with poorly developed pool areas have shallow depths, low habitat availability, low species richness, and low numbers of fish. Diehl (1992) likewise suggested structurally complex habitats (pools) to hold more diverse communities than simple ones.

Table 4. Loadings of individual taxa on the first two principal components extracted from Buck Creek samples (Fall 1999 Station I excluded). Taxa with high loadings are indicated in bold type.

Taxon	PC1 Loading	PC2 Loading
Hypentelium nigricans	0.10806	0.43976
Catostomus commersoni	**0.65755**	0.29019
Campostoma oligolepis	0.41511	**-0.65316**
Phoxinus erythrogaster	-0.36017	0.02019
Pimephales notatus	**0.69274**	0.23689
Lythrurus ardens	**0.73001**	-0.33529
Luxilus chrysocephalus	0.50564	-0.44563
Cyprinella spiloptera	0.17678	-0.50310
Notemigonus crysoleucas	0.15995	0.17699
Semotilus atromaculatus	0.28285	0.36169
Chub x Dace Hybrid	0.57492	-0.11080
Ameiurus melas	0.03883	0.16201
Ameiurus natalis	0.31453	0.08697
Noturus elegans	-0.30089	0.07106
Fundulus catenatus	0.01839	-0.26703
Chologaster agassazi	0.13381	0.26829
Ambloplites rupestris	**0.65755**	0.29019
Lepomis cyanellus	0.51478	-0.04396
Lepomis macrochirus	0.36030	0.24698
Lepomis megalotis	0.42216	0.25811
Pomoxis annularis	0.26001	-0.17288
Lepomis Hybrid	0.14926	0.15257
Micropterus salmoides	-0.09002	-0.39866
Etheostoma barrenense	0.29434	**0.61345**
Etheostoma bellum	**0.71693**	0.29803
Etheostoma squamiceps	0.10093	-0.16177
Etheostoma blennioides	0.43683	**0.64067**
Etheostoma caeruleum	-0.04559	**0.61566**
Etheostoma flabellare	0.26762	0.56682
Etheostoma spectabile	-0.43429	0.38095
Cottus carolinae	-0.02767	0.36769

The onset of a prolonged, two-year drought in 1999-2000 saw the number of fish collected at the upstream riffle station decrease dramatically during the last four collections of the study. Concurrent with the reduction in fish number at the riffle station was a proportional increase in the number of fish at the pool station. Meador and Matthews (1992) described similar occurrences in the temporal consistency of fishes in an intermittent stream in Texas. The proximity of the fish-rich pool area to the drought induced depauperate riffle area amplified the role of the pool as a local species refugia and voided the conclusion that this reach of Buck Creek is a harsh system for its resident fish species. Meador and Matthews (1992) reported a similar conclusion for the fish assemblage in an intermittent Texas stream.

Insectivorous fish species were most abundant in Buck Creek during the Spring while herbivores were the dominant feeding category in the Fall. The increase in insectivores was greatest at the upstream riffle site and appeared to be a concurrent effect of the increased numbers of shiners, bluegill, and darter species that migrated to the upstream reaches in the spring as cited earlier. The herbivore increase in the Fall was predominantly a result of the increase in food availability for that

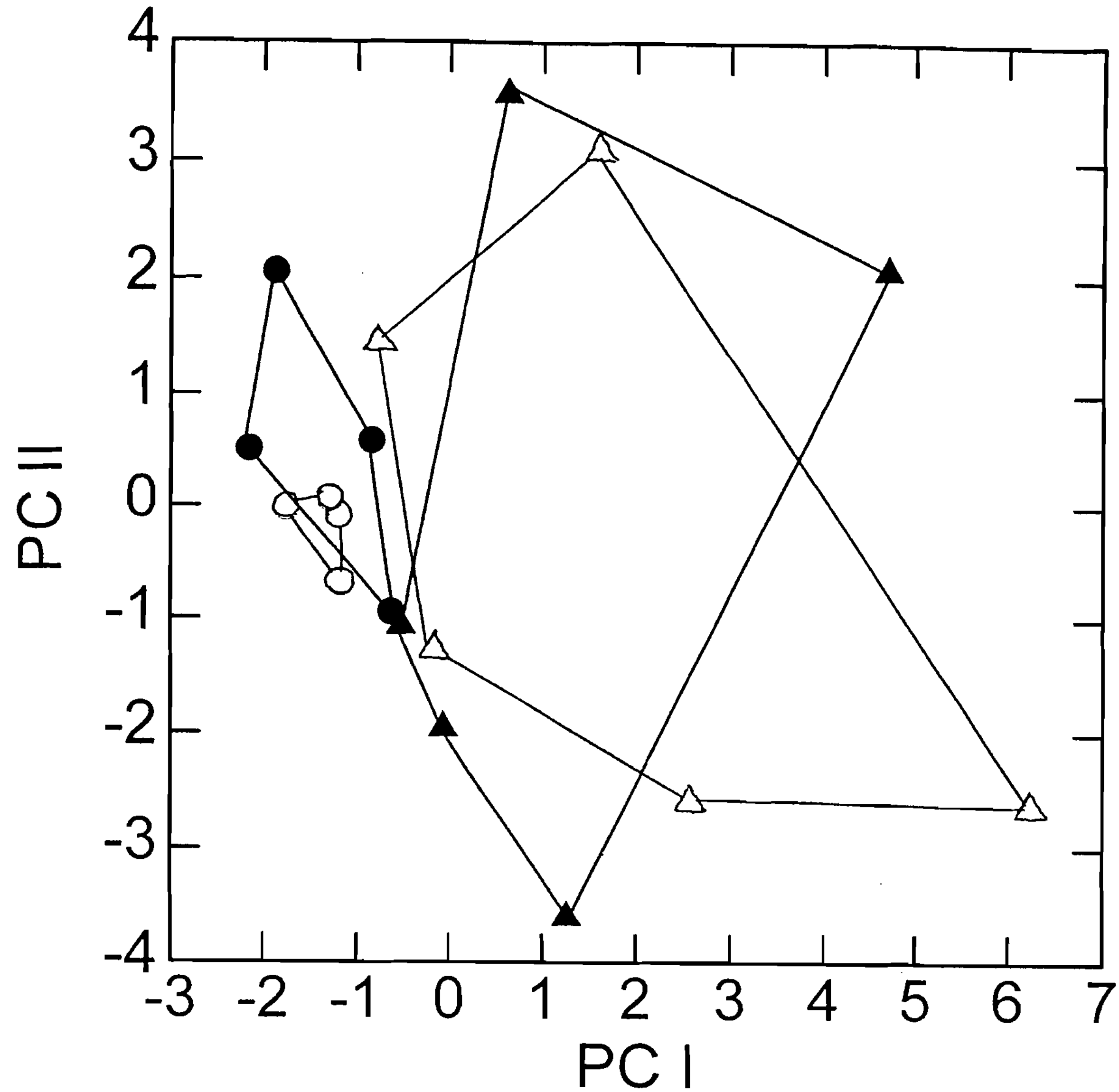

Figure 2. Results of PCA for 31 taxa in Buck Creek and Mays Branch. Axes represent the first two principal components derived from analysis of Buck Creek samples (Fall 1999 Station I excluded); Mays Branch samples are projected onto this space *a posteriori*. Solid symbols represent Buck Creek samples (circles: Station I; triangles: Station II), while grey symbols indicate samples from Mays Branch (circles: Station I; triangles: Station II). Note that PC I separates Station I samples from Station II samples in both streams. Also note the greater variability (larger envelopes) in Station II samples from both Buck Creek and Mays Branch.

feeding category at the pool station. Based upon PCA analysis of macroinvertebrate communities at the two fish collecting sites, VanStone and Jack (1997) reported taxa richness and total numbers of individuals to be higher in the downstream pool site. Although speculative, they suggested the greater macroinvertebrate communities in the downstream pool to result from an increased periphyton/filamentous algae growth as an effect of nutrient enrichment. The pattern of more herbivorous species at that site likewise suggests a feeding shift toward the algal forms present in the extensive *Cladophora* mats present (J. Jack pers. comm.). The Mays Branch samples showed a fish community pattern by station similar to that at the Buck Creek stations, however, suggesting at best a minor groundwater runoff influence at the downstream Buck Creek station.

Potential Influence of Groundwater Runoff

The downstream Buck Creek site is distinct in its fish community structure from the upstream site, i.e., greater species richness, higher species diversity, and greater herbivore/omnivore representation, especially in the Fall. Nevertheless, it is difficult to attribute this pattern to agricultural runoff generated just upstream of that site, for several reasons. First, water quality parameters potentially indicative of agricultural impact (nitrates, nitrites, phosphates, etc.) did not show a significant correlation with patterns of species abundance between sites during the study (pers. obs.). Even if these nutrients were exerting a significant impact on the biological community, their uptake by primary producers would be sufficiently rapid such that detecting their signal through chemical analysis of water samples would be unlikely (W. Matthews pers. comm.). Second, Reash and Berra (1987) reported the rock bass and fantail darter to be missing from polluted waters and darter species as a group to be especially sensitive to anthropogenic disturbances. In Buck Creek, representatives of these species or species groups were all present in the pool station in the Fall, following the influence of any nutrient enrichment on summer algal growth or water quality alteration. However, with the exception of the orangefin darter, which was most abundant in the Fall at the pool site, each of these species did occur in the Fall in percentages of only 29% to 39% of their numbers at the riffle station at the same time. Whether these reductions in occurrence at the downstream station reflected an anthropogenic influence from the surrounding land use or were merely the spurious result of seasonal distribution patterns of the species could not be confirmed. And lastly, the overlap of test stream and reference stream collection sites as shown by the PCA suggests a strong station effect operating on both streams rather than a selective anthropogenic effect at the downstream Buck Creek site.

In summary, data collected from Buck Creek suggest that it supports a fish fauna typical of small, upstream Order III streams in the south-east United States, that stream site differences explain most long-term variations in stream presence, that individual fish species biology is responsible for most seasonal community differences, and that anthropogenic influences were of minimal effect on the fish assemblages during the duration of the study.

ACKNOWLEDGMENTS

The U. S. Environmental Protection Agency 319 is gratefully acknowledged for providing funds which made this study possible. The Kentucky Division of Conservation and Division of Water provided technical assistance at the initiation of the project which is very much appreciated. The Kentucky swine producer was a willing and supportive cooperator throughout the project in providing financial support and logistical assistance in making the field collections possible. The Department of Agriculture at Western Kentucky University provided willing and interested students who assisted in making all field collections. Dr. John Andersland is acknowledged for his kind and expert assistance in making data figures.

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HABITAT ASSESSMENT METHODOLOGY AND COMPARISON OF THREE TENNESSEE STREAMS

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ABSTRACT. Physical habitat description is necessary before any biological monitoring is performed. The Environmental Protection Agency (EPA) has set standards for performing habitat assessments. Evaluating in-stream and out-of-stream parameters can assist in identifying problems that may exist in a particular watershed. Habitat assessment data along with biological and chemical data can give an overall view of water quality. The purpose of this study was to show the different stream types across the state of Tennessee. Habitat assessments were performed in three Tennessee streams. Each stream was divided into three 100 meter reaches and designated as upper, middle, and lower. A habitat assessment evaluation was performed in each stream reach. An Eastern stream was evaluated as a high gradient (high velocity) while Middle and Western streams were evaluated as low gradient (low velocity) streams. Once the assessments were complete, photographs were made of the different physical habitats of these different streams.

CHARACTERISTICS OF ZOOPLANKTON DIAPAUSE IN A RESERVOIR ECOSYSTEM

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ABSTRACT. The eggs of many freshwater zooplankton species diapause in lake bottom sediments throughout much of the year. Some eggs may withstand drying when bottom sediments are exposed and hatch when sediments are rewetted. The extensive water level fluctuations that often occur in reservoir ecosystems may give a survival advantage to species of zooplankton with diapausing eggs. This study examined the effects of drying and rewetting on egg banks in three types of Kentucky Lake sediment: a littoral zone with an annual drying and wetting cycle, a permanently wetted embayment, and a floodplain that is only rarely inundated. We concluded that desiccation and rewetting were cues for the rotifers *Lecane, Lepadella, Keratella,* and *Monostyla*, for the cladoceran *Diaphanasoma*, and for ostracods. The eggs of many other species common in the reservoir did not respond to desiccation, signifying either their need for other environmental cues or lack of viable eggs in the egg bank. Sediments located in either the littoral zone or floodplain that normally experienced drying and rewetting cycles showed greater species diversity and number of total individuals hatched than permanently wetted sediments. The number of hatching eggs increased with depth into the sediment up to at least 20 cm. Hatching success in response to drying and rewetting demonstrates that diapause plays a role in zooplankton dynamics of this reservoir ecosystem. Present studies are analyzing both drying and freezing effects on the breaking of egg diapause.

TRICHOPTERAN SURVEY OF BRUSH CREEK, ROBERTSON COUNTY, TENNESSEE: A PRELIMINARY REPORT

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ABSTRACT. Caddisflies (Insecta: Trichoptera) were sampled from Brush Creek in Robertson County, Tennessee from May 1999 to October 2000. Brush Creek is a third order tributary of Sulphur Fork Creek and Red River in the Western Pennyroyal Karst region of the Interior Plateau. Caddisflies are an important part of the food web in fresh water environments and serve as bioindicators in the assessment of water quality. Adults were collected using ultraviolet light traps and males were identified to species. A total of 71 species representing 32 genera and 14 families have been identified to date. Based on checklists of Tennessee and Kentucky caddisfly fauna and the preliminary data thus far obtained, this poorly surveyed area appears to have a moderately rich trichopteran fauna.

EVALUATION OF AMONG-RIFFLE VARIANCE ON MULTIMETRIC BIOASSESSMENT USING MACROINVERTEBRATE ASSEMBLAGES OF THREE MIDDLE TENNESSEE STREAMS

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ABSTRACT. The United States Environmental Protection Agency has published Rapid Bioassessment Protocols (RBP) for assessing the biotic integrity of streams. These techniques employ several ecologically relevant measures of community structure and function, i.e. metrics, considered to be sensitive to stream degradation. The metrics are selected to cover a wide range of structural and functional properties of aquatic biological communities. The preliminary data of this study tests the implied assumption that sampling two riffles of a single stream reach provides an accurate representation of the macroinvertebrate assemblage of the stream and therefore a reliable bioassessment. Five riffles were sampled in a single stream reach of three streams. Of eleven metrics evaluated, mean values of six varied significantly among streams; however, metric values often varied greatly among riffles within each stream and the range of metric values within streams often overlapped among streams. Thus bioassessments based on any set of single riffle sample from each stream could be expected to yield inconsistent results.

MICROBIAL DIVERSITY OF THE LITTORAL ZONE OF LEDBETTER CREEK EMBAYMENT, KENTUCKY LAKE

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ABSTRACT. A group of faculty associated with the center for Reservoir Research, Murray State University, was awarded a C-RUI grant that began in January 2000. The grant provides funds for students to study the effects of human controlled water fluctuations on ecosystem function in a major reservoir littoral zone, at several trophic levels. A portion of the project seeks to access the influence of water fluctuation on the microbial community and its activity. Thomas Moore, under the direction of Dr. Susan Hendricks, is assessing bacterial productivity by thymidine uptake and assaying for a battery of exoenzymes. Terry Ray, under the direction of Dr. George Kipphut, is measuring chemical flux in and out of sediment to the water column using closed chamber experiments. We are assessing the microbial diversity and microbial succession by restriction endonuclease digestion band pattern analysis of amplified rRNA genes (ARDRA). We have collected samples from the littoral zone of Ledbetter Embayment as the water level was dropped to winter pool, isolated DNA directly from the sediment, amplified rDNA by PCR, and analyzed restriction endonuclease fingerprints of those samples by ARDRA.

MORPHOLOGICAL PLASTICITY OF PHYSID AND PLUEROCERID SNAILS IN THE LEDBETTER EMBAYMENT

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ABSTRACT. **Plasticity allows organisms to mitigate the effects of variable environments. Due to low mobility and the fact that they cannot readily change their habitat, plasticity plays an important role in the life of snails. For example, previous studies have shown that physid snails exhibit predator-induced morphology shifts in the presence of crayfish and pumpkinseed sunfish, two of its major predators. My research was conducted in the littoral zone of Ledbetter embayment on Kentucky Lake. This environment is one of human induced water level fluctuations. The two predominant snail species in the area are *Physella* and *Elimia*. Using morphometric software I am measuring shells collected from the embayment at different depths and locations and determining if these snails are exhibiting morphological plasticity.**

CRAYFISH ECOLOGY OF LEDBETTER EMBAYMENT

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ABSTRACT. Although natural lakes and ponds have been studied extensively, little research has been conducted on reservoir ecosystems. This is surprising, given that reservoirs are the dominant freshwater environment in much of the world. I chose to study crayfish distribution in Ledbetter Embayment of Kentucky Lake, a reservoir on the Tennessee River. Crayfish are opportunistic omnivores that feed on a wide variety of plant and animal material, and thus play an important ecological role as detritivores. Each Sunday evening from June until early August, 14 cylindrical minnow traps were baited with chicken liver suspended in mesh bags. These traps were set 10 meters apart in the littoral zone to cover a wide variety of habitats and depths. The next morning, the traps were checked and the crayfish were identified, sexed, and measured. Surface temperature and lake levels were also recorded for each date. Each trap site was GPSed and all data was logged into a database, which was connected to a global information system (GIS). *Procambarus acutus* was the only species recovered in the traps, with more than 400 individuals captured. Evidence thus far suggests that crayfish distribution changes seasonally with water level fluctuations, but is more closely related to water temperature than lake level. Thus, the ecological role of crayfish within reservoir littoral zones varies both with anthropologic impact (lake level) and natural (temperature) environmental change.

SEDIMENT-WATER FLUXES OF NUTRIENTS AND DISSOLVED GASES IN KENTUCKY LAKE RESERVOIR

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ABSTRACT. We have been measuring sediment-water fluxes of dissolved nutrients and gases in Kentucky Lake, the largest reservoir within the Tennessee River Valley. These studies have been conducted as part of a larger project assessing biogeochemical processes affecting carbon accumulation, metabolism, and mineralization within Kentucky Lake. Approximately thirty flux measurements have been made with benthic chambers. Sediment-water fluxes are strongly dependent on water temperature. Nitrogen and phosphorus fluxes from the sediments to overlying waters are significant in terms of reservoir ecology. We estimate that the sediment-water fluxes supply the majority of the nutrient requirements of primary production within the water column during the summer season. Sediment-water fluxes of phosphorus occur even though the water column is always well oxygenated in this un-stratified reservoir. Concurrent studies are attempting to relate these chemical fluxes to microbial activity in the sediments. The Kentucky Lake water column is supersaturated with carbon dioxide and methane with respect to atmospheric exchange. Benthic chamber measurements suggest that the sediments are a significant, but not the only source for these gases to the water column.

KENTUCKY LAKE WATER PARAMETERS FROM SPECTRORADIOMETER AND LANDSAT TM DATA

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ABSTRACT. The major objective of this study was to assess quantitatively and spatially map the suspended sediment concentration, turbidity, and chlorophyll in the lower reaches of Kentucky Lake. Suspended sediment, turbidity, and chlorophyll readings from several sample sites were obtained for four dates from 1998 and 1999. Landsat TM data of Kentucky Lake from those dates were acquired and utilized to map total suspended solids (TSS), turbidity, and chlorophyll for the reservoir based on correspondence with the sampled data. Spectroradiometer data were also obtained for some study sites and some of the dates and were analyzed for correspondence with the sample data and the TM data.

The total suspended solid (TSS) values, turbidity, chlorophyll, and corresponding TM spectral responses for the first five reflective bands at each sample site for the four data sets were then entered as input to the SAS analysis package and equations to model water parameters were generated. Several models were obtained for each data set: the best single band and the best multi-band. A similar process was followed for the spectroradiometer data. The multi-band TM models for both original data sets exhibited superior performance in predicted suspended sediment and turbidity trends in comparison to the single band models. After removing a few sample points with large residuals multiple correlation coefficient values (R^2) of over 0.5 were obtained for all models. Regression models for each date were significantly different. Atmospheric correction of the TM data was attempted using several methods, including utilizing the spectroradiometer data, but very limited success has been achieved to date. On the other hand the spectroradiometer data did result in much better regression models than those from the TM data in all cases.

TSS, turbidity, and chlorophyll maps were generated for the four dates from the TM models. The resulting maps did appear reasonable in depicting observed and hypothesized spatial trends for the parameters in the reservoir. The resulting maps can be a useful tool in water analysis and ensuing management of the reservoir. Accuracy tests involving exclusion of some samples from model creation and subsequent testing of the resulting model for the excluded points did not show good results for the TM data but were quite satisfactory for the spectroradiometer data.

CONTRIBUTED PAPERS

SESSION II: AQUATIC BIOLOGY AND WATER QUALITY

Saturday, March 1, 2001

Moderator and Editor:

A. Floyd Scott
Austin Peay State University

FLUCTUATING ASYMMETRY AS AN INDICATOR OF HABITAT QUALITY AND FORAGING ABILITY IN THE TIGER SALAMANDER, *AMBYSTOMA TIGRINUM*

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ABSTRACT. Developmental stability, as measured by fluctuating asymmetry (FA), has recently received attention as a potential indicator of stress in a variety of organisms. FA was measured in larvae of the tiger salamander, *Ambystoma tigrinum,* in central Colorado to test the hypothesis that FA is negatively correlated with habitat quality and foraging ability. Twenty-five larvae were collected from each of 13 ponds and each side of each larva was digitally photographed within 24 hours. A water sample was obtained from each pond and analyzed for pH, alkalinity, turbidity, dissolved oxygen, nitrate/nitrite and orthophosphates. An FA index for each population was calculated for each of five traits. A stepwise multiple regression was performed for each trait versus all water quality variables. One trait (foreleg-to-hindleg) showed a significant negative relationship to alkalinity (p=.012) indicating that FA is higher in ponds that are less buffered from acidification. The four traits that were not related to water quality were associated with the head, and there is some evidence from other studies that these traits may be highly canalized and therefore not ideal for studies of FA. During the summer of 2001, this study will be replicated and several new traits not associated with the head will be measured. Larvae from five of the ponds were used in foraging experiments in which they were housed individually and presented with larvae of a pond mayfly, *Callibaetus ferrugineus*, after several days of acclimation. Each salamander larva was observed for 10 minutes, and a ratio of attempted to successful captures was calculated as an estimate of foraging efficiency. FA was related to average foraging efficiency using a simple regression. There was a negative trend between FA of foreleg-to-hindleg and both foraging efficiency (p=.118) and overall number of captures (p=.087), but this relationship was not significant. Ten new populations will be used for the foraging experiment during 2001 and this increased sample size will help determine whether the observed trends are statistically significant. FA may have potential as an indicator of habitat quality and foraging ability, but further study is needed.

POPULATION VIABILITY ANALYSIS OF THE HELLBENDER (*CRYPTOBRANCHUS* SP.)

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ABSTRACT. The population status of *Cryptobranchus alleganiensis* is largely unknown across most of its range. Demographic data suggest the species to be threatened if not endangered. Population viability analysis using extinction prediction software can be a useful means of modeling future demographic scenarios which a species may experience. Using available demographic data and the extinction modeling software, VORTEX, a population extinction prediction was developed for *C. alleganiensis*. The inability of offspring to survive to sexual maturity within populations was determined to be the predominant factor leading to population decline. Concomitantly, populations were not viable unless the existed as an extensive metapopulation. Unfortunately, the degree to which *C. alleganiensis* actually exists as a metapopulation is yet unknown, suggesting an urgent area of research for management of this species.

NATURAL HISTORY NOTES ON A RECENTLY DISCOVERED POPULATION OF *STERNOTHERUS MINOR PELTIFER* (STRIPENECK MUSK TURTLE) IN WHITEOAK CREEK, HOUSTON AND HUMPHREYS COUNTIES, TENNESSEE

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ABSTRACT. **Whiteoak Creek is a tributary of the Tennessee River that flows westward through Middle Tennessee in parts of Houston and Humphreys counties. In the summer of 1999, three specimens of *Sternotherus minor peltifer* (Stripeneck Musk Turtle) were discovered in the creek's lower reaches. These records were well to the west and north of any previous reports for the species. Following this discovery, we initiated a study of *S. m. peltifer* in Whiteoak Creek to obtain information on its distribution, population attributes, and movements. Turtles were captured by hand while wading, canoeing, and snorkeling the creek. All captured specimens were weighted, measured, given an individual mark (notches in marginal scutes), and, when possible, sexed. Seven adults were fitted with radio transmitters. Six sites distributed along a 20-km reach of the creek produced 44 individuals. Females outnumbered males approximately 2 tol (25:14); juveniles numbered five. Twenty-eight individuals were found among ledges, crevices, and boulders of deeper pools along limestone bluffs. Eight were taken among submerged root masses, logs, limbs, and other organic debris not associated with bluffs. At the time of this writing, movement data were too limited to allow any generalizations.** **Funding for this project was provided by The Center for Field Biology, Austin Peay State University, Clarksville, TN 37044.**

DISTRIBUTION AND MOVEMENTS OF ALLIGATOR SNAPPING TURTLES (*MACROCHELYS TEMMINCKII*) IN THE TENNESSEE PORTION OF KENTUCKY RESERVOIR

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ABSTRACT. Although not reported until 1954, the first Alligator Snapping Turtle (*Macrochelys temminckii*) from what is now Kentucky Reservoir (impounded Tennessee River) was found in 1938 near the community of Big Sandy in Benton County, Tennessee. Since then, 23 specimens from 10 additional localities in five counties have been documented. This report includes a detailed summary of the distribution data for the species in Kentucky Reservoir and presents the results of radio-tracking studies carried out over the past 5 years on four adults (2 males and 2 females) in lower Whiteoak Creek, which enters the reservoir in Houston County, Tennessee. **Funding for this project was provided by The Center for Field Biology, Austin Peay State University, Clarksville, TN 37044.**

TRAPPING THE FIVE-LINED SKINK, *EUMECES FASCIATUS*, TO STUDY THE EFFECTS OF TAIL AUTOTOMY ON MALE DOMINANCE RELATIONSHIPS

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ABSTRACT. Capture efficiency and mortality of Five-Lined skinks, *Eumeces fasciatus,* were compared for pitfall, funnel, and modified glue traps. Sixteen *E. fasciatus* were captured over 22 days. Lizards captured on glue traps (N = 9) experienced 22.2% mortality (2 deaths) and those captured in pitfall traps (N = 7) experienced 0% mortality. No lizards were captured in funnel traps. The glue trap mortalities occurred early in the study, but were eliminated by trap and procedural modifications. Glue traps were most efficient on a time of effort basis, but pitfall traps were a safer capture technique that required less researcher time for monitoring. We also studied dominance relationships between male *E. fasciatus* and the effect of tail autotomy on these relationships. We placed a female *E. fasciatus* between two reproductive males to elicit competitive interactions from them that could be classified as dominant or subordinate responses. The duration of the contest, i.e., time at which a male retreats, as well as other behaviors including orientation, tongue flicks, tail undulations, grappling, and bites were recorded. We used an ANOVA to determine the amount of variation in these behaviors between the dominant and subordinate males. Additionally, we used the McNemar test to assess if tail autotomy affects previously established dominant-subordinate relationships among male *E. fasciatus*. We also used ANOVA to test the ability of *E. fasciatus* to recognize dominant/subordinate conspecifics via phermones by presenting each male with a cloacal swab from itself and from its dominant/subordinate conspecifics as determined in the dominance trials. All dominate versus subordinate behaviors (i.e., number of tongue flicks [both], retreat [subordinate], bite [dominant], and stands ground [dominant]) were recorded.

THE UTILITY OF GIS-BASED HABITAT MODELS FOR ASSESSING THE CURRENT AND FUTURE STATUS OF THE SWAMP RABBIT (*SYLVILAGUS AQUATICUS*) IN KENTUCKY

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ABSTRACT. Geographic information systems may provide a cost-effective and accurate means of evaluating the current and predicted availability of critical habitat for species. We tested the utility of GIS-based models to predict the distribution of suitable habitat for the swamp rabbit, which is a species of special concern in Kentucky. Using a geographic information system and logistic regression analysis, we developed three models that predicted the probability of occurrence of swamp rabbits in western Kentucky. The models were compared to the existing Kentucky Gap Analysis model. All models were successful in the prediction of confirmed swamp rabbit observations, both of presence (> 80%) and absence (> 90%), with only slight variation among models. After selection of the best model based on statistical performance and model construction criteria, the best model was applied to geographic areas of Kentucky contiguous to the species' current Kentucky range to investigate the feasibility of swamp rabbit reintroductions. Only five areas for potential reintroduction were identified, with two of marginal quality and the remaining unsuitable for swamp rabbit reintroduction. Land ownership and protection status of all habitat determined to be suitable by our best model was assessed; the vast majority of all land was in unprotected, private ownership. Wildlife Management Areas protected the most swamp rabbit habitat (≈ 8%), but most suitable habitat remains at risk. These models can serve as a solid basis for future swamp rabbit conservation considerations. Field validation and frequent assessments and modifications of the models associated with increased data availability and improved GIS technology are recommended.

DYNAMICS OF A WHITE-TAILED DEER POPULATION IN SOUTHERN HUMPHREYS COUNTY, TENNESSEE

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ABSTRACT. The dynamics and composition of a population of White-tailed deer (*Odocoileus virginianus*) inhabiting 425 hectares (1050 ac) in southern Humphreys County, Tennessee were assessed during August and September 2000 using infrared photography. The study site was divided into seven contiguous plots each measuring 61 ha (150 ac). Each plot was baited with corn and photographed for ten consecutive days with a 35-mm camera. Resulting photographs were examined and the sex and age class of deer seen recorded. Results suggest a population of 32.9 animals with a density of 7.74 deer/km^2 (20.0 mi^2) and a sex ratio of 67 bucks per 100 does. Age structure among the male segment of the population was relatively balanced with mature (≥2.5 yrs old) animals constituting 45% of the total. When results of the 2000 census are compared to data obtained in 1999, the sex and age structures remained essentially unchanged, but the population increased 15% and the doe/fawn ratio improved from 6:1 to 3:1. This indicates an increase in fitness among the reproductive segment of the population over a 2-year period.

STATUS OF ORGANOCHLORINE POLLUTANTS IN TERRESTRIAL AND AQUATIC ENVIRONMENTS OF WESTERNMOST KENTUCKY: BIOLOGICAL INDICATORS

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ABSTRACT. The westernmost Kentucky (Purchase Area) is endowed with variety of industries and state-of-the-art agricultural operations. Industrial and agricultural chemical pollutants such as polychlorinated biphenyls (PCBs), chlorinated pesticides and organotin compounds are known to contaminate terrestrial and aquatic environments of this region. The organachlorine (PCBs, DDTs, hexachlorobenzene, chlordane compounds etc) and organometallic (*mono*-, *di*-, and tributyltins) pollutants are of particular concern because these compounds are persistent, bioaccumulative and toxic and linked to cancer and/or other health effects in wildlife and humans. Biomonitoring of pollutants is a useful tool to evaluate the status or health of an ecosystem. Pine needles and bivalve mollusks have been demonstrated as excellent biomonitoring matrices for the evaluation of the tropospheric and aquatic contamination by these organochlorine and organometallic compounds. A consortium of MSU researchers has amassed bioindicator data to evaluate the extent of contamination by these toxic chemicals during the past several years. The authors have compiled and compared levels of pollutants in both terrestrial and aquatic ecosystems of the region. The results revealed that, in general, contamination levels of PCBs, and chlorinated pesticides were lower than in other severely contaminated sites. The pine needles data revealed that samples from the vicinity of Calvert City Industrial Complex (CCIC) and "downwind" from CCIC showed elevated concentrations of organochlorine compounds when compared to residential, undeveloped sites. Detectable levels of 4,4'-DDT and 4,4'-DDD in mussel tissues and sediment samples from Kentucky Lake and Kentucky Dam tailgate indicate the recent input of these chemicals. A wide range of concentrations of butylating in lowermost Tennessee River and Kentucky Lake sediments and mussel tissues suggest the presence of localized areas of contamination by these compounds.