PROCEEDINGS OF THE

TENTH SYMPOSIUM

ON

THE NATURAL HISTORY OF
LOWER TENNESSEE AND CUMBERLAND RIVER VALLEYS

BRANDON SPRING GROUP CAMP
LAND BETWEEN THE LAKES
MARCH 21 AND 22, 2003

SPONSORED BY

AUSTIN PEAY STATE UNIVERSITY
THE CENTER OF EXCELLENCE FOR FIELD BIOLOGY
AND
MURRAY STATE UNIVERSITY
CENTER FOR RESERVOIR RESEARCH
AND
U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE
LAND BETWEEN THE LAKES NATIONAL RECREATION AREA

PROCEEDINGS OF THE

TENTH SYMPOSIUM

ON

THE NATURAL HISTORY OF LOWER TENNESSEE AND CUMBERLAND RIVER VALLEYS

BRANDON SPRING GROUP CAMP
LAND BETWEEN THE LAKES
MARCH 21 AND 22, 2003

SPONSORED BY

AUSTIN PEAY STATE UNIVERSITY

THE CENTER OF EXCELLENCE FOR FIELD BIOLOGY

AND

MURRAY STATE UNIVERSITY

CENTER FOR RESERVOIR RESEARCH

AND

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE

LAND BETWEEN THE LAKES NATIONAL RECREATION AREA

PROCEEDINGS OF THE 10th SYMPOSIUM ON THE NATURAL HISTORY OF LOWER TENNESSEE AND CUMBERLAND RIVER VALLEYS

HELD AT BRANDON SPRING GROUP CAMP
LAND BETWEEN THE LAKES
MARCH 21 AND 22, 2003

Sponsored by:

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

and

The Center for Reservoir Research
Murray State University, Murray, Ky.

and

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

****

EDITED BY:

Laurina I. Lyle, Edward W. Chester and A. Floyd Scott
The Center of Excellence Field Biology
Austin Peay State University, Clarksville, Tenn. 37044

Published by and available from:
The Center of Excellence for Field Biology,
Austin Peay State University, Clarksville, Tenn. 37044

Price: $5.00

SUGGESTED CITATION

Lyle, L.I., E. W. Chester, and A. F. Scott. 2003. Proceedings of the 10th Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center of Excellence for Field Biology, Austin Peay State University, Clarksville, Tenn.

Published
September 2003

PREFACE

The 10th Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys was held at Brandon Spring Group Camp in TVA's Land Between The Lakes on March 21 and 22, 2003. This biennial gathering of naturalists, field biologists, educators and others interested in related topics was sponsored by The Center of Excellence for Field Biology at Austin Peay State University, the Center for Reservoir Research at Murray State University and U.S. Department of Agriculture (USDA), Forest Service, Land Between The Lakes National Recreation Area.

The symposium began Friday afternoon with brief welcoming comments from representatives of the three sponsoring institutions. Representing Austin Peay State University and The Center of Excellence for Field Biology were its co-directors, Dr. Mack Finley and Dr. Steven Hamilton. Dr. David White, director of the Hancock Biological Station, spoke on behalf of Dr. Gary Bogess, dean of the College of Arts and Sciences at Murray State University. Barry Haley, manager of business performance, represented the USDA Forest Service Area Supervisor William Lisowski. Three invited presentations related to the symposium theme "A Sustainable Future Through Research and Education" followed. The topic of sustainability was approached from three different disciplinary directions: environmental education, scientific and literary. Hamilton moderated the presentations.

The first speaker, Dr. Nicholas Smith-Sebasto, associate director of the New Jersey School of Conservation, Montclair State University, presented, "Environmental Education and Research 'Needs?' for a Sustainable Future." He addressed the educational intricacies and issues complicating solutions towards deriving a sustainable future. Dr. James Karr, University of Washington, followed with "Protection Ecological Health: Challenge for the 21st Century." Known both nationally and internationally for the advancements he has made to aquatic systems assessment, Karr, using a power point presentation, urged scientists and citizens to find better ways to measure environmental health. The invited speakers afternoon session ended with Dr. John Tallmadge, the Union Institute and University. Tallmadge is a professor of environmental studies and nature writer whose work appears frequently in nature magazines such as *Orion Magazine*. His presentation was an excerpt from a book in progress, *The Cincinnati Arch*. Written reports of all three presentations are included in these proceedings.

Friday evening speaker was Tom Butler, director of education and advocacy, wildlands project and editor of *Wild Earth* Journal. Butler presented, "Thinking About Sustainability in Facinorous Times." The primary focus of his presentation was to highlight the Wildlands Project's vision of wilderness recovery and protection in North America through large-scale wildlands conservation planning. Butler used a power point presentation to deliver his talk. He challenged the audience by providing several novel and alternative routes of conservation planning. The lively conversation that precipitated from Butler's presentation continued later in the evening during the informal social gathering.

Contributed papers were read Saturday morning. Two sessions were held. Session I, "Botany" had 23 presentations and was moderated by Dr. Edward W. Chester. Session II, "Aquatic Biology and Zoology," with 17 talks, was moderated by Dr. A. Floyd Scott. Contributors were invited to publish an abstract, short communication or full paper in these proceedings. While most opted to publish an abstract, 11 full-length papers are presented in these proceedings, nine from Session I and two from Session II.

The style and format of these proceedings follow that established in previous proceedings of these symposia. Laurina Lyle organized and edited the preface and the invited papers; Chester edited abstracts and papers from Session I; and Scott edited abstracts and papers in session II. Lyle brought all these papers together into the final format.

ACKNOWLEDGMENTS

The editors thank Elizabeth Murray for assistance in organizing and coordinating activities leading up to and throughout the symposium. We also recognize the participation of many APSU Center of Excellence for Field Biology undergraduate and graduate research assistants for their help before and during this biennial event. The help of these individuals and others who may have been unnamed 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 enhances the quality of these proceedings.

SYMPOSIUM REGISTRANTS

Following, in alphabetical order, is a list of those individuals who registered at the 2003 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.; **Devon Anderson,** Austin Peay State University, Clarksville, Tenn.; **Catherine Aubee,** Murray State University, Murray, Ky.; **Dana M. Ball,** Tennessee Izaak Walton League, Knoxville, Tenn.; **Mary Ball,** Carson-Newman College, Johnson City, Tenn.; **Rex Barber,** Volunteer State Community College, Lebanon, Tenn.; **Joe Barnes;** GTx Inc., Memphis, Tenn.; **Carol Baskin,** University of Kentucky, Lexington, Ky.; **Jerry Baskin,** University of Kentucky, Lexington, Ky.; **Claude Bailey;** TDEC—DNH; **Jane Bensor;** Murray State University, Murray Ky.; **Steve Bloemer;** USFS; **Charles Boehms;** Austin Peay State University, Clarksville, Tenn.; **Jessica Boynton,** Murray State University, Murray, Ky.; **Tim Brown,** Austin Peay State University , Clarksville, Tenn.; **Angelo P. Bufalino,** Saint Louis University, St. Louise, Mo.; **John Butler,** Austin Peay State University, Clarksville, Tenn.; **Tom Butler,** Wildlands Project, Richmond, Vt.; **Willodean Burton,** Austin Peay State University, Clarksville, Tenn.; **David Cano,** Murray State University, Murray, Ky.; **Edward Chester,** Austin Peay State University, Clarksville , Tenn.; **Zacchaeus Compson,** Western Kentucky University, Bowling Green, Ky.; **Terry Derting,** Murray State University, Murray, Ky.; **Hal DeSelm,** UT-Knoxville, Knoxville, Tenn.; **Chris Eden,** Murray State University, Ky.; **Melissa Engleman,** Murray State University, Murray, Ky.; **Dwayne Estes,** Middle Tennessee State University, Columbia, Tenn.; **Forest Evans,** TDEC-DWH, Joelton, Tenn.; **Mack Finley,** Austin Peay State University, Clarksville, Tenn.; **Elizabeth Fitch,** Middle Tennessee State University, Winchester, Tenn.; **Kevin Fitch,** ACS Conservation, Arnold AFB, Tenn.; **Scott Franklin,** University of Memphis, Memphis, Tenn.; **Gary Gerald,** Middle Tennessee State University, Murfreesboro, Tenn.; **Hannah Gillis,** University of Minnesota, Minneapolis, Minn.; **Stephanie Gunn,** Austin Peay State University, Clarksville, Tenn.; **Deborah Hamilton,** Logan-Todd Regional Water Company, Guthrie, Ky.; **Steven Hamilton,** Austin Peay State University, Clarksville, Tenn.; **Mark Hatfield,** Murray State University, Murray, Ky.; **Joell Hill,** Murray State University, Murray, Ky.; **Michael Hill,** APSU/VSCC, Clarksville, Tenn.; **Terri Hogan,** NPS, Stones River National Battlefield, Murfreesboro, Tenn.; **Kyle Hurt,** Middle Tennessee State University,Tenn.; **Robert Hoyt,** Western Ky.; University, Bowling Green, Ky.; **Justin Hunteman,** Murray State University, Murray, Ky.; **Rhonda Johnston,** Austin Peay State University, Clarksville, Tenn.; **Tim Johnston,** Murray State University, Murray, Ky.; **James Karr,** University of Washington, Seattle, Wa.; **Rob Kinsolver,** Kentucky Wesleyan College, Owensboro, Ky.; **George Kipphut,** Murray State University, Murray, Ky; **John Koons,** Jackson State Community College, Jackson, Tenn.; **Bommanna Loganathan,** Murray State University, Murray, Ky.; **Joe Lambrix,** Murray State University, Murray, Ky.; **Leslie Latta,** Austin Peay State University, Clarksville, Tenn.; **Pat Lawless,** University of Kentucky, Lexington, Ky.; **Jeff Lebkeucher,** Austin Peay State University, Clarksville, Tenn.; **Laurina Lyle,** Austin Peay State University, Clarksville, Tenn.; **Patrick McKenney,** Kentucky Wesleyan College, Owensboro, Ky.; **John Mcan,** Austin Peay State University, Clarksville, Tenn.; **Steve Murphree,** Belmont University, Nashville, Tenn.; **Elizabeth Murray,** Austin Peay State University, Clarksville, Tenn.; **Jimmy Mynes,** University Tennessee Knoxville, Knoxville, Tenn.; **Burl Naugle,** Murray State University, Murray, Ky.; **Adam Neblett,** APSU, Clarksville, Tenn.; **Clint Neel,** Tennessee Technical University, Cookville, Tenn.; **William J. Oliver,** Western Kentucky University, Bowling Green, Ky.; **Nathan Parker,** Austin Peay State University, Clarksville, Tenn.; **Zach Pelham,** Austin Peay State University, Clarksville, Tenn.; **Amanda Roberts,** Austin Peay State University, Clarksville, Tenn.; **Danielle Roberts,** Austin Peay State University, Clarksville, Tenn.; **Adriana Sautu,** University of Kentucky, Lexington, Ky.; **Joe Schiller,** Austin Peay State University, Clarksville, Tenn.; **Joe Schibig,** Volunteer State Community College, Portland, Tenn.; **Floyd Scott,** Austin Peay State University, Clarksville, Tenn.;

Nicholas Smith-Sebasto, Montclair State University, New Jersey School of Conservation, Branchville, Nj.; **Chris Somerlot,** MurrayState University, Murray, Ky.; **Kelly Somerlot,** Murray State University, Murray, Ky.; **Bill Spencer,** Murray State University, Murray, Ky.; **Jeremy Spiess,** Middle Tennessee State University, Murfreesboro, Tenn.; **Rachael Sulkers,** Middle Tennessee State University, Murfreesboro, Tenn.; **John Tallmadge,** Union Institute & University, Cincinnati, Oh.; **Ralph Thompson,** Berea College, Ky.; **Valorie Titus,** Murray State University, Murray, Ky.; **Mark Vance,** Volunteer State Community College, Gallatin, Tenn.; **Jeffrey Walck,** Middle Tennessee State University, Murfreesboro, Tenn.; **Thad Wasklewicz,** University of Memphis, Memphis, Tenn.; **David White,** Murray State University, Murray, Ky.; **Howard Whiteman,** Murray State University, Murray, Ky.; **David Withers,** TDEC-DNH; **Ed Zimmerer,** Murray State University, Murray, Ky.

TABLE OF CONTENTS

CONTRIBUTED PAPERS – SESSION II: AQUATIC BIOLOGY AND ZOOLOGY

INVITED PAPERS

A SUSTAINABLE FUTURE THROUGH RESEARCH AND EDUCATION

Friday, March 21, 2003

Moderator and Editor:

Steven W. Hamilton
Austin Peay State University

ENVIRONMENTAL EDUCATION AND RESEARCH OPPORTUNITIES (NEEDS?) FOR A SUSTAINABLE FUTURE

NICHOLAS J. SMITH-SEBASTO, PH.D.

Montclair State University, New Jersey School of Conservation, Branchville, NJ 07826-5116

ABSTRACT. The current environmental crisis is the result of a failure of education and research. If we are to realize a sustainable future, substantial changes to the way we educate our citizens and to the research we conduct both into educational theory and practice and Earth systems must be made. We must change the 'direction' in which we are educating our children and adults concerning the environment and environmental issues and we must change the 'direction' in which we are conducting environmental education research. And, these changes must be substantive; they simply cannot be as Linden observed has been American's "troubling" response to other environmental issues: "with rhetoric and theater". Environmental education must be the change agent for a sustainable future. In this paper I identify several changes in education and research that might support the quest for sustainability.

In 1995, I was invited to present a paper at the Third Conference on Communication and Our Environment in Chattanooga. At the conference I had the privilege of hearing David Crockett, then a city council member, speak. During his talk he related a story about sustainable development. Nearly 10 years after I heard it, I still think often about the relevance of it. It turns out that just prior to the conference President Clinton and Vice-President Gore honored Chattanooga with the distinction of a sustainable city. As I recall, Mr. Crockett explained his interpretation of what it will take to achieve sustainability this way

> *There is an interstate highway just to the south, interstate 40. It runs between Memphis and Nashville. Now, if you want to get to Nashville and you get on 40 heading west, slowing down will not get you there. All it will do is get you further and further from your destination, while prolonging the anguish of being lost. In order to get to Nashville, you would have to stop and turn around and go in an opposite direction.*

While I've adapted Mr. Crockett's highway to be relevant to this presentation, I believe his assessment of the quest for sustainability is absolutely applicable to the role of environmental education and research: nothing short of changing direction will get us to our desired destination of a sustainable future. My thesis is, therefore: The current environmental crisis (more on why it is a crisis shortly) is the result of a failure of education and research. If we are to realize a sustainable future, substantial changes to the way we educate our citizens and to the research we conduct both into educational theory and practice and Earth systems must be made. We must change the 'direction' in which we are educating our children and adults concerning the environment and environmental issues and we must change the 'direction' in which we are conducting environmental education research. And, these changes must be substantive; they simply cannot be as Linden observed has been American's "troubling" response to other environmental issues: "with rhetoric and theater" (p. 86). We must be ever vigilant and mindful of advice Einstein (quote in Calaprice, 2000) offered

The world we have created today as a result of our thinking thus far has problems which cannot be solved by thinking the way we thought when we created them (p. 317).

How Pressing is the Environmental Crisis?

In November 1992, the Union of Concerned Scientists (UCS) released *The World Scientist' Warning to Humanity* (http://www.ucsusa.org/ucs/about/page.cfm?pageID=1009). The late Dr. Henry Kendall, former chair of the UCS's board of directors wrote the *Warning* and circulated it among most of the world's leading scientists. If they agreed with what he wrote, he asked them to endorse it. Nearly 1,700 scientists, including most of the living Nobel laureates in the sciences, did so.

The *Warning* began:

Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know. Fundamental changes are urgent if we are to avoid the collision our present course will bring about

It concluded:

We the undersigned, senior members of the world's scientific community, hereby warn all humanity of what lies ahead. A great change in our stewardship of the earth and the life on it is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated.

Curiously, of the five actions that the *Warning* suggested must be addressed, neither education nor research were mentioned.

The substance of the *Warning* was supported (and largely reiterated) by a report released 8 years later by the Johns Hopkins University School of Public Health, in which it was stated:

As the century begins, natural resources are under increasing pressure, threatening public health and development...In the past decade in every environmental sector, conditions have either failed to improve, or they are worsening. (Hinrichesen & Robey, 2000, p. 1).

Despite the similarity of these forecasts, warnings of comparable urgency have been issued decades, even over a century, ago. Marsh (1867), for example wrote of the "hostile influence of man [sic]" (p. 35) and the "terrible destructiveness of man [sic]" (p. 37). Osborn (1948) wrote:

the present world-wide disturbances in human civilization can at least partially be accounted for by the havoc...that [humans are] working upon [the] *environment. These disturbances will unquestionably increase in violence, even to the point of social disintegration, if the present velocity of destruction of the [E]arth's living resources continues. [Humans have] it in [their] power to remedy enough of the damage that [they have] caused to permit the survival of [their] civilization. The question is, Will [they] do it and will [they] do it in time?* (pp. 30-31).

Nearly 15 years later, Carson (1962) was still able to write about humanity's "war against nature" (p. 7) and to declare that

The most alarming of all [humaniy's] assaults upon the environment is the contamination of air, earth, rivers, and sea with dangerous and even lethal materials (p. 6).

Rodale and staff (1964) warned that

We stand now in danger of inoculating the whole biosphere, ourselves included, with a dose of poison, before our scientists have had time to determine whether or not it will be fatal (p. 9).

Commoner (1974) added that

Any living thing that hopes to live on the [E]arth must fit into the ecosphere or perish. The environmental crisis is a sign that the finely sculptured fit between life and its surroundings has begun to corrode. As the links between one living thing and another, and between all of them and their surroundings, begin to break down, the dynamic interactions that sustain the whole have begun to falter and, in some places, stop (pp. 7-8).

Observations such as these beg the question posed by LaChapelle (1978) 25 years ago, which is still as valid today as it was then:

How did we reach such a state of insanity? [Where ecologically unsustainable behaviors predominate; where the ability of Earth to sustain life is questioned.] Can we honestly believe that the human being, a product of 3 billion years of evolution, came into the world totally cut off from the entire process? (p. 60).

One could substitute the word 'stupid' for insanity, for as Bowers (1995) suggested

In ecological terms being stupid means relying on patterns of thought and behavior that contribute to the destruction of natural systems upon which human life depends....the curriculum of...schools and the ideology of educators are contributing to a form of intelligence that leads to stupid behavior in an ecological sense (p. 115).

Surprisingly, and regardless of whether the perception is one of insanity or stupidity, the answer to these questions may be found by a critical examination of education. As Orr (1992) suggested,

> *Nearly all discussions about the transition to a sustainable society have to do with what governments, corporations, and individuals must do. But one thing that these have in common are people who were educated in public schools, colleges, and universities. We may infer from the mismanagement of the environment throughout the century that most emerged from their association with these various educational institutions as ecological illiterates, with little knowledge of how their subsequent actions would disrupt the Earth...the ecological crisis represents, in large measure, a failure of education* (p. x.).

Spirn (2001) extended this sentiment with her observation that

> *Some of the most challenging issues facing the United States today are the result of well-intentioned policies [presumably education policies included], which had far reaching, unanticipated consequences besides their desired effect* (p. 165).

So, despite the commendable intention of creating an educated citizenry, which has for the most part been accomplished to varying degrees, the education itself, that is one of the belief that humans are somehow not obligated to understand or to comply with Earth's myriad life support systems, has resulted in the unanticipated consequence of a generation (or more) of ecological illiterates and, as a result, societies who consistently behave in environmentally irresponsible manners.

Gigliotti (1990) supported this condition with his observation of the effectiveness of EE when he opined that

> *environmental education has produced ecologically concerned citizens who, armed with ecological myths, are willing to fight against environmental misdeeds of others but lack the knowledge and conviction of their own role in the environmental problems...the necessary changes in values have not really occurred. Instead, people have selectively screened the environmental education messages and constructed belief structures to support their own value systems rather than alter their lifestyles to any great degree.... We seem to have produced a citizenry that is emotionally charged but woefully lacking in basic ecological knowledge* (p. 9).

Weilbacher (1993) echoed this sentiment with his assertion that

> *although students are more environmentally aware, more interested, and more willing to take action, they have never been more ecologically illiterate than they are today* (p. 5).

The Independent Commission on Environmental Education (1997) concluded that after *twenty-five years of experience in environmental education, children still do not know much about the environment (p. 7).*

It may be argued, and supported with some data, that some adults are equally ignorant about the environment, and that both some children and some adults are also ignorant about both many environmental issues and the actions they may take to contribute to the resolution of environmental problems.

Barnett (2001) offered hope, however, with his suggestion that

knowing that public policies helped create today's problems, it is reasonable to expect that public policies can help correct them (p. 3).

Extended to education and research, his observation would be: knowing that education and research helped to create today's environmental problems, it is reasonable to expect that education and research can help correct them. But, what changes to education and research are needed to bring about the change? Maloney and Ward (1973) may have provided early insight into this question when they argued that

the ecological crisis is a crisis of maladaptive human behavior...the solution [for which] lies with the sciences that deal with changing human behavior (p. 583).

So, what is needed is education, and research that supports said education, that changes human behavior. Education that changes the consumptive, ecologically degrading behavior of the majority of humanity, where a word, environmentalist, had to be coined to describe the conduct of those who do not degrade the environment since such conduct is the exception rather than the rule, to ecologically responsible, non-degrading behavior of the majority of humans.

Like VanMatre (1990) who stated, "the point of environmental education is change; if there is no change, there is no point" (p. 19) and Hungerford (2002) who stated, "Any professional educator worth his or her salt knows very well that education does focus on behavior" (p. 8), I believe environmental education must be the change agent for a sustainable future. These opinions are supported by the perception of the International Commission on Environmental Education (1997), which suggested that

engendering a stewardship ethic is clearly an appropriate goal for...education.... Environmental education...is a legitimate area of investigation for anyone who cares both about education and the future protection and sustainable use of our natural resources (p. 5).

I believe Terry (1971) was prophetic when he titled his handbook for environmental education, *Teaching for Survival.* I believe VanMatre (1993) was correct when he stated *"Environmental education [is] the most important learning of the millennium...."* (p. 14). It was important in the millennium in which he wrote it; it may be even more important in this millennium. Unfortunately, as Hungerford and his colleagues (1989) observed *there is far too little known about what precedes or stimulates environmentally responsible behavior even though educational philosophers have written about it and a number of researchers have tried to investigate it* (p. 1).

And, I add, a number of educators have tried to encourage it.

To address Jickling's (1992) questions,

Should education aim to advance a particular end such as sustainable development? Is it the job of education to make people behave in a particular way? (p. 7),

and to present an argument counter to his, my answer is an emphatic yes. I think the real questions should, perhaps must, be: if education does not aim to advance a particular end such as sustainable development, what will? Whose job is it to make people behave in ecologically sustainable ways? If we follow Jickling's logic, then appropriate questions for other fields might be: should education aim to advance a particular end such as safe sex? Is it the job of education to make people behave in a way that reduces the transmission of sexually transmitted diseases? I think most people would agree that it is indeed the role of education to do precisely this. The field of health education, for example, focuses heavily on behavior encouragement or change. Anyone who has a child knows that hand washing after visiting the bathroom is a behavior which must first be taught and then be conditioned to occur. Similarly, behavior that does not degrade the environment and that supports a sustainable future must first be taught and then be conditioned to occur.

To be this change agent for environmentally responsible behavior adoption, environmental education practitioners must consider several factors. First, transition to a sustainable society requires recognition of the root cause(s) for lack of sustainability. Regardless of whether it is religious (cf. White, 1967), cultural (cf. Moncrief, 1970), biological (cf. Chiras, 1992), or as I, and others have argued, because of education and research, curing the symptom will not cure the cause. To paraphrase Thoreau (1854), there are a thousand hacking at the symptoms of environmental degradation to one who is striking at the root (p. 98). Much of what is being offered as education and/or research that will support sustainability is little more than what Crockett would likely describe as "slowing down".

I believe the answers to the questions, "What changes are needed concerning education" and "What changes are needed concerning research" are as obvious (or should be) as those to which White (1904) referred when trying to explain how it was he was able to see deer, which he suggested was "in the elimination of the obvious rests the whole secret of seeing deer in the woods....As soon as you can forget the naturally obvious and construct an artificially obvious, then you too will see deer" (pp. 122-23). So, for sustainability matters, we must focus not on the obvious about too many learners: lack of ecological literacy, lack of affective domain connections to the environment, lack of knowledge of how to and commitment to behave in environmentally responsible manners, lack of data about how to encourage the adoption of and sustained performance of environmentally responsible behaviors, etc., and construct the artificially obvious so that we may see the root cause of the challenges associated with sustainability.

That the field of environmental education should, perhaps must, rise to this challenge is entirely appropriate, if not long overdue. Consider, for example, the recommendation of Lynch and Hutchinson (1992) made during a colloquium at the National Academy of Sciences, where they stated

> *The entire academic enterprise needs...a new focal point....Accompanying the need for the advancement of environmental knowledge, there is a concomitant need for authoritative environmental leadership in the form of dedicated practitioners across the organizational landscape, with continuing exposure to environmental research and a shared commitment to objective environmental analysis. The environmental challenge is permanent–it will never go away. Because of this permanence, it is appropriate to anticipate the development of a* ***new profession****, focused fundamentally on the environment and standing alongside the established professions. This new profession would be devoted to synthesizing the diverse branches of environmental knowledge and research into a workable whole; to defining a suitable ethic relative to the environment; to developing the competent practice of environmental management in government and industry; and to maintaining a vigorous, independent research program focused on emerging problems* (p. 864, emphasis added).

When I read this report many years ago, I was reminded of a informal conversation I had with a new graduate student (not mine) at a conference (in the early 1990s) of the North American Associate for Environmental Education, during which she suggested to me that what was desperately needed in the field of EE was a journal dedicated to the discipline! How, I wondered at the time, could the field of EE be recognized for nearly 30 years and the *Journal of Environmental Education* be published for nearly as long and still scholars from an institution as prestigious as Dartmouth suggest that a new profession, which they identified in the title of their paper as "Environmental education", is needed or a graduate student be entirely unfamiliar with the oldest journal dedicated to the field? How, I also wondered, could nearly 30 years have passed since Stapp and his students and teaching colleague (1969) offered as a definition of EE the following

> *Environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution* (p. 31).

could other scholars suggest that precisely what already exists needs to be created?

The purpose of this paper is not to further criticize EE or EE research, but to construct the *artificially obvious* concerning education and research and to explore some 'root' opportunities (needs?) for them to contribute to a sustainable future.

I understand that this is a daunting prospect, however, I believe, as Kennan (quoted in Hershberg, 2001)[01] stated:

[01] No citation is provided for the quote, so its authenticity is questionable. I did contact the author, but he was unable to provide a citation. Professor Kennan was also contacted. While he indicated that the quote sounds like something he might have said, he, too, could not authenticate it.

history will not excuse the inadequacy of response because of the enormity of the challenge (p. 29).

And, to paraphrase Wallace (1863), if this is not done, future ages will certainly look back upon us as a people so immersed in the pursuit of ecological domination as to be blind to other considerations. They will charge us with having culpably allowed the continued ecological degradation which we had it in our power to avoid caused by ecologically illiterate masses which we had it in our power to educate. We certainly should not wish to learn a comparable lesson to the one E.O. Wilson (1994) learned during his time in Tennessee, namely

the greater problems of history [read sustainability] are not solved; they are merely forgotten (p. 132).

What Changes to Education Are Needed?

The first change that must be made to education is to stop treating environmental education and the topics traditionally covered under its auspices as an add-on to the approved and established curriculum. Education about the environment, how to live in an ecologically sustainable manner, and how to resolve existing environmental problems and how to avoid future ones, must become as essential as reading, writing, and arithmetic. These concepts must, however, be delivered at an age-appropriate level.

Related to this, we must stop debating over the semantics of whether or not environmental education and education for sustainability are the same. In 1996, The President's [Clinton] Council on Sustainable Development opined that

environmental education is evolving toward education for sustainability. Education for sustainability is not an add-on curriculum–that is, it is not a new core subject like math or science. Instead, it involves an understanding of how each subject relates to environmental, economic, and social issues (p. 73).

Yet, in February 2003, McKeown and Hopkins argued that EE is not the same as education for sustainable development (ESD), citing "puzzlement" and "dismay" when questions concerning the difference between the two and/or if EE is becoming ESD are posed (p. 117). This debate has been increasing recently, and I think it will only serve to diminish the credibility of the field. Such controversy will, I believe, only serve to further erode the credibility of the field at a time when its credibility has already been challenged (see, for example, Alder, 1993a; Alder, 1993b, Kwong, 1995; Sanera & Shaw, 1996; and Satchell, 1996;) and when the environment and education are under the greatest attacks they has seen in nearly a decade.

For pre-school through elementary grades, although this learning could, perhaps should, be life-long, especially in light of the increasing mobility of people, which results in many people being born in one area, growing up in another area, and living parts of their lives in still other areas, nature study is a critical missing link in formal education. As Anna Botsford Comstock (1994 edition) suggested, nature study *makes [a learner] familiar with nature's ways and forces,...cultivates [her/his] imagination,...cultivates...a love of the beautiful, [b]ut, more than all,...gives...a sense of companionship with life out-of-doors and an abiding love for nature* (pp. 1-2).

Orr (1992) suggested nature study (which he termed the study of natural history)

is concrete and requires direct involvement in nature. It requires firsthand knowledge of trees, animals, plant life, birds, aquatic life, marine biology, and geology....[It] forces us to deal with nature on nature's terms. It promotes the capacity not only to see but to observe with care, understanding, and, above all else, with pleasure (p. 136).

Golley (1998) echoed these sentiments with his suggestion that

[E]nvironmental literacy begins with experience of the environment (p. x).

This lack of this type of education, which is still common among many present-day aboriginal cultures and was common to many of the early settlers of North America, including inhabitants prior to the Europeans, but which remained an elusive part of the Western formal education until the efforts of Comstock, and regrettably, today are once again nearly non-existent in formal education, is to me the single greatest failing of the discipline called environmental education. As Flicker (1996) noted,

Environmental education...must be far broader than words on a page or images on a screen or even classroom learning. Thousands of Americans live far from the natural world, surrounded by the concrete and steel of cities or by the clapboard and cul-de-sac of suburbia. Those who do live close to the land too often have had limited exposure to the concept of stewardship of the [E]arth's resources (p. 6).

Perhaps, Jim Dunlop (1992) articulated this point most clearly when he wrote:

One of the saddest forms of alienation that currently exists...is the alienation of most people from the [E]arth itself and from the workings of natural systems whose operation is imperfectly understood....This alienation is chronic because education about the [E]arth and about the environment rarely entails more than the provision of facts about specific issues or problems (p. 80).

In our society we teach our children their A,B,Cs and 1,2,3s because it is generally accepted that to be unable to either read and write or to be unable to perform basic mathematical computations would put a child at a competitive disadvantage. We value the ability to read, write, and perform basic mathematical computations. So critical, so valuable, are these skills considered, that we assure that they are essential components of our childrens' formal education for 13 years. And my point here is not to challenge that notion. Rather, it is to stimulate debate about what kind of competitive disadvantage are we at as a species if we remain environmentally illiterate and do not become what I call species literate.

Heinz and Maguire (n.d.) reported, for example, that in Africa, a !Ko bushwoman is thought to have only average knowledge of local plant lore if she can identify and name 206 out of 211 plants in her domain in spite of the effects of a severe drought on the species' appearance. (That's like getting a letter grade of C after correctly answering 98 out of 100 questions on an exam!) Bushmen from the same domain have general botanical knowledge of at least 300 plants. Similarly, Conklin (1969) noted that in the Philippines, Hanunóo farmers can identify more than 450 animals and 1,600 plants! Of these 1,600 plants, 1500 are considered "useful," and 430 of them are grown deliberately for their unique medicinal or other properties. Because they have such a refined classification scheme, the Hanunóo plant categories outnumber the taxonomic species classified by botanists by 400! All over the world other cultures are able to identify their plant and animal brothers and sisters, classify their soils, predict the best days to plant or harvest crops based on phases of the moon, predict weather changes by observing cloud patterns, etc., to a much higher degree than many in the so-called educated cultures. Here in the U.S., for example, I have been asked by supermarket checkout clerks to identify such items as spinach and nectarines! This was not always the case. Early European settlers of North America, for example, treated sore throats with yellowroot (*Xanthorhiza simplicissima*), knowledge they no doubt obtained from Native Americans.

For more experienced learners, namely middle and high school, Earth systems education needs to be addressed more completely. Far too many learners know far too little about the life support systems of this planet. This semester, for example, I am teaching an introduction to environmental science course at a community college. For one of our lab experiences I had the students construct an evolutionary time line. We established a transect of 25 meters in which each meter was equal to 200 million years. The students were then challenged to place on the left side of the line a series of events in Earth's history at the time when they thought they occurred. I would then place the same events on the right side of the line at the time when the events are thought to have actually occurred. The most alarming inconsistency for me was when the students placed the formation of the moon at 20,000 years ago, the same as where they placed the age of the dinosaurs. These are students who have already completed 13 years of formal, structured, mandated education! That I, if I follow any number of college-level environmental science texts (which I do not), would have to teach the water cycle to post-secondary students is also cause for alarm. It would be like teaching the alphabet to college students. Still, my experience has been, and remains, that even the most basic of Earth systems remains completely unknown to the vast majority of people.

Cherrett (1989) provided some guidance about what is important to know if one is to be ecologically literate when he published the findings of a survey of the membership of the British Ecological Society in which the members were asked to rank order 50 key concepts in ecology in their order of importance, Odum (1992) provided a list or 20 great ideas in ecology, and Golley (1996) produced an excellent primer for environmental literacy. Additionally, few publications rival the importance of two of Hardin's contributions to the permanently archived literature. First, his 1960 essay, titled The Competitive Exclusion Principle, may be the most relevant scientific concept related to the current environmental crisis. Closely aligned is the work of MacArthur (1958) who proposed the concept of resource partitioning. These 2 concepts offer significant contributions to understanding species extinction and the concern over sprawl. Hardin's second contribution of major significance concerning ecological literacy is his 1968 classic, Tragedy of the Commons. Sprawl, species extinction, watershed degradation, and the list goes on, can all be traced to this concept. That an understanding of these concepts is not a prerequisite for graduation from high school is likely a root cause of the aforementioned environmental problems.

These concepts must be taught, however, in a context that is relevant and meaningful to the learner. This is why it is essential for nature study to come first. This will allow for the establishment of what Sobel (1996) called an "empathy between the [learner] and the natural world.... (p. 13). Nature study will "cultivate that sense of connectedness so that it can become the emotional foundation" (Sobel, p, 13) for the more cognitively challenging Earth systems science concepts. This is vital, for as Gould (1991) noted:

> *...we cannot win this battle to save species and environments without forging an emotional bond between ourselves and nature as well–for we will not fight to save what we do not love (but only appreciate in some abstract sense)* (p. 14).

I also think that embracing nature study before Earth systems science has the potential to diminish Leopold's (1966) warning that

> *One of the penalties of [environmental] education is that one lives alone in a world of wounds. Much of the damage inflicted [to the environment] is quite invisible to lay[people]. An [environmentally literate person] must either harden [her]his shell and make believe that the consequences of science are none of [her]his buisiness, or he[she] must be the doctor who sees the marks of death in a community that believes itself well and does not want to be told otherwise* (p. 197).

By understanding Earth systems based on an 'emotional foundation', a learner may be more likely to understand, and avoid, the 'maladaptive behavior' that is the root of the environmental problem in question. This may help reduce the potential for what Lazarsfeld and Merton (1957) called the narcotizing disfunction, which they explained as

> *Exposure to this [education] may serve to narcotize rather than to energize the [learner]. As an increasing amount of time is devoted to [learning], a decreasing share is available for organized action. The individual [learns] accounts of issues and problems and may even discuss alternative lines of action. But this rather intellectualized, rather remote connection with organized social action is not activated. The interested and informed citizen can congratulate [her]himself on [her]his lofty state of interest and information, and neglect to see that he[she] has abstained from decision and action. In short, he[she] takes [her]his secondary contact with the world of [ecological] reality, [her]his reading and listening and thinking, as a vicarious performance. He[she] comes to mistake* ***knowing*** *about problems of the day for* ***doing*** *something about them. He[she]* ***is*** *concerned. He[she]* ***is*** *informed. And he[she] has all sorts of ideas as to what should be done.* (p. 464).

They concluded this thought with the notion that at the end of the day, a person who exhibited a narcotized dysfunction would have accomplished little that tangibly affected the issue or problem. Clearly, when the level of concern about the environment as reported by various polling agencies is compared with the actual level of performance of environmentally responsible behavior, this phenomenon gains credibility.

Related to this dysfunction, is a sense of frustration and futility I have witnessed in too many students. For many of the nearly 500 undergraduate and graduate advisees I have counseled thus far in my career, I have met too many to have been ready to change majors or careers aspirations, as they were related to the environment, because too much of what they had or were learning in school was negative. Many programs, perhaps too many, tend to focus only on reactive or proscriptive studies, such as, waste water treatment, environmental pollution abatement, solid waste management, etc., that is, on those courses that deal with what is 'wrong' (at least that is how many students perceive it) with the environment, and not on the connective studies, that deal with what is good with the environment, and allow students to celebrate what attracted them to an 'environmental' major in the first place. Without the empathetic connection that is formed by nature study, many students quickly exhibit the symptoms about which Leopold warned. The work of Mitch Thomashow (1995) and Michael Cohen (1997) are outstanding examples of how to help students overcome such 'penalties'.

By understanding Earth systems and by having an empathetic connection with nature, which will make the understanding of the systems meaningful, learners may be able to more fully comprehend the suggestion by McNeely and Sochaczewski (1988) that people "would be well advised to bear in mind the popular Minangkabua (ethnic group or the west Sumatar) proverb, 'Alam terkembang menjadi guru', which loosely translated means 'you will never go wrong if you take nature as your teacher'" (p. 323). The problem as I see it is that too few people understand Earth systems, so when (if, really) people consider Leopold's (1966) suggestion that

> *A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise* (p. 262).

and try to take nature as a teacher, too few have even a nominal (Roth, 1991) level of environmental literacy and are, for example, unaware of what is a biotic community what represents integrity and stability in it.

This brings me to what should be part of the educational experience of more advanced learners, namely high school and post-secondary learners. At this stage, relying on the 'emotional foundation' and the knowledge of Earth systems in a symbiotic manner, learners may then be prepared to investigate and evaluate environmental issues (Yes, I believe that even with the aforementioned situational antecedents, environmental problems will exist, it's part of the human condition–at least for extractive, carbon-based cultures whose magnitude of scale of environmental degradation is substantial enough to compromise ecosystem processes.) to determine 1) if the issue is one that is of concern and represents an environmental problem, and 2) if action must be taken to resolve the problem. It will serve no purpose to create a generation or more of persons who have an empathetic connection with nature, a firm grasp of Earth systems, and yet take no action to either sustain the quality of the environment or to reduce degradation of the environment. As Roth (1991) suggested

> *A person who is environmentally aware is not yet environmentally literate; nor is a person who possesses broad environmental understanding; nor is one who demonstrates great environmental concern; nor necessarily one who takes action*

on environmental issues. One demonstrates operational environmental literacy only when all the components come together in the actions taken (p. 44).

What Changes to Research Are Needed?

I have already produced an analysis of the pros and cons in EE research (Smith-Sebasto, 1998, 2001). I wish, however, to reiterate a few points: 1) we must also stop debating over which method of inquiry is superior. As Hungerford (1996) suggested

> *arguments about the 'goodness' of alternative paradigms simply must stop. The key to using any paradigm rests with the validity of the research itself and not which paradigm is used.*

2) studies employing quantitative methods of inquiry should use research designs more resistant to internal and external validity threats. Using, for example, a Solomon Four-Group Design instead of a Pretest-Posttest Control Group Design (Campbell & Stanley, 1963, p. 8); and 3) qualitative methods of inquiry, especially grounded theory approaches, should become more common.

Now, I will address specific recommendations which I did not in that analysis. If humanity and nature are indeed on a collision course and if the attendant environmental crisis is the result of human behavior, then if EE is to fulfill this role, it must be guided by research the clearly identifies the areas of need as well as the most appropriate direction for progress. Rather than debate paradigms, I believe it is essential for researchers to fix their sights on the seminal questions surrounding ecologically sustainable development and to pursue them with extreme prejudice and with the most appropriate research methodologies to answer the questions.

The seminal questions I think need to be addressed include:

> *Is the current model of human industrial development ecologically sustainable? That is, are the current models societies are using to either advance their industrial processes or to develop an industrial base compatible with the life support systems of the planet?*

If the answer is no, as many believe it is, then EE does, indeed, have a reason to exist. The key question then becomes:

> *What, precisely, is it about the models of industrial development that are not ecologically sustainable?*

Before educational interventions can be prescribed, a diagnosis must be made. Observation of symptoms will sometimes be sufficient, however, such cursory assessments will frequently be rejected until more tangible evidence is available. The key question then becomes:

> *What, precisely, do learners need to know in order to make the shift from ecologically unsustainable behaviors to ecologically sustainable behaviors?*

The specific needed changes in knowledge, attitudes, and behaviors must be identified before educational interventions may be developed. These changes must be related directly to the quest for ecological sustainability. Change for the sake of change will not likely result in any benefits to society. Now, the question for EE researcher is:

> *What is the most effective strategy to maximize the likelihood that the educational effort will produce the desired change?*

Unlike in Kevin Costner's *Field of Dreams*, EE is not a 'create it and they will provide it' or a 'provide it and they will learn it' situation. EE instruction may be designed, and teachers may provide it, but learners may not learn 'it'. It is imperative that EE research efforts directed at formative and summative evaluation of curriculum intensify. The field (some argue society) cannot afford to squander teachable moments. Not only is a mind a terrible thing to waste, an educational opportunity is also a terrible thing to waste.

I think an excellent example of how EE research must expand its scope involves research into environmentally responsible behavior (ERB). For over 30 years researchers have attempted to identify its situational antecedents, focusing largely on psychometric variables or personological characteristics. The prevailing hypotheses have been that if the characteristics strongly correlated with the performance of environmentally responsible behaviors could be identified, they could then be targeted for instigation.

Locus of control of reinforcement (LOCR) emerged early as a correlate to ERB performance. LOCR is refers to a psychological construct which emerged from Rotter's Social Learning Theory (1954), which states that

> *the potential for behavior to occur in any specific psychological situation is a function of the expectancy that the behavior will lead to a particular reinforcement....* (Rotter, 1975, p. 57).

Rotter (1966) described two orientations for the perceived expectancy of reinforcement: internal and external. Other investigators have proposed alternative descriptions. The basic assumptions of the construct are: individuals with an internal perceived expectancy of reinforcement (an internal orientation for LOCR) believe that their behavior or their personal characteristics have the potential to effect the outcome of a situation, in the way they wish it to be affected. Individuals with an external perceived expectancy of reinforcement do not believe their behavior or their personal characteristics have the potential to effect the outcome of a situation. Research has demonstrated that people can change their orientation from internal to external and vice versa. From a sustainability perspective, clearly it is advantageous to have as many individuals as possible believe that their behavior or personal characteristics will contribute to the quest for a sustainable future. If environmental education can change a person's expectancy of reinforcement from one of believing that her/his behavior will not contribute to the quest for a sustainable future to one of believing that her/his behavior will contribute to the quest for a sustainable future, then, it is presumed, such education should be provided, again, with extreme prejustice.

Efforts to investigate the relationship between LOCR and ERB have been progressing since the early 1970s. So, while the contributions of those scholars who have investigated this relationship, and I am one of them, has been productive, I think it is alarming that EE researchers have not expanded their horizons and investigated other variables that may even better predictors of ERB than LOCR. There seems to be a bandwagoning effect in place.

As a Consulting Editor for the Journal of Environmental Education since 1994, during which time I have reviewed over 70 submissions; and an a member of the International Editorial Board for Environmental Education Research since 1995, during which time I have reviewed over 20 submissions, I have grown increasing alarmed by the lack of research into other variables that may serve as even better predictors/instigators of ERB.

There are two constructs which I believe may hold substantial potential to improve our understanding of the factors that either instigate or sustain the performance of ERB: locus of causality for behavior originally proposed by Heider (1958) and then modified to the personal causation construct by deCharms (1968), and the need for control construct proposed by Korteland (1989).

Locus of control of reinforcement and locus of causality for behavior are often confused. This is because some researchers have used the used only

> *the partial phrases 'locus of control' and 'locus of causality'. These partial phrases leave out the critical distinctive features of the two concepts, namely, reinforcement and behavior* (deCharms, 1981, p. 338).

Since behavior change appears to be the ultimate objective of EE, clearly research is needed into psychological constructs that may influence behavior.

Need for control is defined as

> *the perception that individuals have that they are motivated to direct themselves and their environment* (Korteland, 1989, p. 27).

The idea is that some people exhibit the trait of needing to control the events in their lives. As Korteland (1989) suggested

> *For years, researchers have suggested that the need to control the events in one's life is an important psychological dimension....*(p. 27).

I believe environmental education researchers should consider the question: What effect does the trait need for control have on people's performance of environmentally responsible behaviors? It may well be that the reason so few people actually behave in ways that will contribute to a sustainable future is because they either do not believe that their behavior will effect the outcome of a situation (locus of control of reinforcement), that they may have no "ownership of action" (deCharms, p. 338) (personal causation), or they may not need to be in control of the condition of the environment. While the research literature on the relationship between LOCR and ERB is many decades old and robust in the number of efforts to investigate the relationship, the literature on the relationship between PC/LOCB and NFC and ERB remains a *tabula rasa*. This must change if we are to succeed in the quest for a sustainable future.

We must also address the need for pre-service and in-service teacher training. If it is true that an understanding of Earth systems (variously referred to it the EE literature as ecological foundations) is a necessary pre-requisite to any environmental education, and I believe it absolutely is, then we must research ways to maximize the environmental literacy of pre-service and in-service teachers regarding this component of EE. It should be extraordinarily disturbing to anyone paying attention to education in this country that in the 1999-2000 school year, 57% of middle school students and 27% of high school students were taught science by teachers who did not major in a science and had no teaching certification in the subject (Gruber, Wiley, Broughman, Strizek, & Burian-Fitzgerald, 2002; and Seastrom, Gruber, Henke, McGrath, & Cohen, 2002).

CONCLUSIONS

In conclusion, I think the current situation with environmental education and environmental education research as they have the potential to contribute to a sustainable future is superbly illustrated by a story told by Pritchett (1996). It goes like this:

> I'm sitting in a quite room at the Millcroft Inn, a peaceful little place hidden back among the pine trees about an hour out of Toronto. It's just past noon, late July, and I'm listening to the desperate sounds of a life-or-death struggle going on a few feet away.
>
> There's a small fly burning out the last of its short life's energies in a futile attempt to fly through the glass of the windowpane. The whining wings tell the poignant story of the fly's strategy–*try harder*.
>
> But it's not working.
>
> The frenzied effort offers no hope for survival. Ironically, the struggle is part of the trap. It is impossible for the fly to try hard enough to succeed at breaking the glass. Nevertheless, this little insect has staked its life on reaching its goal through raw effort and determination.
>
> This fly is doomed. It will die there on the windowsill.
>
> Across the room, ten steps away, the door is open. Ten seconds of flying time and this small creature could reach the outside world is seeks. With only a fraction of the effort now being wasted, it could be free of this self-imposed trap. The breakthrough possibility is there. It would be so easy.
>
> Why doesn't the fly try another approach, something dramatically different? How did it get so locked in on the idea that this particular route, and determined effort, offer the most promise for success? What logic is there in continuing, until death, to seek a breakthrough with "more of the same"?
>
> No doubt this approach makes sense to the fly. Regrettably, it's an idea that will kill.

"Trying harder" isn't necessarily the solution to achieving more. It may not offer any real promise for giving what you want out of life. Sometimes, in fact, it's a big part of the problem.

If you stake your hopes for a breakthrough on trying harder than ever, you may kill your chances for success.

If environmental educators and environmental education researchers stake our hopes for a sustainable future on trying harder, we may find out too late that we needed to stop, turn around, and change directions in order to find our destination of a sustainable future. A destination at which will not arrive.

REFERENCES

Adler, J.H. (1993a, September). A child's garden of misinformation. *Consumer's Research, 76*, 11-16.

Adler, J.D. (1993b, April 14). The greening of America's youth. *The Wall Street Journal*, p. A14.

Barnett, J. (2001). Introduction: an agenda for a new century. In J. Barnett (Ed.), *Planning for a new century: the regional agenda* (pp. 1-7). Washington, D.C.: Island Press.

Bowers, C.A. (1995). *Educating for an ecologically sustainable culture: rethinking moral education, creativity, intelligence, and other modern orthodoxies*. Albany, NY: State University of New York Press.

Calaprice, A. (2000) *The expanded quotable Einstein*. Princeton: Princeton University Press.

Campbell, D.T. & Stanley, J.C. (1963). *Experimental and quasi-experimental designs for research*. Boston: Houghton Mifflin Company.

Carson, R. (1962). *Silent spring*. Boston: Houghton Mifflin Company.

Cherrett, J.M. (1989). Key concepts: the results of a survey of our members. In J.M. Cherrett (Ed.), *Ecological concepts: the contribution of ecology to an understanding of the natural world* (pp. 1-16). Oxford: Blackwell Scientific Publications.

Chiras, D.D. (1992). An inquiry into the root causes of the environmental crisis. *Environmental Carcinogenesis & Ecotoxicology Reviews, C10*(1), 73-119.

Cohen, M.J. (1997). *Reconnecting with nature: finding wellness through restroing your bond with the Earth*. Corvallis, OR: Ecopress.

Commoner, B. (1974). *The closing circle*. New York: Bantam Books.

Comstock, A.B. (1994). *Handbook of nature study*. Ithaca, NY: Cornell University Press.

deCharms, R. (1968). *Personal causation*. New York: Academic Press.

deCharms, R. (1981). Personal causation and locus of control: two different traditions and two uncorrelated measures. In H.M. Lefcourt (Ed.), *Research with the locus of control construct (Volume 1): assessment methods* (pp. 337-358). New York: Academic Press.

Dunlop, J. (1992). Lessons from environmental education in industrialized countries. In Schneider, H.J., J. Vinke, & W. Weekes-Vagliani (Eds.) *Environmental education: an approach to sustainable development* (pp. 123-450). Paris: Organization for Economic Co-Operation and Development.

Flicker, J. (1996). Promoting a lifetime of learning. *Audubon, 98*, 2,6.

Gigliotti, L.M. (1990). Environmental education: what went wrong? *Journal of Environmental Education, 22*(1), 9-12.

Golley, F.B. (1996). *A primer for environmental literacy*. New Haven, CT: Yale University Press.

Gould, S.J. (1991). Unenchanted evening. *Natural History, 100*(9), 4, 6, 8, 10, 12, 14.

Hardin, G. (1960, April 29). The competitive exclusion principle. *Science, 131*, 1292-97.

Hardin, G. (1968, December 13). The tragedy of the commons. *Science, 162*, 1243-48.

Heider, F. (1958). *The psychology of interpersonal relations*. New York: Wiley.

Hershberg, T. (2001). Regional imperatives of global competition. In J. Barnett (Ed.), *Planning for a new century: the regional agenda* (pp. 11-29). Washington, D.C.: Island Press.

Hinrichsen, D. & Robey, B. (2000). *Population and the environment: the global challenge*. Population Reports, Series M, No. 15. Baltimore, MD: Johns Hopkins University School of Health, Public Information.

Hungerford, H.R. (1996). Comments made during "EE: a panel discussion of its past, its present, and its future" *25th Annual Conference of the North American Association for Environmental Education*, San Francisco, CA, 1-5/11/96.
International Commission on Environmental Education. (1997). *Are we building environmental literacy?* Washington, D.C.: Author.
Jickling, B. (1992). Why I don't want my children to be educated for sustainable development. *Journal of Environmental Education, 23*(4), 5-8.
Korteland, C. (1989). *The need for control: instrument development and construct validity.* Unpublished doctoral dissertation, Temple University.
Kwong, J. (1995). On coercive environmental education. *Religion & Liberty, 5* (2), 7-10.
LaChapelle, D. (1978). *Earth wisdom.* Silverton, CO: Finn Hill Arts.
Lazarsfeld, P.F. & Merton, R.K. (1957). Mass communication, popular taste and organized social action. In B. Rosenberg & D.M. White (Eds), *Mass culture: the popular arts in America* (pp. 457-473). Glencoe, IL: The Free Press and The Falcon's Wing Press.
Leopold, A. (1966). *A sand county almanac.* New York: Ballantine Books.
Linden, E. (1990, April 23). Will the ballyhoo go bust? *Time, 135*, 86.
Lynch, D.R. & Hutchinson, C.E. (1992). Environmental education. *Proceedings of the National Academy of Sciences, 89*, 864-867.
MacArthur, R.H. (1958). Population ecology of some warblers of northeastern coniferous forests. *Ecology, 39*, 599-619.
Marsh, G.P. (1867). *Man and nature; or physical geography as modified by human action.* New York: Charles Scribner & Co.
Maloney, M.P. & Ward, M.P. (1973). Ecology: let's hear from the people. *American Psychologist, 28*(7), 583-586.
McNeeley, J.A. & Sochaczewski, P.S. (1988). *Soul of the tiger: searching for nature's answers in Southeast Asia.* Honolulu, HI: University of Hawai'i Press.
Moncrief, L.W. (1970, October 20). The cultural basis for our environmental crisis. *Science, 170*, 508-512.
Gruber, K.J., Wiley, S.D., Broughman, S.P., Strizek, G.A., & Burian-Fitzgerald, M. (2002). *Schools and staffing survey, 1999-2000: overview of the data for public, private, public charter, and Bureau of Indian Affairs elementary and secondary schools.* Washington, D.C.: U.S. Department of Education, National Center for Education Statistics.
Odum, E.P. (1992). Great ideas in ecology for the 1990s. *BioScience, 42*(7), 542-545.
Orr, D. (1992). *Ecological literacy: education and transition to a postmodern world.* Albany, NY: State University of New York Press.
Pritchett, P. (1996). *you^2: a high velocity formula for multiplying your personal effectiveness in quantum leaps.* Dallas, TX: Pritchett & Associates, Inc.
Rodale, J.I. and Staff. (1964). *Our poisoned earth and sky.* Emmaus, PA: Rodale Books, Inc.
Roth, C.E. (1991). Towards shaping environmental literacy for a sustainable future. *ASTM Standardization News, 19*, 42-45.
Rotter, J.B. (1954). *Social learning and clinic psychology.* Englewood Cliffs, NJ: Prentice-Hall.
Rotter, J.B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs, 80* (1, whole no. 609), 1-28.
Rotter, J.B. (1975). Some problems and misconceptions related to the construct of internal versus external control or reinforcement. *Journal of Consulting and Clinical Psychology, 43* (1), 56-67.
Sanera, M. & Shaw, J.S. (1996). *Fact, not fear: a parents guide to teaching children about the environment.* Washington, D.C.: Rengery Publishing, Inc.
Satchell, M. (1996, June 10). Dangerous waters? Why environmental education is under attack in the nation's schools. *U.S News & World Report, 120*, 63-64.
Seastrom, M.M., Gruber, K.J., Henke, R., McGrath, D.J., & Cohen, B.A. (2002). *Qualifications of the public school teacher workforce: prevalence of out-of-field teaching 1987-99 to 1999-2000.* Washington, D.C.: U.S. Department of Education, National Center for Education Statistics.
Simmons, B & Volk, T. (2002). Environmental educators: a conversation with Harold Hungerford. *Journal of Environmental Education, 34*(1), 5-8.
Sobel, D. (1996). *Beyond ecophobia: reclaiming the heart in nature education.* Great Barrington, MA: The Orion Society and The Myrin Institute.
Smith-Sebasto, N.J. (1998). The pros and cons of research in environmental education. In H.R. Hungerford, W.J. Bluhm, T.L. Volk, & J.M. Ramsey (Eds.), *Essential readings in environmental education* (pp. 273-291). Champaign, IL: Stipes Publishing L.L.C.

Smith-Sebasto, N.J. (2001). The pros and cons of research in environmental education. In H.R. Hungerford, W.J. Bluhm, T.L. Volk, & J.M. Ramsey (Eds.), *Essential readings in environmental education, 2nd edition* (pp. 305-323). Champaign, IL: Stipes Publishing L.L.C.

Spirn, A.W. (2001). Restoring natural resources and rebuilding urban communities. In J. Barnett (Ed.), *Planning for a new century: the regional agenda* (pp. 165-176). Washington, D.C.: Island Press.

Stapp, W.B., Havlick, S., Bennett, D., Bryan, W., Jr., Fulton, J., MacGregor, J., Nowak, P., Swan, J., & Wall, R. (1969). The concept of environmental education. *Journal of Environmental Education, 1*(1), 30-31.

Terry, M. (1971). *Teaching for survival.* New York: Ballantine Books, Inc.

The President's Council on Sustainable Development. (1996). *Sustainable America: a new consensus.* Washington, D.C.: U.S. Government Printing Office.

Thomashow, M. (1995). *Ecological identity: becoming a reflective environmentalist.* Cambridge, MA: The MIT Press.

Thoreau, H.D. (1854/1997). *Walden.* New York: Quality Paperback Book Club.

VanMatre, S. (1993). *Earth education: a new beginning.* Greenville, WV: The Institute for Earth Education.

Wallace, A.R. (1863). On the physical geography of the Malay Archipelago. *Journal of the Royal Geographical Society, 33*, 217-234.

Weibacher, M. (1993). The renaissance of the Naturalist. *Journal of Environmental Education, 25*(1), 4-7.

White, L., Jr. (1967, March 10). The historical roots of our ecologic crisis. *Science, 155*, 1203-1207.

White, S.E. (1904). *The mountains.* New York: McClure, Phillips & Company.

Wilson, E.O. (1994). *Naturalist.* New York: Warner Books.

PROTECTING ECOLOGICAL HEALTH: CHALLENGE FOR THE TWENTY-FIRST CENTURY

JAMES R. KARR, PH.D.

Professor, University of Washington, Box 355020, Seattle, WA 98195-5020

Think of the earth as a living organism that is being attacked by billions of bacteria whose numbers double every forty years. Either the host dies, or the bacterium dies, or both die.

—Gore Vidal

ABSTRACT. Humanity has prospered, in large part, thanks to what it could take from Earth's ecosystems. Early humans existed in small local populations with limited technology and relatively simple social, political, and economic systems. Advances in technology, especially agriculture, produced material surpluses and gave rise to more-complex social, political, and economic relations. These developments appeared to release humans from dependence on their surroundings, but as cultural constraints withered, environmental degradation followed. The rise of neoclassical economics late in the 1800s further decoupled culture and environment. Today "culture" and "economy" are almost synonymous: we make societal decisions almost exclusively on the basis of economic indicators, unless economic indicators are trumped by political goals. But pioneering efforts to understand the present, gain wisdom from the past, and chart a course for the future are at last expanding the indicators we use to track societal well-being—that is, human and ecological health plus social and economic vitality. Such expanded indicators must explicitly track the condition of the biological capital that is the sustaining wealth of the world. Just as we ought not to deplete the principle in our personal savings accounts, we ought to protect Earth's living systems—or neither our natural nor financial accounts will bear the interest we need. One of the highest priorities of the twenty-first century will be the adoption of comprehensive, integrative, and easily interpreted biological indicators. Without such indicators, declining ecological health will be the dominant twenty-first century trend.

INTRODUCTION

Humanity has prospered, in large part, thanks to what it could take from Earth's ecosystems. But the last 10,000 years of taking have distorted the biosphere in ways that have come back to threaten human health and well-being (Figure 1). Among the disparate challenges are rising asthma rates, food insecurity, declining biodiversity, changing climate, stress syndromes from overcrowding or the pace of modern industrialized life, and mounting numbers of environmental refugees. Because a healthy biosphere is a prerequisite for healthy humans and for societal well-being, humanity today can ill afford to ignore the consequences of actions that degrade ecological health.

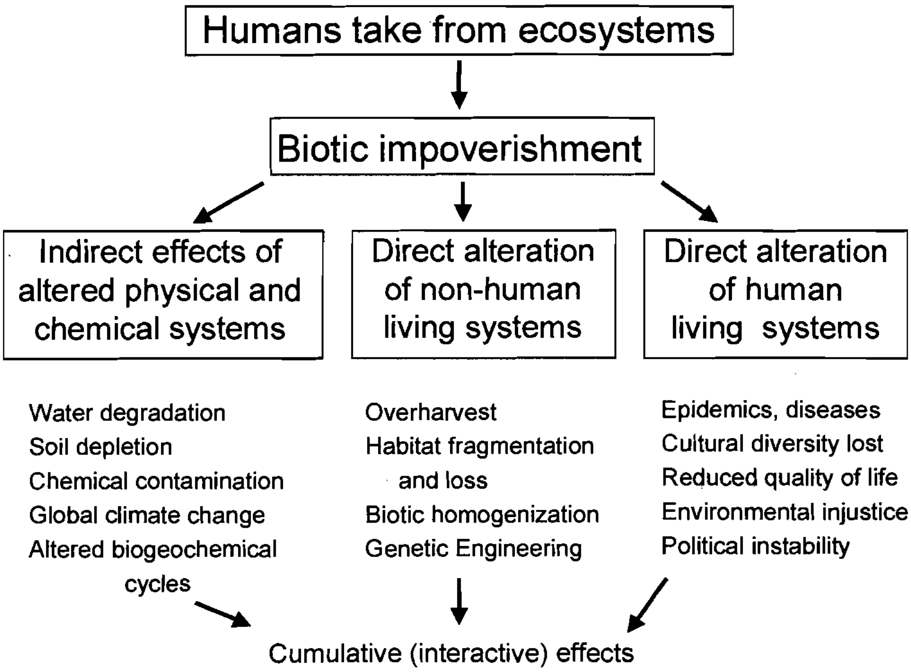

Figure 1. The many faces of biotic impoverishment that result from humans taking from Earth's ecosystems (Modified from Karr and Chu 1995 and Chu and Karr 2001).

Our understanding of the relationship between the biosphere's health and our own has expanded considerably in the last century, thanks to a convergence of public concern, scientific advances, and citizen activism in public policy. First, much of the world recognizes that modern human activity so seriously disrupts the biosphere that the quality of human and nonhuman life is at risk. Second, scholars from diverse disciplines (biology, sociology, history, archaeology, anthropology, medicine, political science, and so on) are interpreting historical patterns in light of their ecological context. But despite what we know, we are not using that knowledge wisely. Hampering the wiser use of knowledge is societal decision making that relies on economic indicators while ignoring the many social and environmental consequences of economic decisions. In short, we are more able than ever in the history of human society to understand the present, learn from the past, and take creative actions to cast a more sustainable future. But our ability to alter trajectories set in motion more than 10,000 years ago is tied directly to adopting indicators that tell us not only the state of global and national economies but about the state of and trends in both human and nonhuman segments of Earth's living systems, the biosphere. If we fail to account fully for our relationship with the rest of the biosphere—if we fail to measure what matters—we will see an even faster decline in social and ecological health.

Ecology and Environment Move into the Mainstream

Just a few decades ago, the words *ecology* and *environment*, and their many contemporary connotations, were not on the public radar. In 1955, for example, the *New York Times Index* did not include the word environment, and neither *environmentalist* nor *environmentalism* was included in the 1971 *American Heritage Dictionary* (Theile 1999). Today, in contrast, diverse segments of society call for business and government to incorporate ecological imperatives into the marketplace, for science and engineering to provide the tools to address environmental challenges, for governments to use those tools more effectively, for educational institutions to teach future generations to respect the great harmonies in their living surroundings, and for religious communities to reverse long-standing patterns of neglect and exploitation of the nonhuman world (see Appendix in Karr 2002a for specific details and complete citations). The unprecedented scale and speed of environmental disruption, many conclude, are serious threats to our children's future.

Ecology has gone from a word designating a relatively narrow scientific discipline known to a limited number of scientists to a life philosophy, a source of guidance, or link to morality (Karr 2002a). The status quo—unwitting or deliberate neglect of the human-environment relationship and its effect on ecological health—is no longer acceptable. Perhaps the most tangible illustration of this shift is the Earth Charter (www.earthcharter.org), currently before the United Nations as a Declaration of Human Interdependence and Mutual (Shared) Responsibilities and a complement to the UN Declaration of Human Rights. The Earth Charter provides a compass or guiding instrument to guide society toward a more just, equitable, and peaceful future, a future that is attainable only through thoughtful societal decision making. The Earth Charter was born out of dissatisfaction with global conferences convened in 1972, 1982, and 1992. Efforts to bring it to the table for the 2002 World Summit on Sustainable Development in Johannesburg, South Africa, were not successful. The Earth Charter derives from the sense that (1) the present economic mode is no longer viable, (2) an increasing gap between the "haves" and "have nots" is no longer acceptable, and (3) the mindless ravaging of resources and abuse of human rights is longer tenable. Design and implementation of the Earth Charter calls upon the wisdom of the past and the best knowledge of the present as it points to hope for the future.

Neither Environmental Distortion nor Environmental Concern Is New

History teaches important lessons for those hoping to influence the future. One lesson is that distortion of the biosphere is not just a twentieth-century phenomenon or a by-product of European advances in the last 500 years. Rather, urbanization, population growth, and the accumulation of capital, or wealth have distorted nature worldwide during the last 5000 years (Chew 2001, Hughes 2001). The archaeological record has revealed that hundreds of societies did not live in harmony with nature (Redman 1999), often with serious social and health consequences for rulers as well as peasants (Fagan 1999, 2000).

These disharmonies only accelerated through the twentieth century, a period in which human consumption grew at unprecedented rates (Table 1). In ancient Rome, the wealthy used slaves, a direct subjugation of members of the current generation, as an inexpensive energy subsidy. Most twenty-first century humans recognize this as repugnant activity. According to McNeill (2000), modern global citizens in 1990 consumed the per capita equivalent of 20 full-time energy slaves. That is, the wealthy in the new millennium practice de facto slavery through excess energy use. They indirectly subjugate today's powerless as well as future generations who will have to contend with a legacy of global climate change and environmental contamination. I suggest that the modern energy subsidy from fossil fuels is as morally repugnant as the slavery practiced in Roman times. Some historians believe that twentieth-century effects of people on the planet will overshadow the importance of sociopolitical events like the world wars, the rise and fall of communism, or the spread of mass literacy (McNeill 2000).

Table 1. Ecological changes in the twentieth century expressed as growth in consumption or the scale of human activity. (Adapted from McNeill 2000).

Item	Increase factor	Item	Increase factor
World population	4	Marine fish catch	35
Urban population	14	Cattle population	4
Global economy	14	Pig population	9
Industrial output	40	Horse population	1.1
Energy Use	16	Forest area	0.8
Coal production	7	Irrigated area	5
Carbon dioxide emissions	17	Cropland	2

Two lessons of history are particularly important: (1) recent ecological history and socioeconomic history make full sense only if seen together (Diamond 1997, McNeill 2000, Hughes 2001); and (2) although humanity did not begin as a global species, it is global now (Clark 2000). Globalization has its roots in the past, and it is as much an ecological and demographic phenomenon as it is economic and political.

Using historical knowledge to guide human behavior in many respects goes against the natural order of things. That is, humans are simply behaving as do other species. Since living organisms first emerged from the primordial soup, success—defined as becoming an ancestor—was determined by an ability to mobilize a continuous flow of resources. Those most effective at this activity often change the environments in which they live and have been labeled "ecosystem engineers." The first photosynthetic prokaryotes changed the Earth's atmosphere by releasing oxygen, for example; land plants and animals formed soils; beavers built dams and altered the flow of rivers and created countless wetlands. Today, humans are the dominant ecosystem engineers, monopolizing 40% of annual terrestrial plant growth, 35% of the ocean's continental shelf production, and 60% of accessible freshwater (Pimm 2001). Still humans alone are capable of recognizing the threat posed by our own natural propensities, but it is certainly not clear whether we can also move beyond our past to protect the interest of future generations.

Furthermore, the search for solutions is not a product of "progressive Western Enlightenment philosophies and their associated rationalization processes" (Chew 2001, p. 157). A sense of caring for the environment can be traced back at least to Mesopotamia and South Asia 4500 years ago. Writings from those times reveal awareness of biodiversity and of the relationships between living things. They reveal knowledge of natural order in the biosphere and of the consequences of disrupting it. Contemporary debate by modern philosophers, ethicists, scientists, and citizens concerned about the future simply extend these discussions (Leopold 1949, Orr 1992, 1994, Rolston 1994, Westra 1998, Pimentel et al. 2000). The need for an ethical compass to constrain the behavior of human society has never been more critical.

Although humans are only one of 10 million or more species on Earth, the current population exceeds 6.1 billion, a huge number considering the size of humans. The human species is one of the most influential species in history. A rapidly expanding population (increasing superexponentially in the last couple centuries) has spread to occupy an extraordinary geographic area and to influence an even larger area. Our influence is magnified by our proliferating technology and massive rates of resource consumption and waste generation.

Environmental laws offer secular evidence that we recognize some limits and responsibilities; implementing those laws is a test of our will (Karr 2001).

Advances in Science and Technology Are a Two-edged Sword

Scientific and technological advances have been key to humans' success as ecosystem engineers because they gave humans the power to capture more and more of Earth's bounty. The resulting material surpluses gave rise to complex social, political, and economic relations, and appeared to release humans from dependence on their surroundings. But as limiting cultural and other constraints withered under this impression, environmental degradation followed. The result has been polluted air and water, soil degradation, human health problems, and local and regional collapse of civilizations.

Most technologies were two-edged swords. They provided solutions to specific challenges, but those benefits were often negated by their aftermath—belated, complex, and often disastrous consequences. Wonder drugs controlled common pathogens, but natural selection strengthened the ability of those pathogens to resist the drugs. Reservoirs in the tropics made water supplies more reliable for humans, but they also created ideal environments for human parasites. Industrialization exposed human society to a remarkable array of chemicals—natural (e.g., heavy metals and nutrients) and synthetic (e.g., chlorinated hydrocarbons)—with diverse impacts on health. "Magic bullets," from pesticides to kill pests or hatchery fish to boost overharvested wild populations, have precipitated unexpected "illnesses" ranging from stronger pests to extinct wild salmon runs. Similarly, many engineering and political schemes for managing rivers to benefit one group of people have led to unanticipated problems for others. Clearing land and straightening upstream river channels to reduce local flooding, for example, worsen flooding downstream and destroy downstream and coastal fisheries.

Worst of all, society has been lulled into self-satisfaction as technology is piled upon technology. When society accepts the notion that technologies make us independent of natural systems, momentum propels us to further ignore our dependence, and the risks to humans from environmental distortions grow.

But science and technology could help turn this momentum and rebalance our relationship to the biosphere. Our technical ability to predict consequences improves although our willingness to use that knowledge to inform political decisions has not kept pace.

Measure What Matters: Select Better Indicators

Humans count things to understand the past, to document the present, and sometimes, to predict the future. But humans neither measure everything nor measure things at random. We may count things because they give us pleasure, such as the number of birds on our "life list" or, in sports, to calculate batting averages (baseball) or determine strokes per eighteen holes (golf). We also count things that are connected to the course of events, either through cause or correlation.

Industrialized humans track their cholesterol levels, annual income, and stock profiles while nations track crime rates, housing starts, and gross domestic product (GDP). Early humans no doubt did not track these same things. Perhaps they tracked the weather instead, or food supplies, heavenly bodies, and the march of seasons. But ancient and modern humans have all measured what mattered to them; they chose indicators they believed represented important properties of a system. When natural systems mattered directly to human survival, people paid attention to natural indicators. As society seemed to move away from dependence on nature, people ceased to track the status of natural systems. The rise of neoclassical economics late in the 1800s further decoupled human culture from its environment. Economic theory assumed that land and natural resources were part of the human economy, rather than the material foundation that makes the human economy possible.

Today "culture" and "economy" are almost synonymous: we make societal decisions almost exclusively on the basis of economic indicators—which may measure the flow of money through the economy but offer no information about social and environmental conditions (Davidson 2000, Manno 2000). Dependence on the standard array of economic indicators leads society to behaviors and decisions that, history has taught, expand social and environmental deficits. Worse, when society relies exclusively on narrow economic indicators, people are implicitly given permission to escape responsibility for the effects of their actions on non-economic entities. Exclusive reliance on economic indicators has not only given rise to, but implicitly endorses values and lifestyles that damage ecological health (Karr 2002b). These lifestyles are not sustainable.

Fortunately, an expanding share of the global human community understands the lessons of past centuries and is working to find better indicators. Some researchers catalog the flow of goods and services from natural systems to human society (Daily 1997) and calculate their economic value (Costanza et al. 1997a, Pimentel et al. 1997). Perhaps narrowly useful as a communication tool, those anthropocentric valuation exercises are very much in an Old Testament mold, seeing the biosphere as existing for human benefit (Smil 2002). Others convert the rate of human consumption to land-area equivalents, estimating the size of humans' ecological footprint (Wackernagel and Rees 1996). This approach stops assuming the benevolent operation of the nonexistent invisible hand (Stiglitz 2002) as it stops ignoring the very real invisible foot (Rees 2000). Still others express the influence of humans by determining the proportion of Earth's annual production consumed by humans (Pimm 2001). These approaches bring the focus back to the connections between humans and their environments, although they do not explicitly track the condition of the biological capital that is the sustaining wealth of the world.

We cannot, however, expect that natural capital to last without comprehensive indicators designed to measure the state of Earth's living systems. Just as we ought not to deplete the principle in our personal savings accounts, we ought to protect Earth's living systems—or neither our natural nor fiscal account will bear the interest we need.

Biological Indicators: Human and Nonhuman

One of the highest priorities of the twenty-first century will be to adopt comprehensive, integrative, and easily interpreted biological indicators to serve as complements of often used economic and human health indicators. Society can no longer ignore any of the key components of Earth systems or their interactions. Some years ago Hazel Henderson conceived of a layer cake to represent the core components and their relationships to each other (Figure 2); a more appropriate metaphor perhaps, is a two-layer cake with human social systems resting on top of the natural resource or ecological system that forms the cake's foundation layer. The economic system is the frosting on the cake, taking its shape from the social and ecological systems that support the economy.

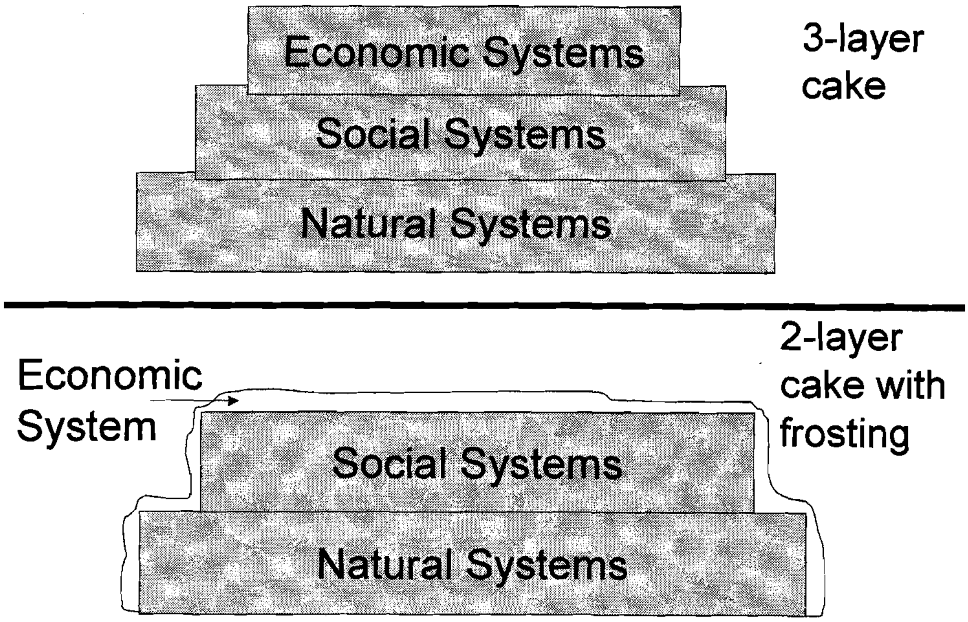

Figure 2. Two layer cake models of the relationships among the economic, social, and natural systems. Human societies depend on the existence of all three "layers."

The intensification of modern human economic and political systems is progressively eroding both the natural resource foundation (biotic impoverishment) and the human system (wealth and other disparities among members of the human community), threatening the very foundations of society (Figure 3). This erosion proceeds apace because of the underlying assumptions of neoclassical economics and the majority of political leaders.

In his 1999 State of the Union message, President Bill Clinton proclaimed that the nation was in the "longest peacetime expansion in history" (Rowe and Silverstein 1999). But no one asked what was expanding and the President didn't tell; this wonderful news went without challenge. As Rowe and Silverstein note, many things are expanding from waistlines to medical bills, from debt to stress and traffic. Perhaps the President had the gross national product (GDP) in mind. GDP is a tremendously influential measure; increasing GDP is typically viewed as a sign of prosperity. But it is nothing of the kind. GDP measures throughput of the economy, the amount of money changing hands, but it fails as a measure of societal well being on several counts. First, important aspects of the economy such as income distribution, unpaid work, and the black-market economy are ignored. Second, nonmonetary contributions to human fulfillment such as health, education, freedom, security, and peace are not evaluated. Third, social and environmental costs are omitted

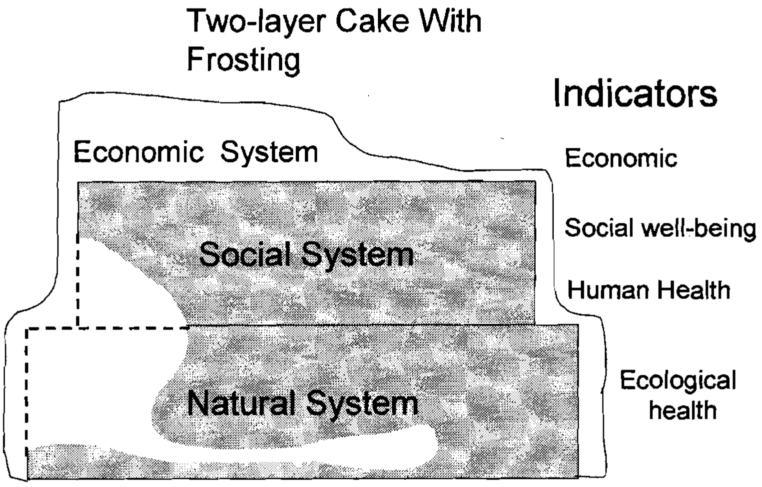

Figure 3. In modern times the influence of human economies erodes segments of the underlying social and ecological systems, threatening the very foundation, the sustainability, of those systems. Note that four levels of indicators (right column) are needed to track the condition of the core components of the conceptual "layer cake."

(pollution, resource depletion, cancer, crime); GDP does not evaluate the state of Earth's ecosystems. Perhaps most perversely, GDP counts social and environmental costs as benefits. Narrow conceptions implicit in many other econometrics from the Dow-Jones industrial average to the index of leading economic indicators and the consumer price index are similarly limited as measures of societal well-being. One effort to improve econometrics is the index of sustainable economic welfare (ISEW), which adjusts GNP for negative impacts on natural capital, wealth disparities across classes, the effects of pollution, and other long-term social and environmental damage (Costanza et al. 1997b). Our planet develops over time without growing and our economy must adapt a similar pattern of development without throughput growth (Daly 1991). Econometric indicators should reflect that reality.

Recent efforts to produce social indicators (measures of the condition of human living systems) show that this vital area is attracting the attention it deserves. Concern about our inability to monitor public human services the way we monitor financial markets stimulated the State of Connecticut to develop an annual social index (Stille 2002). The Social Index of Leading Indicators (Miringoff and Miringoff 1999) combines 16 measures of social health from child poverty to teenage suicide rates to average weekly wages, homicide rates, health insurance coverage, and alcohol related traffic deaths. When aggregated at state levels variation among the states is obvious with Iowa at the top (73 out of a maximum 100) and New Mexico at the bottom (21.4). Three indicators in particular—child poverty, high school completion, and health insurance—were bellwethers of overall social health (Stille 2002). The 1999 Miringoff study showed that although gross domestic product had continued to grow over the preceding 30 years, Americans' social health actually went down rather drastically, as problems such as child poverty, decreased average wages, the youth suicide rate, and lack of health insurance coverage had all worsened.

In a recent book titled *The Wealth of Nations*, Robert Prescott-Allen (2001) developed and applied an index to track human well-being for 184 nations. His Human Well-being Index includes measures of health, population, household wealth, national wealth, knowledge, culture, freedom and governance, peace and order, household equity, and gender equity. The patterns observed by Prescott-Allen are not encouraging. Only three countries—Norway, Denmark, and Finland—are rated good. The distribution of other countries is disappointing but not surprising: fair (34), medium (52), poor (51, and bad (40). These social indicators reinforce the view that conventional economic indicators may yield substantial risk to non-economic dimensions of human society.

Just as many scholars are working to provide more integrative measures of the interactions of human economies, social systems, and ecological systems, many biologists are working to improve our knowledge of the condition of earth's nonhuman living systems. Perhaps the most far-reaching is the Millennium Ecosystem Assessment (MEA), a pathbreaking international assessment that hopes to meet decision-makers' needs for scientific information on the consequences of ecosystem change for human well-being and on the response options available to address undesired changes (Kaiser 2000, Reid 2000, Gewin 2002). While much work has been done to develop the concepts and approaches of MEA, few data are available at this time to assess this program, or to guide decision makers.

Three ongoing efforts within the United States are designed to understand the state of the nation's ecosystems (Heinz Center 2002), biological resources (Mac et al. 1998), or status and trends of the Nation's natural resources (USEPA 2002). The Heinz Center report, a private initiative, is "a succinct and comprehensive—yet unbiased and scientifically sound—examination of the current state of the nation's lands, waters, and living resources." Two major goals of the report are to identify indicators and report the best available data on conditions and trends. The Heinz Report sets in motion a pioneering effort with potential to influence policy discussions today and for generations to come. Recent activities of the USGS (Mac et al. 1998) and the fledgling National Biological Service (LaRoe et al. 1995) were designed to provide improved information about the nation's living resources. Although this goal is widely recognized by many citizens and political leaders, political pressures opposed to such reporting have altered the federal approach to this activity as illustrated by shifts in the NBS mandate and transfer of the program to USGS. A key question remains, how will the political process play out in terms of program development, funding, and reporting of results?

Another activity in North America grew out of work initiated in the Midwest soon after passage of the 1972 Amendments to the Water Pollution Control Act. It began with an expression of concern about the narrow focus of CWA implementation on chemical contaminants and engineering solutions with little effort to connect those activities to the unraveling of living aquatic systems (Karr and Dudley 1981, Karr 1991, Knoopman and Smith 1993). Although water quality programs early in the twentieth century emphasized the effects of human actions on the biota, advancing technologies shifted the focus from the condition of natural systems to the activities of humans. The assumption was made that human activity (permits issued, fines levied) inevitably produced an improved environment. As noted by law professor William Rodgers (1994, page 270), "The most disturbing reality is that we have not succeeded in maintaining the biological productivity of our surface waters despite enormous investments."

Recognition of this problem stimulated the development of monitoring and assessment programs in streams that led to a comprehensive approach to measurement of river condition. The concept of a multimetric index, long used in economic analyses (e.g., index of leading economic indicators) began with the development of indexes of biological integrity (IBI; Karr 1981). Concepts crucial to the success of these indexes include: (1) focus on biological endpoints to define river health; (2) use a concept of reference condition as a benchmark; (3) organize sites into classes with a select set of environmental characteristics; (4) assess change and degradation caused by human effects; (5) require standardized sampling, laboratory, and analytical methods; (6) score sites numerically to reflect site condition; (7) define "bands," or condition classes, representing degrees of degradation; and (8) furnish needed analyses for selecting high-quality areas as acquisition and conservation priorities (Karr and Chu 2000).

IBI integrates multiple biological indicators to measure and communicate biological condition (Davis and Simon 1995). Much as a physician relies on a battery of medical tests, not just one, to diagnose illness, anyone can use an IBI to diagnose the condition of a water body. This robust measure of the biological dimensions of water body condition has by now been applied to challenges in basic science, resource management, engineering, public policy, legal, and community volunteer arenas; on every continent except Antarctica; and in developing as well as developed nations. One advantage of IBI is that it is founded on empirical data so its use does not require resolution of all higher-order theoretical debates in contemporary ecology. Initial work to develop this approach to use of biological indicators concentrated on streams with fish as focal organisms. Adaptations of this multimetric index approach have now been developed for diverse taxonomic groups (fishes, aquatic and terrestrial invertebrates, algae and diatoms, birds, vascular plants), environment types (streams, wetlands, lakes, coastal areas, sagebrush steppe, and others), and even for physical and chemical measures of environmental condition. Several states have incorporated biological criteria into state water quality standards (Ohio, Florida, Maine, Vermont) in the past 20 years and biological monitoring is now a key component of EPA water management guidelines to states.

Among the initiatives to track biological condition just described, only the multimetric biological index (IBI and its clones) has actually made it into the policy arena. Together these approaches to measure the health of local and regional ecosystems or the condition of Earth's living systems illustrate a sharp change in focus and energy among biologists to measure directly the condition of our planet's rich biological capital. One of the highest priorities of the twenty-first century will be to adopt comprehensive, integrative, and easily interpreted biological indicators..

Improvements in our ability to track biological and social indicators coupled with better economic indicators will improve the ability of twenty-first century society to avoid the many dimensions of biotic impoverishment—the depletion in human and nonhuman living systems that results from not measuring all that matters to human well being. Until we have comprehensive biological and social assessment to measure the health of ecological systems (Figure 4), our public policy decisions will lack a crucial foundation for informed decision making. It is simply not enough to know that we derive benefits from those systems. We must also understand their status and trends, how human actions influence those trends, and how we can avoid trends that threaten the well being of human and non-human inhabitants of earth. Coupling improved biological indicators with carefully defined social indicators and better economic indicators will improve the ability of twenty-first century society to avoid continuing disruption of the biosphere.

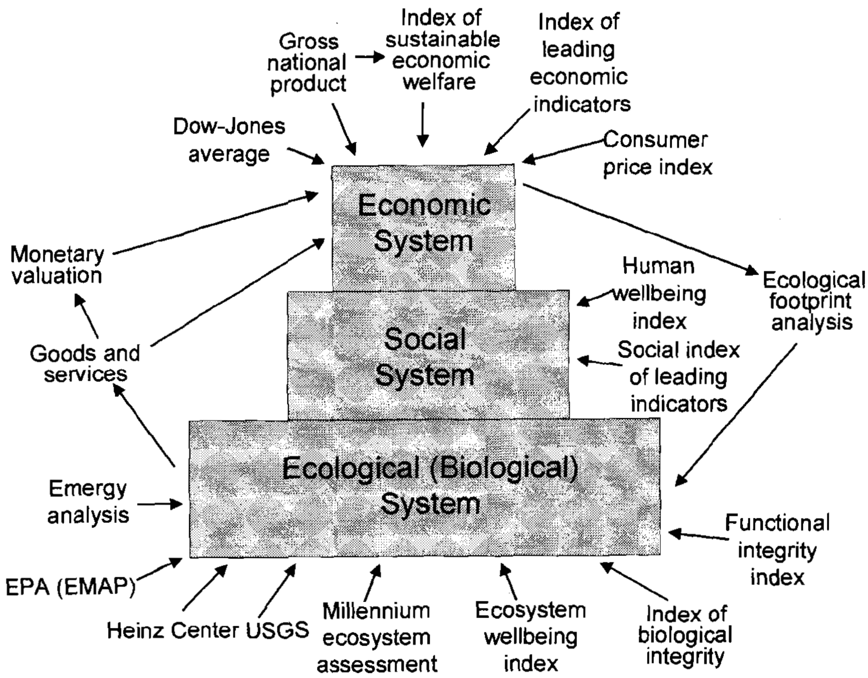

Figure 4. Selected indicators of system condition for each level of the conceptual "layer cake."

ACKNOWLEDGMENTS

This paper was prepared with support from the Consortium for Risk Evaluation (CRESP) by Department of Energy Cooperative Agreement #DE-FG26-00NT40938. I am especially grateful to Ellen W. Chu for her insightful editing of early drafts of this manuscript and to members of the Global Integrity Group for their stimulating conversations during the past eight years.

LITERATURE CITED

Chew, S. C. 2001. World Ecological Degradation: Accumulation, Urbanization, and Deforestation 3000 B.C.–A.D. 2000. Altamira Press, Walnut Creek, CA.
Chu, E. W., and J. R. Karr. 2001. Environmental Impact, Concept and Measurement of. Pages 557-577 in S. A. Levin, editor. Encyclopedia of Biodiversity, Vol. 2. Orlando, FL; Academic Press.
Clark, R. P. 2000. Global Life Systems: Population, Food, and Disease in the Process of Globalization. Rowman and Littlefield, Lanham, MA.
Costanza, R., and 12 other authors. 1997a. The value of the world's ecosystem services and natural capital. Nature 387: 253-260.
Costanza, R., J. Cumberland, H. Daly, R. Goodland, and R. Norgaard. 1997b. An Introduction to Ecological Economics. St. Lucie Press, Boca Raton, Florida.
Daily, G., editor. 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, DC.
Daly, H. E. 1991. Boundless bull. Orion Summer 1991, pages 59–61
Davidson, E. A. 2000. You Can't Eat GNP: Economics as if Ecology Mattered. Perseus, Cambridge, MA.
Davis, W. S. and T, P. Simon, editors. 1995. Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publ., Boca Raton, FL.
Diamond, J. 1997. Guns, Germs, and Steel: The Fates of Human Societies. Norton, NY.
Fagan, B 1999. Floods, Famines, and Emporers: El Niño and the Fate of Civilizations. Basic Books, NY.
Fagan, B. 2000. The Little Ice Age: How Climate Made History 1300-1850. Basic Books, New York.
Gewin, V. 2002. The state of the planet. Nature 417:112-113.
Heinz Center (The H. John Heinz III Center for Science, Economics and the Environment). 2002. The State of The Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States. Cambridge University Press, New York.
Hughes, J. D. 2001. An Environmental History of the World: Humankind's Changing Role in the Community of Life. Routledge, New York.
Kaiser, J. New survey to collect global news you can use. Science 289: 1676–1677.
Karr, J. R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21–27.
Karr, J. R. 1991. Biological integrity: A long-neglected aspect of water resource management. Ecological Applications 1:66–84.
Karr, J. R. 2001. Protecting life: Weaving together environment, people, and law. Pages 175-185 in R. G. Stahl, Jr., R. A Bachman, A. L. Barton, J. R. Clark, P. L. deFur, S. J. Ells, C. A. Pittinger, M. W. Slimak, and R. S. Wentsel, editors. Risk Management: Ecological Risk-based Decision-Making. SETAC Press, Pensacola, FL.
Karr, J. R. 2002a. What from ecology is relevant to design and planning? Pages 133–172 in B. R. Johnson and K. Hill, editors. Ecology and Design: Frameworks for Learning. Island Press, Washington, DC.
Karr, J. R. 2002b. Understanding the consequences of human actions: Indicators from GNP to IBI. Pages 98-110 in P. Miller and L. Westra, editors. Just Ecological Integrity: The Ethics of Maintaining Planetary Life. Rowman and Littlefield, Lanham, Maryland.
Karr, J. R. and E. W. Chu. 1995. Ecological integrity: Reclaiming lost connections. Pages 34–48 in L. Westra and J. Lemons, eds. Perspectives in Ecological Integrity. Kluwer Academic, Dordrecht, Netherlands.
Karr, J. R. and E. W. Chu. 2000. Sustaining living rivers. Hydrobiologia 422/423: 1–14.
Karr, J. R. and D. R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management 5:55–68.
Knopman, D. S. and R. A. Smith. 1993. Twenty years of the Clean Water Act. Environment 35(1):16–20, 34–41.
LaRoe, E. T., G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. 1995. Our Living Resources: A report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. U.S. Department of the Interior, National Biological Service, Washington, DC.

Leopold, A. 1949. A Sand County Almanac. Oxford University Press, Oxford. (Reprinted 1966, Sierra Club/Ballantine Books, New York.)
Mac, M. J., P. A. Opler, C. E. Puckett Haecker, and P. D. Doran. 1998. Status and trends of the nation's biological resources. 2 vols. U.S. Department of the Interior, U. S. Geological Survey, Reston, Virginia.
Manno, J. P. 2000. Privileged Goods: Commoditization and Its Impact on Environment and Society. Lewis, Boca Raton, FL.
McNeill, J. R. 2000. Something New Under the Sun: An Environmental History of the Twentieth-Century World. W. W. Norton, NY.
Miringoff, M. L. and M.-L. Miringoff. 1999. The Social Health of the Nation: How is America Really Doing. Oxford University Press, New York.
Orr, D. W. 1992. Ecological Literacy: Education and the Transition to a Postmodern World. State University of New York Press, Albany, New York.
Orr, D. W. 1994. Earth in Mind: On Education, Environment, and the Human Prospect. Island Press, Washington, DC.
Pimentel, D. and 8 other authors. 1997. Economic and environmental benefits of biodiversity. BioScience 47:747-757.
Pimentel, D., L. Westra, and R. F. Noss, editors. 2000. Ecological Integrity: Integrating Environment, Conservation, and Health. Island Press, Washington, DC.
Pimm, S. L. 2001. The World According to Pimm: A Scientist Audits the Earth. McGraw-Hill, NY.
Prescott-Allen, R. 2001. The Wellbeing of Nations: A Country-by Country Index of Quality of Life and the Environment. Island Press, Washington, DC.
Redman, C. L. 1999. Human Impact on Ancient Environments. University of Arizona Press, Tuscon, AZ.
Rees, W. E. 2000. Patch disturbance, ecofootprints, and biological integrity: Revisiting the limits to growth (or why industrial society is inherently unsustainable). Pages 139–156 in D. Pimentel, L. Westra, and R. F. Noss, editors. Ecological Integrity: Integrating Environment, Conservation, and Health. Island Press, Washington, DC.
Reid, W. V. 2000. Ecosystem data to guide hard choices. Issues in Science and Technology 16(3): 37-44.
Rodgers, W. E., Jr. 1994. Environmental Law, second edition. West Publishing, St. Paul, Minnesota.
Rolston, H., III. 1994. Conserving Natural Value. Columbia University Press, New York.
Rowe, J. and J. Silverstein. 1999. The GDP myth: Why "growth" isn't always a good thing. The Washington Monthly 31(3). http://www.washingtonmonthly.com/features/1999/9903.rowe.growth.html
Smil, V. 2002. The Earth's Biosphere: Evolution, Dynamics, and Change. The MIT Press, Cambridge, Massachusetts.
Stiglitz, J. E. 2002. Globalization and its Discontents. W. W. Norton, New York.
Stille, A. 2002. With the index of leading economic indicators, a social report card. The New York Times, April 27. www.nytimes.com
Thiele, L. P. 1999. Environmentalism for a New Millennium: The Challenge of Coevolution. Oxford University Press, NY.
USEPA (Environmental Protection Agency). 2002. Research Strategy. Environmetnal Monitoring and Assessment Program. EPA 620/R-02/002. Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.
Wackernagel, M. and W. Rees. 1996. Our Ecological Footprint: Reducing Human Impact on the Earth. New Society Publishers, Gabriola Island, British Columbia.
Westra, L. 1998. Living in Integrity: A Global Ethic to Restore a Fragmented Earth. Rowman and Littlefield, Lanham, Maryland.

DANTE'S RIVER: SEARCHING FOR WILDERNESS IN CITY WATER

A reading from *The Cincinnati Arch* – John Tallmadge - copyright 2003

JOHN TALLMADGE. PH.D.

The Union Institute and University, Cincinnati, Ohio, 45206-1925

ABSTRACT. Environmental thought tends to separate nature from culture, focusing on wilderness rather than the city landscapes where most of us live. Yet urban nature is a vital scene of instruction as we enter an ecological age. The author illustrates by selections from "Dante's River," the water chapter in his forthcoming book, *The Cincinnati Arch.* In the first, "The Water Pilgrim," I recall growing up in polluted northern New Jersey and yearning for wilderness with its pristine streams and lakes. The second part, "Spigot and Drain," looks at water through the weary, somewhat bleary eyes of a parent and householder. "The Mill Creek" describes a journey down Cincinnati's most polluted stream, and the last part, "The Baby and the Heron," meditates on the sin of pollution and the spiritual meaning of water itself.

It's a pleasure to stand before this distinguished gathering of scientists and educators as a representative of the humanities, those disciplines concerned with values, ideas, and the language we use to explore them. The two cultures were once closely linked, especially in the practice of natural history, which is not only a mode of interdisciplinary, field-based science, but also a literary genre. Great naturalists such as Darwin succeeded in large part because they were powerful writers; and great nature writers such as Thoreau succeeded because of a scrupulous concern for observed truth. Back in graduate school one of my friends suggested that the scientist uses experience to get to the facts (that is, the laws of nature), whereas the writer uses scientific facts and observations to deepen the reader's experience. In addition, both share a love for field work as well as a genteel poverty, for there's little money in nature writing or natural history, especially in today's academy. A refreshing spirit of amateurism still clings to both.

I myself am pretty much self-taught as a naturalist and a writer. I last took biology as a high school freshman and never have had a writing course, so you will just have to take your chances for the next hour. Nor did I ever expect to be living in Cincinnati, Ohio. As a climber and backpacker, I always dreamed of living somewhere like Bozeman or Seattle, not some old Rust Belt city. I wanted a place known for mountains and forests, not dish soap or jet engines; I wanted panthers and grizzlies, not the Bengals. I was used to thinking about nature in terms of wilderness, not the mixed, ambiguous, and confusing landscapes of the city.

But, as so often happens, nature exceeded my expectations, and now, after fifteen years of homesteading, raising kids, and poking around in the neighborhood, I have become convinced that urban nature is a vital scene of instruction. It is essential to understand the places where we live if we are to create an ecologically sustainable culture. The writer can assist by helping us see and understand a world of life through which we too often pass as if we were sleepwalking. To illustrate, I would like to share some excerpts from a book in progress, *The Cincinnati Arch: Learning from Nature in the City.*

Most of you probably know that the "Cincinnati Arch" is the name geologists give to a huge up warp in the Ordovician strata that underlie this part of the country; the city is located at its crest. But the arch is also a classic architectural form that achieves elevation by using the force of gravity: as the stones fall toward the center, they are held apart by the keystone. The arch therefore symbolizes the aspiration and ingenuity of the built environment. But ancient philosophers also recognized in the parabolic arch the path the mind travels during the process of interpretation; hence the term "parable" in reference to the teaching stories of Jesus. Without claiming divine inspiration, my book does attempt to bring nature and culture together under the sign of interpretation

Since we are in the Ohio River watershed, it seemed appropriate to read from the chapter on water, which I call "Dante's River." It's in four parts. In the first, "The Water Pilgrim," I recall growing up in polluted northern New Jersey and yearning for wilderness with its pristine streams and lakes. The second part, "Spigot and Drain," looks at water through the weary, somewhat bleary eyes of a parent and householder. "The Mill Creek" describes a journey down Cincinnati's most polluted stream, and the last part, "The Baby and the Heron," meditates on the sin of pollution and the spiritual meaning of water itself.

Here's How the Chapter Begins:

To reach my house from the Gulf of Mexico, swim due north till you begin gasping for air. You'll need more than gills to cross the deoxygenated zone that fans from the Mississippi Delta in an arc as wide as New Jersey. Persist until you smell the continent and follow its spoor of clay, rot, coal dust, solvents, urine, detergents, and manure upstream, keeping always to the richest, most concentrated flow. Swing in great lazy arcs past oxbow lakes and bayous as the climate cools. Great tributaries will enter from the left – the Red, the Arkansas bearing feldspar and mica dust from the Rockies – but just ignore them and press on. After seven hundred miles the Ohio enters from the right; you will know it by the smell of hardwood forests, coal ash, steel mills, sandstone, and metamorphic rock. A quick fifty miles brings the Tennessee and the Cumberland, also on the right. Ignore these too, but feel the current build. Press on toward the Great Falls at Louisville; you may have to leap them like a salmon. In fifty miles the Kentucky enters from the right; if you're alert, you can catch the scent of limestone and Appalachian hemlock, perhaps even feel the flickering ghosts of trout.

In another fifty miles the river makes a great bend southward just as the Great Miami enters from the north; it smells inviting, but it is not your path. Go up another ten miles; you'll know Cincinnati by the smell of sewage, dish soap, and hydrocarbons. Turn left at the coffer dam and enter Mill Creek, which drains the city's industrial throat and all its suburbs to the north and west. Here, where Indians camped for centuries on level sand, the stream now snakes through acres of sewage plants and rail yards before entering a concrete trough installed by the US Army Corps of Engineers. Continue on past soccer fields, warehouses, and factories that produce everything from schnapps and sausage to skin creams and jet engines. Keep watch for a stand of old growth forest nodding darkly on the left, then take the next left hand fork and thread your way through the flood control dam that holds back Winton Lake. This is a good place to come up for air; the lake may look like coffee, but I would not advise a drink. Proceed along the south shore to the second bay, where clearer water enters from Daly Creek. You are now two hundred and fifty feet above the Ohio, and more than seven hundred above the Gulf.

From here on you need a trout's body and a carp's gills. Slip among limestone slabs, past wooded yards, through culverts for about two miles, then dive into the sewer that runs beneath the subdivisions. This is the dark night of your journey, the longest buried stretch. When you emerge, the creek will be no more than finger deep. Turn fins, if you have them, into legs. Stand up, regain your balance, then walk up the first swale on the right until it disappears into the level woods. See the straw-colored house beyond the trees? That's mine. Come in and have a drink.

I have never made this journey but often dream of it, especially when oppressed by the dirt and squalor of the city. When Pam and I moved here, I insisted on living at the top of the watershed, as far as possible from the pollution and flooding that plague low-lying neighborhoods. Growing up in urban New Jersey had accustomed me to filthy surface water. Every time it rained, our driveway ran like a braided stream, turbid with mud and cinders from the parking lot above. My friends and I liked to play in the runoff, watching it pour into the street and swirl along the curb until it vanished into a grate, feeding an underground river that eventually spilled into New York Harbor. Hours later, I could still hear it churning beneath the street as I walked to school, holding my nose against the dark, dank smell that wafted up through the manhole covers. And whenever we took the ferry to Manhattan, the same odor rose all around, stale, fetid, sickeningly familiar. I tried not to look down at the gray water strewn with clots of soft, unspeakable debris, but fixed my gaze on the famous skyline that stood out as sharp and pure as crystal.

In those days, gray city water become a symbol of everything to be loathed and shunned. I yearned for clean, wild water, the streams and lakes of the Connecticut hills where deer drank and fish swam, visible six feet down. I wanted water that smelled transparent, sharp as ice, as if it had been scoured by granite sand. I wanted to be able to bend down, like one of Gideon's soldiers, and drink from a cupped hand, then get up and move on without fear. Water become a prime field mark of wilderness for me, along with remoteness, old growth, and godlike summit views. I learned to climb for it, fighting the spirit of gravity like a salmon. The best water was always the highest, pooled among boulders at the edges of snow fields in the Winds or broken to spray in thread cascades that poured out of glacial cirques high in the Sierra Nevada. I found it, too, in shallow basins weathered from slickrock on the Colorado Plateau, or deep lakes in the Boundary Waters where the whole country was as shaggy and rugged as the White Mountain forests of New Hampshire. These were the places where streams began, where heaven touched earth and bestowed the water of life. I became a water pilgrim, searching for sources and origins, taking inspiration from the trout that held themselves poised in the swiftest current, always facing upstream.

This section goes on to elaborate on the climber's urge to taste the highest springs, to win a way upward against the spirit of gravity and persist in regions where life is reduced to its most fundamental expression. That journey seems to reflect the evolutionary path of life itself, to return to its mineral origins carrying the ancestral sea salt in its cells. But that was all far away and long ago; the narrator is now a parent living in the city, with a house to maintain and kids to clean up after. Now he gets water from the tap, out of a city pipe; it's approved, but it still makes him nervous:

When we moved here, I worried about the water. I could not imagine drinking from the Ohio. Just think about what's upstream: the steel mills of Pittsburgh, Wheeling, and Steubenville, the Ashland Oil refinery, DuPont's huge chemical works along the Kanawha up at Charleston, West Virginia, not to mention thousands of square miles of farmland soaked with fertilizer and pesticides, or, indeed, the hundreds of small towns that dump raw sewage directly into the river or its tributaries. And let's not forget those Kentucky coal mines, sour as vinegar and salted with heavy metals. The Indians and the pioneers may have fished and drunk from the Ohio when it ran free, clear, and wild, but only a fool would do so today. Even after living here for fifteen years, I can't turn on the tap without a shudder. And yet our engineers assure us that Cincinnati's state-of-the-art treatment provides some of the best drinking water in the nation...

Down at the water works I heard about the intricate path that Ohio or Great Miami water follows to reach my spigot. A huge station near the upstream edge of town pumps from the Ohio at a rate of 120 million gallons per day. All the way across town another plant pumps 16 million gallons per day from ten artesian wells that tap the aquifer, a bed of glacial sand and gravel two miles wide and 120-200 feet deep that runs from Dayton all the way to the Ohio. In round numbers, this means that greater Cincinnati consumes about 417 acre-feet of water per day. Thoreau, who drank straight from Walden Pond, took a jaundiced view of municipal water projects: "Now the villagers,who scarcely know where it lies, instead of going to the pond to bathe or drink, are thinking to bring its water, which should be as sacred as the Ganges at least, to the village in a pipe to wash their dishes with! — to earn their Walden by the turning of a cock or drawing of a plug!" If Walden supplied Cincinnati at today's rate, it it would be sucked dry in less than a week...

I am told that the average American household consumes fifty gallons of water per person per day. That seemed like a lot until I became a parent. When you're a parent, you do a lot of cleaning. You wash dishes; you wash clothes; you wash faces; you wash bottoms; you wash the floor; you wash the dog; you wash your hands, sometimes six or eight times a day; you wash the sheets — and let me tell you, there is nothing like throw-up on the sheets at night to make you appreciate running water. Thoreau might have moderated his view of pipes if he had had kids to raise. Most of the time, you don't have time to think about where the water comes from or where it goes (carrying throw-up or whatever). You just want it running and the drain unclogged, thanks very much.

As for pollution, it's the last thing on your mind. You *need* detergents and cleansers. You *love* the fact that they cut grease and bleach out stains. I'll even admit to moments of whimsical affection for the sprawling Procter and Gamble works along Mill Creek, thinking, "They make the stuff that leaves my wash looking whiter and brighter." I love the fact that I can fill and rinse at the flick of a wrist or, even better, flush away so much household waste, whether human, animal, vegetable, or mineral, and the more odious the better. A swirl, a gurgle, and down it goes — out of sight, off-site, out of mind. The drain is a black hole, into which it is perilous to look. But who would want to? The sink empties, ready for more. The bowl refills, limpid as a spring. Cleanliness and serenity return, as if by magic, to the house.

It's only on days of exceptional honesty or resolve that I admit to a nagging worry about where all this stuff goes. My house pours all sorts of things into the watershed, from bodily waste to soap suds to latex paint. It is, in fact, a "point source" of pollution. When the kids were young and making lots of messes, I repressed such thoughts. They gnawed at my environmental conscience; it was much easier to dream of wilderness with its pristine streams and lakes. But at some point I began to realize that the urge to roam and the urge to flush were closely linked. It may have been the day I was crossing Mill Creek after a heavy rain and saw a mallard skimming upstream over waves the color of peanut butter. So much beauty set against so much filth! Mill Creek, the third most polluted stream in the country according to an American Rivers survey, represented everything I ever wanted to escape. Yet what made it that way but waste from my very own house? The backpacker, imitating a bear in the woods, simply drops a scat and moves on. The urban householder, who must stay put, expels the waste and has it carried off. Flee or flush, it amounts to the same thing: escape. My quest for purity in the wilderness simply mirrored the city's desire to slough its own waste downstream.

So, the narrator realizes that he can no longer avoid the issue of waste and pollution. He goes on a field trip down the Mill Creek with local naturalists and activists, finding horrors and wonders from one stop to the next, and a surprising manifestation of wildness at the end:

For a water pilgrim, the first step downstream is the hardest. It goes against every instinct, not to mention three thousand years of myth and poetry that associate holiness and inspiration with mountain springs. When Thoreau sang of Walden's purity, he was not thinking chemically but metaphysically. His scorn for the ignorant farmers who had polluted Concord's ponds was fuelled by the wrath of a true believer in the spiritual character of place. For Thoreau, every human act left its signature. You could read the character of people and civilizations on the face of their land.

Considering Mill Creek, I expected the downward path to yield only horror and depression. If pollution signified character, this would be a descent into hell. Dante had given water a big role in the underworld: he and Virgil encounter rivers of boiling blood, roaring cataracts, and putrid swamps. The deeper they go, the worse it gets; the rivers become more violent, smelly, and lethal by degrees until, at the bottom of the universe, they coalesce into a frozen lake where the souls of traitors are trapped like straws in glass. Dante envisions a moral absolute zero, where love's motion ceases under the immense weight of all the sin washed down from above. He and Virgil escape by climbing a small stream that has cut a tunnel through the rock on the other side. Its source, we learn, is the earthly paradise at the top of the mountain of Purgatory. There, repentant sinners who have completed the mountain's therapeutic program undergo a second baptism that removes original sin, leaving them light-hearted and free to mount up to the stars.

Dante's guide through Hell was a Roman poet. Mine, it turned out, was a biologist named Stan Hedeen who had spent two decades studying the Mill Creek with students from Xavier University. I met him, not in a dark wood, but in a mall parking lot where members of the Sierra Club had gathered for a tour sponsored by the Mill Creek Restoration Project. Stan was a wiry, intense man with sharp features and a gray goatee. He looked a bit like Trotsky, except for a mobile grin that flashed at odd moments. He wore rumpled khaki pants and a T-shirt that read "Mill Creek Yacht Club." I could tell he was used to dealing with incredulity, even in a friendly crowd like this. He had the wry wit and granite patience of a maverick.

Robin Carothers, director of the Mill Creek Restoration Project, briefed us on the itinerary and herded us onto a bus, explaining that her group's goal was to turn Mill Creek into a greenway suitable for wildlife and recreation. Today's tour would showcase the challenges and opportunities they faced. Robin was a small, soft-eyed women who looked a young forty, with brown hair and a teacher's earnest manner. I asked her how she had gotten involved with Mill Creek, and she said she had come to Cincinnati seventeen years ago, thinking to stay for five at most. She had always wanted to live by the Pacific and even tried looking in the early 90's, but it didn't feel right. She stayed here and researched the creek, developing a blueprint for its restoration. Her motive, it turned out, was simple: "This has become home."

As we cruised past "Mt. Rumpke," a huge landfill that is the highest point in Hamilton County, Stan gave a brief history of Mill Creek since the Pleistocene, when glaciers changed the drainages and the Ohio captured the lower Licking River, leaving only this small, south-flowing creek to occupy its broad valley. When Indians lived here, Mill Creek was pure, dark, and verdant (its Shawnee name, Maketewah, means "he is black"). They fished its pools and hunted its banks, as did the early white settlers until burgeoning industry found it more useful as a sewer. Tanneries, slaughterhouses, and factories all dumped runoff into the creek throughout the nineteenth century. Though much cleaner now, it is still heavily polluted by household sewage and leachate from buried industrial waste. Nevertheless, Stan assured us with a grin, there were still some reasons not to abandon hope.

Our first stop was a covered bridge high up on one of the western tributaries. It looked like a small barn that someone had plunked down over the creek, which was only about thirty feet wide. Stan said it was the oldest bridge in Hamilton County. Beneath it, the creek chuckled along over limestone slabs that were studded with brachiopods as big as Ritz crackers; Stan said they were *Rafinesquina*, 450 million years old. Algae grew on the edges of the rocks, waving in the current like green hair, but the water looked surprisingly fresh and clean. Huge trees crowded the shore, chiefly cottonwoods and sycamores, suggesting the thick woods that had once covered the entire county and made the creek safe for shade-loving fish and invertebrates.

Stan began turning over rocks, pointing out caddis fly larvae and water pennies, which are good indicators of cleanliness because they have sensitive gills. "You wouldn't want to do this after a rain," he said. "It's best to wear rubber gloves, especially lower down. However, the great thing about streams like this is that they are self-cleaning. If we would just stop dumping all that bad stuff in, these critters would wash down and recolonize. Our studies have shown that it happens surprisingly fast, a matter of two to three years."

We scrambled among the slabs, exclaiming whenever someone found a caddis case, which looked like a matchstick dipped in shredded coconut, or the black thumbnail disk of a water penny stuck to the underside of a rock. It felt like hunting for treasure. Under the dense boughs yellow with autumn, where the bridge cast its dark shadow over sparkling riffles, I could imagine what the whole stream must have looked like two centuries ago. I caught a glimpse of the vision that had inspired Robin and her activist colleagues. A stray foam cup or foil snack packet snagged on a rock looked shockingly out of place.

Back in the bus, we headed downstream toward Winton Lake, which had been built by the Corps of Engineers to protect homes and businesses in the lower valley. Robin explained that the creek was dangerous during rains, not just because of all the bacteria and viruses it carried, but because of flash floods, which are as common here as they are in the Utah desert. I thought of rain falling on roofs, sidewalks, or parking lots like the one we had started from; the water would run right into the sewers and overflow into the creek just as quickly as if it had fallen on slickrock. Someone asked how much of the watershed was impervious surface, and Stan replied that in the lower stretches it was about 35%. The broad, shallow valley was easy to build on but vulnerable to floods, so the Corps had installed containment dams and channelized the bed, with mixed results as we would soon discover.

We crossed Winton Road, a north-south artery, and caught a glimpse of the lake. It looked like mud flats ringed with flood debris — driftwood, plastic jugs, old tires, that sort of thing. "Water's low," someone remarked. Stan explained that the Corps was dredging the lake, which had silted up much faster than expected. We turned down an unmarked dirt road, branches scraping the bus like fingernails, and stopped in a brushy field where a path led through thickets of aster and poison ivy to the lake. We stepped from the woods into a desert scene: acres of dried mud cracked into thick, irregular scales with knee-high weeds and saplings poking up everywhere. "All this year's growth," Stan said, pushing through. "The lake was drained about a year ago."

Out on the flats it was windy and exposed. On one side crouched the tangled woods; on the other, a rampart of crushed rock and compacted earth rose two hundred feet above us. Stan pointed out the gauging station, a concrete tower fifteen stories high that was plugged into the dam by a catwalk; it looked like a big staple holding everything together. A bathtub ring twenty feet up showed the lake's high water mark. It was not much of a lake, depth-wise. But Stan explained that you always build the dam across the deepest part of the valley; in fact, we were standing on fifty to sixty feet of mud! Tracks of heron, deer, and raccoon were pressed into the mud like cuneiform. Poking around, Stan found a mussel shell as big as a mitten. He kicked a scat, "Coyote. This would be a good place to see one. Around five A.M.!"

The group drives down into the valley to look at the main stem of the creek, then visits a superfund site where they learn about leaching and phytoremediation. Stan takes them to a bridge near a big landfill:

"Notice the channelization," he said, pointing downstream from the bridge. "When the Corps does a project like this, they broaden the stream bed two or three times, tear out all the trees, and line the banks with rip-rap using broken rock or old pavement bonded with concrete. The result is 'physical pollution' in the form of sunlight and heat, which the original native species can't tolerate because they're used to cool shade. So, even if we stop dumping, we still have a habitat problem. However," he added, "if you look downstream, you'll notice that Mother Nature has been quietly putting in gravel bars and meanders to rebuild the bed. You can already see a few willows and cottonwoods taking root."

Below the bridge, steel girders had been driven into the bed, interlocking to form a low dam behind which green water pooled, clear to five feet. Below the dam, a school of foot-long bass darted across the plunge pool, ignoring an old tire hung up on one of the girders. Behind us, cars zoomed across the bridge, oblivious. A freight train rumbled past, horn blaring and bells clanging, hauling a string of tank cars and box cars toward P&G. Upstream, the bank was strewn with slabs of old pavement among which young trees had grown up; some were almost a foot in diameter. White butterflies danced over the green water. Swallows darted and wheeled beneath the bridge.

Downstream, afternoon sunlight sparkled on the meanders between the gravel bars. For a moment, Mill Creek looked as glorious as any western river. If I raised my eyes, I saw lines of tank cars worming their way toward a black clot of factories. If I dropped them to the creek, I saw willows, gravel bars, a mallard paddling through a splash of sunfire. I saw wildness and beauty returning. At that moment, Mill Creek appeared as a corridor of serenity. I realized that this was what Stan and Robin were fighting for.

A few more stops brings them to the end of the tour, the place where all the waste water goes:

At the Cincinnati Sanitation Department garage, we turned down a private road that had once been a railroad bed and stopped just before the Western Hills viaduct. Stan said we had reached the Ohio River Pool, where Mill Creek drops its sediment. The sloping concrete walls of the channel looked serene and impenetrable, though we knew that in time they would be covered in silt. They ended, surprisingly, just beyond the viaduct, where trees and shrubs crowded the bank once more. Stan laughed, "The Corps ran out of money right about here. It's original shoreline all the way to the river, most of it on the grounds of the sewage plant." Someone exclaimed and pointed as a kingfisher broke from the bank and flew upstream.

We walked down the old rail bed, which was lined with honeysuckle, locust, and young sycamores. It ran right above the creek, and the air had a moist, stale odor that was disturbingly familiar. I finally recognized it as the smell of New York Harbor! Stan led us down a ramp to a huge, open concrete tank. The smell billowed out of it, nauseous and overpowering. We edged closer and peered over the rail. On one side, a dark tunnel opened into the bank like a mine shaft, out of which gray water trickled over slimy black rocks before disappearing into a grate. This was another combined sewer overflow, much bigger than the one we had seen near GE. Stan explained that the neighborhood sewers fed into a trunk line that ran beneath the creek all the way to the sewage plant. But the line could handle only so much storm water; without these overflows, it would simply explode. Now, he explained, when the water rises toward the top of the tank, it pushes open the heavy steel doors hanging from the rim and pours directly into the creek, saving the trunk line and the sewage plant at the expense of the Ohio River. You wouldn't want to be standing here during a storm, not without goggles and a surgical mask. There are 158 combined overflow ports in the Mill Creek watershed. They open whenever it rains more than a tenth of an inch per hour.

A tenth of an inch — that meant every time it rained! I gripped the rail, momentarily faint, though it may have just been the smell. I tried to imagine gray water surging into the chamber and swirling higher and higher until it burst through the gates in a disgusting flood. Mill Creek would then truly be an open sewer. It happened all the time.

Robin and Stan explained how the problem of combined sewers had arisen long ago, when the city was smaller and homes were converting to flush toilets from backyard privies. At the time it seemed sensible to dilute household waste with storm water. No one was thinking seven generations ahead, and pollution was not yet a household word. Now, we would have to pay dearly for any solution. Laying parallel lines and reconnecting the gutters would disrupt households, business, and traffic for at least a decade, besides costing untold millions. It would be cheaper to build small treatment plants on tributaries higher up the watershed, but land was expensive, and who would want one in their back yard? At present, the planners favored a fantastic scheme to blast an immense cavern into the bedrock one hundred feet or more below the creek bed. The runoff would all go there and be pumped to the treatment plant. I tried to imagine the whole dark labyrinth of the sewer system gathering water from every quarter, all the filth, disease, and waste of human life, and pouring it into the ultimate black hole. Suppose the pumps broke or the intakes clogged? Who would go down to fix them? This was displacement and escape carried to Dantean extremes.

Dazed, I stepped back from the rail and turned toward the creek. Three mallards were paddling upstream, their green heads and gray-brown plumage accented handsomely against the buff concrete. Farther down, framed by the immense parabolic truss that supported the viaduct, a small gray and black bird with a long slender bill stood hunched on a rock. It was just beyond the channelized stretch, and I asked Stan what it was.

He smiled. "That's a black-crowned night heron. Two years ago some workers at the sewage plant noticed one and called the Audubon Society. They had never seen anything like it. We discovered a nesting colony on the plant grounds, which are fenced in and free of coyotes besides being generally quiet and secluded. These birds are wild and secretive; there's only one other known colony in Ohio, out on an island in Lake Erie. Here they fly up along the creek at night, feeding on fish, sometimes all the way to the covered bridge. The fact that they're here means the Mill Creek is starting to clean itself, while we still try to figure things out." He sighed and glanced at his watch. "It'll be dark soon. Let's go. We have seen everything."

In the last section, I ponder the spiritual implications of pollution, a word whose root means "impure, not fit for religious sacrifice." Mill Creek shows that we only want to escape responsibility. "For pollution is nothing more than the history we would like to deny, indelibly written in the flesh of the world. It is what remains when you dissolve nature in money." But nature's method is to receive, embrace, and transform, so that one creature's evil turns to another's good and life can continue into the next generation:

Despair comes easily after long days of exposure to rail yards, roaring interstates, the rainbow smears of leachate, and the stench of combined sewer overflows. The problem feels overwhelming, the whole system too vast and sick ever to be repaired. It's hopeless. But then I remember the heron under the arch and the wildness that always returns with even the smallest opportunity, the aerial plankton seeding rooftop pools, the Mill Creek patiently rebuilding its bed in the midst of a concrete channel. I think of Stan and Robin, people of contrary but capable imagination who, by paying attention, have caught the spoor of a redemptive dream. Somehow, somewhere they made the choice to embrace rather than shun Mill Creek. Perhaps, like Dante, they knew that the downward path, though fraught with horror, would lead to the light if only they followed it all the way through. So they became water pilgrims of another kind, and at the lowest point they met the heron.

Three years after Pam and I moved to the city, our second daughter was born. She came right on time. Pam's water broke as she was getting up from the kitchen table after a late evening cup of tea. She staggered against the counter, seized by a powerful contraction as a dark stain spread down her leg. It was the water of life bursting out as primeval wildness took her once more, but this time we were ready. I bundled her into the car and drove through dark streets down a steep ravine into the valley. We crossed Mill Creek, invisible in its dark trough. No doubt bass were idling along the gravel bars while herons, gifted with keener sight, cruised upstream in search of them. Our hospital was at the top of the hill. Four hours later, Elizabeth leapt into the world all moist and pink and bawling for life. Water was all around us, in the blood and wetness of birth, Pam's soaked brow, my tears, even the damp, warm wash cloth that the nurse was dabbing ever so gently on the faces of mother and child. Later, when we were left alone, Pam sucked ice chips and sipped spring water before teaching Elizabeth how to nurse. I could feel the water cycle, old as life, flowing through us.

Several weeks later we presented Elizabeth for baptism. Standing before the congregation, Pam held her up to the marble font while the minister dipped in his hand and dribbled some water onto her tiny brow, muttering the usual words. This ceremony was supposed to be about washing away original sin, a sort of manufacturer's defect in our nature, but Elizabeth didn't seem to have any defects. She seemed to have a gift for enjoying herself, a confidence and delight that I was struggling every day to attain. If anyone needed cleansing, it was not Elizabeth, but me.

Perhaps, I thought, it would make more sense to think of baptism as a reminder of how much original grace we inherit from the water that runs through our cells. From the oceans to the clouds to the intimate meshwork of tissues and capillaries, it permeates and sustains the world of life. So Jesus spoke literally of living water, but the ancients had long recognized its spiritual value. No matter how divided or scattered, it always gathers together, centering to a stillness that mirrors the sky. In this way, it connects heaven and earth. Because it is pure at heart, it can forgive any indignity; it can bear all uncleanness without being changed. Humbly, it takes the shape of whatever it fills, yet its tendency is always to flow. In this way, by not resisting, it overcomes all things.

Elizabeth gazed out with dark, liquid eyes, taking it all in: the faces smiling up from the congregation, the sunbeams slanting through stained glass, the sparkling baptismal water that had no doubt been drawn from a city pipe, even the black-robed form of the minister bending toward her and looking for one brief moment almost like the silhouette of a heron.

CONTRIBUTED PAPERS

SESSION I: BOTANY

Saturday, March 22, 2003

Moderator and Editor:

Edward W. Chester
Austin Peay State University

EFFECTS OF NUTRIENTS AND SHADING ON *ARUNDINARIA GIGANTEA* (WALT.) WALT. EX MUHL. SEEDLING GROWTH

MARGARET C. CIRTAIN, JENNA R. FRANKLIN AND SCOTT B. FRANKLIN

Department of Biology, University of Memphis, Memphis, TN38152

ABSTRACT. Although extensive canebrakes of *Arundinaria gigantea* (Walt.) Walt. ex Muhl. were historically found throughout the southeastern United States, fragmentation has resulted in a critically endangered ecosystem. Due to extensive cane loss, little is known about the physiological and ecological constraints on cane growth. To determine the effects of these two factors and their interaction on growth, we placed cane seedlings under low and high levels of nutrients and light. Cane seedling growth was significantly reduced under low light conditions while low nutrients did not have a negative effect. Stem growth averaged 0.5 cm/week under shaded conditions and 2.2 cm/week under full light. Final biomass weights of roots and shoots were also significantly greater under the full light treatments. Thus, we suggest canebrake restoration will be most successful by transplanting cane into open fields or thinning forest to increase light penetration to remnant understory canebrakes. Our results suggest fertilization should not be necessary for cane restoration, but further research of nitrogen effects is necessary.

INTRODUCTION

A greater than 98% decline in *Arundinaria gigantea* (Walt.) Walt. ex Muhl. canebrake communities has resulted in a critically endangered ecosystem (Noss et al. 1995). Historical accounts suggest loss of canebrake habitat has resulted in the extirpation (and perhaps extinction) of many species (Remson 1986, Conover 1994, Judziewicz et al. 1999, Brantley and Platt 2001, Platt et al. 2001). Thus, canebrake restoration is necessary for maintaining and enhancing biodiversity in the southeastern United States. However, transplantation attempts to reintroduce cane have met with limited success (Platt and Brantley 1993, Feeback and Luken 1992) and our understanding of the environmental constraints of cane growth is hampered by its fragmented distribution. The goal of our research was to determine the effects of shading and nutrients on *Arundinaria gigantea* (giant cane) seedling growth for use in management and restoration of canebrakes.

Extensive canebrakes of *A. gigantea* were historically found throughout the southeastern United States. Native Americans had a wide variety of uses for cane and hunted in the canebrakes for a variety of fauna. Cane was used in the construction of homes (wattling) and home furnishings, such as chairs, bedding, and woven baskets (Myer 1972, Satz 1979). Early settlers of the southeastern United States reported "extensive" and "vast" stands of cane. In Kentucky in 1794, John Filson wrote, "Here is plenty of fine cane on which the cattle feed and grow fat." Fescule Cuming, 1819, talked to a farmer near Millerstown, KY, who said, " the whole country was an entire canebrake." William Bartram traveled in several states, including Alabama, Louisiana and Georgia and wrote about the "vast cane meadows," "an endless wilderness of canes," and "widespread cane swamps" (Platt and Brantley 1997). Because canebrakes provide a habitat for a diversity of fauna, including endangered butterflies (Platt et al. 2001) and avifauna such as Swainson's warbler (Graves 2001), and because so little is known about the ecology of cane, research is needed to determine factors affecting this unique ecosystem (Thomas et al. 1996).

Historical accounts of canebrakes suggest they were widespread on floodplains and stream terraces (moist soils, but not inundated for long periods of time) throughout the southeastern United States and tolerated a variety of environmental conditions (Caplenor 1968, Gilliam and Christensen 1986, Baskin et al. 1997, Nelson 1997, Platt and Brantley 1997, Fickle 2001, Fralish and Franklin 2002). However, most of the canebrake habitat has been lost due to lack of fire disturbance, replacement by cultivated fields, or being eaten by domestic livestock (Hughes 1966, Platt and Brantley 1997). Thus, the current distribution of cane does not necessarily imply its' physiological or ecological tolerances for various environmental conditions. One hint may be the ubiquitous occurrence of cane along forest edges, suggesting cane is intolerant of shade. Cultivation of bamboo also suggests nutrients may be a factor in growth and distribution of bamboo taxa in general. Meredith (2001) suggests fertilizing similar grasses with relatively higher amounts of nitrogen than other nutrients. Recht and Wetterwald (1999) suggest periodic fertilization (especially nitrogen and silica) based on the typical growth characteristics of bamboo; fertilize when culms sprout and three months later when rhizomes substantially develop.

To gain a greater understanding of the environmental constraints on canebrakes, we developed an experiment to test the effects of shading (full light and shaded) and nutrients (full nutrients and 1/10 full nutrients) on *A. gigantea* seedling growth. We hypothesized that *A. gigantea* seedling growth would be greatest under full light and high nutrient conditions, and that light would be the main factor controlling seedling growth.

METHODS

Arundinaria gigantea seedlings were grown from seed (supplied by Adam Turtle, Earth Advocates Research Farm, Summertown, TN) to 5-7 cm height. Two randomly chosen individuals were transplanted into six-inch azalea pots with Schultz's vermiculite, so we could fully control nutrient levels. A total of twenty pots were planted, then randomly assigned to one of four treatments: (1) low nutrients (LN) and partial light (PL), (2) low nutrients and full light (FL), (3) high nutrients (HN) and partial light, and (4) high nutrients and full light. All pots were placed on a light table with continuous light. Temperature ranged between 18°C and 25°C.

The two nutrient concentrations examined using Peters Professional 20-20-20 All Purpose Plant Food were: (1) typical nutrient pulses as suggested for indoor plants on the Peter's label (1 teaspoon/gal water; high nutrient treatment), and (2) a ten-fold dilution of the concentration suggested by the Peter's label (low nutrient treatment). Phosphorus and nitrogen concentrations were examined following the mixing of the nutrient solutions with a Hach colorimeter (Hach Chemical Company, Loveland, Co.). Nitrate-nitrogen was the same for both solutions, 2.5 mg L^{-1}, owing to the hydrolysis of urea from the Peters nutrient media. Phosphorus was 2.57 mg L^{-1} for the high nutrient solution and 0.45 mg L^{-1} for the low nutrient solution, suggesting a one-fifth dilution.

Two light treatments were also examined: (1) full light and (2) partial light (approximately ¼ full light accomplished using nylon netting). Several light measurements for each treatment taken with a Li-Cor quantum sensor (photosynthetically active radiation) averaged 85 μmol sec^{-1} m^{-2} for the full light treatment and 24 μmol sec^{-1} m^{-2} for the partial light treatment (both of these light measurements are low compared to full sun, around 1500 μmol sec^{-1} m^{-2}).

Two measurements were taken to examine treatment effects. Height growth was recorded approximately every two weeks. We averaged heights of the two individuals for each pot. If an individual had more than one shoot, we combined the lengths of all shoots prior to averaging the two individuals. In addition, all individuals were harvested at the end of the experiment, split into shoot and root modules, dried at 60° C for 48 hours, and weighed to the nearest 0.0001 g on a Mettler balance. We analyzed the height growth data with a repeated measures two-factor ANOVA in SAS (SAS Inst 1990). We analyzed the ending biomass data with a two-factor ANOVA. All analyses were based on pots as replicates (n=5).

RESULTS

A significant Time*Nutrient (Pillai's Trace 6.09, $p>F = 0.007$) and Time*Light (Pillai's Trace 8.54, $p>F = 0.002$) effect was found for stem height over the 54-day period (Fig. 1). There was no significant Time*Nutrient*Shading interaction (Pillai's Trace 1.97, $p>F = 0.164$). Shading significantly decreased stem growth during the first and second sampling intervals, but not during the third sampling interval. Stem growth averaged 0.5 cm/week under shaded conditions and 2.2 cm/week under full light. Nutrients significantly increased stem growth, but only during the first sampling interval and not thereafter. In fact, low nutrient stems appeared to have greater stem height at the end of the experiment, albeit not significant.

Shoot and root biomass were significantly greater under lower nutrient conditions (Table 1, Fig. 2). Lower light conditions, however, significantly lowered stem and root biomass. There was a significant Nutrient*Light interaction effect on shoot biomass. Shoot biomass was significantly greater in the Full Light treatment under low nutrient conditions, while nutrients did not affect shoot biomass in the Partial Light treatment. Root/shoot ratios were significantly affected by light, but not nutrients (Table 1, Fig. 3). Root/shoot ratios were significantly lower under full light conditions.

DISCUSSION

The ability to restore rare communities requires knowledge of the historical range of the community and the life history characteristics of community taxa. Successful restoration requires the development of an attainable target. Although canebrakes represent one of the most rare communities of the southeastern United States, they have received little attention (Brantley and Platt 2001), and land stewards lack information on their structure, composition (flora and fauna), distribution, and function. The present study seeks to gain a greater understanding of the current distribution of *Arundinaria gigantea* by examining two potential environmental constraints, light and nutrients. Our results suggest shading is a major factor controlling the distribution of canebrakes.

Shaded conditions significantly decreased growth based on stem height and total biomass for both roots and shoots. Most authors suggest that cane is intolerant of low light conditions. Indeed, all treatments in the present study had quite low light conditions (< 6% full sun). However, the effects of light were obvious from the results of the data, suggesting light is a major limiting factor for the lateral propagation of giant cane. This may seem contradictory to early accounts of canebrakes as dominant components of the forest understory (Platt and Brantley 1997, Judziewicz 1999, Delcourt 2002). However, forests prior to European settlement tended to be more park-like, with a few large individuals scattered across the floodplain (Franklin 1994, Baskin et al. 1997).

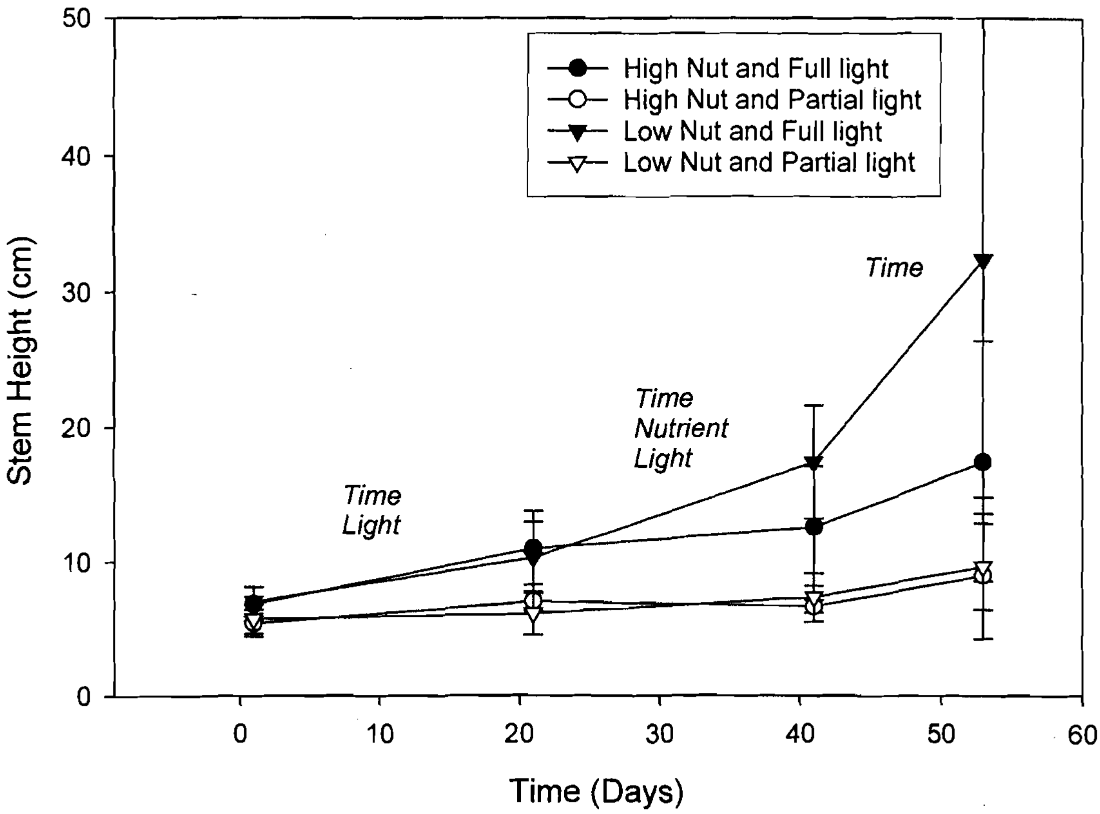

Figure 1. Stem height of *Arundinaria gigantea* (Walt.) Walt. ex Muhl. under a light table over a 54-day period. Treatments include two nutrient levels (high nutrients and low nutrients) and two light levels (full light and partial light). Significant factors are given in italics for respective individual time periods.

Table 1. Two factor analysis of variance (ANOVA) results for *Arundinaria gigantea* (Walt.) Walt. ex Muhl. stem and root biomass grown under a light table for 54 days. Treatments include two nutrient levels (high nutrients and low nutrients) and two light levels (full light and partial light).

Factor	F	p>F
Root		
Nutrients	7.74	0.013
Light	8.11	0.012
Nutrients * Light	1.11	0.309
Shoot		
Nutrients	10.73	0.005
Light	29.15	<0.0001
Nutrients * Light	6.42	0.0221
Root/shoot ratio		
Nutrients	0.02	0.877
Light	6.15	0.025
Nutrients * Light	0.89	0.358

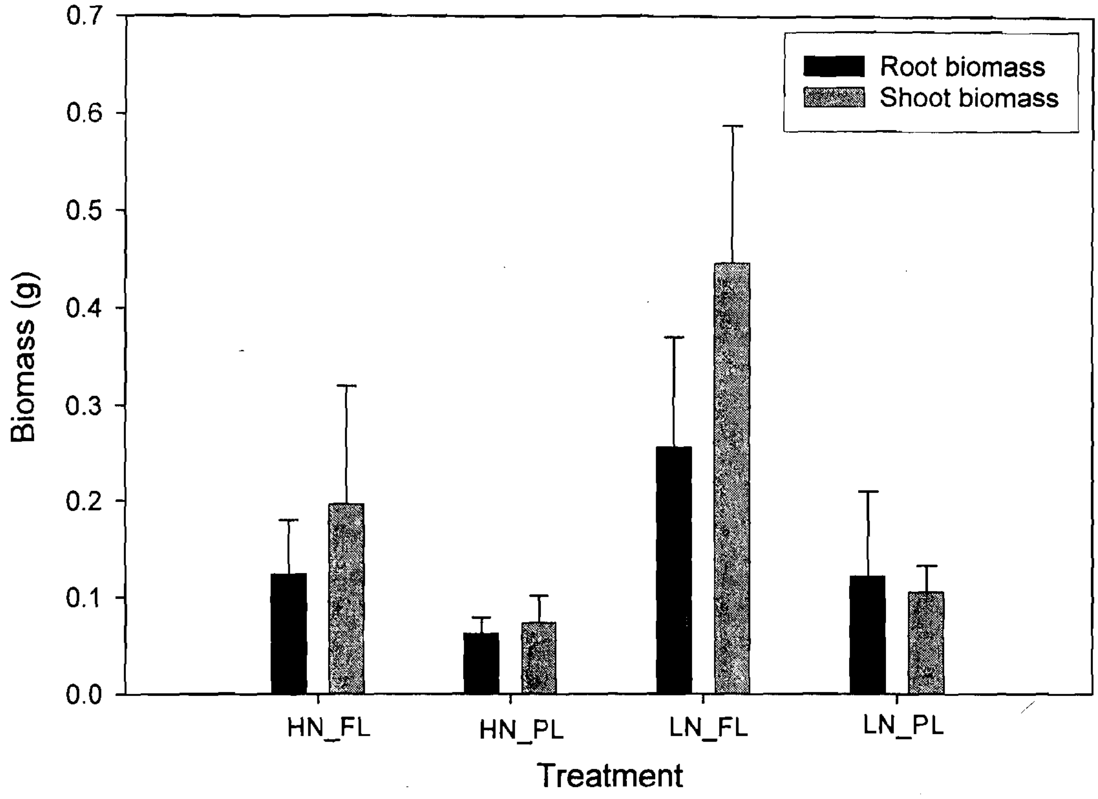

Figure 2. Root and shoot biomass (g) of *Arundinaria gigantea* (Walt.) Walt. ex Muhl. stems grown under a light table over a 54-day period. Treatments include two nutrient levels (high nutrients, HN, and low nutrients, LN) and two light levels (full light, FL, and partial light, PL).

Succession due to the decrease in disturbance (especially fire) in these forests has rendered a more closed canopy, allowing little light penetration and often having dramatic negative effects on understory flora cover and diversity (Fralish, unpublished manuscript). Canebrakes have long been associated with fires (Platt and Brantley 1997, Delcourt 2002) that swept through decreasing the encroachment of more trees and thus the closing in of the overstory canopy. Cane, conversely, responds quite quickly and positively to fires (Hughes 1966) if they are not too frequent (> every 5 years, Brantley and Platt 2001). Thus, the demise of large canebrakes has been due to too much disturbance (e.g., grazing, fire, and transforming to agriculture) and too little disturbance (suppression of fire, transforming open canopy forest to closed canopy forest and smothering cane growth).

We also found significantly lower growth under our full nutrient treatment, contrary to our hypothesis. Two factors may govern this result and should be studied further. First, our nutrient treatment did not alter nitrogen due to the diffusion of urea in our nutrient media, so all treatments were saturated with nitrogen. Because nitrogen may be the most important nutrient (Recht and Wetterwald 1999, Meredith 2001), our results could imply that our treatments had no real effect on nutrient levels. The lack of a significant effect on root-shoot ratios in the present study suggests nutrients were not limited in any of the treatments. Secondly, our full nutrient treatment may have provided too high level of nutrients to the seedlings, negatively affecting their growth. Evidence for this possibility comes from micropropagation research, where nutrient media are generally diluted

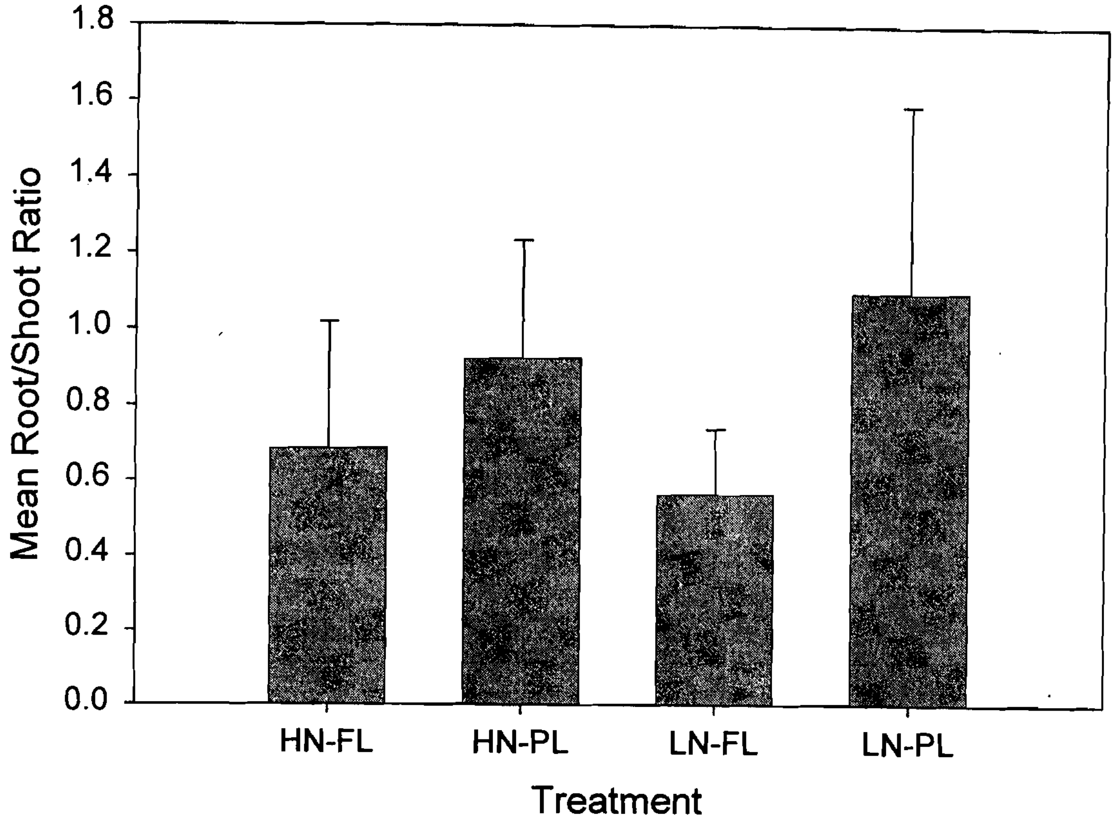

Figure 3. Mean root/shoot ratios of *Arundinaria gigantea* (Walt.) Walt. ex Muhl. stems grown under a light table over a 54-day period. Treatments include two nutrient levels (high nutrients, HN, and low nutrients, LN) and two light levels (full light, FL, and partial light, PL).

due to the negative affects on shoot propagation (Evans et al. 1983, Preece 1995). Preliminary results from current research suggest moderate nitrogen fertilization (Margaret Cirtain, unpublished data) increases height growth and decreases physiological stress of *Arundinaria gigantea* seedlings.

A final point to discuss is the use of seedlings with a species that seldom flowers (McClure 1966, Brantley and Platt 2001) and has no discernable seed bank (Schneider and Sharitz 1986). We chose to examine seedlings as they are most closely matched based on physiology and growth with micropropagated individuals. We are currently developing methods of micropropagating cane plants due to the destructive nature and labor intensiveness of transplanting for restoring canebrakes (Platt and Brantley 1992). To develop an eight hectare canebrake, we estimated the need for two million rhizomes, nearly impossible by transplanting but perhaps accomplished through micropropagation. While micropropagation will provide a much greater number of plants, it is unclear if the overall brake restoration will be faster. Hughes (1951) found that natural seedlings developed very slowly, with heights <30 cm after three years of growth. Artificially propagated seedlings had faster development, but still only reached heights of 8 cm to 13 cm after the first season's growth, and root systems remained simple (no rhizome development). Conversely, new shoots from rhizomes may grow >30 cm day^{-1} (Meredith 2001). Rhizome growth may also be dramatic. Measurements taken at the Edward J. Meeman Biological Field Station in the loess soils of western Tennessee show cane invading old fields at a rate of 2-3 m year^{-1} (Personal observation, SBF).

CONCLUSIONS FOR MANAGEMENT RESTORATION

Light is a major factor controlling the growth and propagation of *Arundinaria gigantea*. Thus, successful establishment of canebrakes will require high light conditions, which can be accomplished in two ways. First, as suggested by Platt and Brantley (1992), cane rhizomes could be transplanted to old fields where high light is available. In addition, remnant stands of canebrakes currently found in the understories of dense forest could be released. This method would offer a different microclimate for cane growth, with less potential wind dessication and higher humidity compared to open field conditions. Due to the general sensitivity of bamboo taxa to humidity and wind dessication (Judziewicz et al. 1999, Recht and Wetterwald 1999, Meredith 2001), these conditions may prove better for growth. In addition, no transplanting of cane rhizomes may be necessary, depending on the current density of stems in the remnant brake. Fire should be examined in combination with canopy thinning treatments (Hughes 1966).

ACKNOWLEDGMENTS

The authors are indebted to Adam Turtle, Earth Advocate, for his generous donation of seeds and would like to thank Jack Grubaugh for help with analyses of nutrient solutions and Deanna Franklin for reviewing the manuscript.

LITERATURE CITED

Baskin, J.M, E.W. Chester, and C.C. Baskin. 1997. Special paper: forest vegetation of the Kentucky karst plain (Kentucky and Tennessee): review and synthesis. Journal of the Torrey Botanical Society 124:322-335.

Brantley, C.G. and S.G. Platt. 2001. Canebrake conservation in the southeastern United States. Wildlife Society Bulletin 29:1175-1181.

Caplenor, D. 1968. Forest composition on loessial and non-loessial soils in west-central Mississippi. Ecology 49:322-331.

Conover, A. 1994. A new world comes to life, discovered in a stalk of bamboo. Smithsonian Mag. (October):120-129.

Delcourt, H. 2002. Forests in Peril: Tracking Deciduous Trees from Ice-age Refugees into the Greenhouse World. McDonald & Woodward Pub Co., Granville, Ohio.

Evans, D.A., W.R. Sharp, P.V. Ammirato, and Y. Yamada. 1983. Handbook of Plant Cell Culture, Vol. 1. Techniques for Propagation and Breeding. Macmillan Publishing Co., New York, New York.

Feeback, D., and J.O. Luken. 1992. Proper transplanting method critical in restoration of canebrakes (Kentucky). Restoration and Management Notes 10:195.

Fickle, J.E. 2001. Mississippi Forests and Forestry. University Press of Mississippi, Jackson, Mississippi.

Fralish, J. S., and S. B. Franklin. 2002. Taxonomy and Ecology of Woody Plants in North American Forests (Excluding Mexico). John Wiley & Sons, Inc., New York.

Franklin, S.B. 1994. Late-Pleistocene and Holocene vegetation history of Land Between The Lakes, Kentucky and Tennessee. Transactions of the Kentucky Academy of Sciences 55:6-19.

Gilliam, F.S., and N.L. Christensen. 1986. Herb-layer response to burning in the pine flatwoods of the lower coastal plain of South Carolina. Bulletin of the Torrey Botanical Club. 113:42-45.

Graves, G.R. 2001. Factors governing the distribution of Swainson's warbler along a hydrological gradient in Great Dismal Swamp. The Auk 118: 650-664.

Hughes, R.H. 1951. Observation of cane (*Arundinaria*) flowers, seed, and seedlings in the North Carolina Coastal Plain. Bulletin of the Torrey Botanical Club 78:113-121.

Hughes, R.H. 1966. Fire ecology of canebrakes. *In* E.V. Komarek (ed.), Proceedings of the Fifth Annual Tall Timbers Fire Ecology Conference, pp. 149-158. Tall Timbers Research Station, Tallahassee, Florida.

Judziewicz, E.J., L.G. Clark, X. Londono, and M.J. Stern. 1999. American Bamboos. Smithsonian Institution Press, Washington, D.C.

McClure, F.A. 1966. The Bamboos: a Fresh Perspective. Harvard University Press, Cambridge.

Meredith, T.J. 2001. Bamboo for gardens. Timber Press. Portland, Oregon.

Myer, W.E. 1972. Two Prehistoric Villages in Middle Tennessee. Southeastern Indian Antiques Survey, Inc., Nashville.

Nelson, J.C. 1997. Presettlement vegetation patterns along the 5th principal meridian, Missouri Territory, 1815. American Midland Naturalist 137:79-94.

Noss, R.F., E.T. Laroe, III, and J.M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. United States Department of Interior, National Biological Service, Biological Report 28, Washington, D. C., USA.

Platt, S.G., and C.G. Brantley. 1992. The management and restoration of switchcane (Louisiana). Restoration and Management Notes 10(1):84-85.

Platt, S.G., and C.G. Brantley. 1993. Switchcane: propagation and establishment in the southeastern United States. Restoration and Management Notes 11(2):134-137.

Platt, S.G., and C.G. Brantley. 1997. Canebrakes: An ecological and historical perspective. Castanea 62(1):8-21.

Platt, S.G., C.G. Brantley, and T.R. Rainwater. 2001. Canebrake fauna: wildlife diversity in a critically endangered ecosystem. The Journal of the Elisha Mitchell Scientific Society 117(1):1-19.

Preece, J.E. 1995. Can nutrient salts partially substitute for plant growth regulators? Plant Tissue Culture and Biotechnology 1:26-37.

Recht, C., and M.F. Wetterwald. 1999. Bamboos. Timber Press, Portland, Oregon.

Remson, J.V. 1986. Was Bachman's warbler a bamboo specialist? Auk 103:216-219.

SAS Inst. 1990. SAS/STAT User's Guide, Volume 6, Fourth Edition. SAS Institute Inc., Cary, North Carolina.

Satz, R.N. 1979. Tennessee's Indian Peoples from White Contact to Removal, 1540-1840. University of Tennessee Press, Knoxville, Tennessee.

Schneider, R.L. and R. R. Sharitz. 1986. Seed bank dynamics in a southern riverine swamp. American Journal of Botany 73:1022-1030.

Thomas, B.G., E.P. Wiggins, and R.L. Clawson. 1996. Habitat selection and breeding status of Swainson's warbler in southern Missouri. Journal of Wildlife Management 60(3):611-616.

BEDLOAD TRANSPORT IN CHANNELIZED TRIBUTARIES, HATCHIE RIVER, TENNESSEE

[1,3]THAD WASKLEWICZ, [2,3]SCOTT FRANKLIN, AND [1]TIMOTHY BILLS

[1]Department of Earth Sciences – Geography Program, University of Memphis, Memphis, TN 38152
[2]Department of Biology, University of Memphis, Memphis, TN 38152
[3]Edward J. Meeman Biological Field Station, Department of Biology, University of Memphis, Memphis, TN 38152

ABSTRACT. Channelization has been a common management tool in many of the agricultural- and urban-dominated drainage basins of the southeastern United States. Channel modification has accomplished the desired goal of increasing surface runoff and passage of flood peaks more efficiently, but it has altered sediment dynamics along many drainage networks. Changes in sediment transport and deposition rates continuously alter habitat and have deleterious impacts on riverine biological populations. Despite knowledge of these shifts in ecology, quantitative data on sediment transport remains elusive. The current study explores amount and texture of bedload sediment transport in channelized streams. Our findings indicate much higher rates of bedload transport along channelized tributary streams than nonchannelized trunk streams and provide a basis for future studies.

INTRODUCTION

Channelization within the Hatchie River drainage basin was conducted to accelerate storm water drainage, protect agricultural land from flooding, and lower the water table in bottomland areas, thereby increasing the amount of acreage suitable for cultivation. Human alteration of channels accomplished these desired goals, but it also changed sediment dynamics throughout the basin. Numerous tributary streams increased their sediment carrying capacity, which led to channel incision and modification of channel morphometry (Simon 1989, 1994). This produced higher rates of floodplain sedimentation along tributary streams (Simon and Hupp 1992) and development of shoals and valley plugs within tributaries and the catchment's main-stem rivers (Diehl 1994, 2000). Recent studies provide compelling evidence for accelerated sedimentation within and along channelized streams posing a significant threat to the preservation and restoration of wetland communities (Brookes 1986, Nakamura et al. 1997, Franklin et al. 2001, Wyzga 2001). The excess sediment has changed edaphic conditions, specifically nutrient, particle size, and moisture characteristics, which subsequently leads to changes in forest community patterns (Nakamura et al. 1997, Nakamura et al. 2002). Despite knowledge of these changes in riverine habitat and populations, there is a complete lack of reported field-based measures of sediment discharge. The present study explores mass and particle size distributions of bedload material transported at a cross-section of Richland Creek (drainage area ~126 km^2) and Sugar Creek (drainage area ~57km^2) during various flood stages.

Channelization of tributary streams leads to bed-level lowering because of stream degradation (Simon and Darby 1999). Richland and Sugar Creeks exhibit characteristics of an upstream progressing degradation event that is common along many channelized streams in the lower Mississippi River Valley (Galay 1983). Hupp and Simon (1986) proposed a model of upstream progressing degradation in streams. The initial phase of degradation begins with channelization (Stage 3, with Stage 1 being the pre-modified conditions and Stage 2 the construction of the channelized reach) and continues to progress in an upstream direction. This coincides with aggradation in a downstream direction. Bed-level lowering in the degrading reaches creates unstable, over-heightened stream bank profiles (Stage 4). Slab or rotational (low angle, often created by prolonged wetting or incision) bank failures are common events and contribute a large amount of material for sediment transport via channel widening (Stage 5). Over time, the stream aggrades, changing from an incised channel, back towards a meandering floodplain environment (Stage 6). Richland Creek exhibits characteristics of Stages 3 and 4 throughout its drainage basin, while Sugar Creek has numerous tributaries and a large section of the trunk stream in the upper section of its drainage basin that are in Stages 3 and 4. The lower portion of the trunk stream has not been channelized.

Upstream progressing degradation results from shortening the channel length, which creates a steeper gradient. The increased streambed gradient produces higher unit stream power during flow events and ultimately channel incision. The incision is a direct result of excess energy associated with steeper gradient whereby the excess energy is used to erode bed material. The incision leads to increases in sediment erosion rates at cross-sections above the knickpoint and increased deposition at locations along downstream reaches. Channel incision leads to higher sediment production and yields (Simon 1989).

Increases in sediment yields are often equated with higher rates of suspended and bedload sediment. Streams in west Tennessee are frequently dominated by suspended sediments. Simon's (1989) empirically derived data suggest ratios of suspended load to bedload ranging from 3:1 on the South Fork Obion River, 5:1 on the Wolf River, 6:1 on the Hatchie River, 10:1 on the Loosahatchie River, and 17:1 on the Obion River. The PIs hypothesize the channelized tributary streams, because of their steeper gradient, move a larger quantity of material by bedload than has been previously proposed from empirical data. This postulation garners support from Simon's study (1989), which identified an initial order of magnitude increase in suspended sediment yields, but a two-order magnitude increase in bed-material yields along channelized streams. Simon (1994) later identified bed-material yields were greatest during Stage 3 and the initial phases of Stage 4 of the evolution model. The novel goal of the present work was to provide more realistic estimates of bedload transport based on field-collected measurements.

METHODS

Sediment Sampling

Cross-sectional data: In advance of flooding events and after each flood event, channel cross-section dimensions were gathered at the sample sites. A tape method from a fixed location on the left bank (looking upstream) was the starting point for measurements in each cross-sectional survey. Channel width was a fixed measure because the concrete abutments of the bridge were used as banks. Depth measures were determined from stage elevations based upon an arbitrarily defined datum at the beginning of the study. Numerous measures of depth were taken each time across the cross-section using the various stages sampled during bedload sampling. Depth values were averaged. During each flood-event, stream velocity was measured by timing a float over a known distance. These measures were used to calculate discharge for each stage sampled. The channel width measure was also used to assist in dividing the channel in 10 to 15 evenly spaced vertical units that were revisited in each bedload sampling event. Not all of the verticals were sampled in each event because of shallow depths or deposition of sediment near the bridge abutment.

Bedload sampling techniques: The bedload sampling scheme was consistent with procedures outlined by Guy and Norman (1982). A channel cross-section was established at lower bridge crossing along Richland and Sugar Creeks. The cross-section was divided into evenly spaced verticals. A Helley-Smith sampler with an extended wading pole was used to sample bedload material from the bridge crossing. Sand waves near the streambed were sampled from the bridge. The bridge abutments offered the most stable cross-sectional area to sample. The upstream side of the bridge was always sampled to minimize bridge-scouring effects. The sampler was plunged into the channel and held on the bed of the stream for 60 seconds. After each vertical was sampled, the sampling bag was emptied into a large zip-loc and subsequently analyzed for mass and texture.

Sediment Analysis

Sediment Mass and Texture Lab Techniques: Sediment samples were dried in an oven at 95 °C for 48 hours. Samples were stirred twice to release as much moisture as possible during this 48-hour period. After the samples were dried, organics (twigs and leaves) were hand picked from the samples using tweezers. The mass of the sediment from each vertical was measured in grams.

Texture analysis was performed on a 100g sub-sample from each vertical. Sediment samples from each vertical were quartered to produce a 100g sub-sample. A majority of the sediment samples had to be quartered numerous times to reach a 100g fraction. Sediment texture data were acquired using dry sieving techniques. A sieve stack containing four sieve sizes (2mm, 500 μm, 250 μm, and 63 μm) produced five separate sediment size fractions (>2mm [very coarse sand and gravel], 2mm - 500 μm [coarse sand], 500 μm - 250 μm [medium sand], 250 μm - 63 μm [fine sand and very fine sand], and <63 μm [silt and clay]). Each 100g sub-sample was placed in the sieve stack and agitated using an electronic shaking unit for 10 minutes. The individual size fractions from each sample were weighed and the percentage of each size fraction was determined from the total sample.

Quantification of Bedload Discharge: Bedload transport was measured using the total cross section method, which assumes that (1) sample times at each vertical are equal and (2) verticals were evenly spaced across the cross section. A bedload discharge for the total cross-section was measured using the following equation:

$$Q_b = (K)(W_T/T)M_T$$

Where Q_b = bedload discharge, as measured by the bedload sampler, in tons per hour per foot:

W_T = total width of the stream, in feet;
T = total time the sampler was on the bed, in seconds;
M_T = total mass of sample collected from all verticals; and
K = conversion factor which is equal to 0.0002646 for a 3-inch nozzle width

Bedload discharge is often expressed in tons/day/foot within the literature (e.g. Simon 1989). However, this measure does not accurately represent small tributary streams like those sampled for this exploratory study. Runoff in small drainage basins, like Richland and Sugar Creek, typically lasts less than a day. This creates a scenario whereby large variations in a discharge and sediment concentrations are the norm. The "flashy" nature of events is further exacerbated by channelization, which accelerates runoff to the channel. Therefore, we used a measure of tons/hour/foot. However, this measure is contingent on the maintenance of the particular river stage over at least a one-hour period. We also would like to clearly state that the limited number of samples collected for this study has considerable uncertainty associated with it because of the discontinuous conditions associated with these streams. Despite this uncertainty, the field-collected data provide valuable, more realistic (than current empirical estimates) information of sediment transport.

RESULTS

Average bedload discharge (Q_b) for Richland Creek and Sugar Creek during the four sampling events was 1.46 ton/hour/foot and 0.71 ton/hour/foot respectively. There is a large degree of variability in Q_b dependent upon sampled stream stages (Tables 1 and 2). A positive trend exists between Q_b and discharge for both sites; signifying bedload transport continues to occur at high stages. At Richland Creek, stages did surpass 1.25m, but our equipment could not sample the highest stages. Larger caliber particles from bedload samples suggest the positive linear relationship should hold even at stages higher than 1.25m.

Table 1. Bedload discharge calculations and hydrologic variability at the two sampled sites, Richland Creek and Sugar Creek, western Tennessee.

Richland Creek

Sample Date	Stage(m)	Velocity(m/sec)	Discharge(cms)	Qb (tons/hour/foot)
11/28/2001	0.5	2.4	33.52	0.99
11/28/2001	1.25	3.9	44.62	3.05
05/04/2002	0.25	1.9	21.46	0.82
05/04/2002	0.5	2.2	25.17	0.96

Sugar Creek

Sample Date	Stage(m)	Velocity(m/sec)	Discharge(cms)	Qb (tons/hour/foot)
11/28/2001	1.1	0.95	12.86	0.14
11/28/2001	1.4	1.3	17.59	0.24
05/04/2002	2.25	2	27.07	0.88
05/04/2002	2.45	2.1	28.42	1.57

Particle size distributions ranged from gravel to silt size particles during each of the events at both sites. Sugar Creek exhibits minimal differences in sediment texture with increasing discharges. The bulk of the Q_b is composed of medium sand (Fig. 2). Richland Creek also displays a high amount of medium sand, but at higher discharges, the amount of coarser materials (gravel and coarse sand) increases (Fig. 1). The opposite trend holds for Sugar Creek and likely results from a lack of source material in its drainage basin because of drainage basin geology.

Changes in bedload transport rates indicated a minor shift in the thalweg across the channel along Richland Creek (Fig. 2c and 2d). The thalweg shifted to left bank during a smaller flood event on 05/04/02 (Fig. 2d) and to the right bank on 11/28/01, a larger flood (Fig. 2c). Field observations

Table 2. Empirically derived bedload discharge data for Stage 3 channelized streams in western Tennessee (from Simon 1989). *The Hatchie River site at the bottom of the table is different from all other sites because it is in Stage 1 of the channelized evolutionary model presented by Hupp and Simon (1986).

Stream	Station No.	Gage Location	Q_b (tons/day /foot)	Basin Area (mi^2)
N.F. Forked Deer	07029100	Dyersburg	6.91	939.00
N.F. Obion River	07025400	Near Martin	6.95	372.00
Rutherford F. Obion	07025100	Near Kenton	7.81	267.00
S.F. Forked Deer	07027800	Near Gates	4.06	932.00
S.F. Forked Deer	07028100	Near halls	6.32	1,019.00
S.F. Obion River	07024500	Near Greenfield	2.22	383.00
S.F. Obion River	07024800	Near Kenton	9.91	752.00
Wolf River	07031700	Raleigh	11.0	771.00
*Hatchie River	07029500	Bolivar	0.04	1,480.00

indicated the thalweg was pushed left by a small drainage channel entering Richland Creek above the bridge from the right stream bank. The drainage channel responded quicker to the precipitation event and dominated flow in this section until Richland Creek was at a high enough stage to overcome flows from the tributary channel and began to work its way back toward the right bank (i.e. the 11/28/01 flood). The two sampling events along Sugar Creek show similarities in the location of the thalweg (Fig. 2a and 2b). However, it is interesting to note the large amount of Q_b along the left side of the channel (Fig. 2b at vertical 3.79), which is likely the result of a single pulse of sediment moving through at that location. Overall, verticals near the stream banks contained slightly smaller amounts of bedload because friction from the bed and bank reduces stream power and decreases transport potentials (Fig. 2).

DISCUSSION

The average Q_b was 1.46 tons/hour/foot for the events sampled on Richland Creek, but ranged from 0.86 to 3.05 tons/hour/foot. To place these values in context, we present empirically derived bedload transport values from several channelized streams in west Tennessee (Simon 1989), which were in Stage 3 of the evolutionary (similar state to a majority of Richland Creek) model proposed by Hupp and Simon (1986).

Richland Creek Q_b was higher on a per event basis than all other Stage 3 channelized streams (data in Table 2 are in different units; we use a measure of tons/hour/foot and Simon (1989) used tons/day/foot). This is despite the other sites having much larger drainage basin areas and discharges. The differences are likely a result of two factors: (1) smaller channelized streams have a steeper gradient, which results in higher Q_b rates as has been purported by Simon (1989, 1994); and (2) the present data were collected from the field as opposed to empirically derived data given in the table. We argue our data are more realistic estimates of Q_b, although not without limitations.

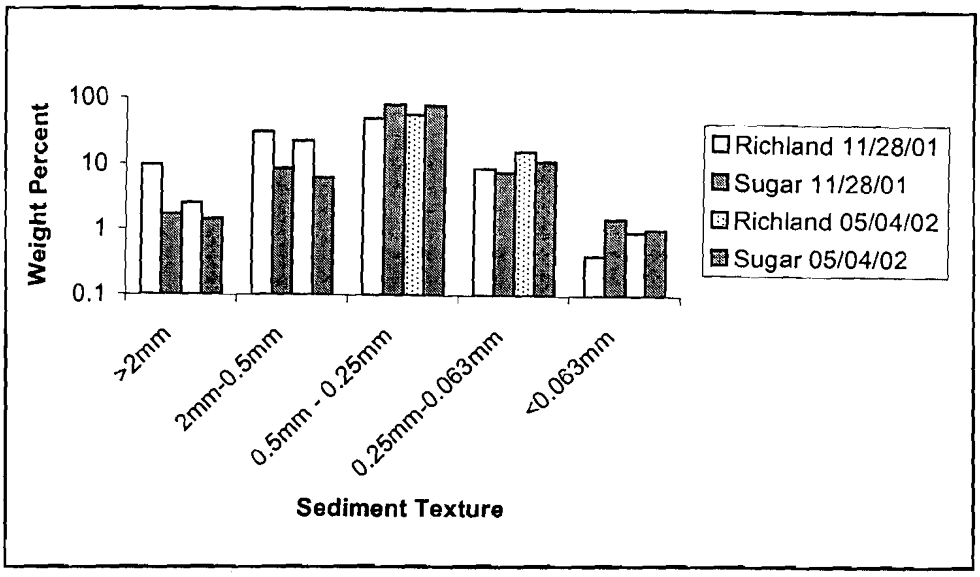

Figure 1. Average sediment texture derived by averaging the weight percentages of all verticals within the cross-section over the entire sampling period at a particular stage for Richmond and Sugar Creeks in western Tennessee. The size distribution is as follows: >2mm [very coarse sand and gravel]; 2mm - 500µm [coarse sand]; 500µm - 250µm [medium sand]; 250µm - 63 µm [fine sand and very fine sand]; and <63µm [silt and clay].

Table 2 also contains a gaging station from the Hatchie River, which was in Stage 1 (premodified) of the evolutionary model proposed by Hupp and Simon (1986). The site is located upstream from where Richland Creek enters into the Hatchie River. The Hatchie River has not been channelized and like many nonchannelized or sections of nonchannelized streams of this region, Q_b is extremely low, with a majority of the sediment movement accomplished through suspended sediment transport (Simon 1989, 1994). The high rates of Q_b from events along Richland Creek produce large amounts of sediment that are transported to the mouth and deposited in the Hatchie River. The Hatchie River, as indicated by low bedload transport at the Bolivar station, is not capable of transporting the additional sediment. The result is the development of shoals, which is a common event along many rivers in west Tennessee (Diehl, 2000). The shoals are analogous to alluvial fan boulders that have been deposited by tributary streams and form rapids in the Grand Canyon (Howard and Dolan 1981). The boulders carried to the Colorado River are too large to be moved except during extreme flood events. The deposition of shoals, like the alluvial fan boulders, constricts the channel. However, unlike the canyon environment of the Colorado River, the Hatchie River can avulse and shift direction (i.e., meander) following channel constriction (Diehl 2000). Therefore, the high Q_b from Richland and Sugar Creeks as well as other tributaries have and will continue to change the sediment dynamics and morphometric characteristics of the Hatchie River.

Differences in sediment characteristics and quantities between Sugar and Richland Creeks result from variation of sediment sources. Richland Creek drainage basin is formed within the Hatchie Terrace of the Hatchie River. The Hatchie Terrace is one of four major terraces formed from complex degradation and aggradation processes throughout the Tertiary and Quaternary (Saucier 1987; Parks, 1992). Sugar Creek drains an area at the edge of the Pleistocene loess deposits. On Richland Creek, however, Parks (1992) has identified the prevalence of quartz, quartzite, and

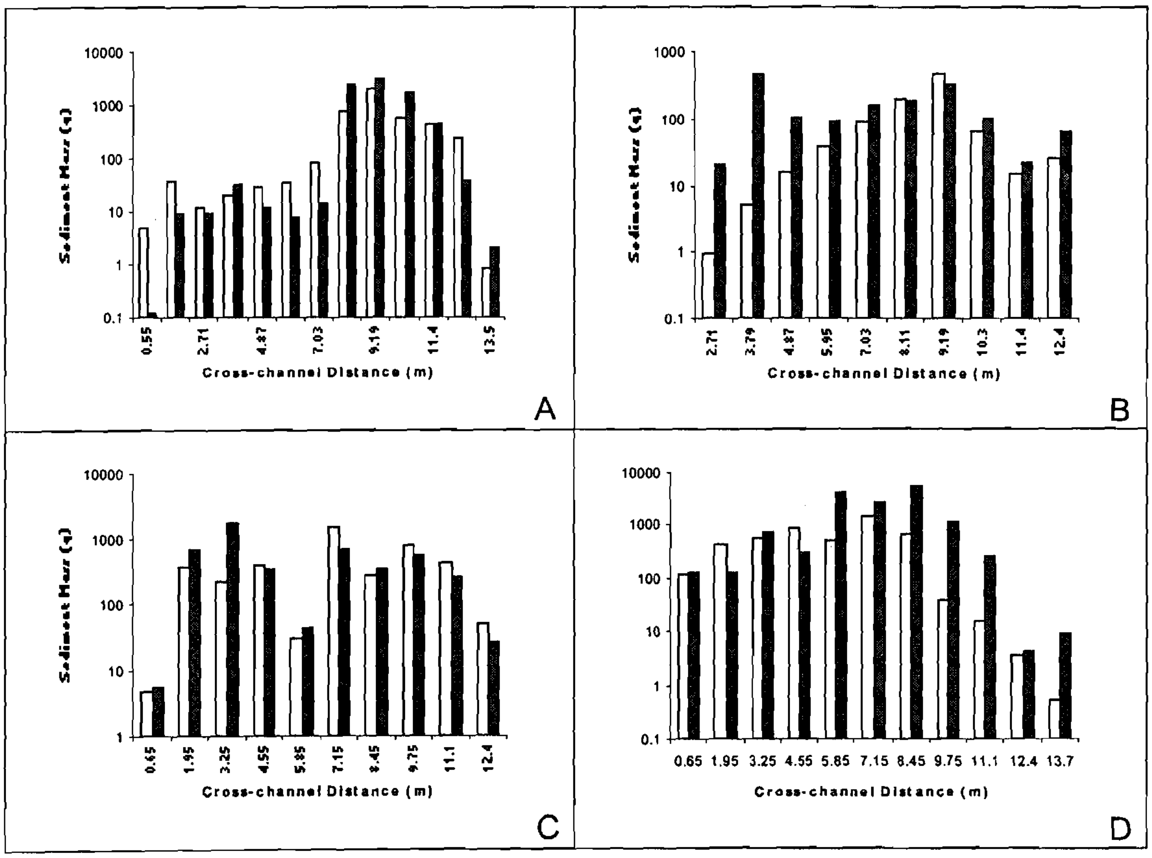

Figure 2. Spatial variations of bed material transport rate for two creeks in western Tennessee. A = Sugar Creek sampled 5/04/02; white bars were sampled at 2.25 m stage and black bars were sampled at 2.45 m stage. B = Sugar Creek sampled 11/28/01; white bars were sampled at 1.1 m stage and black bars were sampled at 1.4 m stage. C = Richland Creek sampled 11/28/01; white bars were sampled at 0.5 m stage and black bars were sampled at 1.25 m stage. D = Richland Creek sampled 5/04/02; white bars were sampled at 0.25 m stage and black bars were sampled at 0.5 m stage.

sandstone pebbles and gravel in several creeks that drain across the Hatchie Terrace south of Hatchie River. The differences in source material thus explain the larger particle sizes found in the bedload of Richland Creek. This is a localized difference as many tributaries on the north side of the Hatchie River (the Sugar Creek side of the river) cut across terraces.

From a management and restoration standpoint the erosion of bank and bed material are major concerns, especially with regard to stream corridor degradation within Richland and Sugar Creek and loss of habitat along the Hatchie River. Our field observations and data analysis indicate that it is unlikely Richland and Sugar Creeks can ever be returned to their "natural" conditions and at best, a partial restoration is possible. It is also the case that given enough time the system will restore itself to some state of dynamic equilibrium, provided rechannelization does not occur (Darby and Simon 1999). The basis for this supposition is outlined in the evolutionary model proposed by Hupp and Simon (1986). In the case of Richland Creek, the majority of the drainage basin has to go through

2 or 3 evolutionary phases in order to attain the quasi-equilibrium. Sugar Creek is slightly less impacted and throughout much of the basin would only have to go through 1 or 2 evolutionary phases. If the time-scale required by fluvial processes to restore the channel by itself are not acceptable and without a major shift in land use management, the only solution is to structurally modify basic geomorphic channel parameters to reduce sediment erosion and reestablish natural geomorphic features that will serve as habitat for species in the stream corridor.

We would like to clearly identify concerns and limitations associated with this study. These comments are made in light of the potential use of the results for future studies, support for research, and management/rehabilitation schemes along channelized tributary streams.

(1) Bedload transport on Richland and Sugar Creek is a critical component of sediment transport throughout its drainage basin. The limitation of only sampling flood events on the rising flood limb and intermediate flood stages means that the values provided in the current study grossly underestimate the total amount of Q_b within the creeks. However, we argue these field-based estimates are better than previous empirically-derived estimates, and we suggest bedload transport in chanelized streams is much greater than previously predicted.

(2) The collection of bedload samples is critical to unraveling sediment transport along Richland and Sugar Creeks, but the limited number of samples provides only a snap-shot of bedload transport. A longer-term record is required to predict spatial and temporal changes in bedload sediment as well as an accurate budget of sediment yields in the drainage basin.

(3) The large amount of sediment moved as bedload material is without a doubt a major component of sediment transport along channelized tributary streams, and helps explain the recent development of shoals and valley plugs (Diehl 2000) within the Hatchie River floodplain. However, suspended sediment is also an important part of the sediment budget. A total sediment budget for Richland and Sugar Creek would require a better understanding of suspended sediment transport. The results of the current study have shown increases of gravel movement at higher floods and reductions in coarse and very coarse sand. The sand most likely began to saltate above the bedload sampler and/or is incorporated into the suspended sediment load.

(4) Depsite these limitations, there is a high desire to understand sediment transport in floodplain systems, as sediment dynamics have the ability to control floodplain structure and function. Our preliminary estimates of bedload transport provide a base for comparison with other tributaries along the Lower Mississippi Alluvial Valley.

ACKNOWLEDGMENTS

We would like to thank the Nature Conservancy for funding the exploratory research on Richland Creek. Alex Wyss, Director of the Nature Conservancy Hatchie River Project, was instrumental in involving us with the project. He provided valuable field advice on the nature of the conditions in the Richland Creek drainage basin. We would like to thank Dr. Peter Bridson in the Office of

Research at the University of Memphis for supplying matching money to the Nature Conservancy Grant for travel expenses to our field sites. Dr. Jack Grubaugh, Director of the Meeman Biological Field Station at the University of Memphis, provided insights into sampling schemes and for use of the Field Station facilities and equipment. Sommer Choate, Kelsey McNally, and Marcus Pearson helped in the initial design and field sampling.

LITERATURE CITED

Brookes, A. 1989. Channelized rivers: Perspectives for environmental management. John Wiley,New York.

Darby, S.E. and A. Simon. 1999. Incised River Channels: Processes, Forms, Engineering, and Management. John Wiley and Sons, New York.

Diehl, T.H. 2000. Shoals and valley plugs in the Hatchie River Watershed. USGS Water Resources Investigations Report, WRIR#00-4279.

Emmett, W.W., 1980, A field calibration of the sediment-trapping characteristics of the Helley-Smith bedload sampler. U.S. Geological Survey Professional Paper 1139.

Franklin, S.B., Kupfer, J.A., Pezeshki, S.R., Scheff, T., Hanson, R. and R. Gentry. 2001. Floristic, edaphic, and hydrologic conditions of Stokes Creek, TN prior to dechannelization. Physical Geography 22:254-274.

Galay, V.J. 1983. Causes of river bed degradation. Water Resources Research, 19:1057-90.

Gomez, B. 1991. Bedload Transport. Earth-Science Review 31:89-132.

Graf, W.L. 1988. Fluvial Process in Dryland Rivers. Springer-Verlag, New York.

Guy, H.P. and V.W. Norman. 1982. Field methods for measurement of fluvial sediment. USGS SurvTech Water Resources Investigation, Book 3, Chapter C2.

Happ, S., Dobson, G., and C.G. Rittenhouse. 1940. Some principles of accelerated stream and valley sedimentation. Technical Bulletin No. 695, USDA, Washington D.C.

Howard, A. and R. Dolan. 1981. Geomorphology of the Colorado River in the Grand Canyon. Journal of Geology, 89:269-298.

Hupp, C.R. 1992. Riparian vegetation recovery patterns following stream channelization: A geomorphic perspective. Ecology, 73:1209-1226.

Hupp, C.R. and A. Simon. 1986. Vegetation and bank-slope development, *in* 4th Interagency Sedimentation Conference, Las Vegas, Nevada. Proceedings: Interagency Committee on Water Data, Subcommittee on Sedimentation, 2:5-83.

Knighton, D. 1998. Fluvial Forms and Processes, London, Arnold.

Maddox, R.S. 1915. West Tennessee gullied lands and their reclamation. Resources of Tennessee 5:8-22.

Meade, R.H. 1985. Wavelike movement of bedload sediment, East Fork River, Wyoming. Environmental Geology and Water Science 7:215-225.

Nakamura, F., Sudo, T., Kameyama, S., and M. Jitsu. 1997. Influences of channelization on discharge of suspended sediment and wetland vegetation in Kushiro Marsh, northern Japan. Geomorphology 18:279-289.

Nakamura F., Jitsu M., Kameyama S., and S. Mizugaki. 2002. Changes in riparian forests in the Kushiro Mire, Japan, associated with stream channelization. River Research and Applications 18:65-79.

Parks, W.S. 1992. Four levels of terrace deposits and remnants of high-level fluvial deposits in the Hatchie River Valley, Hebron area, Hardeman County, Tennessee. Mississippi Geology, 13:63-70.

Saucier, R.T. 1987. Geomorphological interpretation of Late Quaternary terraces in Western Tennessee and their regional tectonic implications. USGS Professional Paper 1336-A.

Shankman, D. 1996. Stream channelization and changing vegetation patterns in the U.S. coastal plain. The Geographical Review 86:216-232.

Shields Jr. F.D., Knight, S.S., and C.M. Cooper. 2000. Cyclic perturbation of lowland river channels and ecological response. Regulated Rivers: Research and Management 16:307-325.

Simon, A. 1989. The discharge of sediment in channelized alluvial streams. Water Resources Bulletin 25:1177-1188.

Simon, A. 1994. Gradation processes and channel evolution in modified west Tennessee streams: process, response, and form. USGS Professional Paper # 1470.

Simon, A., and C.R. Hupp. 1992. Geomorphic and vegetative recovery processes along modified stream channels of West Tennessee. U.S. Geological Survey, Denver, Colorado.

Wyzga, B. 2001. Impact of the channelization-induced incision of the Skawa and Wisloka rivers, southern Poland, on the conditions of overbank deposition. Regulated Rivers: Research and Management 17:85-100.

STATUS OF *CASTANEA DENTATA* ON THE NORTHERN HIGHLAND RIM OF KENTUCKY AND TENNESSEE

LOUIS J. SCHIBIG[1], ROBERT R. BARBER[1], MICHAEL J. HILL[2], JEANNIE L. KATZENMILLER[1], CLINT NEEL[3], JACK C. TORKELSON[1], AND JONATHAN M.VANCE[1]

[1]Volunteer State Community College, Gallatin, Tennessee 37066
[2]Austin Peay State University, Clarksville, Tennessee 37043
[3]Tennessee Technological University, Cookeville, Tennessee 38505

ABSTRACT. From October 2001 to March 2003, native populations of *Castanea dentata* were studied on the northern Highland Rim of Kentucky and Tennessee. A total of 208 live specimens in 15 counties were documented. For each specimen, GPS coordinates, diameter at breast height (dbh), estimated height, health, topographic aspect, elevation, soil conditions, and associated tree and shrub species were recorded. Chestnuts were distributed in small isolated populations throughout the region with the exception of relatively large populations at Land Between the Lakes (LBL).Twenty-four trees with a dbh ≥10.2 cm were found, 23 on dry sites and one on a mesic site, and 13 of these were fruiting. Scions (twigs) were gathered from many of these larger and older trees for nut grafting. Most chestnuts were growing on deep, well-drained, cherty, acidic soil overlying the Fort Payne formation. Sixty-eight percent of all chestnuts (141 of 208) were found on ridges or dry slopes (mostly west to south-facing) while 32% (67 of 208) occupied mesic ravines or slopes (mostly east to north-facing). The average growth rate in diameter was 0.5 cm/yr. on dry sites and 0.8 cm/yr. on mesic sites. On relatively dry sites occupied by chestnuts, the five most ecologically significant trees in order of descending Importance Value (IV) were *Quercus prinus*, *Acer rubrum*, *Q. velutina*, *Oxydendrum arboreum*, and *Q. alba*. *Kalmia latifolia*, *Smilax spp.* and *Vaccinium* spp. often occurred with chestnuts on dry sites. On mesic sites, the five most important tree species were *Liriodendron tulipifera*, *Quercus alba*, *Acer saccharum*, *A. rubrum*, *Oxydendrum arboreum*, and *Cornus florida*. *Lindera benzoin* and *Vaccinium* spp. were frequently found with chestnuts on mesic sites. Only 14.9% (31 of 208) of live trees showed signs of blight, but 58.3% (14 of 24) of the larger trees (dbh ≥10.2 cm) were blighted. Of the 57 dead stems examined, 35% were 6-10 years old, 35% were 11-15 years old, 16% were 16-20 years old, 7% were 21-25 years old, and 7% were 26-30 years old. Of all chestnuts encountered, 11.1% (26 of 234) were completely dead (no live sprouts in a cluster) and of these, 73.1% (19 of 26) showed signs of blight. Chestnuts at Land Between the Lakes were surviving much better than in the other areas studied. Only 1 of the 137 specimens (0.7%) found in LBL was completely dead while 25 of 96 (26.0%) were completely dead at other locations on the northern Highland Rim.

INTRODUCTION

There has been no published scientific research concentrating on the status of native populations of *Castanea dentata* on the Highland Rim region (the Rim) since the blight pandemic destroyed most of the chestnuts there in the late 1930s and early 1940s. Prior to the pandemic, published research on *Castanea dentata* was scant; however, Ashe (1911) published a small book titled "*Chestnut in Tennessee*" in which he noted that *Castanea dentata* was an abundant and valuable species on the Rim in the early 1900s. DeSelm (1999) reported that land survey data from 1826-1839 in Putnam and Jackson counties, Tennessee (northeastern Rim), indicated that 7.6% of the trees were chestnut; however, he noted that only 0.5% of the trees in Stewart County, Tennessee, were chestnut in the period 1789-1818. Frick (1939) reported some live chestnut trees on an upper south-facing slope on the edge of the northern Rim approximately 21 km northwest of Nashville. This was probably just before the blight struck this region about 1940. Lucy Braun (1950), who did most of her field studies in the 1930s and early 1940s, reported that *Castanea dentata* was the fourth most abundant tree species in the white oak-black oak-tuliptree forest of the upland slopes in the "Big Woods" area of Mammoth Cave National Park; she placed this old growth forest in the Shawnee Hills region of Kentucky, but it is very near the boundary with the northeastern Highland Rim. Tragically, by the early 1940s, practically all chestnuts were dead or dying on the Rim.

The chestnut blight was caused by the accidental introduction of an Asian fungus, *Cryphonectria parasitica,* in the late 1800s. Sandra Anagnostakos, a chestnut expert in Connecticut, believes the blight was first introduced into the northeastern U.S. on imported *Castanea crenata*, the Japanese chestnut (email correspondence in 2003, on file with the senior author, Volunteer State Community College). The blight was first noticed in New York in 1904, but spread rapidly throughout the eastern U.S., destroying nearly all the native chestnut trees by 1950. Following the pandemic, this species was so rare that only a few authors of vegetational/floristic studies on the Rim mentioned its presence, usually referring to it as small rare sprouts (e.g., Chester et al. 1976, Schibig and Chester 1988, Barber 1998). Presently, this species is designated as endangered by the Kentucky State Nature Preserves Commission and as special concern by the Tennessee Natural Heritage Program.

The objectives of our research were to: (1) construct a database of live and dead American chestnut trees on the northern Rim, including data on location, size, health, fruiting, site conditions, and associated tree species; (2) from the database of live specimens, determine geographic distribution, preferred habitat conditions, size class distribution, incidence of blight, and ratio of fruiting to non-fruiting trees; (3) from the database of dead stem specimens, determine growth rates on mesic and dry sites, longevity, and compare mortality of different age groups; and (4) find large, long-lived American chestnuts to clone, and locate fruiting chestnut "mother" trees for The American Chestnut Foundation's pollination program.

THE STUDY AREA

The Highland Rim, an elevated region surrounding the Nashville Basin, is a Subsection of the Highland Rim Section, Interior Low Plateau Province (Fenneman 1938). The Fort Payne Formation (cherty Mississippian limestone) is the lowest formation of the Rim; beneath it is the Chattanooga shale, the highest formation of the Nashville Basin. In some areas the Fort Payne is overlain by more recent Mississippian limestones, e.g., the Warsaw, Salem, St. Louis, and Ste. Genevieve formations.

The Rim is bordered on the west by the Tennessee River and on the east by the more elevated Cumberland Plateau. To the north, the Rim is bounded by the Dripping Springs Escarpment, the transition from the Rim to the Shawnee Hills Section. Our research was concentrated on the northern Rim of south-central Kentucky and northern middle Tennessee. The Cumberland River, flowing mostly from east to west-northwest, and its tributaries dissect and drain parts of the study area, while the Tennessee River and its eastern tributaries drain the western portion of the study area. The Barren and Green rivers drain the northeastern section of the Rim. The topography is also highly dissected in the transition from the Outer Basin to the Rim. Generally, the elevations are higher in the northeastern portion of the Rim, often exceeding 300 meters, while elevations greater than 230 meters are rare on the northwestern Rim. We inventoried chestnuts in the south-central Kentucky counties of Adair, Metcalfe, Monroe, and Trigg. In northern middle Tennessee, we inventoried in

Clay, Davidson, Dekalb, Hickman, Humphreys, Jackson, Robertson, Smith, Sumner, Stewart, and Williamson counties.

Soils in the study area are derived mostly from cherty Mississippian limestones, although in Trigg County, Kentucky, some are based on cretaceous gravels. A silty mantle of varying depth veneers much of the western portion of this region. Soil drainage is variable and soil pH is quite acidic on most sites. Fertility varies depending on such factors as degree of erosion, parent materials, and type of land use. Soils in ravines and on north to east-facing slopes are often more shaded, cooler and moister than soils on ridges and south to west-facing slopes.

The northern Highland Rim is within the Deciduous Forest Formation, Western Mesophytic Forest Region, where a mosaic of community types occur due to highly variable microclimatic, edaphic, and topographic conditions (Braun 1950). Forests of the northwestern Rim are often dominated by oaks, especially *Quercus alba*, and hickories (Fralish and Crooks 1989, Chester et al. 1995, Barber 1998), while more mesophytic conditions occur on the northeastern Rim. Some of the northeastern Rim forests, such as those of the Taylor Hollow Natural Area, tend to be more like Braun's Mixed Mesophytic Forest in that they are dominated by such mesophytic species as *Acer saccharum*, *Fagus grandifolia*, and *Liriodendron tulipifera*, even on some ridges and south-facing slopes (Schibig 1999).

METHODS

Botany professors, foresters, students, and others helped us locate chestnuts in the study area. A GPS instrument was used to determine coordinates for each chestnut tree; this allowed the pinpointing of specimens on topographic maps and elevation determinations (Topozone 2003). Chestnut site positions were plotted on physiographic and geological maps. Diameter at 1.4 m above ground was recorded for most chestnut stems; basal diameter was recorded for the smallest stems. Height was estimated for all stems. A hand-held compass was used to determine slope aspect for specimens. Notes on signs of blight, soil conditions, and associated species were made. Soil information for sites in Trigg County, Kentucky, and Davidson, Sumner, and Stewart Counties, Tennessee, were determined from county soil surveys. The pH of topsoil samples taken close to large chestnut trees on six sites was determined using the Adams-Evans method.

Quarter-point sampling was used to ascertain the dominant tree species associated with chestnuts; 160 stems ≥ 10.2 cm dbh were measured on four dry sites (two ridges, one west-facing slope and one south-facing slope) and 200 stems were measured on five mesic sites (three ravines and two north-facing slopes) on the northern Rim. On each selected ridge or ravine site, we used used one sampling line with 10 points spaced at 16 m intervals which followed the ridge crest or the center of the ravine floor. On each slope site, we used two 5-point sampling lines (16 m between points) that followed the contour, one midway between the slope crest and the middle of the slope and the second midway between the ravine floor and the middle of the slope. Fifty-seven dead chestnut stems with an age ≥ 6 yr. were cut at 1.4 m above ground and a small section of each stem was stored at Volunteer State Community College (VSCC) for tree ring examination. Quantitative data were stored as a growing database on an Excel spreadsheet.

Digital photos were made of the investigators, their operations, and the largest chestnut trees; selected photos along with information about the ongoing research were placed on Schibig's chestnut web site (Schibig 2003) which is sponsored by VSCC. Large fruiting specimens were reported to officials of The American Chestnut Foundation (TACF); some of these fruiting trees may be used as "mother" trees in TACF's pollination program. We also provided twigs (scions) from the largest, most promising chestnut trees to Ed Greenwell, Director of Tennessee operations for the American Chestnut Cooperators Foundation (ACCF), who may use them in that foundation's breeding program to develop blight-resistant, pure American chestnut trees for reforestation.

RESULTS AND DISCUSSION

A total of 208 live *Castanea dentata* specimens were observed in 15 counties on the northern Highland Rim. Figure 1 shows the counties where the larger American chestnuts were found. Four of these counties (Clay, Jackson, Robertson and Smith) had no previous official records of this species according to the online database of Tennessee Vascular Plants (University of Tennessee Herbarium and Austin Peay State University's Center for Field Biology 2003). Sixty-six percent (137 of 208) of the specimens were found in Land Between the Lakes (LBL) in Stewart County, Tennessee, and Trigg County, Kentucky. These were found on the western edge of LBL, mostly on the very dry ridges and slopes facing Kentucky Lake. The other specimens were found as isolated small populations (1-19 individuals) in 13 other counties; most of these were on the northern Rim although a few were in the Outer Basin. Trees ≥ 10.2 cm dbh were quite rare-only 24 of 208 (11.5%) were in this size class and of these, 13 were fruiting. Burs, but not fertile nuts, were found; although monoecious, chestnuts usually require a second tree in close proximity for cross pollination.

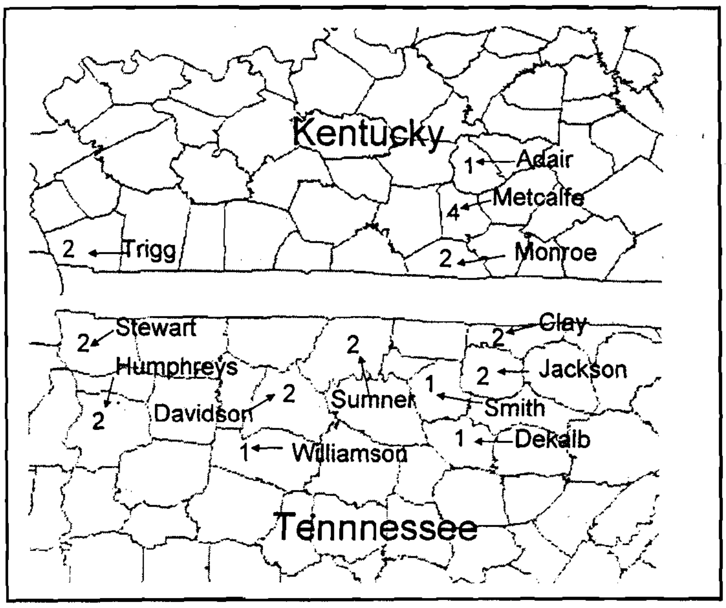

Figure 1. Counties in south-central Kentucky and northern middle Tennessee where 24 American chestnuts ≥10.2 cm were found and the number of specimens in each county. Most were on the northern Highland Rim but a few were in the Outer Basin on high ridges or slopes; 23 specimens were on dry sites (ridges or south to west slopes) and one was on a mesic site. Background maps from http://www.ngdc.noaa.gov/seg/topo/state.shtml (2003).

All live chestnut stems (often specimens consisted of more than one basal stem) were placed in 3.05 m height classes. In the <3.05 m class, 311 stems were found. Other height class results were: 3.05-6.10 m, 40 stems; 6.10-9.15 m, 20 stems; 9.15-12.20 m, 14 stems; 12.20-15.25 m, 7 stems; 15.25-18.30 m, 4 stems; 18.30-21.35 m, 1 stem; and 21.35-24.40 m, 1 stem. This may be an invalid representation for the entire northern Rim since there was bias toward finding larger trees, especially in the eastern section of the study of the area. A more representative set of height classes for the northwestern portion of the study area was obtained in LBL because there was no bias there toward finding just the larger chestnut trees. The height classes for LBL were: <3.05 m class, 220 stems; 3.05-6.10 m, 26 stems; 6.10-9.15 m, 11 stems; 9.15-12.20 m, 7 stems; 12.20-15. 25 m, 1 stem.

Sixty-eight percent of the live chestnuts (141 of 208) were found on relatively dry sites (mostly ridges and slopes with a southern to western exposure) and even the ones growing on mesic sites (ravines and north to east-facing slopes) were on deep, gravelly, well-drained soil. Twenty-three of the 24 large chestnuts (≥10.2 cm dbh) were found on dry sites. These findings agree with those of other researchers. Griffin (1992) noted that most of the American chestnut population in the former oak-chestnut forest region consists of small trees in the understories of xeric slope hardwood forests in which oak species dominate. Dr. Fred Hebard, a chestnut expert in Virginia, made this observation in a recent email correspondence (on file with the senior author, Volunteer State Community College):

> "*Regarding chestnut being on the drier sites, this is true today. They were eliminated from moister sites during the original pandemic. For instance, today around Meadowview, you can climb up many a north slope and see plenty of old chestnut stumps but no living sprouts. As soon as you crest the hill onto a southern exposure, living sprouts abound.*"

Stephenson et al. (1991) noted the conspicuous absence of *Castanea dentata* from many of the mesic sites in their study of upland forest communities in Virginia. Our observations were similar, i.e., we found chestnut sprouts in open-canopy forests on xeric ridges and upper south to west-facing slopes, but usually found no specimens on the more mesic closed-canopy forests on the nearby north to east-facing slopes. On one mesic north-facing slope in Sumner County, Tennessee, we recorded nine completely dead chestnuts with an average dbh of 9.9 cm and an average height of 9.1 m; there were no survivors. These chestnuts grew rapidly (we examined their xylem rings) after they were released from competition by a logging operation about 20 years ago, but all died within 14 years of the logging, apparently from the combined effects of blight and renewed competition from surrounding tree species. On another mesic ravine/north-facing slope site in Sumner County, Tennessee, 28.9% (6 of 21 chestnut saplings) died within the past 12 years following a selective timber harvest. Within 5 more years it is likely that many of the remaining 15 live chestnuts in this stand will die from blight and/or severe competition from surrounding trees.

In marked contrast, mortality of chestnuts was very low on the mostly xeric, open-canopy sites in LBL-only one of the 137 chestnuts (0.7%) we encountered there was completely dead and blight incidence was low. We think it is probable that chestnut sprout survival was greater on the more xeric sites in LBL and elsewhere in our study area due to the chestnut's ability to grow on sites too harsh for many other tree species. Only a few other tree species, such as *Quercus prinus* and *Oxydendrum arboreum*, can grow on the very acidic, dry, nutrient-poor sites occupied by chestnuts, thus competition may be less severe on these sites than on more mesic sites. Concerning other hardwoods competing with chestnuts, Griffin (1992) stated that hardwood competition is lower on xeric sites than on mesic sites. Perhaps the greater exposure to sun on open-canopy ridge and south to west facing-slope sites has some suppressing effect on *Cryphonectria parasitica* directly or indirectly while promoting photosynthesis, growth, and sprout regeneration in chestnuts.

According to Ashe (1911), before the blight, chestnut competed well with other tree species on diverse sites, xeric to mesic, but never did well on poorly drained or thin soils. Evidence indicates that, since the pandemic, the residual blight has, for the most part, limited *Castanea dentata*'s site preferences to ridges and dry slopes in our study area and in some other parts of the country. Ashe (1911) made these observations concerning the distribution of chestnut in middle Tennessee in the early 1900s:

> *"Chestnut constitutes only a small proportion of the forests of the Central Basin, but is one of the chief trees of the Rim. In portions of Hickman County, which occupies a typical position on the western part of the Rim, 10 per cent of the forest aggregating several thousand acres, consists of chestnut. On the sandier soils of the Rim, chestnut comprises up to 20 percent of the forest on the better sites."*

In our study, we found no chestnuts on the thin soils of the Central (Nashville) Basin, but we did find a few chestnuts on the deep cherty soils on the high ridges and upper dry slopes of the outer region of the Central Basin.

On the northwestern Rim, most of the chestnuts were on loess and Cretaceous gravel-based soils (e.g. Brandon, Guin, and Saffel series), but some were on cherty limestone soils (e.g. Baxter, Bodine, Hammack and Nixa series). The Stewart County soil survey (United States Department of Agriculture 1953) noted that chestnut trees were previously abundant on the droughty, acidic, cherty Bodine soils. On the north central to the northeastern Rim, chestnut soils were derived primarily from the cherty Fort Payne Formation (e.g. Bodine and Sugargrove series). A topsoil sample close to a large chestnut (dbh $\geq$20 cm) was taken from each of six sites in our study area; the pH readings were 3.4 from a topsoil sample taken in Clay County, 3.4 (Jackson County), 4.3 (Monroe County), 3.4 (Trigg County), and 4.9 (Williamson County). Generally, chestnuts on the northern Rim were on upland, deep, gravelly, well-drained, acidic, and nutrient-poor soils. This, for the most part, agrees with Ashe (1911) who stated:

> *"Chestnut soils must be of considerable depth... and must be moderately supplied with moisture in the subsoil, but well-drained on the surface. It seldom grows on clay soils, and practically never on limestone soils. Chestnut does not require either a sweet or a fertile soil...and will grow thriftily upon sandy soils with a subsoil deficient in lime as well as potash."*

On the xeric sites, the five most important tree species associated with *Castanea dentata* sprouts in descending order of importance value (IV) were *Quercus prinus*, *Acer rubrum*, *Q. velutina*, *Oxydendrum arboreum*, and *Q. alba* (Table 1). The shrubs which were frequently observed with *C. dentata* on dry sites were *Kalmia latifolia*, *Vaccinium spp.* and *Smilax spp.* In our study area, *Kalmia latifolia*, a generally rare shrub in the study area, was found in 6 of 24 (25%) chestnut stands on mostly dry sites with an open canopy. In chestnut stands (clearcut and understory) in Virginia and West Virginia, Griffin (1989) found *Kalmia latifolia* in 18 of 24 (77%) plots. *Kalmia* is typically found on dry sites, usually upper south to west- facing slopes and ridges, where the forest canopy is open and the soil is well-drained, cherty, and acidic. The two largest chestnuts we found in Tennessee were growing on such sites with *Kalmia latifolia*.

On mesic sites, the dominant trees found with *Castanea dentata* were *Liriodendron tulipifera*, *Quercus alba*, *Acer saccharum*, *A. rubrum*, *Oxydendrum arboreum*, and *Cornus florida* (Table 2). In the shrub stratum, *Lindera benzoin* and *Vaccinium spp.* were frequently observed on chestnut sites. Interestingly, *Acer rubrum*, *Oxydenrum arboreum* and *Q. alba* were important associates of *C. dentata* on both dry and mesic sites and *Vaccinium spp.* (indicators of acidic soil) were observed in over 50% of the chestnut stands. Figure 2 shows the counties where xeric and mesic sites were sampled.

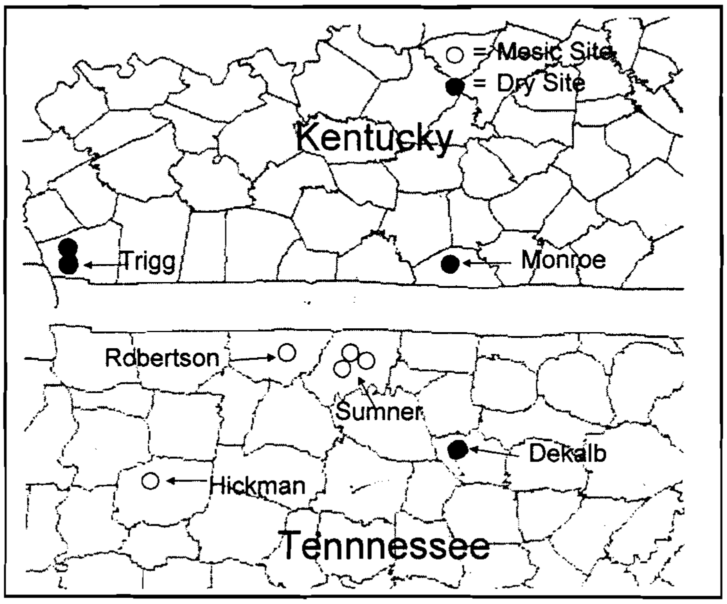

Figure 2. Counties where xeric and mesic American chestnut sites were sampled using the quarter-point method to determine importance values of associated tree species. Background maps from http://www.ngdc.noaa.gov/seg/topo/state.shtml (2003).

Only 14.9% (31 of 208) of all live trees showed signs of blight, but 58.3% (14 of 24) of the larger trees (dbh ≥10.2 cm) were blighted. Three very large, long-lived trees were observed in the study area, one in Adair County, Kentucky (dbh = 96 cm, height = 14 m), one in Jackson County, Tennessee (dbh = 58 cm, height = 17 m), and one in Smith County, Tennessee (dbh = 41 cm, height = 21 m). These survivors were all living with blight as evidenced by cankers on the trunk and branches; photos of these impressive trees are shown at Schibig's chestnut website (Schibig 2003). The Adair County chestnut was already a large tree in the 1940s according to the property owners, thus it was one of the very rare chestnuts that withstood the initial surge of the blight around 1940 in this region and which still lives today. We estimate the other two to be about 60 years old, and perhaps they were the initial sprouts from trees killed in the early 1940s. The Jackson County tree shows a section of an old stump at its base, an indication that it is a large surviving sprout. Such rare large survivors may have lived that long because of a combination of these factors: (1) the attacking blight pathogens are hypovirulent, (2) the trees have a low level of resistance to the blight, and (3) the trees are growing on sites conducive to chestnut growth and survival. Griffin (1986) believed such factors explained the survival of the large long-lived American chestnut in Amherst County, Virginia. Fred Hebard informed me (email correspondence in 2003, on file with the senior author, Volunteer State Community College) that he has tested many American chestnuts for blight resistance and has found some that show a low level of resistance to the blight, but none that displayed a high level of resistance as is the case in some of the Asian chestnuts.

Table 1. Data for tree species (stems ≥10.2 cm) associated with *Castanea dentata* on four xeric sites[1] on the northern Highland Rim of Kentucky and Tennessee.

Tree Species	Occur. in 40 Points	No. of Trees/ha	Basal Area (m^2)	% Occur.	% Density	% Basal Area	IV(100)[2]
Quercus prinus	14.00	75.89	4.60	12.50	12.70	30.02	18.41
Acer rubrum	16.00	101.27	2.50	14.29	16.94	16.32	15.85
Quercus velutina	16.00	85.52	2.78	14.29	14.31	18.12	15.57
Oxydendrum arboreum	17.00	113.25	0.79	15.18	18.95	5.13	13.09
Quercus alba	7.00	27.91	1.79	6.25	4.67	11.66	7.53
Nyssa sylvatica	7.00	39.09	0.85	6.25	6.54	5.56	6.12
Quercus marilandica	6.00	33.47	0.46	5.36	5.60	3.02	4.66
Acer saccharum	5.00	29.39	0.40	4.46	4.92	2.62	4.00
Quercus coccinea	5.00	16.86	0.33	4.46	2.82	2.14	3.14
Quercus stellata	5.00	19.27	0.12	4.46	3.22	0.77	2.82
Sassafras albidum	4.00	16.86	0.14	3.57	2.82	0.91	2.43
Carya tomentosa	3.00	12.60	0.21	2.68	2.11	1.40	2.06
Liriodendron tulipifera	2.00	8.40	0.11	1.79	1.40	0.75	1.31
Amelanchier arboreum	2.00	5.31	0.02	1.79	0.89	0.12	0.93
Quercus muehlenbergii	1.00	4.20	0.12	0.89	0.70	0.76	0.79
Ostrya virginiana	1.00	4.26	0.05	0.89	0.71	0.35	0.65
Ulmus alata	1.00	4.20	0.05	0.89	0.70	0.35	0.65
Totals	112.00	597.75	15.32	100.00	100.00	100.00	100.00

Average dbh per tree = 34.8 cm
Average basal area per tree = 0.10 m^2
Basal area of all trees per ha = 55.50 m^2/ha

[1]The quarter-point method was used to sample four xeric sites occupied by chestnuts. Two ridge forests were sampled (one in Monroe County, Kentucky, and one in Trigg County, Kentucky; one south-facing slope forest in Dekalb County, Tennessee, and one west-facing slope forest in Trigg County, Kentucky were sampled. A total of 40 points (160 trees) were sampled.

[2]IV(100) = (% occurrence + % density + % basal area)/3; it is a measure of the ecological importance of a tree species in a community.

Table 2. **Data for tree species (stems ≥10.2 cm) associated with *Castanea dentata* on five mesic sites[1] on the northern Highland Rim of Kentucky and Tennessee.**

Tree Species	Occur. in 50 Points	No. of Trees/ha	BA (m^2)	% Occur.	% Density	% BA	IV (100)[2]
Liriodendron tulipifera	22.00	85.26	2.38	14.47	20.36	20.41	18.41
Quercus alba	16.00	36.75	2.16	10.53	8.77	18.56	12.62
Acer saccharum	13.00	36.65	1.08	8.55	8.75	9.24	8.85
Acer rubrum	11.00	34.38	0.87	7.24	8.21	7.44	7.63
Oxydendrum arboreum	13.00	35.37	0.38	8.55	8.44	3.30	6.76
Cornus florida	10.00	30.38	0.20	6.58	7.25	1.75	5.19
Carya glabra	10.00	17.98	0.49	6.58	4.29	4.22	5.03
Quercus rubra	7.00	15.56	0.66	4.61	3.72	5.66	4.66
Carya tomentosa	8.00	16.20	0.55	5.26	3.87	4.73	4.62
Fagus grandifolia	5.00	25.74	0.51	3.29	6.14	4.36	4.60
Carya ovata	6.00	12.89	0.26	3.95	3.08	2.27	3.10
Ostrya virginiana	6.00	15.41	0.15	3.95	3.68	1.30	2.98
Nyssa sylvatica	5.00	10.82	0.33	3.29	2.58	2.84	2.90
Liquidambar styraciflua	3.00	9.04	0.39	1.97	2.16	3.37	2.50
Prunus serotina	3.00	9.09	0.18	1.97	2.17	1.52	1.89
Quercus velutina	2.00	4.64	0.28	1.32	1.11	2.42	1.61
Platanus occidentalis	2.00	3.46	0.25	1.32	0.83	2.14	1.43
Carya ovalis	2.00	3.95	0.21	1.32	0.94	1.78	1.35
Fraxinus americana	2.00	3.90	0.19	1.32	0.93	1.65	1.30
Ulmus rubra	3.00	4.99	0.05	1.97	1.19	0.47	1.21
Sassafras albidum	1.00	3.01	0.01	0.66	0.72	0.12	0.50
Quercus prinus	1.00	1.83	0.04	0.66	0.44	0.34	0.48
Ulmus alata	1.00	1.63	0.01	0.66	0.39	0.11	0.39
Totals	152.00	418.96	11.66	100.00	100.00	100.00	100.00

Average dbh per tree = 27.2 cm

Average basal area per tree = 0.06 m^2

Basal area of all trees per ha = 23.3 m^2 (this is quite low compared to the basal area/ha for trees on xeric sites probably due to the effects of logging within the last 20 years in three of the five sampled mesic sites).

[1]**The quarter-point method was used to sample five forested sites occupied by chestnuts. Two sites were north-facing slope forests in Sumner County, Tennessee, and three sites were ravine forests, one in Hickman County, Tennessee, one in Robertson County, Tennessee, and one in Sumner County, Tennessee. Ten points were sampled on each sites; a total of 50 points (200 trees) were sampled.**

[2]**IV(100) = (% occurrence + % density + % basal area)/3; it is a measure of the ecological importance of a tree species in a community.**

Of all chestnuts encountered in our study, 11.1% (26 of 234) were completely dead (no live sprouts) and of these, 73.1% (19 of 26) showed signs of blight. Clearly, blight remains a chief cause of chestnut mortality today. The *Cryphonectria parasitica* spores probably are not as abundant today as they were during the pandemic years when countless chestnut trees were infected and shedding spores, however, the blight will continue to persist on live and dead chestnut sprouts and various oaks which harbor the blight. Some information on the longevity and growth rate of chestnut sprouts was gleaned by examining the annual rings of cut, dead chestnut stems that were at least 6 years old. Of the 57 dead stems examined, 35% were 6-10 years old, 35% were 11-15 years old, 16% were 16-20 years old, 7% were 21-25 years old, and 7% were 26-30 years old. As was expected, the average growth rate in diameter was higher on mesic sites (0.8 cm/yr.) than on dry sites (0.5 cm/yr.).

American chestnut restorationists are optimistic that blight-resistant strains of *Castanea dentata* will be perfected by TACF and the ACCF so that many of us will eventually see this great tree restored to the forests of the eastern U. S. According to Professor Gary Griffin (American Chestnut Cooperator's Foundation 2003):

> *"It is not beyond the grasp of science to restore the American chestnut to economic importance. It could be accomplished within the next 50 years."*

However, the native chestnut trees are rapidly dwindling from sustained attacks by blight and other diseases; damage by cattle, deer, rodents, and insects; competition from surrounding trees; adverse weather; and anthropogenic disturbances. This perilous loss of germplasm is being countered somewhat by ACCF workers who clone (graft) "superior" native chestnuts in different parts of the country and grow and intercross them in orchard or forest settings. In its breeding program, TACF is capturing the genes of "mother trees" in many regions of the country. As we expand our study to include the entire Highland Rim region we will, no doubt, find more "superior" native chestnut trees which may be used by TACF and the ACCF in their restoration efforts.

ACKNOWLEDGMENTS

We wish to thank the many individuals who helped us with the various phases of this research. Dr. Edward W. Chester, Austin Peay State University, showed us some key chestnut sites in Land Between the Lakes and gave us access to APSU's herbarium. Dr. Kurt Bloom, Middle Tennessee State University, gave us access to the chestnut specimens housed in the MTSU herbarium. Sam Vinson, VSCC geology instructor, advised us on the geology and soils of the study area. Rick Schibig helped us gather field data. Foresters in south central Kentucky (Billy Fudge, Charlie Johnson, Sarah Moore, Kenneth Pyles, and Brian Yager) assisted us in finding large chestnuts in Adair, Metcalfe, and Monroe Counties, Kentucky, and John Donahue, LBL forester, helped us obtain a permit to conduct chestnut research in LBL. Property owners who granted us permission to study chestnuts on their properties included Lou Armstrong, Kelly Burgess, Ray Clements, Billy Durham, Charles England, Gwin Grinestaff, Brian Huey, and Charles Tally. Ed Greenwell showed us how to make nut grafts which allowed us to clone some of the outstanding chestnut trees we encountered. Roger Draper and Harold Kemp showed us the locations of the two largest American chestnuts (to our knowledge) in Tennessee. Nancy Morris, biology professor and chair of VSCC's science department, has supported us in several ways and Paul Sisco, TACF science coordinator of the southeastern region, helped us secure American Forestry Foundation funding which will make possible current and future chestnut research on the Highland Rim. To these people and others who made this project possible, we are deeply grateful.

LITERATURE CITED

American Chestnut Cooperators Foundation. 2003. Retrieved April 22, 2003,from: <http://www.ppws.vt.edu /griffin/accf.html>

Ashe, W.W. 1911. Chestnut in Tennessee. Report No. 10-B, Tenn. Geol. Survey Series, Nashville, Tennessee.

Background Maps. 2003. Available at: < http://www.ngdc.noaa.gov/seg/topo/state.shtml>

Barber, R.R. 1998. Forest Composition and Communities of a Western Highland Rim Forest, Hickman County, Tennessee. M.S. Thesis. Middle Tennessee State University, Murfreesboro, Tennessee.

Braun, E.L. 1950. Deciduous forests of eastern North America. The Blakiston Publishing Co., Philadelphia, Pennsylvania.

Chester, E.W., R.J. Jensen, and J.Schibig. 1995. Forest communities of Montgomery and Stewart counties, northwestern Middle Tennessee. Journal of the Tennessee Academy of Science 70:82-91.

Chester, E.W., L.J. Schibig, and R.J. Jensen. 1976. The woody flora of Land Between the Lakes, Kentucky and Tennessee. Journal of the Tennessee Academy of Science. 51:124-129.

DeSelm, H.R. 1999 Vegetation Results from early land surveys in five counties of Tennessee, 1788-1839. Pp. 89-109. *In*: Hamilton, S.W. E.W. Chester, and M.T. Finley (eds.). Proceedings of the Eighth Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Fralish, J.S., and F.B. Crooks.1989. Forest composition, environment and dynamics at Land Between the Lakes in Northwest Middle Tennessee. Journal of the Tennessee Academy of Science. 3:107-111.

Fenneman, N.M. 1938. Physiography of eastern United States. McGraw Hill Book Co., New York.

Frick, T.A. 1939. Slope vegetation near Nashville, Tennessee. Journal of the Tennessee Academy of Science 14:342-420.

Griffin, G.J. 1992. American chestnut survival in understory mesic sites following the chestnut blight pandemic. Canadian Journal of Botany 70:1950-1956.

Griffin, G.J. 1989. Incidence of chestnut blight and survival of American chestnut in forest clearcut and neighboring understory sites. Plant Disease 73:123-127.

Griffin, G. . 1986. Chestnut blight and its control. Horticultural Reviews 8:291-336.

Schibig J. 2003. Resurrecting the the American Chestnut. Available at: http://www2.volstate.edu/jschibig/ resurrectingthechestnut.htm>

Schibig, J. 1999. Structure of forest communities at Taylor Hollow Nature Preserve, Sumner County, Tennessee. Pp. 135-145. *In*: Hamilton, S.W., D.S. White, E.W. Chester, and M.T. Finley (eds.). Proceedings of the Eighth Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Schibig, J. and E.W. Chester. 1988. Vegetational and floristic characterization of a mixed hardwoods-shortleaf pine stand in Stewart County, Tennessee. Journal of the Tennessee Academy of Science. 63:83-88.

Stephenson, S.L., H.S. Adams, and M.L. Lipford. 1991. The present distribution of chestnut in the upland forest communities of Virginia. Bull. Torrey Bot. Club. 118:24-32.

Topozone. 2003. Available at: < http://www.topozone.com.

United States Department of Agriculture. 1953. Soil Survey of Stewart County, Tennessee. Soil Conservation Service, Washington, D.C.

University of Tennessee Herbarium and Austin Peay State University's Center for Field Biology. 2003. Tennessee Vascular Plants-Database. Retrieved April 2003 from: <http://tenn.bio.utk. edu/vascular/ database/vascular>

COMMUNITY STRUCTURE AND COMPOSITION OF A WESTERN HIGHLAND RIM FOREST, HICKMAN COUNTY, TENNESSEE

REX BARBER

Department of Biology, Volunteer State Community College, Gallatin, Tennessee 37066

ABSTRACT. The quarter-point plotless technique was used to sample a 403 ha, relatively mature and diverse forest in Hickman County, Tennessee. The forest, known as the Middle Tennessee State University Wildlife Management Area, is in the Western Highland Rim Subsection just south of Whitson Bend of the Duck River. The area apparently has not been influenced by point disturbances for more than a century, and there are few signs of non-point disturbances. The landscape is highly dissected and consists of wide ridges, steep to moderate slopes, ravines and foot slopes, and some riparian land. Segregate communities were analyzed and documented utilizing Importance Value statistics. Data from the entire forest show a *Quercus alba-Q. prinus-Oxydendrum arboreum* community, with a *Q. alba-Q. stellata-Q. prinus* community on the ridges, a *Q. alba-Carya tomentosa-Liriodendron tulipifera* community in the ravines and footslopes, a *Q. alba-O. arboreum-Q. falcata* community on the xeric slopes, and a *Q. alba-Q. prinus-C. tomentosa* community on the mesic slopes. Riparian land is dominated by a *Platanus occidentalis-Acer saccharum-Liquidambar styraciflua* community. Physiography, climate, edaphic conditions, vegetational setting and history are discussed. Annual growth data of *Q. alba*, based on corings from several trees, and visual observations also are reported.

INTRODUCTION

The importance of research, analysis, and documentation of forest communities and their composition is evident. Knowledge of and about the ecological stability of naturally occurring forests is a vital link in understanding and protecting local ecosystems as well as the global environment. Documentation of existing forests conditions before they are destroyed or altered by unnatural disturbances not only provides the data for long term monitoring of detrimental impacts, but may also help perpetuate the restoration of native flora. Due to increased urban development, logging, and other point and non-point disturbances, forests of Tennessee are consistently threatened and often irreversibly disturbed. Most of the Western Highland Rim of Kentucky and Tennessee was originally heavily forested but remaining forests now are largely fragmented and in various states of development (Martin et al. 1993).

Few historic Middle Tennessee forest composition surveys are known, although there are descriptions of woody and herbaceous flora, as by Andre Michaux (Thwaites 1966), Gattinger (1901), and others. In the last three decades knowledge of local Middle Tennessee forest communities has increased (e.g., Carpenter et al. 1976, Chester and Ellis 1989, Chester et al. 1995, Duncan and Ellis 1969, Quarterman et al. 1972, Schibig and Chester 1988, Schibig 1999, and numerous others). However, many forest communities of Middle Tennessee have not been studied.

The goal of this research was to analyze the communities and document the composition of a Hickman County forest. Secondary goals included assimilating information that may be useful to cooperative efforts on the Tennessee flora, to begin analysis of growth rates of specific dominant trees, and to promote the continued protection of this forest by describing its unique characteristics.

This report will offer observations, research analysis, and historical speculation that this secondary forest has developed relatively undisturbed for more than one hundred years.

THE STUDY AREA

The study area is a 403 ha, relatively mature and undisturbed forest in west-central Hickman County, Tennessee, known as the Middle Tennessee State University Wildlife Management Area (MTSU WMA).The forest is just south of the Duck River's Whitson Bend, about two miles north of Highway 50, five miles west of Centerville, and is partially bordered on the east by Trace Creek Road. Whitson Bend Road is part of the northern boundary, which is partially adjacent to the Duck River flood plain. The western boundary is now designated Smithfield Road (old maps designate this road as a "jeep trail") (Figure 1). The only observable utilization includes occasional visits by outdoor enthusiasts, natural science researchers, and game hunters. There are few signs of pollution, invasive flora, or other disturbances.

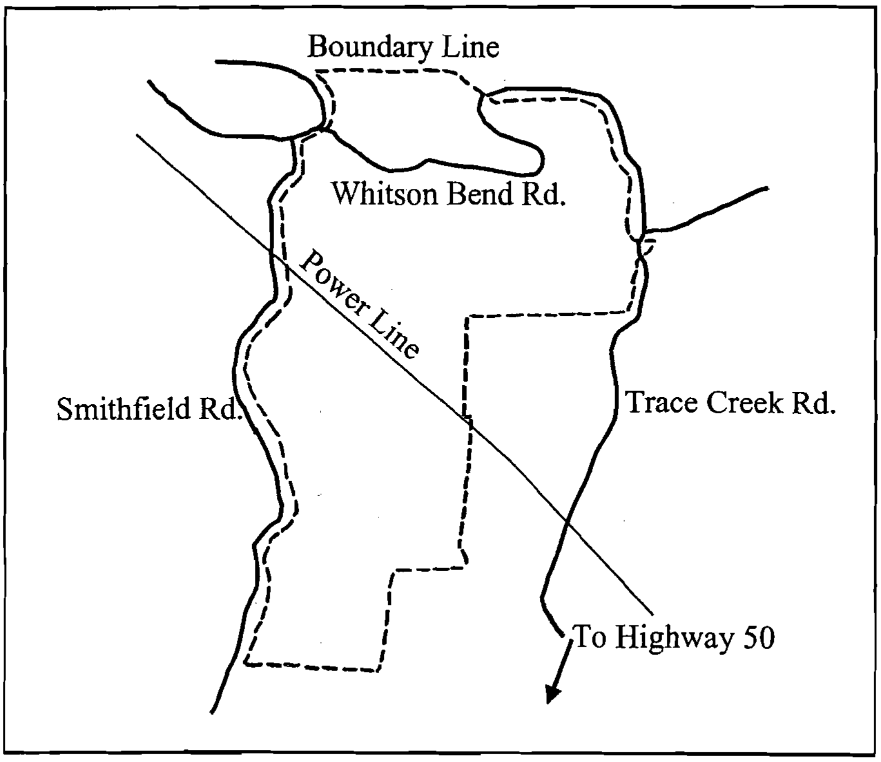

Figure 1. Location of the study area; Highway 50 is two miles south of the study area and connects the town of Centerville, about five miles to the east, with Interstate 40, which is about 10 miles to the northwest.

Physiography, Climate, and Edaphic Conditions

The study area is on the Western Highland Rim Subsection, Highland Rim Section, of the Interior Low Plateau Physiographic Province (Fenneman 1938, Quarterman and Powell 1978). This Subsection is a maturely dissected, rolling plateau that is crossed by numerous streams; it lies between the Central Basin to the east and the Western Valley of the Tennessee River to the west (Figure 2).

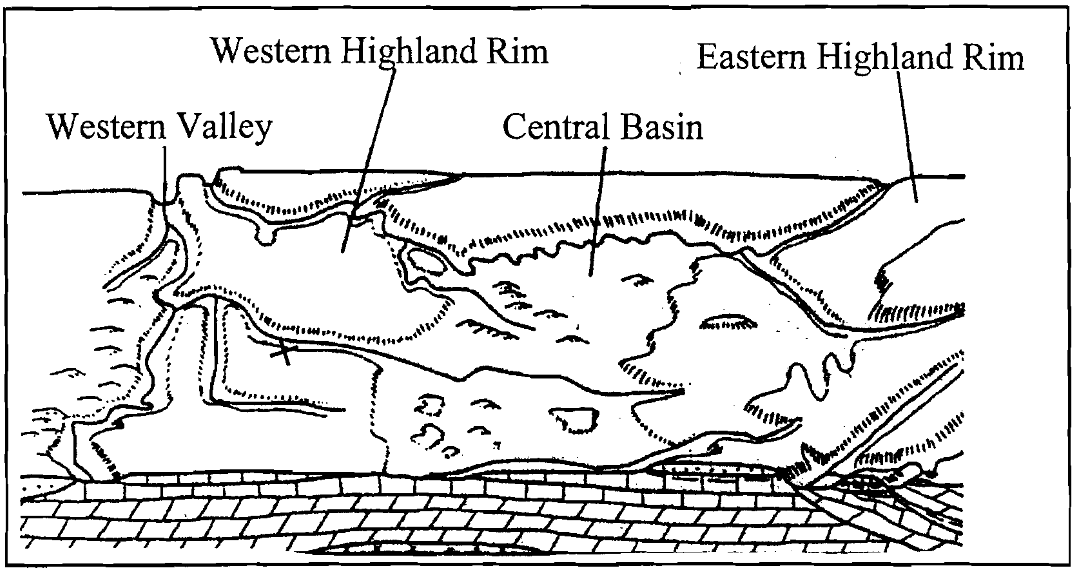

Figure 2. Relief map of Middle Tennessee (modified from Miller 1974). The X approximates the location of the study area just south of the Duck River.

The entire study area is forested and includes wide ridges, steep to moderate slopes, ravines and foot slopes, and a small amount of riparian land along Moss Springs and Trace Creeks. Moss Creek drains into Trace Creek, a tributary of the the Duck River. Moss Springs Branch is about 140.2 masl and the highest ridge is about 225.6 masl (U.S. Geological Survey 1952, photorevised 1968). The approximate center of the forest has Universal Transverse Mercator (UTM) coordinates of Zone 16, 448000 m east and 3961800 m north.

The climate of Hickman County is humid, mesothermal with mild winters and warm summers. Centerville has an average annual temperature of 15^0 C, but single and triple digit temperatures (Fahrenheit scale) are not uncommon. The growing season averages about 200 days and extends from mid-April to late October. Precipitation averages 139.7 cm annually and is adequate for all seasons; March is the wettest month and October is the driest (Smalley 1980).

Uplands of the study area developed primarily from St. Louis and Warsaw Limestones (Miller 1974). Some major units of rock outcrop communities include Bangor, Lebanon and Lenoir (Martin et al. 1993). Soils are mostly loess derived, characterized as Utisols (Martin et al. 1993), and coincide with the primary topography. Wide ridges are comprised of Sengtown-Montview complex, characterized by 5-12%, often eroded, slopes. The surface layer is 15.24 cm, consists of brown gravelly silt loam, and the soil reaction is 4.5-6.0. The slopes are comprised of Biffle gravelly silt loam often with 30-60% slopes. The surface layer is 5.08 cm, consists of brown gravelly silt loam, and the soil reaction is 3.6-5.0. There may be a small amount of Biffle gravelly silt loam with 5-15% slopes on narrow convex ridge tops, but the areas are small and not shown on the Hickman County Soil Survey maps. The foot slopes and ravines are a Tarklin-Humphreys complex, where the surface layer is 15.24 cm, consists of dark brown gravelly silt loam, and the soil reaction is 3.6-6.0. The wetter, more gravelly ravines may have Riverby soils intermingled with Lobelville silt loam. Riverby soils are a gravelly sandy loam found in narrow flood plains in watersheds dominated by cherty limestone; they are frequently flooded. The soil reaction is 5.6-7.3 and the surface layer is 12.7 cm, consisting of dark brown gravelly sandy loam. Lobelville soils are a silt loam, occasionally flooded and not as gravelly as Riverby. The surface layer is 15.24 cm and consists of a dark yellowish brown silt loam with a soil reaction of 4.5-6.0. The riparian zone along Trace Creek and Moss Springs Branch Creek is too narrow to be discerned by soil maps, but is primarily comprised of Riverby soils (Clenendon 1994).

History And Vegetational Setting

According to Edward Dotson, Hickman County historian, the Whitson Bend area of the Duck River was originally part of a 4,858 ha tract entered by William J. Council in 1810. William Whitson, Sr., who settled in this area in about 1830, purchased about 1012 ha sometime prior to the 1850 census. The alluvial land of his Whitson Bend farm was used for agricultural enterprises and the large amount of forested area was used for timbering. Whitson's two sons came into possession of their father's farm after his death. A daughter of William Whitson, Jr. married Dr. Clifford Stark, who taught at Cornell University for several years before coming to MTSU to head the Agriculture Department. He ultimately sold much of the land, but in 1969 donated approximately 403 ha to the Tennessee Board of Education (now the Tennessee Board of Regents), with the written and expressed intent of "recreational and educational use by and for MTSU." The forest has developed with little disturbance. In May 1997 the MTSU Foundation purchased this land from the TBR for a sum of $10.00. In 1998, a MTSU Foundation Committee, appointed to decide the best use of this forest, sold the land to the Tennessee Wildlife Resources Agency (TWRA). As published in several local newspapers, TWRA pledged to keep the forest as undisturbed as possible in meeting their management objectives.

The study area is part of the southern portion of the Central Forest, one of the six major natural forests types in the contiguous 48 states (Sharpe et al. 1986). Braun (1950) placed the area within the transitional Western Mesophytic Forest Region, where the climax vegetation exhibits a mosaic pattern, contrasting strongly to the single climax type and its segregates which often dominate the Mixed Mesophytic Forest region to the east. Martin et al. (1993) described the Western Highland Rim as part of the Western Mesophytic/Oak-Hickory Forests. Chester and Ellis (1989) placed the study area within "slope forest communities of dissected uplands."

METHODS AND MATERIALS

The quarter-point plotless sampling method was employed, with sampling points designated by gridding the study area. Transect lines running north-south and east-west were drawn on a soil survey map at one-quarter inch intervals (0.635 cm), or 500 feet apart (152.4 m). Each intersection on the grid was numbered and became one of 152 sampling points. At each point the tree $\geq$10.2 cm in diameter nearest to the point in each quadrant of the point was identified, diameter at breast height (dbh) determined, and point-to-plant distances measured; thus four trees were sampled at each point for a total of 608 trees sampled. The dbh measurements were taken 137 cm from the ground, on the uphill side of the tree. The point-to-plant distances were measured from the point to the center of the rooted base. Sampling was conducted during 1997.

From the sampling data, total density (unit area/mean point-to-plant distance squared), frequency (number of points at which species occurs/total number of points sampled), relative frequency

(frequency value for a species/total of frequency values for all species x 100), relative density (individuals of a species/total individuals of all species x 100), and relative dominance (total basal area of a species/total basal area of all species x 100) was calculated. The sum of the relative values (frequency, density, and dominance) gives an Importance Value (IV) of maximum 300 (Cox 1976, Phillips 1959). Land associations were designated as ridges, ravines-foot slopes, or slopes, and aspects designated as mesic (slopes with northwest, north, northeast or east aspect) or xeric (slopes with southeast, south, southwest or west aspect).

A separate study was conducted on the small area of riparian land. The quarter-point method was again utilized. This survey began on Trace Creek 1 m from the actual running water. At approximately 50 m intervals following the creek and branches, sampling points were alternated from one side of the creek to the other; 16 sampling points were accumulated, or 64 surveyed trees.

Trees within the study area that were not included in the quantitative survey were sought and recorded. During the winter of 1997-1998, a tree borer was used to extract cores of several *Quercus alba* trees to estimate age and growth rates.

RESULTS AND DISCUSSION

Summaries of sampling data are listed in Tables 1-7 (all tables are in Appendix 1). Table 8 is a family dominance comparison of the entire forest and Table 9 is a family dominance comparison for the riparian land. Table 10 is a comparison of age and growth rate of some select *Quercus alba* trees.

The forest community, including ridges, slopes, ravines and foot slopes but not including the riparian zone, may be described as a white oak-chestnut oak-sourwood association, with respective Importance Values of about 92, 30.5 and 25. *Carya tomentosa* is the most important hickory, followed by *Carya glabra*. Xeric-oriented species dominate, but the occurrence of mesophytic species supports the transitional nature of the region. An interesting comparison involves *Fagus grandifolia* and *Quercus stellata*. Numerous beech are >60 cm dbh; post oak may reach dbh's >78 cm. Beech, a mesophyte, occurs in all of segregates of this forest, but has its highest IVs on the ridges and in the riparian community, the two most contrasting segregates. Post oak, a xerophyte, is the second most important tree of the ridges, an important component of the slopes, and was not surveyed in the ravine-foot slopes or riparian segregates.

Other interesting points can be made: *Acer rubrum* and *A. saccharum*, the only maples sampled, were not found on ridges, but *A. rubrum* has a higher IV in the ravines-foot slopes and *A. saccharum* has a substantially higher IV in the riparian community. *Carya tomentosa* is the dominant hickory, but has its highest IVs in mesic conditions, such as the ravines-foot slopes and mesic slope segregates. *Carya glabra* is more dominant on the ridges. Conifers are localized and limited to *Juniperus virginiana, Pinus taeda* and *P. virginiana.* Their combined IV in the entire forest is about 4.0. *Juniperus virginiana* occurs primarily in the more open areas of the ravine-foot slopes and along the riparian land. The pines primarily occur along the roads partially surrounding this forest, but there is a small stand of *P. virginiana* within the interior where a high amount of tree fall occurs in larger individuals (>50 cm dbh). *Oxydendrum arboreum* occurs in all segregates, but has its highest IV on xeric slopes and lowest IV on the ridges.

Although *Q. alba* was the dominant species of all segregates except the riparian land, its IV is larger in the xeric segregates. Other dominant oaks include *Q. prinus, Q. stellata, Q. falcata, Q. rubra*, and *Q. velutina.* At least five other oaks occur in more localized areas. *Cornus florida* is consistently the most important understory species, and appears in all of the segregates except for the riparian land. *Nyssa sylvatica, Ostrya virginiana* and *Sassafras albidum are* other important understory species, but the latter species rarely reaches 10.2 cm dbh and was not sampled.

Liriodendron tulipifera and *Liquidambar styraciflua* are important mesophytes and were respectively the third and fourth most important species of the ravines-foot slopes. The former species occurred on mesic but not on xeric slopes or ridges. The latter species has an IV of <5 on the ridges and was not surveyed on the slopes. *Juglans nigra, Prunus serotina* and *Ulmus rubra* are relatively rare except *J. nigra* and *U. rubra* have substantial IVs in the riparian zone. Also of interest is the presence of *Ostrya virginiana* (IV 19.6) in the riparian zone, making it the sixth most important species there. Species limited to the riparian zone are *Quercus muehlenbergii, Platanus occcidentalis, Ulmus rubra, Morus rubra, Fraxinus americana,* and *Carpinus caroliniana*. Table 7 lists several other species that typically occur on dry, limestone soils but occur along the riparian land in this forest. Analysis of the soils along the riparian land show that the Riverby soil has a soil reaction of up to 7.3, much more alkaline than the other soils of this forest, and that it is well drained.

Species observed but not quantitatively sampled include: *Acer nigrum, Carya ovata, C. cordiformis, Castanea dentata* saplings, *Celtis occidentalis, Cercis canadensis, Diospyros virginiana, Quercus coccinea, Q. marilandica, Sassafras albidum, Q. shumardii*, and *Ulmus alata*.

The total densities, as estimated from point to plant measurements, are given in Tables 1-7. The entire forest has a total density of 48.19 m^2/ha. The slopes are slightly higher with a value of 48.75 m^2/ha, but the ridges and ravines are substantially higher and lower with respective values of 64.55 m^2/ha and 32.20 m^2/ha. The xeric slopes have a slightly higher value at 50.27 m^2/ha as compared to the mesic slopes with a value of 47.96 m^2/ha. These data indicate that xeric conditions in this forest have higher total densities, but mesic conditions show more diversity.

The 12 families represented (excluding the riparian land) include about 67% of total IV and 8 of 24 species are Fagaceae. The second most important family is the Juglandaceae with 4 species and about 9% of total IV. The Ericaceae is represented by one species and 8% of total IV. The family statistics indicate an oak-hickory association. The American sycamore-sugar maple-sweetgum community of the riparian zone is represented by an Aceraceae-Platanaceae family association.

Quercus alba growth rates are highly variable and localized (Table 10). Much more research is needed to delimit age and growth criteria. However, based on 16 core samples of large trees (I was limited with size due to a 28.8 cm bore), the average dbh was 49.6 cm (19.5 inches), the average age was 100 years, and the average growth rate was 0.5 cm per year.

SUMMARY

Approximately one-third of the trees occurring in the MTSU WMA are *Quercus alba.* The remaining stems (≥10.2 cm dbh) include 41 species, resulting in a relatively diverse forest, with segregates aligned primarily along topography and soil gradients.

This forest has many trees >61 cm dbh, especially beech, tulip poplar, several species of oaks, and occasionally black cherry, black walnut, slippery elm and others. Signs of forest maturity include: a lack of stumps, limited evidence of disturbance, the presence of high quality commercially important trees, a wide range of tree sizes and ages, and an uneven-aged, multilayered canopy. Oaks and hickories constitute 76% of this forest, and the remaining taxa are mostly other slow growing hardwoods. The forest appears to be second growth and has developed free from anthropogenic disturbance for a century or longer.

In summary, this forest is unique in many ways. It is a large parcel of land primarily consisting of relatively mature, high-quality, commercially important trees supporting an ecosystem that is existing, developing, and evolving in a relatively natural and undisturbed environment. The forest is aesthetically pleasing, and the outdoor recreation and natural sciences research possibilities it provides are numerous.

ACKNOWLEDGMENTS

This research was completed at MTSU in partial fulfillment of my Masters of Science Degree in Biology. The author wishes to acknowledge Dr. Kurt Blum, my advisory professor; Dr. Steve Howard and Dr. Phillip Mathis, my advisory committee; and Dr. George Murphy, Biology Department Chair. I would also like to acknowledge Dr. Rick Phillippe, Illinois Natural History Survey Botany Collection Manager, for his help and advice; Edward Dotson, Hickman County Historian; Doug Clendenon, Hickman County Soil Scientist; the Hickman County Chamber of Commerce; the Tennessee Department of Forestry; the Natural Heritage Division of the Tennessee Department of Environment; and others who have supplied me with information pertaining to this project. Special thanks for many reasons to Dr. Blum and Dr. Phillippe, and my wife, Denise Barber. I regard the insight of Dr. Clifford Stark, the donor of this forest for educational and recreational uses by and for MTSU, with a high amount of respect and admiration. I strongly urge and will continue actively participating in support of continued protection and preservation of this forest, as he envisioned. This research is dedicated to the memory of my little sister, Dana Kay Barber.

LITERATURE CITED

Braun, E.L. 1950. Deciduous forests of eastern North America. Hafner Publishing Co., New York.

Carpenter, L., J. Turner and J. Schibig. 1976. Forest communities of the Radnor Lake Natural Area, Davidson County, Tennessee. Journal of the Tennessee Academy of Sciences 51:58-72.

Chester, E.W. and W.H. Ellis. 1989. Plant communities of northwestern Middle Tennessee. Journal of the Tennessee Academy of Science 64:75-78.

Chester, E.W., B.E. Wofford and R. Kral. 1997. Atlas of Tennessee Vascular Plants Volume 2. Angiosperms: Dicots. The Center for Field Biology. Austin Peay State University. Clarksville, Tennessee.

Clendenon, D.F. 1994. Soil Survey of Hickman County, Tennessee. U.S. Department of Agriculture, Washington, D.C.

Cox, G.W. 1967. Laboratory Manual of General Ecology. Wm. C. Brown Company Publishers, Dubuque, Iowa.

Duncan, S.H. and W.H. Ellis. 1969. An analysis of the forest communities of Montgomery County, Tennessee. Journal of the Tennessee Academy of Science 44:25-32.

Fenneman, N.M. 1938. Physiography of eastern United States. McGraw Hill Book Co., New York, New York.

Gattinger, A. 1901. Flora of Tennessee and a philosophy of botany. Gospel Advocate Publishing Co., Nashville, Tennessee.

Martin, W.H., S.G. Boyce and A.C. Echternacht. 1993. Biodiversity of the southeastern United States. Upland terrestrial communities. John Wiley & Sons, New York, New York.

Miller, R.A. 1974. The Geologic History of Tennessee. Department of Conservation, Division of Geology, Nashville, Tennessee.

Phillips, E.A. 1959. Methods of Vegetation Study. Holt, Rinehart and Winston, Inc. New York.

Quarterman, E. and R.L. Powell. 1978. Potential ecological/geological natural landmarks on the Interior Low Plateaus. U.S. Department of the Interior, National Park Service, Washington, D.C.

Quarterman, E., B.H. Turner and T.E. Hemmerly. 1992. Analysis of virgin mixed mesophytic forests in Savage Gulf, Tennessee. Bulletin of the Torrey Botanical Club. 99:228-232.

Schibig, J. 1999. Structure of forest communities at Taylor Hollow Nature Preserve, Sumner County, Tennessee. Pp. 135-145. *In*: Hamilton, S.W., D. White, E.W. Chester, and M.T. Finley (eds.) Proceedings of the Eighth Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Schibig, J. and E.W. Chester. 1988. Vegetational and floristic characterization of a mixed hardwoods-shortleaf pine stand in Stewart County, Tennessee. Journal of the Tennessee Academy of Science 63:83-88.

Sharpe, G.W., C.W. Hendee and W.F. Sharpe. 1986. Introduction to Forestry. McGraw-Hill Book Co., New York..

Smalley, G.W. 1980. Classification and evaluation of forest sites on the Western Highland Rim and Pennyroyal. General Technical Report SO-30, U.S. Department of Agriculture, Forest Service, Washington, D.C.

Thwaites, R.G. 1966. Early Western Travels. Volume 3. AMS Press, Inc., New York. 382 pp.

U.S. Geological Survey. 1952, photorevised 1968. Whitfield Quadrangle, Tennessee-Hickman County, 7.5 minute series topographic quadrangle. USGS, Washington, D.C.

Appendix 1. Tables 1-10.

Table 1. White oak-chestnut oak-sourwood community: entire forest.

Species	Relative Frequency	Relative Density	Relative Dominance	I V
Quercus alba	23.65	32.24	36.11	92.00
Quercus prinus	9.60	10.03	10.91	30.54
Oxydendrum arboreum	11.01	10.86	3.11	24.97
Quercus falcata	6.56	5.76	11.20	23.51
Carya tomentosa	7.96	5.92	5.94	19.83
Quercus stellata	7.26	5.92	6.46	19.64
Quercus rubra	5.62	4.77	6.93	17.32
Quercus velutina	4.22	3.62	5.39	13.23
Cornus florida	5.85	4.93	0.99	11.78
Liriodendron tulipifera	3.28	2.96	4.29	10.53
Carya glabra	2.58	1.97	1.84	6.39
Nyssa sylvatica	3.04	2.30	1.04	6.38
Acer rubrum	1.87	1.32	0.79	3.98
Liquidambar styraciflua	1.64	1.32	0.87	3.83
Fagus grandifolia	1.41	1.15	0.65	3.21
Juniperus virginiana	0.47	1.15	0.82	2.44
Ostrya virginiana	0.94	1.15	0.32	2.41
Acer saccharum	0.94	0.66	0.70	2.29
Prunus serotina	0.70	0.66	0.26	1.62
Quercus palustris	0.47	0.33	0.54	1.34
Pinus taeda	0.23	0.33	0.31	0.87
Pinus virginiana	0.23	0.33	0.19	0.76
Juglans nigra	0.23	0.16	0.24	0.64
Carya ovalis	0.23	0.16	0.11	0.51

Total Trees: 608 — Mean Point to Plant: 4.39 m

Total Points: 152 — Total Density: 48.19 m^2/ha

Table 2. White oak-post oak-chestnut oak community: ridges.

Species	Relative Frequency	Relative Density	Relative Dominance	I V
Quercus alba	27.54	42	42.07	111.61
Quercus stellata	18.84	12	10.30	41.14
Quercus prinus	10.14	11	8.54	29.68
Quercus falcata	5.80	5	17.33	28.13
Carya glabra	5.80	6	6.46	18.26
Cornus florida	4.35	4	0.91	9.26
Fagus grandifolia	4.35	3	1.01	8.35
Carya tomentosa	4.35	3	0.98	8.32
Quercus velutina	2.90	2	2.64	7.54
Nyssa sylvatica	2.90	2	1.43	6.33
Quercus rubra	2.90	2	1.40	6.30
Pinus taeda	1.45	2	2.11	5.56
Oxydendrum arboreum	2.90	2	0.59	5.49
Juglans nigra	1.45	1	1.64	4.09
Liquidambar styraciflua	1.45	1	1.21	3.66
Quercus palustris	1.45	1	1.21	3.66
Ostrya virginiana	1.45	1	0.18	2.63

Total Trees : 100 — Mean Point to Plant: 3.79 m

Total Points: 25 — Total Density: 64.55 m^2/ha

Table 3. White oak-mockernut hickory-tulip poplar community: ravines-footslopes.

Species	Relative Frequency	Relative Density	Relative Dominance	I V
Quercus alba	19.30	25	41.19	85.49
Carya tomentosa	10.53	8.33	13.20	32.06
Liriodendron tulipifera	10.53	9.72	10.63	30.88
Liquidambar styraciflua	10.53	9.72	4.53	24.78
Acer rubrum	8.77	6.94	2.69	18.41
Quercus rubra	5.26	4.17	7.21	16.64
Juniperus virginiana	3.51	6.94	4.70	15.15
Oxydendrum arboreum	7.02	5.56	1.49	14.06
Ostrya virginiana	3.51	6.94	1.41	11.87
Cornus florida	5.26	4.17	1.16	10.59
Quercus prinus	3.51	2.78	1.85	8.14
Quercus falcata	1.75	1.39	4.12	7.26
Nyssa sylvatica	1.75	1.39	1.66	4.80
Quercus velutina	1.75	1.39	1.22	4.36
Carya glabra	1.75	1.39	1.06	4.20
Fagus grandifolia	1.75	1.39	0.74	3.89
Acer saccharum	1.75	1.39	0.71	3.85
Prunus serotina	1.75	1.39	0.41	3.55

Total trees: 72 — Mean Point to Plant: 5.37 m

Total Points: 18 — Total Density: 32.20 m^2/ha

Table 4. White oak-chestnut oak-sourwood community: all slopes.

Species	Relative Frequency	Relative Density	Relative Dominance	I V
Quercus alba	23.68	31.19	33.76	88.64
Quercus prinus	10.53	11.01	13.38	34.91
Oxydendrum arboreum	13.49	13.76	3.99	31.24
Quercus falcata	7.57	6.65	11.49	25.70
Carya tomentosa	8.22	6.19	5.37	19.79
Quercus rubra	6.25	5.50	8.00	19.76
Quercus stellata	6.25	5.50	7.09	18.84
Quercus velutina	4.93	4.36	6.88	16.17
Cornus florida	6.58	5.28	0.97	12.83
Liriodendron tulipifera	2.63	2.52	3.78	8.94
Nyssa sylvatica	3.29	2.52	0.82	6.63
Carya glabra	1.64	1.15	1.05	3.85
Acer saccharum	0.99	0.69	0.84	2.51
Acer rubrum	0.99	0.69	0.54	2.21
Fagus grandifolia	0.66	0.69	0.56	1.90
Prunus serotina	0.66	0.69	0.28	1.63
Quercus palustrias	0.33	0.23	0.52	1.08
Pinus virginiana	0.33	0.46	0.28	1.06
Juniperus virginiana	0.33	0.46	0.14	0.93
Carya ovalis	0.33	0.23	0.15	0.71
Ostrya virginiana	0.33	0.23	0.11	0.67

Total Trees: 436 — Mean Point to Plant: 4.36 m

Total Points: 109 — Total Density: 48.75 m^2/ha

Table 5. White oak-sourwood-southern red oak community: xeric slopes.

Species	Relative Frequency	Relative Density	Relative Dominance	I V
Quercus alba	27.27	40.79	47.77	115.83
Oxydendrum arboreum	21.21	19.08	5.51	45.80
Quercus falcata	12.12	8.55	11.16	31.83
Quercus stellata	10.10	7.89	9.32	27.31
Quercus prinus	7.07	7.24	8.18	22.49
Quercus rubra	6.06	5.26	7.67	19.00
Quercus velutina	4.04	3.29	4.15	11.48
Cornus florida	3.03	1.97	0.33	5.34
Carya tomentosa	2.02	1.32	1.70	5.04
Acer rubrum	2.02	1.32	1.33	4.67
Nyssa sylvatica	2.02	1.32	0.69	4.03
Carya glabra	2.02	1.32	0.60	3.93
Quercus palustris	1.01	0.66	1.58	3.25

Total Trees: 152 — Mean Point to Plant: 4.30 m

Total Points: 38 — Total Density: 50.27 m²/ha

Table 6. White oak-chestnut oak-mockernut hickory community: mesic slopes.

Species	Relative Frequency	Relative Density	Relative Dominance	I V
Quercus alba	21.89	26.06	26.95	74.89
Quercus prinus	12.44	13.03	15.91	41.37
Carya tomentosa	11.44	8.80	7.16	27.41
Oxydendrum arboreum	9.95	10.92	3.24	24.11
Quercus falcata	5.47	5.63	11.65	22.75
Quercus rubra	6.47	5.63	8.16	20.27
Quercus velutina	5.47	4.93	8.21	18.61
Cornus florida	7.96	7.04	1.28	16.29
Quercus stellata	4.48	4.23	6.00	14.71
Liriodendron tulipifera	3.98	3.87	5.62	13.47
Nyssa sylvatica	3.98	3.17	0.88	8.03
Acer saccharum	1.49	1.06	1.24	3.79
Fagus grandifolia	1.00	1.06	0.83	2.88
Carya glabra	0.50	1.06	1.28	2.83
Prunus serotina	1.00	1.06	0.42	2.47
Pinus virginiana	0.50	0.70	0.41	1.61
Juniperus virginiana	0.50	0.70	0.21	1.41
Carya ovalis	0.50	0.35	0.23	1.08
Ostrya virginiana	0.50	0.35	0.17	1.02
Acer rubrum	0.50	0.35	0.15	1.00

Total Trees: 284 — Mean Point to Plant: 4.40 m

Total Points : 71 — Total Density: 47.96 m²/ha

Table 7. American sycamore-sugar maple-sweetgum community: riparian land.

Species	Relative Frequency	Relative Density	Relative Dominance	I V
Platanus occidentalis	16	20.31	25.95	62.26
Acer saccharum	18	20.31	10.55	48.87
Liquidambar styraciflua	12	9.38	12.31	33.69
Acer rubrum	8	10.94	7.01	25.95
Liriodendron tulipifera	6	6.25	8.97	21.22
Ostrya virginiana	10	7.81	1.75	19.56
Juglans nigra	4	4.69	9.31	17.99
Ulmus rubra	4	3.13	6.28	13.40
Fagus grandifolia	2	1.56	9.07	12.63
Oxydendrum arboreum	4	3.13	1.17	8.29
Quercus alba	2	1.56	1.85	5.41
Carya glabra	2	1.56	1.85	5.41
Juniperus virginiana	2	1.56	1.35	4.92
Morus rubra	2	1.56	1.16	4.72
Quercus muehlenbergii	2	1.56	0.43	3.99
Carya tomentosa	2	1.56	0.37	3.93
Fraxinus americana	2	1.56	0.37	3.93
Carpinus caroliniana	2	1.56	0.26	3.82

Total Trees: 64 Mean Point to Plant: 5.28 m

Total Points: 16 Total Density: 33.29 m^2/ha

Table 8. Number of species, total IV, and relative IV of families in the entire study.

Families	Species	Total IV	% Total IV
Fagaceae	8	200.78	66.9
Juglandaceae	4	27.35	9.1
Ericaceae	1	24.97	8.3
Cornaceae	1	11.78	3.9
Magnoliaceae	1	10.53	3.5
Nyssaceae	1	6.38	2.1
Aceraceae	2	6.27	2.1
Hamamelidaceae	1	3.83	1.3
Cupressaceae	1	2.44	0.8
Betulaceae	1	2.41	0.8
Pinaceae	2	1.63	0.5
Rosaceae	1	1.62	0.5
Totals	24	300.0	100.0

Table 9. Data for the number of species, total IV, and relative IV for families in the riparian study.

Families	Species	Total IV	% Total IV
Aceraceae	2	74.82	24.9
Platanaceae	1	62.26	20.8
Hamamelidaceae	1	33.69	11.2
Juglandaceae	3	27.34	9.1
Betulaceae	2	23.38	7.8
Fagaceae	3	22.03	7.3
Magnoliaceae	1	21.22	7.1
Ulmaceae	1	13.40	4.5
Ericaceae	1	8.29	2.8
Cupressaceae	1	4.92	1.6
Moraceae	1	4.72	1.6
Oleaceae	1	3.93	1.3
Totals	18	300.00	100.0

Table 10. *Quercus alba* specimens cored, their age, dbh, and topographic location.

DBH inches	DBH cms	AGE years	Topographic Position
16.6	42.16	90	Ridge
20.7	52.58	105	Slope
22.2	56.39	75	Slope
14.9	37.85	68	Ridge
17.4	44.20	8	Ravine
18.7	47.50	93	Slope
19.2	48.77	92	Slope
20.5	52.07	148	Ravine
19.5	49.53	153	Ridge
20.1	51.05	98	Slope
19.4	49.28	87	Slope
22.5	57.15	98	Ridge
19.0	48.26	86	Ridge
16.2	41.15	85	Ridge
23.2	58.93	119	Slope
22.2	56.39	125	Ravine
Avg.: 19.5	49.58	100.4	Av./Year = 0.49 cm

Appendix 2: Scientific and Vernacular Names of Taxa.

Acer nigrum Michx., Black maple
Acer rubrum L., Red maple
Acer saccharum Marshall, Sugar maple
Carpinus caroliniana Walt., American hornbeam
**Carya cordiformis* (Wang.) K. Koch, Bitternut hickory
**Carya glabra* (Mill.) Sweet, Pignut hickory
**Carya ovalis* (Wangenh.) Sarg., Red hickory
**Carya ovata* (Miller) K. Koch, Shagbark hickory
**Carya tomentosa* (Poiret) Nutt., Mockernut hickory
Castanea dentata (Marsh.) Borkh., American chestnut
**Celtis occidentalis* L., Northern hackberry
**Cercis canadensis* L., Redbud
Cornus florida L., Dogwood
Diospyros virginiana L., Persimmon
Fagus grandifolia Ehrh., American beech
**Fraxinus americana* L., White ash
**Juglans nigra* L., Black walnut
Juniperus virginiana L., Eastern red cedar
**Liquidambar styraciflua* L., Sweet gum
Liriodendron tulipefera L., Tulip poplar
**Morus rubra* L., Red Mulberry
Ny*ssa sylvatica* Marshall, Black gum
Ostrya virginiana (Miller) K. Koch, Hop hornbeam
Oxydendrum arboreum (L.) DC., Sourwood
Pinus taeda L., Loblolly pine
Pinus virginiana Mill., Virginia pine
**Platanus occidentalis* L., Sycamore
Prunus serotina Ehrh., Wild black cherry
Quercus alba L., White oak
**Quercus coccinea* Muenchh., Scarlet oak
Quercus falcata Michx., Southern red oak
Quercus marilandica Muenchh., Blackjack oak
**Quercus muehlenbergii* Engelm., Chinkapin oak
**Quercus palustris* Muenchh., Pin oak
Quercus prinus L., Chestnut oak
Quercus rubra L., Northern red oak
**Quercus shumardii* Buckl., Shumardi oak
Quercus stellata Wang., Post oak
Quercus velutina Lam., Black oak
**Sassafras albidum* (Nutt.) Nees, Sassafras
Ulmus alata Michx., Winged elm
**Ulmus rubra* Muhl., Slippery elm

*Trees that are not listed in Chester et al. (1997) as occurring in Hickman County.

VEGETATION RESULTS FROM EARLY LAND SURVEY RECORDS FROM HAMILTON COUNTY, TENNESSEE, 1824-1897

H. R. DE SELM

Department of Botany, University of Tennessee, Knoxville, Tennessee 37966

ABSTRACT. Metes and bounds surveys for property ownership of land have been used to characterize the forest composition of Hamilton County. The surveys were accomplished between 1824 and 1897 in the area acquired from the Cherokee Nation in treaties of 1805, 1819 and 1835. Useable surveys numbered 357, tree stems (including mountain laurel) totaled 669, species or species groups totaled 38. A comparison of percent "species" composition with inventories in the middle third of the twentieth century reveals that some taxa, as pines, have increased in importance, some, as the white oak group, have decreased, but the percent forest composition regards many other taxa have remained essentially without change. Differences are believed due chiefly to disease, forest disturbance and modern sample placement. Plant communities known today are suggested by survey species co-occurrences. Although survey methods and locations are inexact, the data furnish considerable information about the forest landscape of the period.

INTRODUCTION

Field scientists are those interested in landscape vegetation cover at or near the time of its settlement by European-Americans. Vegetation cover information is useful to soil scientists (as Jenny 1980), historians (Williams 1989), paleoecologists (Delcourt et al. 1993), anthropologists (as Chapman and Shea 1981) and vegetation biomass modelers (Waring and Schlessinger 1985). Past vegetation patterns are used by vegetation ecologists (De Selm 1994) to interpret the impacts of environmental and historical factors on modern vegetation (Mueller-Dombois and Ellenberg 1974).

Congressional Land Survey records or similar survey records have been used to characterize vegetation (De Selm 1994). Such rectilinear surveys contrast with metes and bounds surveys which have a less geographical and chronological pattern. The metes and bounds surveys have been seldom used in studies of early settlement vegetation (but see De Selm 1995, 1997, 1999, 2001, De Selm and Rose 1995).

This paper contains vegetation results obtained from metes and bounds survey data in Hamilton County. Average forest composition, as seen by surveyors, is compared with similar data from more modern inventories.

CHARACTER OF THE SURVEYED AREA

Hamilton County lies in southwestern East Tennessee (Figure 1). This area has a subtropical humid climatic type. Precipitation varies from 140 to 150 cm per year and local floods and late growing season droughts are common (Trewartha 1968, Dickson 1960, De Selm and Schmidt 2001). Flooding of the Tennessee River was an annual occurrence before river and tributary dams were built in the 1930s-1960s (McCarthey and Voigtlander 1983). January mean maximum temperatures are in the 9-10°C range. January mean minimum temperatures range from about 01-10C°. July mean maxima and mean minimum range from about 30-32°C to 18-19°C (Dickson 1960).

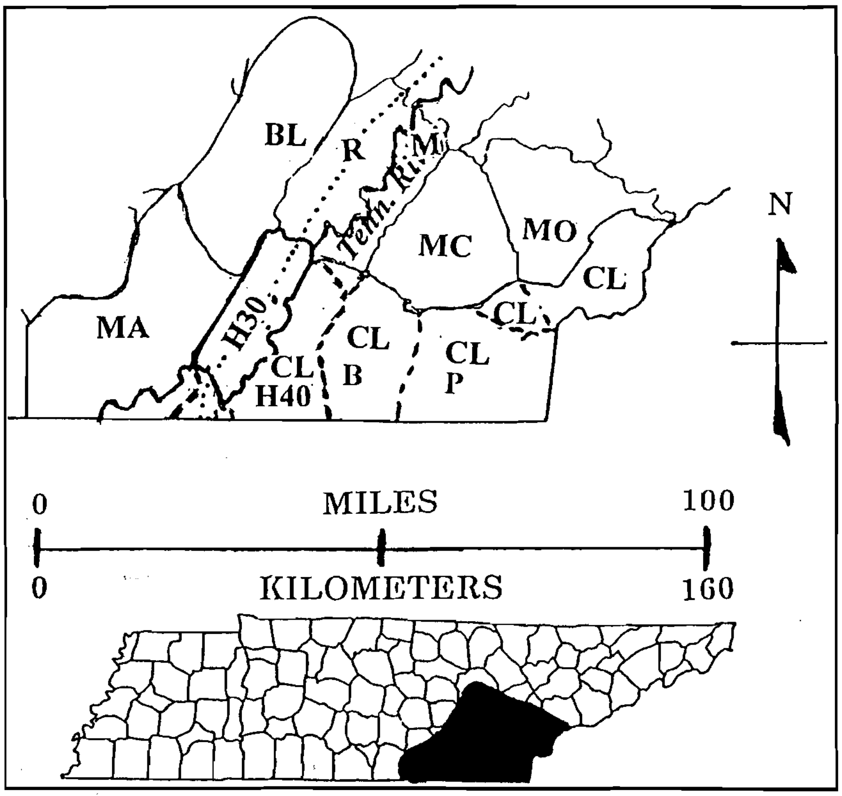

Figure 1. Map of southeastern Tennessee showing the approximate boundaries of counties in 1830 (Foster 1923) on a modern base map: BL—Bledsoe, B—Bradley, CL—Cherokee Nation Land which became Ocoee District, H30—Hamilton 1830, H40—Hamilton 1840, M—Meigs, MA—Marion, MC—McMinn, MO—Monroe, P—Polk, R—Rhea. Cumberland Plateau, west, and Ridge and Valley, east, are physiographic—floristic provinces separated by a dotted line. Dashed lines show the Hamilton County (H40) addition and other county boundaries after extirpation of Cherokee title (Foster 1923).

Hamilton County lies mainly in the Ridge and Valley Physiographic Province; its western third lies in the eastern edge of the Appalachian Plateau Province (Fenneman 1938); the Plateau here is called the Cumberland Plateau and its eastern ridge is called Walden Ridge. Elevations on Waldens Ridge vary from about 490-670 meters; bedrocks are chiefly flat-lying Pennsylvanian age sandstones, shales and coals. The eastern escarpment is precipitous and is cut by valleys of Sale, Possum, Soddy and Chickamauga Creeks (Hardeman 1966). Underlying the sandstones and shales are essentially flat-lying Mississippian limestones (Hardeman 1966, Tennessee Division of Geology 1979). Elevations in the Ridge and Valley vary from about 215 to 335 meters. Bedrocks are tipped up and lie in northeast to southwest treading beds; they are prevailingly Cambrian and Ordovician shales, limestones, dolomites and sandstones. The Devonian age Chattanooga Shale also outcrops. These rocks have eroded/weathered into ridges (dolomite and sandstone) and rolling lands and valleys (shale, limestone, dolomite).

Soils of the Plateau are Ultisols and Inseptisols and surface soils are undulating to rolling, loamy and shallow to moderately deep. Soils of steep slopes are shallow to deep, loamy and generally stony (Springer and Elder 1980, Roberts et al. 1947). Soils of the Ridge and Valley are classed as Ultisols, Inseptisols and Alfisols. They are undulating to steep, shallow to deep, mostly well-drained, rocky, or loamy or clayey. Along streams and the Tennessee River, floodplain and terrace soils occur which are at least partly flat-lying and poorly drained. Most soils everywhere are acid and have low natural fertility—exceptions are young terrace and floodplain soils and those shallow to limestone bedrock (Springer and Elder 1980, Roberts et al. 1947).

The flora of the area is relatively well known (Wofford and Kral 1993, Chester et al. 1993, 1997, Van Horn 1981, 1981). Native vascular plants totally 595 taxa are known (University of Tennessee Herbarium 2000). Forest vegetation has been described as part of the Appalachian Oak Forest (Stephenson et al. 1993), the mixed Mesophytic Forest (Hinkle et al. 1993) and the Oak-Hickory-Pine Forest (Skeen et al. 1993). The first of these is not much different from the Oak-Chestnut Forest Region (Braun 1950).

A few communities have been described: a few forest stands (De Selm 1984), the barrens and cedar-pine glades (De Selm 1992, 1993, 1984, De Selm and Murdock 1993, Van Horn 1980, 1981), sandstone outcrops (flatrock, Perkins 1981), and the Amnicola marsh (Van Horn 1986). Most natural or seminatural areas are forested; forests fall into upland oak, oak-hickory, oak-pine or oak-cedar types as well as bottomland types and mesic lower slope or cove hardwood or cove hemlock types. These classes of vegetation are mapped (Tennessee Valley Authority 1941).

The study area was visited or some sites occupied by Native American people beginning at least 10,000 years before present (Paleoindian and Archaic cultures). Later cultures built villages and cleared fields along major streams and the uplands were used for hunting and gathering of wild plant food. Fire in the forest was common (Hudson 1976, Lewis and Kneberg 1946, 1958, Lewis and Lewis 1995). By early in the nineteenth century, the Cherokee people were sedentary farmers.

Hamilton County was acquired from the Cherokee Nation in treaties of October 1805 (the northwestern part of the county—the Sale Creek area), the treaty of February 1819 in which lands north of the Tennessee River were acquired, and the treaty of December 1835 in which areas south and east of the Tennessee River were acquired (Raulston and Livingood 1974). The land from the last treaty became the Ocoee District (for land sale) and included eastern Hamilton, Bradley, Polk and parts of McMinn (of that period) and Monroe counties. The area was to be surveyed into townships six miles on a side (Folmsbee et al. 1969, Crouch 1968). The survey lines appear on the Johnson (1862, 3, 4) and Mitchell (1876) maps of Kentucky and Tennessee (cf. Phillips 1909) and is reproduced on the map of the southern end of the Cherokee National Forest (USDA Forest Service 1968). Hundreds of post-1838 land sales are listed by McClure (1990). The surveys had a distinct effect on property boundary location still visible on 1938 aerial photographs in Monroe County (Hiwassee District, O'Farwell 1974).

Upon land acquisition by Euro-Americans, forests were cleared, some valleys drained and row crops were planted. Slopes were logged for farm timber, grazed by stock and usually burned in the spring (Killebrew et al. 1874, Goven and Livingood 1977).

METHODS

The *Entry Takers Book* for Hamilton County became available to the public in printed form (Hamilton County 2001). This describes land transfer surveys for the period 1824-1897. These handwritten records from the State Archives in Nashville were typed, 1937, as part of the Works Progress Administration Historical Records, Women's and Professional Project. Included are 591 surveys but only 357 surveys had tree or other plant presence data. Tree/plant citations number 669. Compilation of average forest composition is made possible by the surveyor's recording of corner trees by name. The records appear in the table with scientific names-authority for which may be found in Wofford and Kral (1993).

The use of the typed version of the manuscript survey descriptions means that possible spelling or other errors were introduced by the typists. The few typographical errors seen may have been in the originals. The typists apparently copied the records as they found them, and nineteenth century spellings are reproduced (and are copied here in the text and table). The typists underscored some spellings and statements unclear to them.

The surveys generally started with a tree at a previous survey corner or edge and surveyed out to other trees, stakes, or topographic features. A total of 268 stakes were use. Surveys often used the compass and measured distances in poles (rarely rods). No attempt has been made to find survey lines on the ground. No tree diameters nor point-to-tree distances are given. Specific locations are unknown. In this period in this place most surveyors were called locators and most surveys used few compass lines beyond the cardinal directions; or descriptors as northwardly, southwardly, eastwardly or westwardly directions. Some surveys followed meanders of streams or ridges or unnamed natural features as boundaries. Many surveys were done by the buyer (enterer). These facts suggest that few trained surveyors were available and then many surveys were geographically approximate.

Although surveys through 1897 are recorded, only 122 trees (18.2 percent) were cited in surveys after 1835. Surveys were recorded in the "place of holding courts," at first Dallas, then Harrison, and after 1870, Chattanooga. Some surveys crossed trails, roads, paths, and fields. Some surveys duplicated corners representing land resale; duplicate tree data has been eliminated when recognized.

RESULTS

Vocabulary. In scrutinizing each survey entry for tree names, the writer noted the fairly large descriptive vocabulary used by the surveyors/locators. The fact that this vocabulary is larger than previously reported (De Selm 1995, 1997) is due to the presence of the Tennessee River and its landforms, the time scale (some man-made features were not present initially but were developed later), and the large number of surveyors/locators (Appendix).

Vegetation. Table 1 contains the percentages of total stems seen by the 38 "species" recorded in the Hamilton County surveys. To the right are data from Cowan (1946) and TVA (1955). Far fewer "species" and species group categories are found in the modern inventory data—species are grouped (not all inventory groups are shown). Surveyors of the nineteenth century also grouped taxa as maple, ash, hickory, hackberry, walnut, pine, locust and elm. The black oak or red oak of the surveyors may also include scarlet oak and Shumard oaks (see later).

Only 14 species/species groups are available for comparison because of grouping. Taxa with similar low percentages are maple, ash, sweet gum, black gum, poplar, hemlock (merged by TVA with eastern red cedar) and elms. Lack of change in percentages over time is due to proportional

Table 1. Percent occurrences in surveys from Hamilton County. Survey data are percent of stems. TVA data as percent merchantable stems ≥5 inches (12.7 cm). Cowan data is board feet based on merchantable stems ≥5 inches.

	Survey	TVA 1955	Cowan 1946
	PERCENT		
Acer negundo, boxelder	1.2		
A. spp. maple, mapel	3.7		0.6
Betula spp. birch, burch, mountain burch	0.2		
Carpinus caroliniana, ironwood	0.1		
Carya spp., hickory	6.1	12.4	10.7
Castanea dentata, chestnut, chesnut	5.2		
Celtis spp., hackberry	1.2		
Cornus florida, dogwood	2.1		
Diospyros virginiana, persimmon, possimon	0.4		
Fagus grandifolia, beech, beach	0.3		
Fraxinus spp., ash	1.7	1.2	
Ilex cf. *opaca*, holly	0.1		
Juglans nigra, black walnut	0.7		
J. spp. Walnut	0.7		
Kalmia latifolia, laurel, lorrel	0.3		
Liquidambar styraciflua, sweet gum	1.3	1.8	
Liriodendron tulipifera, poplar	4.2	0.9	4.7
Morus rubra, mulberry	0.7		
Nyssa sylvatica, black gum	2.5	2.1	0.2
Oxydendron arboreum, sourwood	0.3		
Pinus spp., pine	4.9	29.5	
P. echinata, P. taeda, P. virginiana, shortleaf, loblolly and Virginia pines			40.7
P. strobus, white pine	0.2		
Platanus occidentalis, sycamore	1.2		
Prunus cf. *serotina*, cherry	0.1		
Quercus, spp. white oaks	29.8	21.9	6.7
Q. alba, white oak	17.8	6.8	
Q. falcata, southern red oak, Spanish oak	3.1		
Q. falcata, Q. rubra, Q. velutina, southern red, northern red, and black oaks		10.5	
Q. marilandica, blackjack oak	0.7		
Q. spp. other red oaks, chiefly *Q. coccinea*, scarlet oak		10.8	
Q.montana, chestnut oak, chesnut oak, mountain oak	2.7	7.8	
Q. spp., red oaks	27.5	21.3	28.7
Q. rubra, red oak	2.2		
Q. stellata, post oak	9.3		
Q. velutina, black oak	21.5		
Robinia pseudoacacia, black locust	0.6		
Robinia/Gleditsia triacanthos, locust	0.1		
Sassafras albidum, sassafras	1.2		
Tsuga canadensis, hemlock, spruce pine, spruse pine	1.2		
Tsuga/Juniperus virginiana, hemlock and cedar		2.0	
Ulmus rubra, red elm, red ellum	0.6		
U. spp., elm, ellum, elum	0.3	0.6	

reproduction after logging and may be due to compensation. For example, loss of silver maple on wet sites in early surveys may be made up by growth of the increaser red maple in later inventories on dry or logged sites. Similarly American elm seen among elms in the surveys may be replaced by red elm and winged elm in drier sites (after logging and disease losses of American, Hepting 1971).

The percentages of three taxa increase in the modern inventories. These are pines, hickory and chestnut oak. The increase in pine is due to its invasion of opened forest stands, and stand edges (greatly increased by extensive logging, and site conversion to agriculture), old field invasion and planting (Smith 1968, Burns and Honkala 1990). The increase in chestnut oak may be a sample location phenomenon. A large proportion of the surveys were carried out in the best land available (deepest, most fertile soil), but modern inventory plots are more likely placed on dry uplands (where forests still occur and chestnut oak is common) since the lower slopes have been converted to agricultural uses. The increase in hickory may have this sample placement cause or it may be that hickories have been left to grow in forest stands in the absence of a local industry using that particular wood. A decline in species abundance is seen in chestnut (due to disease, Hepting 1971), white oak and the white oak group that includes post oak. The red oak group has held more or less constant (compare to Cowan 1946), or declined a few percent (compare to TVA 1955).

A list of "species" co-occurrences was prepared (not shown). Among 30 taxa, 200 co-occurrences brought 82 pairs of taxa (including duplication as white oak with white oak). White oak occurred with 13 other tree taxa—especially black oak. Black oak occurred with seven other tree taxa, especially white, post and Spanish oaks and chestnut. Post oak occurred with five other taxa, especially Spanish oak and pine. Pine occurred with seven other taxa and was paired mainly with itself, post and white oaks. Chestnut was paired with four other taxa but mainly with itself (it is a well-known sprouter) (Burns and Honkala 1990). Hickories were paired with 12 other taxa, but especially white and black oaks. Hemlock was paired with five other taxa including maple and holly. Red oak was paired with five other taxa especially hickory.

Swamp taxa each had low occurrences and co-occurrences, among 16 potential taxa; there were only 15 pairs. The taxa included in pairs included ash, black gum, poplar, sweet gum, walnut, black walnut, sycamore, birch, elm, red elm, ironwood, boxelder, hackberry and hickory. Chestnut oak stands were few as were red oak stands; Spanish oak was mainly an associate as was chestnut and the more widespread hickories. Hemlock gorges were rarely sampled (they are rare indeed)—hemlock here is about 160 miles from the southwestern edge of its range (Little 1971). Swamps were seen occasionally but were mainly on the corners of surveys which then seem to have proceeded upslope.

Man-made open areas reported by surveyors were habitations, roads, fields and an old (waste) field. Natural openings were flat rocks (on the Plateau) and pools and ponds. They did not report cedar-pine glades, barrens, nor marshes (though pools and ponds may have had marsh borders).

DISCUSSION AND CONCLUSIONS

The metes and bounds surveys from the nineteenth century have become a useful data source for reconstruction of early forest composition (De Selm 1995, 1997, 1999, 2001, De Selm and Rose 1995). In this study, 25 taxa can be assigned to species, four to probable species, eight to genus and one (locust) is intergeneric. And among the assigned names, the red oaks such as red and black oaks may be less than certain since scarlet and Shumard oaks are not mentioned. (In defense of the surveyors, Shumard oak was not described until 1860, cf. Little 1979.) The use of generic names, as pine, and the grouping of species by twentieth century inventory-takers makes some comparisons impossible.

The surveyors worked on the edges of streams, and the Tennessee River, out across the rolling to steep uplands, including a few cliff edges and ridges and got into a very few Plateau gorges. Forests are mostly oak dominated, oaks total 57.7 percent of the total associated taxa chestnut, hickory, pine and poplar varied from 4.2 to 6.1 percent. The sequence of abundance: oak>hickory>chestnut=pine argues for the areas inclusion in the Appalachian oak forest (cf Stephenson et al. 1993) since the subdominant taxa percentages are low. The high oak percentage was also seen on the 1818 Georgia-Tennessee boundary survey of the Plateau and Ridge and Valley parts (only 43 trees) totaled 60.5 percent oaks (Coulter 1951).

Co-occurrences suggest forests dominated by white, black and post oaks and combinations of these. Such vegetation was reported by Hinkle 1978, 1989, Hinkle et al., 1993, Martin 1971, 1978, 1989, Martin and De Selm 1976, and also reported in the syntheses by Hinkle et al. 1993, Skeen et al. 1993 and Stephenson et al. 1993. Chestnut oak and pine dominated forests occurred as well as hemlock dominated gorges, and elsewhere, swamp forests. These are also reported by the workers noted above. The absence of buckeye (*Aesulus flava*), basswood (*Tilia heterophylla*), and paucity of beech in the samples argues for absence or rarity of the deciduous mixed mesophytic forest known in the Plateau (Braun 1950, Hinkle et al. 1993).

The various land uses by people of the Cherokee Nation prior to the surveys suggests that disturbance increasers might be a significant part of the survey vegetation. However, the effects seem to be slight; the sum of pine and poplar percentages is 9.1, intermediate in the range of 5.5 to 16.1 already reported (Hawkins County, De Selm 1999, northern Sevier County, De Selm and Rose 1995, the Fifth Survey District, De Selm 1995, Campbell County, De Selm 1991, and Blount, Roane and Rhea counties, De Selm 2001). It is much lower than the average of 23.9 percent found in survey records of 1832 on Cherokee Nation land in Floyd County, Georgia, approximately 60 miles south of the survey area (Lipps 1966).

In the surveys, the percentage of most taxa varied only slightly from those of later inventories. The large increase was that of pine and with smaller increases from chestnut oak and perhaps hickory. Oak, especially white oak percentages decreased considerably on the landscape probably due to logging and conversion of oak lands to agricultural uses.

The relatively small number of trees (669) available for this study is in great contrast to the large numbers of trees (4,442) available from, e.g., Richard Cooke's surveys of Putnam and Jackson counties (De Selm 1999). One reason for the low tree number is the use of stakes instead of trees at corners. Another reason is the use of topographic features as "natural boundary" or undescribed boundaries but which were "to the best advantage" instead of trees. In many the surveyor/locator extended the line, e.g., to the north in a certain number of poles than turned to a different direction without further reference to the corner. The writer presumes that the surveyors were better botanists than they were survey technologists.

Survey data may have deficiencies because of the level of surveying and taxonomic expertise, the possible non-random choice of corner trees and the use of generic names. The metes and bounds surveys in particular are deficient in statement of the exact location of the starting point—and thus the surveyed lines. Some surveys went through disturbed areas with probable successional vegetation. Despite these deficiencies, the metes and bounds survey data constitutes the only detailed record of vegetation present near the time of land occupancy by European-Americans and thus they make a large contribution to our historical botanical geographic knowledge.

ACKNOWLEDGMENTS

The writer acknowledges the help of the Special Collections of the University of Tennessee library for bibliographic assistance.

LITERATURE CITED

Braun, E.L. 1950. Deciduous Forests of Eastern North America. The Blakiston Company, Philadelphia, Pennsylvania.

Burns, R.M., and B.H. Honkala. 1990. Silvics of North America. Vol. 1: Conifers, Vol. 2: Hardwoods. Handbook 654. U.S. Dept. of Agriculture, Washington, D.C.

Chapman, J., and A.B. Shea. 1981. The archaeobotanical record: early Archaic period to contact in the lower Little Tennessee River valley. Tennessee Anthropologist 6:61-84.

Chester, E.W., B.E. Wofford, and R. Kral. 1997. Atlas of Tennessee Vascular Plants. Vol. 2: Angiosperms: Dicots. Misc. Publ. No. 13. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Chester, E.W., B.E. Wofford, R. Kral, H.R. De Selm, and A.M. Evans. 1993. Atlas of Tennessee Vascular Plants. Vol. 1: Pteridophytes, Gymnosperms, Angiosperms: Monocots. Misc. Publ. No. 9. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Coulter, E.M. 1951. The Georgia-Tennessee boundary line. Georgia Historical Quarterly 35:303-306.

Cowan, W.F. 1946. The forest resources of Tennessee. Processed report. American Forestry Association and Tennessee Conservation Department, Forestry Division, Nashville, Tennessee.

Crouch, G.E. 1968. A study of land surveying in Tennessee. M.S. Thesis. The University of Tennessee, Knoxville, Tennessee.

Delcourt, P.A., H.R. Delcourt, D.F. Morse, and P.A. Morse. 1993. History, evolution, and organization of vegetation and human culture. pp. 47-79. *In*: W.H. Martin, S.G. Boyce, and A.C. Echternacht (eds.). Biodiversity of the Southeastern United States. Lowland Terrestrial Communities. John Wiley and Sons, Inc., New York.

De Selm, H.R. 1984. Potential national natural landmarks of the Appalachian ranges Natural Region. Ecological Report. Prepared for the U.S. Department of the Interior, National Park Service: No. CX-0001-10079. University of Tennessee, Knoxville, Tennessee

De Selm, H.R. 1992. Flora and vegetation of the barrens of the Cumberland Plateau of Tennessee. pp. 27-65. *In*: D.H. Snyder (ed.). Proceedings of the Fourth Annual Symposium on the Natural History of the Lower Tennessee and Cumberland River Valleys, Contributed Papers. The Center for Field Biology of Land Between the Lakes, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. 1993. Barrens and glades of the southern Ridge and Valley. pp. 81-135. *In*: S.W. Hamilton, E.W. Chester and A.F. Scott (eds.). Proceedings of the Fifth Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. 1994. Vegetation results from an 1807 land survey of southern Middle Tennessee. Castanea 59:51-68.

De Selm, H.R. 1995. Vegetation results from the 1807-1810 land surveys in the Fifth Survey District of Tennessee. pp. 281-290. *In*: S.W. Hamilton, D.S. White, E.W. Chester, and A.F. Scott. Proceedings of the Sixth Symposium on the Natural History of the Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. 1997. Vegetation results from early land surveys recorded in register's books, Campbell County, Tennessee, 1806-1833. pp. 193-203. In: A.F. Scott. S.W. Hamilton, E.W. Chester and D.S. White (eds.). Proceedings of the Seventh Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. 1999. Vegetation results from early land surveys in five counties of Tennessee, 1788-1839. Pp. 89-108. *In*: S.W. Hamilton, E.W. Chester and M.T. Finley (eds.). Proceedings of the Eighth Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys, The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. 2001. Vegetation results from land surveys in three East Tennessee counties, 1807-1887. Pp. 51-63. *In*: E.W. Chester and A.F. Scott (eds.). 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.

De Selm, H.R. and N. Murdock. 1993. Grass-dominated communities. Pp. 87-141. *In*: W.H. Martin, S.G. Boyce and A.C. Echternacht (eds.). Biodiversity of the Southeastern United States. Upland Terrestrial Communities. John Wiley and Sons, Inc., New York.

De Selm, H.R. and D.M. Rose, Jr. 1995. Vegetation results from early land surveys of northern Sevier County, Tennessee. Pp. 291-230. *In*: S.W. Hamilton, D.S. White, E.W. Chester and A.F. Scott (eds.). Proceedings of the Sixth Symposium on the Natural History of the Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. and G. Schmidt. 2001. A new isohyetal map of Tennessee and adjacent area. pp. 65-68. In: E.W. Chester and A.F. Scott (eds.). 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.

Dickson, R.R. 1960. Climate of Tennessee. Climatography of the United States 60-409. U.S. Dept. of Commerce, Weather Bureau, Washington, D.C.

Fenneman, N.M. 1938. Physiography of eastern United States. McGraw Hill Book Company, Inc., New York.

Folmsbee, S.J., R.E. Corlew and E.L. Mitchell. 1969. Tennessee, a short history. The University of Tennessee Press, Knoxville, Tennessee.

Foster, A.P. 1923. Counties of Tennessee. Department of Education, Division of History, State of Tennessee, Nashville. New Material Copyright, 1990. Southern Historical Press, Inc., Greenville, South Carolina.

Govan, G.E. and J.W. Livingood. 1977. The Chattanooga County 1541-1976. From Tomahawks to TVA. Third Ed. The University of Tennessee Press, Knoxville, Tennessee.

Hamilton County. 2001. Entry Takers Book, 1824-1897. Mountain Press, Signal Mountain, Tennessee.

Hardeman, W.D. 1966. Geologic map of Tennessee. Tennessee Division of Geology, Nashville, Tennessee.

Hepting, G.H. 1971. Diseases of forest and shade trees of the United States. Handbook 386. U.S. Department of Agriculture, Washington, D.C.

Hinkle, C.R. 1978. The relationship of forest communities and selected species to edaphic and topographic factors on the Cumberland Plateau of Tennessee. Ph.D. Diss., University of Tennessee, Knoxville, Tennessee.

Hinkle, C.R. 1989. Forest communities of the Cumberland Plateau of Tennessee. J. Tennessee Acad. Sci. 64:123-129.

Hinkle, C.R., W.C. McComb, J.M. Safley, Jr., and P.A. Schmalzer. 1993. Mixed mesophytic forest. Pp. 203-253. *In*: W.H. Martin, S.G. Boyce and A.C. Echternacht (eds.). Biodiversity of the southeastern United States: Upland terrestrial communities. John Wiley and Sons, Inc., New York.

Hudson, C. 1976. The Southeastern Indians. The University of Tennessee Press, Knoxville, Tennessee.

Jenny, H. 1980. The Soil Resource. Origin and Behavior. Springer Verlag, New York.

Johnson, A.J. 1862-3-4. Kentucky and Tennessee (map). Johnson's New Illustrated Family Atlas. Johnson and Ward, New York.

Killebrew, J.B. and J.M. Safford assisted by C.W. Carlton and H.L. Bentley. 1874. Introduction to the Resources of Tennessee. 1st and 2nd reports of the Bureau of Agriculture. Tavel, Eastman and Howell Printers, Nashville, Tennessee.

Lewis, T.M.N. and M.D.K. Lewis. 1995. The Prehistory of the Chickamauga Basin in Tennessee (compiled and edited by L. P. Sullivan). Two volumes. University of Tennessee Press, Knoxville, Tennessee.

Lewis, T.M.N. and M. Kneberg. 1946. Hiwassee Island. University of Tennessee Press, Knoxville, Tennessee.

Lewis, T.M.N. and M. Kneberg. 1958. Tribes That Slumber. The University of Tennessee Press, Knoxville, Tennessee.

Lipps, E.L. 1966. Plant communities of a portion of Floyd County, Georgia—especially the Marshall Forest. Ph.D. Diss., University of Tennessee, Knoxville, Tennessee.

Little, E.L., Jr. 1971. Atlas of United States Trees. Vol. 1. Conifers and important hardwoods. U.S.D.A. Misc. Publ. No. 1146.

Little, E.L., Jr. 1979. Checklist of United States trees (native and naturalized). Agric. Handbook 541, Washington, D.C.

Martin, W.H. 1971. Forest communities of the Great Valley of East Tennessee and their relationship to soil and topographic properties. Ph.D. Diss., University of Tennessee, Knoxville, Tennessee.

Martin, W.H. 1978. White oak communities in the Great Valley of East Tennessee—a vegetation complex. Pp. 39-61. *In*: P.E. Pope (ed.). Central Hardwoods Forest Conference II. Purdue University, West Lafayette, Indiana.

Martin, W.H. 1989. Forest patterns in the Great Valley of Tennessee. J. Tennessee Acad. Sci. 64:137-143.

Martin, W.H. and H.R. De Selm. 1976. Forest communities of dissected uplands in the Great Valley of East Tennessee. Pp. 11-29. *In*: J. S. Fralish, G. T. Weaver, and R. C. Schlesinger (eds.). Central Hardwoods Forest Conference, Southern Illinois University, Carbondale, Illinois.

McCarthy, D.M. and C.W. Voigtlander (eds.). 1983. The first fifty years: changed lands, changed lives. Tennessee Valley Authority, Knoxville, Tennessee.

McClure, L. 1990. Abstracts of Ocoee District Early Land Records-Entries. Mountain Press, Signal Mountain, Tennessee.

Mitchell. S.A. 1876. Mitchell's New General Atlas. S. A. Mitchell Publisher, Philadelphia, Pennsylvania.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation in Ecology. John Wiley and Sons, Inc., New York.

O'Farrell, P.J, Jr. 1974. Survey boundary adjustment: an example in the Hiwassee District of Southeastern Tennessee. M.A. Thesis, East Tennessee State University, Johnson City, Tennessee.

Perkins, B.E. 1981. Vegetation of sandstone outcrops of the Cumberland Plateau. M.S. Thesis, University of Tennessee, Knoxville, Tennessee.

Phillips, P.L. (comp. and ed.). 1909. A list of geographical atlases in the Library of Congress. Government Printing Office, Washington, D.C.

Raulston, J.L. and J.W. Livingood. 1974. Sequatchie. A story of the Southern Cumberlands. University of Tennessee Press, Knoxville, Tennessee.

Roberts, W., J. Tyer, C.A. Moger and K.V. Goodman. 1947. Soil Survey of Hamilton County, Tennessee. U. S. Department of Agriculture, Tennessee Agricultural Experiment Station and the Tennessee Valley Authority, Washington and Knoxville.

Skeen, J.N., P.D. Doerr, and D H. Van Lear. 1993. Oak-hickory-pine forests. Pp. 1-33. *In*: W. H. Martin, S. G. Boyce and A. C. Echternacht (eds.). Biodiversity of Southeastern United States. Upland Terrestrial Communities. John Wiley and Sons, Inc., New York.

Smith, D.W. 1968. Vegetational changes in a five-county area of East Tennessee during secondary succession. M.S. Thesis, University of Tennessee, Knoxville, Tennessee.

Springer, M.E. and J.A. Elder. 1980. Soils of Tennessee. University of Tennessee Agriculture Expt. Station Bull. 596. Knoxville, Tennessee.

Stephenson, S.L., A.N. Ash, and D.F. Stauffer. 1993. Appalachian oak forests. Pp. 225-303. *In*: W.H. Martin, S.G. Boyce and A.C. Echternacht (eds.). Biodiversity of the Southeastern United States—Upland Terrestrial Communities. John Wiley and Sons, Inc., New York.

Tennessee Division of Geology. 1979. Geology of Hamilton County, Tennessee. Department of Conservation, Division of Geology Bull. No. 79, Nashville, Tennessee.

Tennessee Valley Authority Division of Forestry Relations. 1941. Areas characterized by general forest types in the Tennessee Valley. Map. Norris, Tennessee.

Tennessee Valley Authority Division of Forestry Relations. 1955. Forest inventory statistics for Hamilton County, Tennessee. Forestry Bull. No. 33, Norris, Tennessee.

Trewartha, G.T. 1968. An Introduction to Climate. Fourth Ed. McGraw-Hill Book Co., New York.

United States Department of Agriculture Forest Service. 1968. Cherokee National Forest (Ocoee, Hiwassee and Tellico Ranger Districts). Map. Washington, D.C.

University of Tennessee Herbarium. 2000. County Collection Diversity Map of Tennessee. Herbarium Internet Homepage.

Van Horn, G.S. 1980. Additions to the cedar glade flora of Northwest Georgia. Castanea 45:134-137.

Van Horn, G.S. 1981. A checklist of vascular plants of Chickamauga and Chattanooga National Military Park. J.

Tennessee Acad. Sci. 56:92-99.

Van Horn, G.S. 1981. The success of alien angiosperm species in Chickamauga Battlefield. J. Tennessee Acad. Sci. 56:1-4.

Van Horn, G.D. 1986. The flora of Amnicola Marsh in Hamilton County, Tennessee. J. Tennessee Acad. Sci. 61:3-4.

Waring, R.H. and W.H. Schlesinger. 1985. Forest Ecosystems. Concepts and Management. Academic Press, New York.

Williams, M. 1989. Americans and Their Forests. A Historical Geography. Cambridge University Press, Cambridge, England.

Wofford, B.E. and R. Kral. 1993. Checklist of the vascular plants of Tennessee. Sida Bot. Misc. No. 10.

APPENDIX - Some Surveyor Vocabulary

Human occupation

Travel: road (rode), public road, trace, turnpike road, path, tollgate, polebridge, ferry
Habitation: house, place, plantation, improvement, cabin (cabbin), well, mill, field, waste (wast) field, orchard, sawmill, warehouse, camp
Boundaries: corners, edges, county lines, civil district line, old Indian boundary, 20,000 acre survey of McClung and Cosby

Natural features

Mountains and colorful place names: Cumberland Mountain, Lookout Mountain, Mountain Creek Ridge, Rogerses Rockhouse, Ridge by the name of Robin Hoods Barn, Toe of the big horseshoe of North Chickamauga Creek
Landscape forms: mountain, hill, knob, foothill, bench, flat, valley, hollow, cove, gulf.
Ridges: river ridge, diving ridge, spur, bluff, cliff (clift), break, gap. (Clift was also a local surname)
Plateau forms: flatrocks, rockhouses, coal (stone coal)
Caves: salt peter, alum (allum), copreus (with dung)
Streams: many named streams such as Roaring Fork, Sale Creek, Laurel (Lorrel) Creek
Tennessee River forms: suck (see also the Suck Creek tributary), bar, island, towhead, slough (sou, sluce, slouice), tumbling shoals, pond, pool, swamp
Stream descriptions: creek (crick), drain (drean), fork, draft, fowling water, spring branch, tributary, rivulet, headwater, bank, steep bank, cliff bank, meanders
Springs: cave springs, the "spring that rises and sinks," sartan (certain?) spring, mineral springs, sulfur, freestone, ones rich in iron called chalybeate springs (chalybiate, calebiate, kalebiate)
Trees: double, forked, large, small, marked, blazed, cut with numbers

A FIRST LOOK AT BOTANICAL FORERUNNERS EARLY IN TENNESSEE HISTORY

H. R. De Selm

Department of Botany, The University of Tennessee, Knoxville, Tennessee 37996

ABSTRACT. In a library study using mostly secondary/summary sources, the names of 133 men and women are found to have contributed to our knowledge of plants in the eighteenth and nineteenth centuries in Tennessee. Most eighteenth century persons were explorers/observers who wrote in general terms about forests, forest openings, or Native American crops. Plants were noted, when by type, generally at the generic level. Medical people contributed articles in their journals-some about plants. Geologists included plants in landscape descriptions. Agriculturalists wrote in current journals, the Bureau of Agriculture sponsored societies, meeting and fairs. Nurserymen advertised numerous woody fruit tree (and grape) varieties for sale. Surveyors recorded plants (mostly trees) at property corners. Botanical and agricultural sciences received a larger impetus with the establishment, the College of Agriculture and the Agricultural Experiment Station at the University at Knoxville. Throughout the period, dedicated laypersons and specialist were collecting and compiling the flora. Specimens were used, or were given to herbaria where they could be used for systematic studies. Colleges and universities became the seat of the development and teaching in the disciplines of pure and applied botany and the source of new knowledge through research.

INTRODUCTION

Tennessee has been favored with equitable climates and a variety of kinds of soils where many introduced cultivated plants and a fairly large and diverse native flora thrive. Both Tennesseans and visitors have collected, written about and/or cultivated these plants. The people, with some exceptions, are not well known and little has been written about the accomplishments of those who are chiefly from the eighteenth and nineteenth centuries. Who were the people of those two centuries who dealt with plants? What kinds of spontaneously derived or religious or medical or government organizations facilitated spread of interest and knowledge? It is the purpose of this paper to list active people and classify their activities within the context of their job/profession and some historical changes.

Native Americans were the first people to support themselves using plants in Tennessee. Their uses are noted by the early travelers Steiner and De Schweinitz (1799) and are known from modern archeological and ethnological studies (cf. Banks 1953, Hudson 1976, Moerman 1998). During Tennessee's first 120 years, most settlers made their living as farmers, ranchers, or loggers (Folmsbee et al. 1969) and so their livelihood depended directly upon plant growth. Further, in the ecosystem sense, all humans, indeed almost all organisms, are dependent on green plants for fixed energy and oxygen (Odum 1996).

METHODS

Sources of information in this study are many but primarily from secondary compilations. Eighteenth and nineteenth century people with some biographies are cited by Andre (1971) or in the Reference List of Collectors (Pennell 1935). Some middle nineteenth century workers are cited in the papers of James Corgan. Publications of the State Agricultural Bureau, the University of Tennessee Experiment Stations, the book by Killebrew et al. (1874) and histories by Smith (1999) and Whatley (1995) are used. Scientists and laypersons who contributed plant specimens to Gattinger are cited in his floras (Gattinger 1887, 1901). Career details of a few scientists have been checked in Stafleu and Cowan (1976-1988), Stafleu and Mennega (1992-2000), and Gilmour (2002). Names of persons have been sought in Temple and Temple (1912), Anonymous (1911), and Somerset Publishers (2000). Names of early academies, colleges and of a few teachers have been found in Van West (1998), Goodspeed (1887, 1887) and Merriam (1893).

EARLY OBSERVERS

Many of the early explorers/travelers/observers noted the great forests or fine timber as did, for example, Price Hughes (Crane 1927), Filson, and Boone (Imlay 1797). Haywood (1823) tells of the long hunters' (1760s) explorations in the great forests of Tennessee and Kentucky. William Blount (Sims 1947) noted the "heavy growth of large timber," the understory "generally covered with thick and high cane…or with a thick underwood." Openings in the forest covered by graminoids, cane and scrub were also reported. The Hutchins Survey of the Cumberland River (1768) noted buffalo licks (grassy openings) (Williams 1928) and licks on the Duck River are also recorded (Haywood 1823). Several Native American villages or campsites (grassy or scrub vegetation) are recorded (Harbert 1947). The occurrence of upland grassy to scrubby forest openings—the barrens—is reported (Imlay 1797; Baily 1856; the Bright Survey of 1807, De Selm 1994; Booklet Committee 1972; Gardner 1963; Ridenour 1941). Native American old fields (grassy) are known from settlement records (Hyder 1903, Peters 1957). Traditions of local open land (barrens, glades, fields, fire scars) are reported by such modern writers as Hicks (1968, Creekmore 1988, Patton 1958, and Krechniak and Krechniak 1974).

In Williams (1928) *Early Travels in the Tennessee Country*, he reprints 37 narratives of travels in Tennessee extending chronologically from DeSoto of 1540-1541 to Steiner and De Schweinitz in 1799. In 35 mostly short accounts the writers relate seeing 34 kinds of plants (mostly generic level, including two unknown (including bear grass in a swamp) in 82 sightings including 18 sightings of seven cultivars. The most commonly seen wild plant was cane (reeds, rushes, *Arundinaria* cf. *gigantea*) 16 sightings; the most commonly seen cultivar was maize (corn, *Zea mays*) eight sightings. The French botanist Andre Michaux crossed parts of Middle and East Tennessee during 1793-1796 and had 37 sightings of 29 (mostly generic) taxa including two fields of corn. The diary of the missionaries Steiner and De Schweinitz in 1799 at 107 pages is the fullest account of those included; their travels took them into several Cherokee villages as well as the Cumberland settlements. They report 113 sightings of 41 (mostly generic) taxa, including two unknowns. These included 50 sightings of 15 cultivated plants. Again the most common wild plant seen was cane since most roads (trails) followed valleys where cane was ubiquitous. And corn (maize) was the most commonly reported cultivar.

Some of these accounts were in the form of letters or reports that received little circulation, but some were published as travel accounts that served to educate the literate resident public, and to inform and stimulate travelers and potential immigrants. One of the above, the plant explorer, Andre Michaux, not only collected plants but also described species and genera and wrote a flora (Michaux 1803). The Moravian missionary teacher Anna Gambold collected, distributed specimens, and kept a garden which included native plants in nearby Springplace, Murray County, Georgia (Gambold 1819, McKinley 1994). John James Audubon, the ornithologist, was boating down the Mississippi River in November 1820 and reported "...big cypress...cypress swamps," and on the river border "...the thick set of the young cottonwood trees..." (Irmscher 1999).

PRE-CIVIL WAR MEDICINE

As nineteenth century physicians drew away from bloodletting, purging and blistering as medical treatments, the use of herbs became more accepted. Early pharmacopoeias and dispensatories used by physicians had large materia medica. The doctrine of signatures (cf Chevallier 1996) suggested herb use, and Native American cultures and many rural people used herbs extensively which were supplied from local sources (DeFiore 1998, Gattinger 1894, Youngken 1950) and as suggested by self-treatment books (as Ewell 1822, Goodlett 1838, Gunn 1830). In Memphis in the 1840s there was a short-lived Botanico-Medical College (Corgan 1980). Pharmacopoeias and dispensatories were available (Coxe 1818, General Convention 1820, Wood and Bache 1836).

As the population of physicians became larger, they came together to form medical societies, some with journals as the Nashville Journal of Medicine and Surgery wherein, in 1860, G.S. Blackie wrote of a medical flora of Nashville, and B. S. Hopkins wrote a paper that included a list of the flora of Marion County (Corgan 1977a, 1994a). In the Southern Journal of Medical and Physical Sciences, in 1853, Richard O. Currey wrote of *Gelsemium sempervirens*, a beautiful native vine now in cultivation (Corgan 1994a, 1994d). Currey also collected plants for John Torrey and Asa Gray (McNeely and Hemmerly 2001) who were writing a flora of North America. Men of this (and later) periods, trained as physicians, often became amateur or professional botanists; for example, Augustin Gattinger, Tennessee's first resident botanist, was an M.D. [The tradition continues with the late Dr. John Churchill who collected for Michigan State University, Dr. Margaret Rhinehart who has collected for the University of Tennessee, and the late Dr. Vernon McNeilus who collected for and was a volunteer in the herbarium of the University of Tennessee.]

PRE-CIVIL WAR AGRICULTURE

The need for rural farmers to communicate problems and solutions arose. The Cumberland Agricultural Society was active as early as 1819 and the Washington [County] Agricultural Society as early as 1824 (DeFiore 1998). Similarly, serial publications arose (and fell with economic tides). The Agriculturalist (1840-1845) developed from merging of two journals one of which has been started by 1834 (DeFiore 1998). Besides the Agriculturalist, the Farmer and Mechanic, Southern Cultivator, Southern Homestead, Southern Planter, and Tennessee Farmer were published mostly for short periods. In the early 1840s, contributions to the Agriculturalist included botanical/crop articles by D. Clayton, Tolbert Fanning, L. Garrett, W. Williams and Samuel B. Buckley (Corgan 1976a, 1976c, 1988, 1994a).

STATE BUREAU OF AGRICULTURE - ITS EFFECTS - 1850s

In 1854 an act of the Tennessee General Assembly established the State Agricultural Bureau and authorized incorporation (each with a $200 "bounty") of county agricultural societies. The stipend is believed to have been used toward lease, purchase or improvement of a county fairground. Fairs in some counties had arisen on local initiative as early as 1838 in Williamson and Smith counties (Corgan 1988). Under Bureau auspices, most county organizations began functioning in 1856 or 1957 but a few began in 1854 (Knox, Sevier, Sumner, White counties). The local organizations called themselves e.g. ___ County Agricultural Society/Associations or ___ County Agricultural and Mechanical Society. By 1856 there were about 36 local organizations (Proceedings of the State Agricultural Bureau 1856).

An important function of each organization was the sponsoring of an annual fair. The Agricultural Bureau sponsored a State Fair or Exhibition in 1856. In 1856 and 1857 Eastern Division fairs were held in Knoxville. By about 1853 Western Division fairs were being held. In 1857 the fourth annual Middle Division fair was held. Hickman and Obion county fairs were held first in 1858. At least 44 counties had held fairs by 1858 (Proceedings of the State Agricultural Bureau 1858).

Although a primary function of each fair was the judging of manufactured products, home productions, crops and livestock, various men wrote essays on subjects of importance to farmers/ranchers/plantation owners; some of these were prize winners. Addresses were made and essays published by John H. Bain (John R. Bain?), J.O. Lusby, H.D. Metcalf, Andrew J. Peeples, H. M. Bitman, Samuel H. Stout and George Thompson on plant subjects (Proceedings State Agricultural Bureau 1856). All of this activity came to an end during the Civil War and for years afterward during economic depression.

AGRICULTURE 1874-1899

The State Bureau of Agriculture was reinstated in the 1870s. The first and second reports of the Bureau were the 1193-page "Introduction to the Natural Resources of Tennessee" by J. B. Killebrew, J. M. Safford assisted by C.W. Charlton and H.L. Bentley. At that time Killebrew was secretary to the Bureau and the geologist Safford was chemist. This report contains an extensive description of the state's natural and cultural features as well as descriptions for each county of geology, soils, agriculture with comments on vegetation or native timber. Many counties are noted with agricultural societies/associations, clubs or granges sponsoring fairgrounds and fairs (Killebrew et al. 1874).

A state Stock Breeders Association was in operation by 1876. A convention was held in 1878 where B.F. Cockrill read "The Grasses of Tennessee" (Report of the Bureau of Agriculture, Statistics and Mines, 1876, 1878). During the 1890s a new series was published, the Biennial reports of the Bureau of Agriculture, Statistics, and Mines (Bureau of Agriculture 1891-1896). The existence/meetings of various agricultural organizations are mentioned: Cotton growers and merchants association meetings, West Tennessee Horticultural Society with annual meetings, East Tennessee Horticultural Society in 1890, East Tennessee Agricultural Society meetings in 1874, and 1877-1893, Anderson County Fair and Stock Association in 1886, Concord Live Stock Association in 1886, Salton Stock Association, Graveston Agriculture and Stock Association in 1881, London Fair and Turf Association in 1885, Roane County Fair and Stock Association in 1892, East Tennessee Dairy Association in 1890. Farmers' conventions were held in 1894 in Columbia, Jackson, Knoxville and Shelbyville. One anonymous report was made on the "Vegetable and fruit industry...and French method of asparagus cultivation." At these meetings addresses were made and published by O.W. Blackwell, F.M. Dearing, H.R. Fiser, R. Gallagher, Prof. Heiges, G.C. Hoffman, J.W. Morton, J.M. Priestly, R.S. Sounders, and J.G. Sims as well as statements by other authors.

In the Report of the Commissioner of Agriculture of 1899-1900, the widespread meetings of farmers' institutes were reported. These included the Central Farmers Institute held at Nashville in 1899, the State Farmers Institute at Nashville in 1900, Northern Middle Tennessee Institute at Gallatin in 1899, Southern Middle Tennessee Institute at Shelbyville in 1900, Intercounty Institute at Fayetteville in 1899, Lower East Tennessee Institute in Monroe County in 1900. In 1899 and 1900 county level institutes were widespread and are reported in 39 counties. They are primarily in Middle and West Tennessee; they are mentioned in the east in Knoxville, Sweetwater, Hawkins County and that in Monroe County mentioned above. All of these activities via societies, associations, institutes, and fairs were at least partly educational in purpose and the essays and addresses noted above suggests that the cultivation of plants was high on the list of topics of interest.

PLANT COLLECTORS AND SYSTEMATISTS

More than a dozen and a half state residents and non-residents collected for Gattinger, who notes their contributions in his floras (Gattinger 1887, 1901). They are Mrs. Lydia S. Bennett, Mr. Bicknell, Mrs. E.I. Britton, William Canby, R.O. Currey, A.H. Curtis, G. Egeling, Heinrich Eggert, J.S. Imborden, J.F. James, Edmund Kirby-Smith, R.M. Middleton, Mrs. M.S. Percival, Albert Ruth, J.K. Smith, Mrs. Hattie R. Stratton, Mrs. Turner and Col. Wilkins.

A few others traveled to Tennessee and collected (Andre 1971, Stupka 1964, Geiser 1948). They are George G. Ainslie, George L. Ames, A.C. Beardslee, Jr., P. de Beauvois, N.K.E. von Beyrich, William Cooper, Allen H. Curtin, John Donnell-Smith, A. Fendler, J. Fraser, Clarence E. Hemingway, Mathias Kinn, C.A. Kofoid, G. Kunze, Ferdinand Rugel, and Charles S. Williamson. About two dozen people collected plants in Tennessee and wrote floristic/systematic statements about those and other collections. (This list excludes most of the agricultural scientists mentioned elsewhere.) It should be noted that only Bain, Gattinger, Kearney, and Lamson-Scribner actually lived in Tennessee. The contributors are: William Willard Ashe, Samuel M. Bain, Chauncey D. Beadle, Eugene P. Bicknell, Charles L. Boynton, Samuel B. Buckley, John W. Chickering, S. Coulter, Moses A. Curtis, D.C. Eaton, George Engelmann, J. H. Ferris, Augustin Gattinger, Asa Gray, T.G. Harbison, D.L. James, Thomas H. Kearney, Frank Lamson-Scribner, Leo Lequereaux, Curtis G. Lloyd, John Lyon (his journal was published by Ewan and Ewan 1963), Andre Michaux, Francois Andre Michaux, Thomas Nuttall, Constantine S. Rafinesque, Henry N. Ravenel, Lewis D. De Schweinitz, William S. Sullivant, William Trelease, and Lester F. Ward, J. Williamson (various sources, Andre 1971, Corgan 1976b, Bates 1985, Chickering 1880, Petersen 2001).

EDUCATION—PRIMARY AND SECONDARY

Most of the 30 East Tennessee counties had named academies in the 1800s; Goodspeed (1887) lists 29 with names (sometimes more than one per county) 1806-1867, plus Martin Academy of Washington County (of North Carolina) established in 1795 and Washington College Academy founded in 1780. Girls were taught in six of these (1813-1853). There were several special schools "institutes" for girl students between 1827 and 1855. Churches were involved in the establishment of many academies that were budgeted mainly from student fees. In 1799, Steiner and De Schweinitz (Williams 1928) found near Nashville, "English schools are everywhere and the youths learn, at least, to read, write and the fundamentals of figuring." Public schools/common schools were not noted until 1867 (Goodspeed 1887) and are noted in all counties by 1874 (Killebrew et al. 1874). Little is known of the instructors in such schools—occasionally the name of the person who started a private school is known. Even less is known about the curriculum, although in the late 1800s some classes collected wildflowers and wrote species "diagnoses" (Stella De Selm, personal communication, January 1970). It is likely that circumstances such as these occurred here and there in Tennessee.

EDUCATION—COLLEGES

Beginning in 1794 with the chartering of Greeneville College and Blount College, schools of higher education proliferated in Tennessee. Including several institutes whose academic level is not known for certain, at least 71 colleges were begun by 1899. This number includes names of several schools that were forerunners of later ones—sometimes with different names. Many of the schools were church supported and a few were theological (articles in Van West 1998, Goodspeed 1887, 1887, Meriam 1893). Natural philosophy (at first), natural history or some part of botanical science was doubtless taught. Curricula and instructors are rarely known with some exceptions. George T. Bowen was professor of chemistry and natural history at the University of Nashville, 1826 (Corgan 1978b). In the 1840s, Tolbert Fanning taught agricultural chemistry at Franklin College, Nashville, and founded Elm Crag Agricultural School at his farm outside of Nashville. In 1841, Turner Vaughn was Professor of Agriculture at Union University, Murfreesboro and in 1846 R.O. Bradley taught a laboratory botany course at East Tennessee University (Corgan 1980) where John C. Minor taught chemistry and natural sciences in 1866 and Albert Ruth worked in the preparatory department in 1871 (Merriam 1893, Corgan 1977b, 1978a, 1978b, 1980, 1994a, 1994b).

The following other teaching assignments are noted by Merriam (1893). Teachers of natural philosophy at the University of Nashville were George W. McGehee 1824-1827, James Hamilton intermittently 1827-1849, John Thomson 1830-1831, Abram Litton 1835-1838, and Alexander P. Stewart 1849-1850. At Vanderbilt University after 1875 John Safford taught mineralogy, botany and economic geology. Teaching materia medica and pharmacy were E. A. Ruddiman, Thom Atchison, and William G. Ewing. At Cumberland University, Lebanon, in 1844, John Hinds was teaching chemistry and natural sciences. At Stewart College, Clarksville, 1850s-1870s, W. W. LeGare was teaching natural philosophy among other subjects, and James A. Lyon was teaching natural sciences. At Union University, Murfreesboro in the middle half of the nineteenth century, T. J. Dupree taught natural sciences and S. M. Bain was assistant professor of natural sciences and French. At Fisk University, Frederick. A. Chase taught natural sciences, 1893.

AGRICULTURAL EXPERIMENT STATION

In 1862 the United States Congress passed the Morrill Act providing funds from land sales to designated universities for establishment of an agriculture curriculum. In 1867 Tennessee accepted the Act and East Tennessee University at Knoxville became the land grant institution. In 1869 East Tennessee University became the University of Tennessee and in 1877 the College Agriculture was established. The first teachers of botany, horticulture and agriculture were Hunter Nicholson, John M. McBryde and John M. Glenn. In 1887 the Experiment Station was established with Charles Dabney as its director. Following this, teaching and research (published in free-to-the-public bulletins) grew. By 1890 Ralph L. Watts was teaching and doing research in horticulture. Andrew M. Soule, Samuel M. Bain, Frank Lamson-Scribner, Charles A. Mooers, Charles A. Keffer taught/researched in the 1890s. Other experiment station bulletins with botanical subjects were authored by those above and the following: L.P. Brown, C.W. Dabney, F. Lamson-Scribner, C.L. Newman, C.S. Plumb, P.O. Vanatter and R.L. Watts (Dabney 1890, Smith 1999, Agricultural Experiment Station 1888-1900, Hilty and Peterson 1997, Whatley 1994, Anonymous 1954). Gattinger complained in a letter to George Engelmann in December 1879, "It has been my misfortune to spend thirty years of my life with these half civilized Tennesseans and up to now I have not seen a single living Tennessee botanist" (Oakes 1932). There were several professional botanists/agriculturalists, teachers of natural science in Tennessee but for one who kept an herbarium and described new species, as he did, Gattinger had to wait for the arrival, at the University of Tennessee Agricultural Experiment Station, of Frank Lamson-Scribner in 1888.

OTHER SCIENTISTS AND PROFESSIONS

Three prominent nineteenth century Tennessee scientists wrote of plants that they observed. Two were geologists, John Safford (1869) and Gerald Troost (Corgan 1977, 1994c, 2000, 2002, Corgan and Gibson 1995). For the 1880 U. S. Census, Safford was a special census agent and wrote the Report on the Cotton Production of the State of Tennessee in the Report on Cotton Production in the United States. He and 126 respondents wrote of the native growth on cotton lands and occasionally adjacent soils (Safford 1884, De Selm 2001). J. B. Killebrew wrote on agricultural crops and plants based on his extensive travel, reading and on his own farm activities (Killebrew 1878, 1898, Anonymous 1954).

Nineteenth century visitors to Roan Mountain (Laughlin 1999) included people not otherwise mentioned here: Helen R. Edson, Charles Lanman, John Strothers, J. H. Redfield, Elizabeth G. Britton, and John Muir. They wrote of their experiences there. Charles Minor, nurseryman, educated his public to the existence and availability for sale of fruit crop varieties by advertising in local and regional newspapers/agricultural journals (1830s-1840s). He offered dozens of varieties of grapes, apples, peaches, pears and plums from among thousands of young nursery plants (Corgan 1978b). Killebrew et al. (1874) mention several nurseries around the state.

Men who surveyed potential sale areas using compass and chain established land ownership boundaries. The areas were usually metes and bounds (many cornered/sided) with a tree recorded at most corners. Survey records (locations, angles, distances, trees, topographic features) were written into an entry takers book at the survey district office. The tree proportion records have been used as sources of early forest composition estimates (cf. De Selm 1999). A few entry takers books have been published (cited in De Selm 1995, 1997, 1999, 2001). Many men served as surveyors in the eighteenth and nineteenth centuries apparently mostly for short periods of time. An exception was Richard F. Cooke who surveyed in Putnam and Jackson counties 1826-1839; he made 783 surveys citing 4442 trees distributed among 57 taxa (De Selm 1999).

The books in libraries serve as reservoirs of knowledge which may be dispersed like the spoken word. Private book collections/libraries accumulated by professionals as educators, physicians and lawyers were probably extant. The personal libraries of Lamson-Scribner (1892) and Gattinger (Oakes 1932) are known. A local bar association library, a secondary school library, a literary society library and Sunday school library are cited by Killebrew et al. (1874). Other secondary schools may have had libraries as did colleges and universities. The library at the College of Agriculture/Agricultural Experiment Station had a faculty member as assigned librarian (Dabney 1900). Perhaps two dozen subscription and beneficent libraries were extant in antebellum West Tennessee (Corgan 1995) and were no doubt extant throughout the state during that century. However, nothing is known of types of books shelved, nor of their use, nor effects upon the users.

Biltmore [Estate] botanists, at Asheville, North Carolina, were active (see Beadle, Boynton and Harbison preceding)—forestry was being developed there in the late 1800s (see also Ashe 1897). The famous study of Appalachian forests was begun in July 1900 (Wilson 1902) which syntheses were "Forests and Forest Conditions in the Southern Appalachians" (Ayres and Ashe 1902, Ayres and Ashe 1905). Parts of the Blue Ridge of Tennessee were included.

SUMMARY AND CONCLUSIONS

Early observers, those from the eighteenth and nineteenth centuries, included persons who knew some plants and some other persons who either knew none or did not write about those they saw. They functioned as explorers describing their travel routes, landscapes, and encounters with Native Americans. They publicized the beauties and great development potentials of the regions through which they moved. In a sense, the land surveyors were local explorers and were an indispensable part of land ownership and development. There were probably hundreds of them over the decades each working for a few too many months or years with varied botanical skills. Their knowledge was essential to legal partitioning of the land among owners. Land ownership was prerequisite to the free enterprise operations to follow.

Antebellum medical practitioners, working in the absence of even the germ theory of disease, and in the face of chronic malaria and cholera epidemics were faced with enormous problems. Treatment for some simpler medical problems lay outside their doorsteps in native herbs and the developing pharmacology/pharmacognosy (Youngken 1927, 1950, Stannard 1969). The communication between physicians via societies was beginning. Post-Civil War medicine was facilitated by the growth of science and improved medical education. Their contribution to botanical knowledge, however, was slight. However, other scientists, geologist, in particular Gerald Troost and John Safford, contributed to describing and writing about the landscape's botanical features. The agriculturalist, J. B. Killebrew, operating as a Commissioner of Agriculture and private citizen, made a large contribution to knowledge about Tennessee plants. A federally funded study of the forests of the Southern Appalachians including parts of easternmost Tennessee was begun in 1900.

Antebellum agriculture also dealt with its problems with neither developed botanical, nor crop culture, nor soil sciences. Private serials published both good and bad crop culture information to those who could afford the subscription. The State Bureau of Agriculture in the 1850s stimulated the formation of agricultural societies that held annual fairs where information exchange occurred and individual farmers/ranchers could see and hear about high-level crop and stock production. At the time, as later, nursery operators acquired, advertised, and sold dozens of regional/local varieties of vine and tree crop plants.

Post-Civil War agricultural development was stimulated by reports of the Bureaus of

Agriculture/Bureau of Agriculture, Mines and Statistics. The Bureau sponsored many societies and meetings promulgating information about plants. In 1867 East Tennessee University was designated the Tennessee Morrill Act land grant school. The agricultural curricula were broadened and botany and horticulture had designated professorships. With the establishment of the University of Tennessee Agriculture Experiment Station in 1887, the staff grew, and official bulletins were published containing results of scientific research. By this time, chemistry was an established discipline, disease causes were presumed microbial (or e.g., from nematodes), plant selection, plant genetics, plant breeding, plot studies with replication and mathematical data treatment were then or soon to be used. Soil science was in its infancy but developing.

Some Tennesseans and state visitors recorded observations and some collected plants for botanists compiling floras or for nurseries or botanical gardens. The complete names of some persons are not known. An additional group of a few residents and a larger number of other persons collected plants and wrote as professionals about them. The specimens of both groups of collectors often were given to herbaria where, barring destruction as from decay, insects, fire or war, they became available for study by then and future scientists compiling floras, or carrying out plant systematic research.

Knowledge about plants spread through formal educational procedures, academies/schools, colleges, and universities. Little is known to the writer of academy/pre-college educational content. Similarly, many colleges may have taught some botany in natural philosophy or natural history courses. The content of these courses and the qualifications of instructors are often unknown. However, the colleges and universities became the sites of development of research and training of teachers and researchers in the pure and applied disciplines of botany. And these places became the sites of the higher education of its citizens.

In this library study using mostly secondary/summary sources of information, the names of 133 men and women are given who were found to have contributed to the growth of knowledge of the plant sciences in the eighteenth and nineteenth centuries in Tennessee. With further study, there are doubtless many more people whose names should be included. Little is known of most of these listed people-further study could well elucidate more of their lives and accomplishments.

The efforts of the people listed here have brought fruit. Much of the land use of Tennessee today is devoted to agricultural production—an additional large area is used as lawns, forests, and parks. The 1999 value of crop plant production was 768M (million dollars), of timber products was 380M, of nursery products 137M, and of floriculture products 58M dollars (Tennessee Agricultural Statistical Service 2001). The Tennessee Academy of Science membership was about 600 in 2000. The Association of Southeastern Biologists membership (1993) doubtless includes over 160 plant scientists. In addition, citizen organizations in the state such as the Native Plant Society, Oak Ridge Arboretum Society, Keep Tennessee Green, The Nature Conservancy and garden clubs have membership totaling thousands of people interested in plants and vegetation. These citizens are the direct intellectual heirs of the forerunners listed in this paper. To those forerunners we must acknowledge our gratitude.

ACKNOWLEDGMENTS

I acknowledge assistance or advice from Dr. Clint Allison, Dr. Dan Bing, Dr. James Corgan, Dr. Henry Fribourg, Dr. Ronald Petersen, Dr. John Reynolds, and the University of Tennessee Library.

LITERATURE CITED

Agriculture Experiment Station, University of Tennessee 1888-1900. Bulletins, Knoxville, Tennessee.

Andre, J.E. 1971. The history of systematic botany in Tennessee: 1771-1942. M.S. Thesis, University of Tennessee, Knoxville, Tennessee.

Anonymous. 1911. Who's Who in Tennessee. Paul & Douglass Co., Publishers, Memphis, Tennessee.

Anonymous. 1954. A Century of Tennessee Agriculture—The Department Re-established. Pp. 213-221. *In*: 40th Biennial Report of the Tennessee Department of Agriculture, 1952-1954. Nashville, Tennessee.

Ashe, W.W. 1897. Forests of North Carolina. Pp. 141-224. *In*: G. Pinchot and W.W. Ashe (eds.). Timber trees and forests of North Carolina Geol. Surv. Bull. 6. Raleigh, North Carolina.

Ayres, H.B. and W.W. Ashe. 1902. Appendix A. Forests and forest conditions in the Southern Appalachian Mountains. Pp. 45-109. *In*: T. Roosevelt. Message from the President of the United States transmitting A Report of the Secretary of Agriculture in relation to the forests, rivers and mountains of the Southern Appalachian Region. Government Printing Office, Washington, D.C.

Ayres, H.B. and W.W. Ashe. 1905. The Southern Appalachian Forests. U. S. Geological Survey Prof. Paper No. 37, Series H, Forestry 12. Government Printing Office, Washington, D.C.

Baily, F. 1856. Journal of a tour in unsettled parts of North America in 1796 and 1797. Baily Brothers, London.

Banks, W.H. 1953. Ethobotany of the Cherokee Indians. M.S. Thesis, University of Tennessee, Knoxville.

Bates, V. 1985. The vascular plants of Tennessee: A taxonomic and geographic guide to the floristic literature. J. Tennessee Acad. Sci. 60: 66-76.

Biennial report of the Tennessee Bureau of Agriculture, Statistics and Mines 1891, 1892. Marshall and Bruce Printers, Nashville, Tennessee.

Biennial report of the Tennessee Bureau of Agriculture, 1893, 1894, 1895. F. M. Paul Printers, Nashville, Tennessee.

Biennial report of the Tennessee Bureau of Agriculture, 1895, 1896. F. M. Paul Printers, Nashville, Tennessee.

Booklet Committee. 1972. Carroll County, Carroll County Historical Society, Huntingdon, Tennessee.

Boon, D. 1784. The adventures of Colonel Daniel Boon, formerly a hunter; containing narratives of the wars of Kentucky. Pp. 324-362. *In*: George Imlay. Topographical Description of the Western Territory of North America. Printed for J. Debrett. London.

Chevallier, A. 1996. The Encyclopedia of Medicinal Plants. Dorling-Kindersley Publishing, Inc., New York.

Chickering, J.W. 1880. A summer on Roan Mountain. Bot. Gaz. (Crawfordsville) 5:144-148.

Corgan, J.X. 1976a. Science in the Naturalist, 1850. J. Tennessee Acad. Sci. 51:145.

Corgan, J.X. 1976b. Science in the Agriculturalist. J. Tennessee Acad. Sci. 51:109-111.

Corgan, J.X. 1976c. Science in the Southern Cultivator, 1839-1840. J. Tennessee Acad. Sci. 51:84.

Corgan, J.X. 1977a. Non-medical functions of the Nashville Journal of Medicine and Surgery, 1851-1861. J. Tennessee Medical Assoc. 70:168-170.

Corgan, J.X. 1977b. Offbeat pioneers. J. Tennessee Medical Assoc. 70:873-876.

Corgan, J.X. 1978a. Richard Owen Currey, a little known intellectual figure in antebellum Tennessee. East Tennessee Historical Society's Publ. No. 50.

Corgan, J.X. 1978b. Notes on Tennessee's pioneer scientists. J. Tennessee Acad. Sci. 53:2-7.

Corgan, J.X. 1980. Some firsts? In the colleges of Tennessee. J. Tennessee Acad. Sci. 55:86-91.

Corgan, J.X. 1988. Toward a history of scientific agriculture in antebellum Williamson County. Williamson County Historical Society Publ. 19:65-72.

Corgan, J.X. 1994a. Annotated bibliography of the plant sciences in antebellum Tennessee. J. Tennessee Acad. Sci. 69:77-78.

Corgan, J.X. 1994b. Tolbert Fanning. Pp. 92-93. *In*: W.D. Miles and R.F. Gould (eds.), American Chemists and Chemical Engineers. Gould Books, Guilford, Connecticut.

Corgan, J.X. 1994c. Gerald Troost. Pp. 274-275. *In*: W.D. Miles and R.F. Gould (eds.), American Chemists and Chemical Engineers. Gould Books, Guilford, Connecticut.

Corgan, J.X. 1994d. Richard Owen Currey. P. 53. *In*: W.D. Miles and R.F. Gould (eds.), American Chemists and Chemical Engineers. Vol. 2. Gould Books, Guilford, Connecticut.

Corgan, J.X. 1995. Some libraries of antebellum West Tennessee. The West Tennessee Historical Society Papers 49:218-228.

Corgan, J.X. 2000. Troost's legacy. The Tennessee Conservationist 66:6-8.

Corgan, J.X. 2002. Geology in antebellum Tennessee. Tennessee Department of Environment and Conservation Division of Geology Bull. 85. Nashville, Tennessee.

Corgan, J.X. and M.A. Gibson. 1995. Geological exploration in East Tennessee: Gerald Troost's travels in 1834. Tennessee Historical Quarterly 54:140-153.

Coxe, J.R. 1818. The American dispensatory. 4th Ed. T. Dobson and Son. Philadelphia, Pennsylvania.

Crane, V.W. 1927. The southern frontier 1670-1732. The University of Michigan Press, Ann Arbor, Michigan.

Creekmore, B.B. 1988. Knox County, Tennessee—A history in pictures. Donning Company, Norfolk, Virginia.

Dabney, C.W. 1900. History of the Tennessee Experiment Station 1882-1900. Thirteenth annual report of the Agricultural Experiment Station of the University of Tennessee, Knoxville, Tennessee.

DeFiore, J.C. 1998. Medicine. Pp. 597-600. *In*: C. Van West (Editor-in-Chief), The Tennessee Encyclopedia of History and Culture. Tennessee Historical Society, Rutledge Hill Press, Nashville, Tennessee.

De Selm, H R. 1994. Vegetation results from 1807 land survey of southern Middle Tennessee. Castanea 55: 51-68.

De Selm, H.R. 1995. Vegetation results from the 1807-1810 land surveys in the Fifth Survey District of Tennessee. Pp. 281-290. *In*: S.W. Hamilton, D.S. White, E.W. Chester, and A.F. Scott (eds.). Proceedings of the Sixth Symposium on the Natural History of the Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. 1997. Vegetation results from early land surveys recorded in register's books, Campbell County, Tennessee, 1806-1833. Pp. 193-201. *In*: A.F. Scott, S.W. Hamilton, E.W. Chester and D.S. White (eds.). Proceedings on the Seventh Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. 1999. Vegetation results from early land surveys in five counties of Tennessee, 1788-1839. Pp. 89-108. *In*: S.W. Hamilton, E.W. Chester and M.T. Finley (eds.). Proceedings of the Eighth Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. 2001. James Safford and his respondents' plants of West and Middle Tennessee in 1880. Pp. 69-80. In: E.W. Chester and A.F. Scott (eds.). 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.

De Selm, H.R. 2001. Vegetation results from land surveys in three East Tennessee counties, 1807-1887. Pp. 51-63. *In*: E.W. Chester and A.F. Scott (eds.). 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.

Ewan, J.A. and N. Ewan. 1963. John Lyon, nurseryman and plant hunter, and his journal, 1799-1814. Trans. Am. Philos. Soc. N. S. 53:5.

Ewell, J. 1822. The medical companion or family physician. 6th Ed. Printed by B. Eder. Baltimore, Maryland.

Filson, J. 1784. The discovery and present state of Kentucky. Pp. 267-323. In: George Imlay. Topographical description of the western territory of North America. Printed for J. Debrett, London.

Folmsbee, S.J., R.E. Corlew and E.L. Mitchell. 1969. Tennessee, a short history. The University of Tennessee Press, Knoxville, Tennessee.

Gambold, A.R.K. 1819. A list of plants found in the neighborhood of Connasauga River (Cherokee County) where Springplace is situated. American J. Science and Arts 1:245-251.

Gardner, J.A. 1963. Early times in Weakley County: Address (delivered in 1876). West Tennessee Historical Society Papers 17:68-84.

Gattinger, A. 1887. The Tennessee flora; with special reference to the flora of Nashville. Carlon and Hollenbeck, Indianapolis, Indiana.

Gattinger, A. 1894. The medicinal plants of Tennessee. Department of Agriculture of the State of Tennessee. Franc. M. Paul, Printer to the State, Nashville, Tennessee.

Gattinger, A. 1901. The flora of Tennessee and a philosophy of botany. Gospel Advocate Publishing Company, Nashville, Tennessee.

Geiser, S.W. 1948. Biographical note on Dr. Ferdinance Rugel, American Botanist. Field and Laboratory 16:113-119.

General Convention. 1820. The pharmacopoeia of the United States of America. S. Converse, New York.

Gilmour, R.W. 2002. Foundations of southeastern botany: An annotated bibliography of southeastern American botanical explorers prior to 1834. Castanea, Occasional Papers in Eastern Botany No. 1, pp. 1-142.

Goodlett, A.G. 1838. The family physician or everyman's companion. Printed at Smith and Nesbit's Steam Press, Nashville, Tennessee.

Goodspeed, W.A. 1887. General History of Tennessee. Goodspeed Publ. Co., Nashville, Tennessee.

Goodspeed, W.A. 1887. History of Tennessee containing historical and biographical sketches of thirty East Tennessee counties. Goodspeed Publ. Co., Nashville, Tennessee.

Gunn, J.C. 1830. Gunn's domestic medicine or poor man's friend in the hours of affliction of pain and sickness. (Second Ed., 1833, printed by F. S. Heiskell, Knoxville, Tennessee).

Harbert, P.M. 1947. Early history of Hardin County, Tennessee. West Tennessee Historical Society Paper 1:38-67.

Haywood, J. 1823. The civil and political history of the State of Tennessee. Printed for the author by Heiskell and Brown, Knoxville, Tennessee.

Hicks, N.L. 1968. The John Adair Section of Knox County, Tennessee. Privately published, Knoxville, Tennessee.

Hilty, J.W. and P.D. Peterson, Jr. 1997. Frank Lamson-Scribner: botanist and pioneer plant pathologist in the United States. Ann. Rev. Phytopath. 35:17-26.

Hudson, C. 1976. The southeastern Indians. The University of Tennessee Press, Knoxville, Tennessee.

Hyder, N.E. 1903. Watauga old fields. The American Historical Magazine 8: 253-255.

Imlay, G. 1797. A topographical description of the western territory of North America. Third Edition. Printed for J. Debrett, London, England.

Irmscher, C. (ed.). 1999. John James Audubon, Writings and Drawings. Penguin Putnam, Inc., New York.

Killebrew, J.B. 1878. The grasses of Tennessee including cereals and forage plants. The American Co. Printers, Nashville, Tennessee.

Killebrew, J.B. 1898. Grasses and forage plants. Bulletin of the Agricultural Experiment Station of the University of Tennessee, Vol. 11 (2, 3, 4), Knoxville, Tennessee.

Killebrew, J.B. and J.M. Safford, assisted by C.W. Charlton and H.L. Bentley. 1874. Introduction to the resources of Tennessee, 1st and 2nd reports of the Bureau of Agriculture. Tavel, Eastman, and Howell Printers, Nashville, Tennessee.

Krechniak, H.B. and J.M. Krechniak. 1956. Cumberland County's First Hundred Years. Centennial Committee, Crossville, Tennessee. Williams Printing Co., Nashville, Tennessee.

Lamson-Scribner, F. 1892. The grasses of Tennessee—Part I. University of Tennessee Agric. Expt. Sta. Bull. Vol. 5, No. 2, Knoxville, Tennessee.

Laughlin, J.B. 1999. Roan Mountain: A Passage of Time. Second Edition. Overmountain Press, Johnson City, Tennessee.

McKinley, D. 1994. Anna Rosina (Kliest) Gambold (1762-1821), Moravian missionary to the Cherokees, with special reference to her botanical interests. Trans. Moravian Historical Society 28:59-99.

McNeeley, B. and T.E. Hemmerly. 2001. Early contributions to Tennessee botany: Richard Owen Currey. J. Tennessee Acad. Sci. 76:27 (abstract).

Merriam, L.S. 1893. Higher education in Tennessee. H.B. Adams (ed.). Contributions to American Educational History. Bureau of Education Circular of Information No. 5, Washington, D.C.

Michaux, A. 1803. Flora Boreali-Americana. 2 vols. Paris and Strasbourg.

Moerman, D.E. 1998. Native American Ethnobotany. Timber Press, Portland, Oregon.

Oakes, H.N. 1932. A brief sketch of the life and works of Augustin Gattinger. Cullom and Ghertner Co., Printers and Publishers, Nashville, Tennessee.

Odum, E.P. 1996. Ecology a Bridge between Science and Society. Sinauer Associates, Inc., Sunderland, Massachusetts.

Patton, T.W. (ed.). 1958. Thomas Lenoir's journal of Tennessee in 1806. Tennessee Hist. Quart. 17:156-166.

Pennell, F.W. 1935. The Scrophulariaceae of eastern temperate North America. Acad. Nat. Sci. Phila., Monograph 1.

Peters, K.J. (ed.). 1957. Lauderdale County from Earliest Times. McCowet-Mercer Press, Inc., Jackson, Tennessee.

Petersen, R. H. 2001. New World Botany: Columbus to Darwin. A. R. G. Ganter Verlag. K.G.

Proceedings of the State Agricultural Bureau. 1856, 1958. Nashville, Tennessee.

Report of the Commissioner of Agriculture. 1899, 1900. Gospel Advocate Publ. Co., Nashville, Tennessee, 1901.

Report of the Tennessee Bureau of Agriculture, Statistics and Mines. 1876, 1878. Nashville, Tennessee.

Ridenour, G.L. 1941. The land between the lakes—a history of Campbell County, Tennessee. LaFollette Publ. Co., LaFollette, Tennessee.

Safford, J.M. 1869. Geology of Tennessee. S. C. Mercer Printer, Nashville, Tennessee.

Safford, J.M. 1884. Report on the Cotton Production of the State of Tennessee with a discussion of its general agricultural features and a note on cotton production in the State of Kentucky. Pp. 367-491. *In*: E.W. Hilgard, Special Agent in charge. Report on Cotton Production in the United States. Part I. Mississippi Valley and Southwestern States. Department of Interior, Census Office. Government Printing Office, Washington, D.C.

Sims, C.C. (ed.). 1947. A History of Rutherford County. Privately published, Murfreesboro, Tennessee.

Smith, H.C. 1999. An honored calling. A history of the College of Agricultural Sciences and Natural Resources. Institute of Agriculture, The University of Tennessee, Knoxville.

Somerset Publishers. 2000. Tennessee Biographical Dictionary. Second Edition. St. Claire Shores, Michigan.

Stafleu, F.A. and R.S. Cowan. 1976-1988. Taxonomic literature. Second Edition. Boh, Scholtema and Hokeman, Utrecht, The Netherlands.

Stafleu, F.A. and E.A. Mennega. 1992-2000. Taxonomic literature, Supplement. Loeltz Scientific Books, Kenigstein, Federal Republic of Germany.

Stannard, J. 1969. Medical botany. Pp. 146-152. *In*: J. Ewan (ed.). A Short History of Botany in the United States. Hafner Publishing Company, New York.

Steiner, A. and F.C. De Schweinitz. 1799. Report of the journey of the Brethern Abraham Steiner and Frederick C. De Schweinitz to the Cherokees and Cumberland settlements. Pp. 448-523. *In*: S.C. Williams. 1928. Early Travels in the Tennessee Country 1540-1800. Watauga Press, Johnson City, Tennessee.

Stupka, A. 1964. Trees, shrubs and woody vines of the Great Smoky Mountains National Park. University of Tennessee Press, Knoxville, Tennessee.

Temple, O.P. and M.B. Temple. 1912. Notable men of Tennessee from 1833-1875. The Cosmopolitan Press, New York.

Tennessee Agricultural Statistical Service. 2001. Tennessee Agriculture—2000. Bull. 35. Nashville, Tennessee.

Van West, C. (Editor-in-Chief). 1998. The Tennessee Encyclopedia of History and Culture. Tennessee Historical Society. Rutledge Hill Press, Nashville, Tennessee.

Whatley, T.J. 1994. A history of the Tennessee Agricultural Experiment Station. The University of Tennessee Agricultural Experiment Station, Knoxville, Tennessee.

Williams, S.C. 1928. Early travels in the Tennessee county (1580-1800). Watauga Press, Johnson City, Tennessee.

Wilson, J. 1902. Forests and forest conditions of the Southern Appalachian Mountain region. Report of the Secretary of Agriculture. Pp. 13-40. *In*: T. Roosevelt. Message from the President of the United States transmitting a Report of the Secretary of Agriculture in relation to the forests, rivers and mountains of the Southern Appalachian Region. Government Printing Office, Washington, D.C.

Wood, G.B. and F. Bache. 1836. The dispensatory of the United States of America. 3rd ed. Grigg and Elliot. Philadelphia, Pennsylvania.

Youngken, H.W. 1927. A College Textbook of Pharmaceutical Botany. Sixth Edition. The Blakiston Co., Philadelphia.

Youngken, H.W. 1950. Textbook of Pharmacognosy. Sixth Edition. The Blakiston Co., Philadelphia.

THREADS – REMARKS ON TENNESSEE VEGETATION ECOLOGY IN THE TWENTIETH CENTURY

H. R. DE SELM

Department of Botany, The University of Tennessee, Knoxville, Tennessee 37996

ABSTRACT. Understanding the dynamics of the landscape mosaic is an objective of the vegetation ecologist. The twentieth or early twenty-first century ecologist reads of, seeks and examines remnants of more or less stable vegetation of the late twentieth century. He is faced with enormous potential changes resulting from the invasion of non-native insects and diseases which kill forest community dominants, and pollution and climatic change, which place many species under stress. These factors and others should stimulate the ecologist to initiate long-term vegetation studies and to establish monumented plots or plot centers on public land subject to little human interference. Several classes of public lands are discussed; private lands are available for short-term study but may be subject to development. Funds must be found for research/travel, analysis of data, and publication of results.

INTRODUCTION

The Tennessee vegetation ecologist working in the late twentieth and early twenty-first centuries finds himself in an affluent society which may provide him the opportunity, the means, and natural landscape in which to do his research. That ecologist's objectives are to describe the vegetation in terms of its floristic composition, structure, its relationship to soils, geologic, and microclimatic factors (physical and chemical forces long and short term), fire, species competition, and animal, including human influences (past and present). But the ecologist works in a society continually changing economically and socially, and on a landscape where vegetation of interest continually diminishes in area and diversity. What kinds of previously acquired knowledge are available? What private and government agencies contribute data collections or research? What cultural changes contribute and have contributed or detracted from the ability of present or past ecologists to function? What areas are available to study? Are studies with objectives noted above still necessary? Are long-term studies pertinent; and where, when should a baseline be established? These questions are addressed here. This brief sketch is written mainly from my experience while at the University of Tennessee in Knoxville. No attempt has been made at completeness of literature. Some aspects of this will be treated more fully in De Selm (in progress).

PREVIOUS STUDIES

Pre-1900s Period

Early travelers in Tennessee observed and reported plant findings and early scientists such as Andre Michaux collected and described species and genera (De Selm 2003). Prior to and during periods of land settlement and continuing thereafter, surveys of treaty land and land purchase units have been accomplished. Nineteenth century maps show survey lines in southeastern East and in West Tennessee. Part of Middle Tennessee also had a rectilinear survey of the township level.

Tennessee's resident scientists include the floristic botanist Gattinger who collected plants, developed an herbarium, described new species, and published lists of the flora (Gattinger 1887, 1901), Killebrew (1878, 1898) who wrote about the grasses and forage plants, and Lamson-Scribner who developed an herbarium, described new species and wrote a manual of grasses (Lamson-Scribner 1892, 1894). John Safford wrote a "Geology of Tennessee" (Safford 1869), a work never duplicated, and Vanderford (1897) wrote of the soils. Killebrew, Safford and others (1874) combined their talents and examined natural features (geology, soils and some vegetation), and agricultural features of each county. Sargent (1884) wrote a massive volume on the forests of the United States with comments on Tennessee forests. W. W. Ashe and others contributed related work in the Southern Appalachians (see below). For more details, see De Selm (2003).

1900-Ca. 1950 Period

Relevant and easily obtained floristic manuals available during this period included *Gray's Manual* (Robinson and Fernald 1908), and Britton and Brown (1913)–both manuals of the northeastern flora. Small's floras of the southeast (Small 1903, 1913, 1935) were available. Also published during this period was the national grass manual (Hitchcock 1935), the manual of trees (Sargent 1933), cultivated trees and shrubs (Rehder 1927), cultivated plants (Bailey 1924), and the atlas of distribution of important forest trees (Munns 1938).

Significant forest inventories and vegetation studies were being made by foresters and ecologists during this period. Forest inventory statistics were provided by the State (Cowan 1946 partly from T.V.A. data), by the Forest Service (based on plot data, see Duerr 1949) and by T.V.A. Division of Forestry Relations (1941). Detailed forest studies were made at Sewanee (Foley 1903), a study of chestnut biology (Ashe 1911), and a State forest survey was provided by Hall (1910). The Secretary of Agriculture (1902, with appendices by various scientists), and Ayres and Ashe (1905) wrote of the forest conditions of the Southern Appalachians. Harshberger (1911) summarized vegetation studies for North America with a map; some vegetation types can be recognized from his species lists. Summaries of some forest studies were compiled as cover types (Hawley 1932, Committee on Forest Types 1952). Shantz and Zon (1924) provided a framework for integrating and understanding some vegetation information and also published an excellent map. Very brief descriptions are to be found in Maddox (1926), and Frothingham (1926). Livingston and Shreve (1921) provided a vegetation type map with a discussion of the relationships between vegetation and climate. The T.V.A. Division of Forestry Relations (1941) provided a more detailed map of the forest types of the Tennessee Valley. Ecological studies were carried out by Shaver and Dennison (1928), Shaver (1933) and others at Reelfoot Lake, and his students elsewhere (as Frick 1939). Shaver also began his statewide study of ferns (Shaver 1934, 1954). Braun (1935) was working in the nearby Cumberland Mountains. Cain (1930) was working in the Great Smoky Mountains of Tennessee. Most of these studies are still useful today.

Post-1950 Studies–Floristics

Determination of plants and their proper nomenclature is greatly aided by the collections in and the personnel of the Herbarium of the University of Tennessee. Curators, assistants and associates of the herbarium have aided in plant determinations. Useful lists of the state flora are Shanks (1952), Sharp et al. (1956, 1960), Wofford and Kral (1993), the atlases of the flora (Chester et al. 1993, 1997), the manual and key to the ferns (Shaver 1955, Sharp 1955), the manual of the grasses (Underwood et al. 1973) and the flora of the Great Smokies (White 1982).

During the past nearly 50 years, the floras of greatest usefulness have been the illustrated flora of Gleason (1952), and Gleason and Cronquist (1963, 1991), with Holmgren (1998). Other extremely useful keys are those of Shanks and Sharp (1963), Blackburn (1952), Wofford (1989), and Wofford and Chester (2002).

Post-1950–Ecology

Field biologists, and especially vegetation ecologists, were favored at mid-century with the publication of Braun's synthesis of her observations and those of others on the composition and organization of the eastern North American deciduous forest (Braun 1950). Later her large units were conceptualized and mapped slightly differently (Kückler 1964, map republished in U.S. Department of Interior Geological Survey 1970).

The groundwork laid by Cain (1930) and Shanks (Shanks and Norris 1950, Shanks 1958), and the interest shown by Sharp (1957) provided valuable impetus in carrying out vegetation studies in Tennessee. Also the definition of the aims and methods of vegetation ecology (Mueller-Dombois and Ellenberg 1974) helped in research direction and methodology. At the University of Tennessee, faculty and graduate student work expanded during the first decade: Woods (1952), Barclay (1957), Chapman (1957), Shanks (1954), Crandall (1958), De Selm (1959). Formation of the Graduate Program in Ecology (in 1967)/Department of Ecology and Evolutionary Biology (in 1995) has stimulated faculty and graduate student research. Botany/Ecology faculty and students have been active; Amundsen (1989, 1995), Clebsch (Busing et al. 1993), De Selm and Murdock (1993), McCormick (Arends 1981). Faculty and students of the Department of Forestry, Wildlife and Fisheries have also been active: Buckner (Steed 1979), Thor and Summers (1971), Dimmick (Wheat and Dimmick 1986), and Rennie (West and Rennie 1998). In total, in this half century hundreds of theses, dissertations, papers and reports have appeared. With the retirement of above faculty, ecology/plant geography remains in the hands of Jake Weltzin, Sally Horn, and Hazel and Paul Delcourt.

Similarly, work has appeared from the faculty and students at East Tennessee State University (Warden 1989), Middle Tennessee State University (Walck et al. 1996; Rucker and Hemmerly 1976), Tennessee Technological University (Lebkoecher and Hunter 1991), Volunteer State College (Schibig 1996), University of Memphis (Miller), Austin Peay State University (Ellis, Chester), the University of Tennessee at Chattanooga (Van Horn 1981) and Martin (Henson 1990), Vanderbilt University (Quarterman, Caplenor 1965) and University of the South (Evans and McCarthy 2000; Ramseur 1986). Vegetation scientists from Southern Illinois University (Fralish and Crooks 1989) have worked intensively at Land Between the Lakes. Aids to study were the species reports in Fowells (1965, later revised and republished by Burns and Honkala 1990), and by summaries in Barrett (1962), and Eyre (1980).

In the 1970s (mostly) university scientists contracted with the Heritage Conservation and Recreation Service/National Park Service to find Potential National Natural Landmarks in the various physiographic-floristic regions of the United States. These searches found previously unrecognized natural areas of significance. Several reports are pertinent to Tennessee: in Middle Tennessee Keever (1971) and Quarterman and Powell (1978), the Cumberland Plateau (Baer et al. 1982), and the Ridge and Valley (De Selm 1984).

Forest Service continuous forest inventory (CFI) plot points were established in Tennessee in the 1940s and the reports from these examinations have continued (cf. Sternitzke 1955, Schweitzer 2000). The first T.V.A. forest inventory reports were based on temporary samples (cruises); reports based on CFI appeared later (T.V.A. Division of Forestry Relations 1960). T.V.A. inventory statistics were reported from 1952 until the middle 1970s. The permanent plot/point system with periodic remeasurement has proved extremely useful in following land use changes, past logging effects, and in projecting future forest product availability (cf. U.S.D.A. Forest Service 1981). An annual forest inventory system is being implemented (Reams and Van Deusen 1999).

Permanent plots were established on Forestry Experiment Station land to follow the effects of understory burns (De Selm and Clebsch 1991) and in the Smokies to follow forest growth and change (Busing 1993, Busing et al. 1993). On a large scale the use of aerial photography, high flight (as RB57) photography (including color and infrared, Krumpe et al. 1971), satellite imagery in various bands (see an early use, De Selm and Taylor 1973), and Geographic Information Service has made regional land use change quantifications possible (Wear and Balstad 1998) and shows promise use in vegetation mapping (Rehder 1996).

Vegetation research in the Smokies, reinitiated by Whittaker (1956) was furthered by Bratton (1979), White (1984), and others. Vegetation studies in the Cherokee National Forest are being continued by Rennie and his students (as West and Rennie 1998). Funds from the Spruce-Fir Research Cooperative of the joint United States Environmental Protection Agency–U.S. Forest Service Forest Response Program of the National Acid Precipitation Assessment Program were used in extensive research in high elevation forests of eastern United States. Some of the work was carried out in the Smokies (Eagar and Adams 1992). Recently the Smokies scientists have initiated an All Taxa Biodiversity Inventory in which largely volunteer biological scientists sample the Park ecosystems for species (cf. ATBI Quarterly, Vol. 1, 2000). The advent of individual to group tree death and subsequent crown growth or understory replacement in canopy gaps in hardwood and mixed forests was examined especially in the 1980s (Barden 1980) after earlier papers (Woods and Shanks 1959, Trimble and Tryon 1966).

Bryophytes and lichens form important types of cover in understory and epiphytic vegetation in the high spruce-fir forests (Cain and Sharp 1938, Crandall 1958, Dey 1984). Species and whole communities are at risk from the loss of fir bark as substrate (Smith 1984). At least three byrophyte taxa cover decreased with change associated with fir death (De Selm and Boner 1984); eight bryophytes of fir bark face extinction (Smith et al. 1991). The growth decline in spruce associated with acid precipitation (Eagar and Adams 1992) and the sensitivity of vascular plants to elevated atmospheric ozone concentrations (Neufeld et al. no date) suggests also that these substances, among other factors, may be affecting bryophyte and lichen species cover/persistence.

A summary of many physical cultural and biological characteristics of the Southern Appalachians has appeared (Southern Appalachian Man and the Biosphere Cooperative 1996); this summarizes past and probable future trends in many dynamic human population, cultural characteristics and biological features. Southern Appalachian studies are so numerous as to require special bibliographic volumes (DeYoung et al. 1982, Nodvin et al. 1993).

The interest of Quarterman in the vegetation of the cedar glades of the Central Basin

(Quarterman 1950, Quarterman et al. 1993) has been expanded to an intensive study of the autecology of the glade flora (cf. Baskin and Baskin 1989). Studies of secondary succession have been made by Quarterman (1957), Smith (1968), and Miller and Holyfield (1986).

The interest in Tennessee vegetation shown by the Natural Heritage Division of the Department of Environment and Conservation is exemplified by the Highland Rim forest study by Smith et al. (1983) and their contributions to Weakley et al. (1998).

Austin Peay State University faculty and students have examined vegetation of the northern Highland Rim beginning in the 1960s (cf. Duncan and Ellis 1969), and with financial aid from T.V.A. (cf. Phillips 1974), but the establishment of the Center for Field Biology of Land Between the Lakes funded in the 1980s by the State as a Center of Excellence has led to many studies on the northern Rim and adjacent Pennyroyal of Kentucky and other areas (see this Proceedings volume and preceding volumes for examples).

Summary statements have appeared (chapters in Martin et al. 1993, 1993), Chester (1989), Campbell (1987), De Selm and Schmalzer (1982), De Selm (1984), Anderson et al. (1999), Somers (1986), Tyndall (1994), White (1984), Pittilo and Wentworth (1998), Eagar and Adams (1992), Southern Appalachian Man and the Biosphere Cooperative (1996), and Griffith et al. (1997). Other brief summaries of deciduous forest vegetation composition and structure have appeared (Barbour and Billings 1999, Daubenmire 1978, and Vankat 1979). A comprehensive summary is that of Weakley et al. (1998).

For our understanding of the history of pre-European land use, we are indebted to studies by Lewis and Kneberg (1958), Hudson (1979), Swanton (1946) and later writers. For vegetation history we are indebted to the studies of the Delcourts (as Delcourt and Delcourt 1987) and Graham (1972, 1999). Vegetation results from both rectilinear surveys through the presettlement or just-settled landscape in Middle Tennessee (as De Selm 1994) and from metes and bounds surveys in the eastern two thirds of the State (as De Selm 2001) have been published. Nineteenth century land use was described by Killebrew et al. (1874), and for the twentieth century by McCarthy and Voigtlander (1983) and Martin and Luebke (1960).

LANDSCAPE CHANGES

Native American and European-American actions impinging on the landscape and its vegetation have been severe and extensive. Most of the natural vegetation (largely forest in Tennessee) has been cleared for agriculture, cities, roads and other uses. Even today, our current rate of loss of open land is over 100,000 acres per year. Remaining forests have been high graded; logging and clearcutting, expanded agricultural land use in some areas, and building of rural dwellings (including second homes) continues. Hardwood stands are converted directly to planted (usually) loblolly pine or are converted or recommended for conversion to pine-hardwood by cutting (shearing), herbiciding, burning and planting pine seedlings (McGee 1989, Woldrop et al. 1989, Zahner and Smalley 1989). Such severe treatments are resulting in loss of tree species biodiversity as seen from the middle 1960s to the middle 1990s (Rosson 1999). Effects upon soil character are not yet known. Many showy, medicinal or culinary herbs, and showy shrubs are now rare (Nordman 2001). Some have been extirpated, or almost so. Barberry (*Berberis canadensis*) has been removed because it is a host of stem rust of wheat (*Puccinia graminis tritici*). Remaining forests on all but steep topography were (and some still are) grazed by stock, and were formerly regularly burned (spring surface fires until about 1945) eliminating many herb species. Open vegetation as glades and barrens are grazed and also often become the site of roads, trails, and of trash dumping. Lowlands have been drained for cropland. Beginning in the 1930s and subsequently, valleys of major streams were flooded as reservoirs for power generation downstream flood control, water transportation, recreation and agricultural, municipal and industrial water sources. Upland wetlands were often converted to farm ponds for stock use or drained for cropland.

The loss of large mammals began in the 1600s from hunting–the fur trade of the 1600s and 1700s eastward (McShea et al. 1997) and the long hunters in Middle and West Tennessee in the 1760s (Haywood 1823). The large herbivores as white-tailed deer (*Odocoileus virginianus*), elk (*Cervus canadensis*) and bison (*Bison bison*) may well have had an influence on the forest understory density and composition and the presence and size of forest openings such as barrens. Certainly modern deer population increases are known to influence seedling survival of oaks (*Quercus* spp.), hemlock (*Tsuga canadensis*) (McShea et al. 1997) and various shrubs and herbs (Christensen 1963) including state and federal rare taxa (Miller et al. 1992). At Heart's Content (Pennsylvania), 59-80 percent of herb species were lost between 1929 and 1995 (Rooney and Dress 1997) under deer browse pressure.

Landscapes of the presettlement and early settlement periods were characterized by swampy or marshy valleys, the stream water flow was slowed and the water table raised at and upstream of beaver ponds. Beavers (*Castor canadensis*) were eliminated in the settlement period. Beaver populations are currently expanding from reintroductions and invading streams and reservoir borders. Whether society will allow continued nuisance "value" (tree cutting, Crawford et al. 1976, and ponds in beaver-chosen locations), in the face of the perceived more positive values, aesthetic, recreational, water flow and water table control, meadows formed after pond drainage, watershed sediment loss reduction, and increased landscape biodiversity, remains to be seen.

Presettlement bird populations and diversity were reportedly high. The loss of habitat, rise in population sizes of predators such as man, and broadcast use of pesticides in some crops in the United States and in the tropics has put our bird fauna, especially neotropic migrants, at risk (Thompson 1996). Many birds function as seed dispersers (Webb 1986), some are seed planters (Deen and Hodges 1991), and many are predators on herbivores. Their population declines cannot but be felt in the natural systems (Franzreb and Phillips 1996).

Competitors, especially woody taxa, have been introduced from other continents (Tennessee Exotic Plant Pest Council 1996). These intrude, alter composition, structure, and compete in natural native communities. Similarly, native trees, shrubs and vines planted out of their native range for various uses escape, enter native communities, and compete just as introduced/naturalized species.

In the past few years, chip mills have been built in and near Tennessee; these require many acres of forest annually–accomplished by complete clearcuts (Joint Federal Agency 1973). Atmospheric pollution as ozone (Neufeld et al. no date, Moore et al. 2002) and acid rain have deleterious effects on lowland forests and severe growth reduction effects on high elevation spruce (*Picea rubens*) (Eagar and Adams 1992). Worldwide increased temperature may have lengthened the growing season with little known effects on the vegetation; effects of higher temperature are under study

(Birdsey et al. 1996, Moore et al. 2002, Dale et al. 2001). Decreased periods of, and severity of, winter low temperatures allow injurious insects to over-winter in larger numbers.

Biological catastrophes caused by our introduction of non-native disease/insect pests into native forest stands includes the death of chestnut (*Castanea dentata*) caused by chestnut blight (*Cryphonectria parasitica*), the death of elms (*Ulmus* spp.) especially American elm (*U. americana*) caused by Dutch elm disease (*Ophiostomi ulmi* and *O. nova-ulmi*) and phloem necrosis (virus caused) is nearly complete (cf. Hepting 1971, Schlarbaum et al. 1997). The native southern pine beetle (*Dendroctonus frontalis*) (Kowal 1960), whose numbers are apparently high because of warm winters, is decimating native pine stands. These attacks place many landscapes at risk because of the current management of oak forests (log the forest then manage for pine or pine-hardwood or replace the oak stand with planted pine).

The introduced balsam wooly adelgid (*Adelges piceae*) (Mitchell et al. 1970) has largely eliminated Fraser fir (*Abies fraseri*) as a dominant and codominant in high elevation forests. Death of fir roots, interlaced with those red spruce, may be responsible for the susceptibility of spruce to tip-ups–now frequent in the high forests. Atmospheric pollution, in the form of acid precipitation and fog (Eagar and Adams 1992) is apparently causing diameter growth decline and upper bole (stag-headed trees) and some death of spruce.

In the past generation, butternut (*Juglans cinerea*) has become quite rare in the forest as a result of the endemic attacks of butternut canker (*Sirococcus clavigigenti-juglandacearum*). In the past few years, live, mature flowering dogwood (*Cornus florida*) has become much less common in the forest as a result of the effects of dogwood anthracnose (*Discula destructiva*) (see Schlarbaum et al. 1997, Hiers and Evans 1997). Oak wilt (*Ceratocystis fagacearum*) and oak die-back have been problems in oak forests (Boyce 1957, Ward and Mistretta 2002).

There are other endemic diseases/ pests now invading Tennessee with severe effects in the forests at our borders. These are the hemlock wooly adelgid (*Adelges tsugae*) which kills the community dominant eastern hemlock (*Tsuga canadensis*), and the beech bark disease caused by an insect *Cryptococcus fagisuga* and the fungi *Nectaria coccinea faginata* and *N. galligena* which kill the community dominant American beech (*Fagus americana*). The European gypsy moth (*Lymantria dispar*) has devastated oak (*Quercus* spp.) and mixed conifer-hardwood forests to the north (cf. Fosbroke and Gottschalk 1999, Gottschalk and Twery 19989, Montgomery et al. 1989, Moore et al. 2002).

The imported fire ant (*Selanopsis saevissima ricteri*) (cf. Baker 1972) is spreading into Tennessee from the south; this makes land it occupies, with many mounds per acre, virtually unusable by stock and difficult to use as study areas. The Africanized honey bee (*Apis mellifera*) is in Texas spreading northward (Glauber et al. 2000) influencing other pollinator populations.

The understory of many forests is being heavily modified by grazing/browsing of white-tailed deer (*Odocolleus virginicus*) which herds are growing after the "successful" reintroduction by game managers (cf. McShea et al. 1997). The deer and the "sang" hunters who search the mesic forest stands for ginseng (*Panax quinquefolia*) and many other edible, medicinal (Gattinger 1894), and beautiful herbs and shrubs used in the nursery and florist trades have virtually eliminated many herb species and some shrub species from many/most stands (cf. Nordman 2001).

The European wild boar (*Sus scrofa*) has spread from a single introduced population into the forests of the Blue Ridge where it is trapped for release into other forest areas. Bratton (1974) notes several kinds of ecosystem disruptions caused by these animals including destruction of plant populations such as wildflower species, wildflower beds, grass turf, and disruption/uprooting of tree seedlings.

INFORMATION-ACQUIRING AND LAND-HOLD AGENCIES AND INSTITUTIONS

The following section notes several public and a few private agencies which contribute information to the working vegetation ecologist. Some agencies control land that should be considered for study.

The United States Forest Service "manages" the Cherokee National Forest, with forested mountain land dedicated in 1920, and which occupies parts of 10 eastern counties. There forests are maintained on a commercial/scientific basis with a few areas set aside as wilderness areas, scenic areas and study areas. The Forest Service also maintains regional experiment stations with research accomplished and published on local species and communities of interest. For a few years the Southern Research Station maintained the Silvicultural Laboratory at Sewanee which worked on local problems (as Smalley 1986). The Forest Service accomplishes periodic vegetation sampling over the entire state to assess timber acreage and quantity through its Forest Inventory and Analysis Research Work Unit (Schweitzer 2000).

The State Division of Forestry also maintains and manages several state forests and participates in the forest inventory. The National Park Service administers several parks of more than one kind in Tennessee–in these parks no logging nor commercial grazing is permitted and development has been minimal. The Great Smoky Mountains National Park occupies parts of three Tennessee Blue Ridge counties (and extends into North Carolina). During the 1930s the vegetation of the Smokies was sampled by forestry and Civilian Conservation Corps personnel (MacKenzie and White 1998) and a vegetation map was produced (Miller 1941). The Smokies are unique in that the same naturalist, Arthur Stupka, worked these many years collecting information and specimens from the Park (Stupka 1964). Also, it was close to the University of Tennessee from which botany staff, associates and students traveled to the park (Cain 1931, Sharp 1939, Hoffman 1964, Golden 1981, among others).

There are other national parks all or partly in Tennessee. The Cumberland Gap National Historical Park, established 1940, occupies part of Claiborne County, Tennessee, and adjacent areas of Kentucky and Virginia. The Big South Fork National River and Recreation Area lies in the Cumberland Mountains of Scott and Fentress counties and adjacent Kentucky. The Obed Wild and Scenic River occupies gorges in Cumberland and Morgan counties of the Cumberland Plateau. Narrow strips of National Park land are preserved on the Natchez Trace Parkway (with the Meriwether Lewis National Monument) and the Foothills Parkway. The northern end of the Chickamauga-Chattanooga National Military Park lies on Lookout Mountain in Hamilton County. Shiloh National Military Park and Cemetery is in Hardin County. The Stones River National

Battlefield Park and Cemetery is in Rutherford County and the Donelson National Battlefield Park and Cemetery is in Stewart County. All of these areas contain some protected vegetation and have been or are being studied biologically.

The National Park Service Southeastern Region has published a series of very useful Research/Management Reports dealing with park problems. The Tennessee Division of Parks acquires and maintains, albeit some disturbance, lands suitable for parks in Tennessee and manages them as State parks.

Studies in geology, geologic history and geologic mapping are efforts carried out jointly by the United States Geological Survey and the Tennessee Division of Geology. Also, faculty and students of the University of Tennessee (especially George W. Swingle) and Vanderbilt University (especially Charles W. Wilson, Jr.) have contributed to the mapping program (Jones 1979). Much of the state is now mapped geologically at the scale of 1/24,000, and where not so, it is mapped at smaller scales.

The U.S. Geological Survey National Mapping program, in cooperation with the Tennessee Valley Authority Maps and Surveys Branch, publishes topographic maps at the scales of 1/24,000, 1/250,000 and 1/500,000--the whole state is so covered. Maps of the largest scale are most useful for locating vegetation sample areas precisely. Topographic maps of the state have been compiled into an atlas at 1/151,500 (Delorme Mapping Company 1989). Aerial photos may be available from T.V.A., Maps and Surveys Branch, U.S.G.S., or in local offices of Natural Resource Conservation Service or county tax assessor.

The Biological Resources Division and the National Wetlands Research Center are now part of the U.S. Geological Survey. The Wetlands Center publishes 1/24,000 scale maps of wetlands. The Tennessee State Department of Transportation publishes and periodically revises maps of each Tennessee county showing streams and a few other natural features, with municipalities, roads and many other cultural features at a scale of 1/126,720. These have been compiled into an atlas at 1/141,400 (County Maps, no date).

The United States Department of Agriculture Soil Conservation Service (now the Natural Resource Conservation Service) sponsors the National Cooperative Soil Survey which, in cooperation with the State Agricultural Experiment Station, publishes county soil surveys. Nearly half of our counties have a modern survey and a few have older, useable surveys. More than a quarter of the counties have surveys completed but which are awaiting publication. A statewide summary has appeared (Springer and Elder 1980).

The National Weather Bureau has maintained many first order weather stations throughout the State for decades. Here temperature, precipitation, humidity and in some stations solar radiation data (see also Fribourg 1976) are collected. Much of the data are published, and when mapped, are useful aids in distinguishing the State's natural regions. The Climate of the States series is most useful (as Dickson 1960; see also De Selm and Schmidt 2001). A microclimatic study has been done in a valley near Knoxville (Shanks and Norris 1950).

The Tennessee Valley Authority, established in the 1930s, bought land for reservoirs. Much of that land was submerged, but peripheral areas, owned or with flooding rights, were managed for many years with little disturbance. However, in the last generation, much of this peripheral land has been sold for development. Some scraps of private and public land, little developed, remain. On reservoir borders, T.V.A. established a series of natural areas and small wild areas in natural vegetation.

The T.V.A. Division of Forestry Relations sampled forest vegetation widely in the valley and published results ca. 1952-1975 by county or county group sample unit (T.V.A. Division of Forestry Relations 1960). Forest ecology remains of interest (Smith and Nicholas 1999). T.V.A. established a Heritage Program to monitor populations of rare wild biota in the Tennessee River valley—this continues (cf. Collins and Wiebolt 1992). T.V.A. Hydrolic Data Branch of the Division of Water Control Planning maintains a network of rain gauges through the Tennessee Valley. From 1935 through the 1970s, they produced maps of monthly and annual precipitation and also reported on extreme weather events (Tennessee Valley Authority Hydrolic Data Branch 1957, 1959). T.V.A. established Land Between the Lakes National Recreation Area where some special vegetation (natural areas) is set aside from logging or development. The area is now administered by the U.S. Forest Service which will write a new area management plan. The future fate of the natural areas is unknown.

The United States Fish and Wildlife Service owns seven refuges (Trani(Griep) 2002) and the Tennessee Wildlife Resources Agency purchases or leases land for the use of hunters and fisherman as Refuges or Wildlife Management Areas. Some areas are little disturbed. The Fish and Wildlife Service also assesses the rarity of plant and animal species and attempts to manage populations of rare species (with the Tennessee and T.V.A. Heritage programs). (United States Fish and Wildlife Service 2002.)

Oak Ridge National Laboratory, in Anderson and Roane counties, was established during World War II (Krause 1992) and has held some land with little or no development but access may now be restricted. The Environmental Sciences Division has carried out research of local interest in vegetation, ecosystem, and watershed ecology (Johnson and Van Hook 1989).

The Department of Defense maintains several reservations in Tennessee. The Arnold Engineering Development Center in Coffee and Franklin counties has sponsored extensive study of its rare biota (Lillie and Ripley 1998, Pyne 2000) and land management there is carried out with conservation of that biota in mind. Other Defense facilities are Fort Campbell Military Reservation in Stewart County and adjacent Kentucky (cf. Chester 1988), the Holston Ordinance Works (Hawkins County), the Volunteer-Ordinance Works (Hamilton County) and other facilities, at Milan in Gibson County and at Erwin in Unicoi County.

The U. S. Army Corps of Engineers manages seven lakes on the Cumberland River drainage; they own forest land immediately adjacent to the lake that are managed at least partly as natural forest vegetation.

The Nature Conservancy has been active acquiring private wild lands as natural areas. Some lands acquired by gift or public fundraising campaigns are held by the Conservancy, but most are given to an appropriate state or federal agency. The Conservancy sponsored formation of the Natural Heritage Division in the State Department of Environment and Conservation. The Conservancy has developed a commonly used species-rarity ranking system to evaluate the biological quality of vegetation landscape units (Stein et al. 2000). It has also developed a classification system for the vegetation of the Southeastern United States which includes descriptions of units (Weakley et al. 1998).

Other Conservancy groups also raise funds in Tennessee for purchase of wild lands. These include the Highlands Conservancy and the Foothills Conservancy both interested in lands in the Blue Ridge of Tennessee. In October 2000, the Virginia Conservancy purchased the Gulf Tract (including part of Max Patch, Cocke County) which land has been transferred to the State for a new park or to the Forest Service as an addition to the Cherokee National Forest.

The State Natural Heritage Division monitors state and national rare biotic populations–those in private land, especially, are frequently under the threat of elimination by land development (cf. Nordman 2001). The division also acquires and manages State Natural Areas and has made vegetation studies (as Smith et al. 1983).

Colleges and universities contribute many of the personnel for the study of natural areas and also may own land functioning as natural areas. The Botany Department and the Agricultural Experiment Station of the University of Tennessee own small tracts so maintained. East Tennessee State University, Austin Peay State University and the Vanderbilt University (Observatory Hill) also own small tracts.

Several biological stations have operated in Tennessee training students in field biology, supporting the research of students and faculty, and enhancing the public image of field biology. Tennessee Technological University operated, during the 1970s and 1980s, Tech Aqua Biological Station on Center Hill Reservoir. The E. J. Meeman Biological Field Station of the University of Memphis at Meeman-Shelby Forest State Park has operated since 1981. The A. D. Oxley Biological Field Station of Lambeth College has operated near Jackson since the 1980s. In addition colleges and universities have joined to operate such stations, the Mid-Appalachian College Council Field Biology and Research Center (MACCI) operated in the 1970s. The oldest jointly operated and funded station was the Reelfoot Lake Biological Station which operated from 1932 to about 1968. Supported in part by the State through Tennessee Academy of Science, it sponsored 93 published research papers based largely on work at Reelfoot.

PRIVATE LAND AND PEOPLE—PERSONAL EXPERIENCES

Although there are thousands of acres of managed public lands in the State, there are many more thousands owned by large private landowners (as development or timber companies) and small private acreages who maintain farm woods. One may find vegetation of interest serendipitously during reconnaissance on foot or by automobile, or from aerial photography. Or a site may be recommended by the very helpful public agency representatives, the county agent, county soil scientists, regional foresters, or other professionals or interested citizens.

Many hundreds of sites have been sampled by the writer on land of small acreage farms whose local landowners allowed the trespass; some were interested or even helpful. Negative owners are rare. Culturally isolated rural people of mountain counties seen by Kephardt (1913) and Caudill

(1963), or by Wharton (1972) in Middle Tennessee–all descriptions from past generations—can scarcely be found. Vicious dogs and dog packs seen early in the twentieth century by Wharton (1972) are rare or are chained or penned. Automobile use on the extensive road network, telephone, radio, motion pictures, television, military service, centralized schools and more available healthcare have been factors in homogenizing our culture. Increased numbers of manufacturing and other jobs, the growth of cottage industries as crafts, heavy input of federal funds through road construction, the National Guard, T.V.A. and the Appalachian Regional Commission, and the road, railroad, and air mode of moving farm, forest, mineral and manufactured products to markets have been factors in raising incomes and increasing human interactions.

Transportation and Fund Sources

In about the past 80 years, the automobile has come into common use and its quality, speed, safety and other features have made its use mandatory. Gasoline tax money brought road construction–the Tennessee network is continually extended and improved. In the past generation or two, the interstate system has been developed–interstate roads now pass through one-third of our counties. During the Alexander administration, many county roads became state roads with improved surfaces and signage. Increased resources have enabled paving of many previously gravel roads. County installation of the Emergency Communication Districts (911) has resulted in placement of road name or number signs on all public roads (and some private roads) in most counties. On land, movement on, e.g., old logging roads may be aided by use of the all terrain vehicle (off-road vehicle). Boat transportation is also possible along the larger waterways.

Outside financial support for travel has been difficult to find. The University of Tennessee especially the Botany Department Hesler Fund, the Center for Field Biology, The Nature Conservancy and the National Park Service have funded some of my studies in the past two decades. During the barrens studies, other agencies contributed (see De Selm 1993). However, most travel funds are personal and without this financial and moral support from the family, little work would be possible.

In the Stands

Stand selection is based upon its aspect at a distance and the writer's experience. Forest stands, on inspection, must have trees of some maximum size (trees ≥24 inches D.B.H.), a closed canopy, and multiple strata, no recent logging, and no obvious grazing effects. Woodland stands which have smaller trees or an incomplete canopy, and must be distinguishable from recently logged forests. Savanna vegetation with shrubs or trees scattered in dense herb cover or scattered herb-bryophyte-lichen cover (Daubenmire 1968) is rarely seen. Open vegetation, as sandstone flatrocks, glades, barrens and marshes, must meet aspect and species-presence criteria. Vegetation on slopes greater than 70 percent has been inadequately sampled.

Possibly dangerous animals occur in native vegetation. Poisonous snakes (as *Agkistrodon* spp.) are now rare due to habitat loss and persistent killing by land users. Draining of most lowlands and the availability of modern insect repellant has made insect pests (as mosquitoes, *Aedes* spp., *Culex* spp.) rarely a problem, although on uplands and many lowlands attacks by bees and wasps (*Vespula* spp.) occur. The successful reintroduction of white-tailed deer and the growth of the herds almost everywhere is the likely cause of the growth of deer tick (*Ixodes sapularis*) populations but other ticks as the dog tick (*Dermacentor variabilis*) and the lone-star tick (*Amblyomma americana*) all attach to people. Attacks by the potentially dangerous European boar or the black bear (*Ursus americanus*) are rare.

Modern technology has made available global positioning systems for stand location, light-weight materials used in winter clothing and musette (over the shoulder) bags, "breathable" waterproof clothing, cheap but adequate hand lenses and binoculars, and in non-remote areas, cell phones are a safety measure.

Writing and Publication

Availability of private reprint collections, such as that of the author, that of R. E. Shanks and of A.J. Sharp, adequate library and cartographic services (but also including departmental and private map collections) have been very helpful. Knowledge of pertinent or parallel studies or methods depends upon contact with other research workers or their writings. With dwindling travel resources and library resources (in the face of more journals and books used as publication outlets) and the lack of hard copies of abstracting journals and Current Contents (now on the web as Contents First), newsletters and the internet/web become more important as information sources and contact links. Data compilation and analysis is aided by use of the computer and certain programs at first available from Cornell University.

Publication outlets for local studies have changed in the past generations. At least two dozen journals have taken southeastern American vegetation papers in the past fifty years. In addition there are a few newer journals: *Canadian Journal of Forest Research, Conservation Biology, Forest Ecology and Management, Landscape Ecology, Natural Areas Journal,* and *Restoration Ecology. Castanea*, the Journal of the Southern Appalachian Botanical Association, accepts more ecological papers than formerly. *Southeastern Biology* (formerly *ASB Bulletin*) takes few papers now but may change its stance later. The *Journal of the Tennessee Academy of Science* prefers short papers. The new *Southeastern Naturalist* may take vegetation ecology papers. Conferences with published proceedings with both field biologists and geologists ("geobotany conferences") have been few (but see Romans 1977, 1981). Several biennial conferences with published proceedings are: Central Hardwoods Forest Conference, Southern Silviculture Research Conference, North American Prairie Conference and the Symposia on the Natural History of Lower Tennessee and Cumberland River Valleys. Special, single occasion conferences proceedings may result in publication of a multi-chaptered/authored book (as Anderson et al. 1999) or a journal issue (as Chester 1989, or Somers 1986). A book-length, single-subject study may be handled as a book as noted later.

SUMMARY AND CONCLUSIONS

This paper seeks to illustrate the many threads of information transfer, landscape-to-study availability, and special problems facing today's local vegetation ecologists. Even before resident scientists began to study the flora and vegetation, the landscape had been altered in drastic ways. Land-use conversion, especially to agriculture, forest logging, valley submersion under reservoirs, individual plant removal by theft or grazing have all impacted our remaining vegetation. Air pollution, climatic change, the spread of insect and disease organisms from other lands, and competition from weeds place our vegetation in a state of stress. The probability of resulting vegetation change indicates that permanent plot–long-term studies need to be initiated now for baseline establishment. These should be initiated in land-protected areas in as many communities as feasible. Special attention should be paid to fir, hemlock, beech, oak, and pine dominated communities because of environmental/disease change effects on canopy and subcanopy species, and also paid to the understory of dogwood, a calcium accumulator (Coile 1937). Federal and State sponsored forest "management" techniques, such as those favoring pines on oak and oak-pine sites, place those whole environments in peril in the face of warm winters, higher pine beetle populations, pine death, increased probability of fire, and stand replacement by hardwood scrub.

Eight categories of federal or State government agencies/institutions manage land mostly accessible to the vegetation ecologists. The road network enables travel directly to or near to most areas. Hundred, perhaps thousands of privately owned stands of vegetation of interest occupy parts of the landscape and, with proper owner contact, permission to study may be obtained.

Maps and related geological and soils information is available for most areas. Computer programs are available for compilation and analysis of field-collected and related data. Remotely sensed imagery is available for assessment of vegetation boundaries and vegetation/land use change. A moderately large amount of previous study results are available from widely scattered sources for comparison with results from any new study. Nineteenth century rectilinear surveys from East and West Tennessee need to be found in archives and used to characterize landscapes of the period.

The popularization of ecology in the 1960s and later decades in the face of global radiation balance and pollution challenges, the national concern with endangered biota, and other problems noted above have had only a slight effect on public support for vegetation studies. Funds for such studies are sparse. Should a project be completed, publication outlets and funds must be found. An example of serialized chapters in a journal or proceedings, suggested earlier, does not come to mind. A small volume of results, the "Natural Vegetation of Ohio in Pioneer Times" (Gordon 1969) was published as a bulletin in the publicly supported Ohio Biological Survey. Lindsey's (1966) "Natural Vegetation Features of Indiana" was published by the Indiana Academy of Science. Knight (1994) acknowledges in his "Mountains and Plains," long-term public travel and research support, but none for publication. In two much larger, more comprehensive volumes, Tester (1995) author of "Minnesota's Natural Heritage," and Jackson (1997), the editor of "Indiana's Natural Heritage," both acknowledge publication funds from private foundation and public sources.

The fragmentary nature of most natural vegetation units, the continuing pressure placed on it by owner/manager-use-practices and the added pressures of environmental change, new weeds, insects, and disease shows clearly that the present-day understanding of our vegetation composition, distribution, structure and processes must change. Clearly, if we are to have a modern understanding of the character and processes of our vegetation, to aid Tennesseans in managing and conserving their natural heritage, we must undertake to obtain it now, without fail.

ACKNOWLEDGMENTS

The writer acknowledges constructive critical comments by Dr. C. C. Amundsen.

LITERATURE CITED

Amundsen, C.C. 1989. Reservoir interpool plant habitat dynamics. Pp. 92-105. *In*: F. Quinones and B.H. Balthrop (eds.). Second Tennessee Hydrology Symposium. American Water Resources Association–Tennessee Section, Nashville, Tennessee.

Amundsen, C.C. 1995. A seasonally hydric reservoir riparian zone in the Tennessee River Valley. Pp. 272-293. *In*: C. C. Trettin, W.M. Augst, and J. Wisniewski (eds.). Wetlands of the interior southeastern United States. Kluwer Academic Publishers, New York.

Anderson, R.C., J.S. Fralish, and J.M. Baskin (eds.). 1999. Savannas, Barrens and Rock Outcrop Plant Communities of North America. Cambridge University Press, New York.

Arends, E. 1981. Vegetation patterns a half century following the chestnut blight in the Great Smoky Mountains National Park. M.S. Thesis, University of Tennessee, Knoxville, Tennessee.

Ashe, W.W. 1911. Chestnut in Tennessee. Tennessee Geol. Surv. Bull. 10-B, Nashville, Tennessee.

Ayres, H.B. and W.W. Ashe. 1905. The Southern Appalachian forests. U. S. Geol. Surv. Prof. Paper No. 37. Series E, Forestry 12. Government Printing Office, Washington, D. C.

Baer, C., R.E. Behling, and R.S. Little. 1982. A survey of potential Natural Landmarks of the Appalachian Plateau Region. Prepared for the Natural Landmarks Division of the National Park Service. University of West Virginia, Morgantown, West Virginia.

Bailey, L.H. 1924. Manual of cultivated plants. Macmillan Co., New York. Second edition, 1951.

Baker, W.L. 1972. Eastern Forest Insects. U.S.D.A. Misc. Publ. 1175. Government Printing Office, Washington, D. C.

Barbour, M.G. and W.D. Billings (eds.). 1999. North American Terrestrial Vegetation. Second edition. Cambridge University Press, New York.

Barclay, F.H. 1957. The natural vegetation of Johnson County, Tennessee: Past and present. Ph.D. Diss., University of Tennessee, Knoxville, Tennessee.

Barden, L.S. 1980. Forest development in canopy gaps of a diverse hardwood forest in the southern Appalachian Mountains. Oikos 37:205-209.

Barrett, J.W. (ed.). 1962. Regional silviculture of the United States. Ronald Press, New York. Last edition published by John Wiley & Sons, Inc., 1994.

Baskin, J.M. and C.C. Baskin. 1989. Cedar glade endemics in Tennessee, and a review of their autecology. J. Tennessee Acad. Sci. 64:63-74.

Birdsey, R., R. Mickler, D. Sandberg, R. Tinus, J. Zerbe, and K. O'Brian (eds.). 1996. Global change research program highlights: 1994-1995. U.S.D.A. Forest Service Northeastern Forest Experiment Station Gen. Tech. Report NE-237, Radnor, Pennsylvania.

Blackburn, B. 1952. Trees and shrubs in eastern North America. Oxford University Press. New York.

Boyce, J.S., Jr. 1957. Oak wilt spread and damage in the Southern Appalachians. J. Forest. (Washington) 56:499-505.

Bratton, S.P. 1974. An integrated ecological approach to the management of European wild boar (*Sus scrofa*) in Great Smoky Mountains National Park. Management Report No. 3.

Bratton, S.P. 1979. Preliminary status of rare plants in Great Smoky Mountains National Park. National Park Service–Southeast Region Research/Resources Management Series No. 25, Springfield, Virginia.

Braun, E.L. 1935. The vegetation of Pine Mountain, Kentucky. Amer. Midl. Naturalist 16: 517-565.

Braun, E.L. 1950. Deciduous forests of eastern North America. The Blakiston Company, Philadelphia, Pennsylvania.

Britton, N.L. and A. Brown 1913. Illustrated flora of the northern United States and Canada. Second Edition. New York Botanical Gardens, Bronx, New York.

Burns, R.M. and B.M. Honkala. 1990. Silvics of North America, Vol. 1. Conifers, Vol. 2. Hardwoods. U.S.D.A. Forest Service Agric. Handbook No. 654. Government Printing Office, Washington, D.C.

Busing, R.T. 1993. Three decades of change at Albrights Grove. Castanea 58:231-242.

Busing. R.T., E.E.C. Clebsch, and P.S. White. 1993. Biomass and production of southern Appalachian cove forests re-examined. Can. J. For. Res. 23:760-765.

Cain, S.A. 1930. An ecological study of heath balds of the Great Smoky Mountains. Butler Univ. Bot. Stud. 1:176-208.

Cain, S.A. and A.J. Sharp. 1938. Bryophytic unions of certain forest types of the Great Smoky Mountains. Amer. Midl. Naturalist 20:249-301.

Campbell, J.J.N. 1987. Gradients of tree species composition in the central hardwoods region, pp. 325-346. *In*: Hay, R.L., F.N. Woods and H. De Selm (eds.), Proceedings of the Central Hardwoods Forest Conference VI, Knoxville, Tennessee.

Caplenor, D. 1965. The vegetation of the gouges of the Fall Creek Falls State Park in Tennessee. J. Tennessee Acad. Sci. 40:27-39.

Caudill, H.M. 1963. Night comes to the Cumberlands. Little, Brown and Company, Boston, Massachusetts.

Chapman, J.A. 1957. The natural vegetation of English Mountain, Tennessee. Ph.D. Diss., University of Tennessee, Knoxville, Tennessee.

Chester, E.W. 1988. The Kentucky prairie barrens of northwest middle Tennessee: An historical and floristic prospective. Pp. 145-163. *In*: D. H. Snyder (Ed.). Proceedings of the First Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Chester, E.W. (ed.). 1989. The vegetation and flora of Tennessee. Proceedings of a symposium sponsored by the Austin Peay State University Center of Excellence for Field Biology of Land Between the Lakes, The Tennessee Acad. of Science and TVA-LBL held at Brandon Springs, Tennessee, 3 March 1989. J. Tennessee Acad. Sci. 64(3).

Chester, E.W. and A.F. Scott (eds.). 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.

Chester, E.W., B.E. Wofford, and R. Kral. 1997. Atlas of Tennessee Vascular Plants. Vol. 2. Angiosperms: Dicots. Misc. Publ. No. 13. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Chester, E.W., B.E. Wofford, R. Kral, H.R. De Selm, and A.M. Evans. 1993. Atlas of Tennessee vascular plants. Vol. 1. Pteridophytes, Gymnosperms, Angiosperms: Monocots. Misc. Publ. No. 9. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Coile, T.S. 1937. Composition of leaf litter of forest trees. Soil Sci. 43:349-355.

Collins, J.L. and T.F. Wiebolt. 1992. *Trifolium calcaricum* (Fabaceae), a new clover from limestone barrens of eastern United States. Castanea 57:282-286.

Committee on Forest Types. 1952. Forest cover types of the eastern United States. J. Forest. (Washington) 30:11-48.

County Maps. No date. C. J. Puetz, compiler, Lyndon, Wisconsin.

Cowan, W.F. 1946. The forest resources of Tennessee. Processed report. American Forestry Association and Tennessee Conservation Department, Forestry Division, Nashville.

Crandall, D.L. 1958. Ground vegetation patterns of the Great Smoky Mountains National Park. Ecol. Monogr. 28:337-360.

Crawford, H.S., R.G. Hooper, and R.F. Harlow. 1976. Woody plants selected by beavers in the Appalachian Ridge and Valley Province. U.S.D.A. Forest Service Research Paper NE-346, Upper Darby, Pennsylvania.

Christensen, E.M. 1963. Herbaceous vegetation in lowland winter habitats of white-tailed deer in northern Wisconsin. Ecology 44:411-414.

Dale, V.H. 2001. Climate change and forest disturbances. Bioscience 51:723-734.

Daubenmire, R. 1968. Plant communities. Harper and Row, Publishers, New York.

Daubenmire, R. 1978. Plant geography with special reference to North America. Academic Press, New York.

Deen, R.T. and J.D. Hodges. 1991. Oak regeneration in a abandoned fields: presumed role of the blue jay. Pp. 84-93. *In*: S.S. Coleman and D.G. Neary (comps. and eds.), Proceedings of the Sixth Biennial Southern Silvicultural Research Conference, Vol. 1. Southeastern Forest Experiment Station, Asheville, North Carolina.

Delcourt, P.A. and H.R. Delcourt. 1987. Long-term dynamics of the temperate zone. Springer-Verlag, New York.

Delorme Mapping Company. 1989. Tennessee Atlas and Gazetteer. Freeport, Maine.

De Selm, H.R. 1959. A new map of the Central Basin of Tennessee. J. Tennessee Acad. Sci. 34:66-72.

De Selm, H.R. 1984. Potential National Natural Landmarks of the Appalachian Ranges Natural Region. Ecological Report. Prepared for the U. S. National Park Service. Contract No. CX-0001-1-0079. The University of Tennessee, Knoxville, Tennessee.

De Selm, H.R. 1993. Barrens and glades of the southern Ridge and Valley. pp. 81-135. *In*: S.W. Hamilton, E.W. Chester and A.F. Scott (eds.), Proceedings of the Fifth Annual Symposium on the Natural History of the Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. 1994. Vegetation results from an 1807 land survey of southern Middle Tennessee. Castanea 59:51-68.

De Selm, H.R. 2001. Vegetation results from land surveys in three East Tennessee counties, 1807-1897. pp. 51-63. *In*: E.W. Chester and A.F. Scott (eds.), 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.

De Selm, H.R. 2003. A first look at botanical forerunners early in Tennessee history. Tenth Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

De Selm, H.R. The terrestrial vegetation of Tennessee. In progress.

De Selm, H.R. and R.R. Boner. 1984. Understory changes in spruce-fir during the first 16-20 years following the death of fir. pp. 51-69. *In*: P.S. White (ed.), The Southern Appalachian Spruce-Fir Ecosystem: Its Biology and Threats. National Park Service, Research/Resources Management Report SER-71.

De Selm, H.R. and E.E.C. Clebsch. 1991. Response types to prescribed fire in oak forest understory. pp. 22-33. *In*: S.C. Nodvin and T.A. Waldrop (eds.), Fire and Environment: ecological and cultural perspectives. Proceedings of an International Symposium, Knoxville, Tennessee, March 20-24, 1990. Southeastern Forest Exper. Sta. Tech. Rep. SE-69, Asheville, North Carolina.

De Selm, H.R. and N. Murdock. 1993. Grass-dominated communities. pp. 87-141. *In*: W.H. Martin, S.G. Boyce and A.C. Echternacht (eds.), Biodiversity of the Southeastern United States–Upland Terrestrial Communities. John Wiley & Sons, New York.

De Selm, H.R. and P.A. Schmalzer. 1982. Classification and description of the ecological themes of the Interior Low Plateaus. Prepared for the U. S. Department of the Interior, National Park, Service, Contract No. TX 0001-0-0674. Processed Report, University of Tennessee, Knoxville.

De Selm, H.R. and G. Schmidt. 2001. A new isohyotal map of Tennessee and adjacent area. pp. 65-68. *In*: E.W. Chester and A.F. Scott (eds.), 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.

De Selm, H.R. and T.W. Taylor. 1973. Vegetation boundaries on ERTS-1 imagery. Remote Sensing of Earth Resources II:925-933.

Dey, J.P. 1984. Lichens of the Southern Appalachian Mountain spruce-fir zone and some unanswered ecological questions. pp. 139-150. *In*: P.S. White (ed.), The Southern Appalachian Spruce-Fir Ecosystem: Its Biology and Threats. National Park Service Research/Resources Management Report SER-71.

DeYoung, H.R., P.S. White and H.R. De Selm. 1982. Vegetation of the Southern Appalachians: An indexed bibliography, 1802-1902. Research/Resources Management Report SER-63. National Park Service Southeast Regional Office, Atlanta, Georgia.

Dickson, R.R. 1960. Climate of Tennessee, Climates of the States. Climatography of the United States 60-40. U. S. Department of Commerce, Weather Bureau, Washington, D. C.

Duerr, W.A. 1949. Forest statistics for western and central Tennessee. Forest Survey Release No. 63. Southern Forest Experiment Station, New Orleans, Louisiana.

Duncan, S.H. and W.H. Ellis. 1969. An analysis of the forest communities of Montgomery County, Tennessee. J. Tennessee Acad. Sci. 44:25-32.

Eager, C. and M.B. Adams (eds.). 1992. Ecology and decline of red spruce in eastern United States. Ecological Studies 96. Springer-Verlag, New York.

Evans, J.P. and S. McCarthy. 2000. Population dynamics of overcup oak (*Quercus lyrata*) in a seasonally flooded Karst depression. J. Torrey Bot. Club 127:9-18.

Eyre, F.H. (ed.) 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, D.C.

Foley, J. 1903. Conservative lumbering at Sewanee, Tennessee. U.S.D.A. Bureau of Forestry Bull. 39, Washington, D.C.

Fosbroke, S.L.C. and K.W. Gottschalk (eds.). 1999. Proceedings, U.S. Department of Agriculture Interagency Research Forum on gypsy moth and other invasive species. U.S.D.A. Forest Service Northeastern Research Station Gen. Tech. Report NE-266. Radnor, Pennsylvania.

Fowells, H.A. 1965. Silvics of forest trees of the United States. U.S.D.A. Forest Service Agric. Handbook No. 271. Government Printing Office, Washington, D. C.

Fralish, J.S. and F.B. Crooks. 1989. Forest composition, environment and dynamics at Land Between the Lakes in Northwest Middle Tennessee. J. Tennessee Acad. Sci. 64:107-111.

Franzreb, K.E. and R.A. Phillips. 1996. Neotropical migratory birds of the Southern Appalachians. U.S.D.A. Forest Service Southern Research Station General Technical Report SE-96, Asheville, North Carolina.

Fribourg, N.A. 1976. Solar variability and its variability at Knoxville, Tennessee. Tennessee Farm and Home Science. 1976, pp. 24-27.

Frick, T.A. 1939. Slope vegetation near Nashville, Tennessee. J. Tennessee Acad. Sci. 14:342-420.

Frothingham, E.H. 1926. National Forests of the eastern district. Pp. 387-395. *In*: V.E. Shelford (ed.). Naturalists Guide to the Americas. Williams and Wilkins Co., Baltimore.

Gattinger, A. 1887. The Tennessee flora; with special reference to the flora of Nashville. The author, Nashville, Tennessee.

Gattinger, A. 1894. The medicinal plants of Tennessee. Department of Agriculture of the State of Tennessee. Franc. M. Paul, Printer to the State, Nashville, Tennessee.

Gattinger, A. 1901. The flora of Tennessee and a philosophy of botany. Gospel Advocate Publishing Company, Nashville, Tennessee.

Glauber, B., B. Joel, and H. Meta. 2000. Alien nation, map. Harper's Magazine, September 2000: 88.

Gleason, H.A. 1952. The New Britton and Brown Illustrated Flora of the northeastern United States and adjacent Canada. The New York Botanical Garden. Macmillan Publishing Co., New York.

Gleason, H.A. and A. Cronquist. 1963. Manual of vascular plants of northeastern United States and adjacent Canada. The New York Botanical Garden, Bronx, New York.

Gleason, H.A. and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. Second edition. New York Botanical Garden, Bronx, New York.

Golden, M.S. 1981. An integrated multivariate analysis of forest communities of the central Great Smoky Mountains. Amer. Midl. Naturalist 106:37-53.

Gordon, R.B. 1969. The natural vegetation of Ohio in pioneer days. Bulletin of the Ohio Biological Survey, Bull. N.S. Vol. 3(2):1-109.

Gottschalk, K.W. and M.J. Twery. 1989. Gypsy moth impacts in pine-hardwood mixtures. pp. 50-58. *In*: T.A. Woldrop (ed.). Proceedings of Pine-Hardwood Mixtures: A symposium on management and ecology of the type. Southeastern Forest Experiment Station Gen. Tech. Report. SE-58. Asheville, North Carolina.

Graham, A. (ed.). 1972. Floristics and paleofloristics of Asia and eastern North America. Elsevier Publishing Co., New York.

Graham, A. 1999. Late Cretaceous and Cenozoic history of North American vegetation. Oxford University Press, New York.

Griffith, G.E., J.M. Omernik and S.H. Azevedo. 1997. Ecoregions of Tennessee. United States Environmental Protection Agency. EPA/600/R-97/022. Corvallis, Oregon.

Hall, R.C. 1910. Preliminary study of forest conditions in Tennessee. Tennessee Geol. Surv. Bull. 10-A. Nashville, Tennessee.

Harshberger, J.W. 1911. Phytogeographic survey of North America. G. E. Stechert and Co., New York.

Hawley, R.C. et al. 1932. Forest cover types of the eastern United States. J. Forest. (Washington) 30:1-48.

Haywood, J. 1823. The civil and political history of the State of Tennessee. Printed for the author by Heiskell and Brown, Knoxville, Tennessee.

Henson, J.W. 1990. Aquatic and certain wetland vascular vegetation of Reelfoot Lake, 1920s-1980s. II. Persistent marshes and marsh-swamp transitions. J. Tennessee Acad. Sci. 65:69-74.

Hepting, G.H. 1971. Diseases of forest and shade trees of the United States. U.S.D.A. Forest Service Agric Handbook No. 386. U. S. Government Printing Office, Washington, D. C.

Hiers, J.K. and J.P. Evans. 1997. Effects of anthracnose on dogwood mortality and forest composition of the Cumberland Plateau (U.S.A.). Conservation Biology 11:1430-1435.

Hitchcock, A.S. 1935. Manual of the grasses of the United States. U.S.D.A. Misc. Publ. 200, Washington, D.C.

Hoffman, H.L. 1964. Checklist of vascular plants of the Great Smoky Mountains. Castanea 29:1-45.

Holmgren, N. and others. 1998. Illustrated companion to Gleason and Cronquist's Manual. The New York Botanical Garden, Bronx, New York.

Hudson, C. 1976. The southeastern Indians. The University of Tennessee Press, Knoxville, Tennessee.

Jackson, M.T. (ed.). 1997. The Natural Heritage of Indiana. Indiana University Press, Bloomington and Indianapolis, Indiana.

Johnson, D.W. and R.I. Van Hook (eds.). 1989. Analysis of biogeochemical cycling processes in Walker Branch Watershed. Springer-Verlag, New York.

Joint Federal Agency. 1973. Final Environmental Impact Statement Chip Mill Terminals on the Tennessee River. Tennessee Valley Authority, Army Corps of Engineers, Fish and Wildlife Service, Knoxville.

Jones, M.L. 1979. An index to geological mapping associated with theses and dissertations at the University of Tennessee, Knoxville (through 1975). J. Tennessee Acad. Sci. 54:23-28.

Keever, C. 1971. A study of the mixed mesophytic, western mesophytic and oak-chestnut regions of the eastern deciduous forest including a review of the vegetation and sites recommended as potential natural landmarks. Prepared for the National Park Service. Millersville State College, Millersville, Pennsylvania.

Kephart, H. 1913. Our Southern Highlanders. Macmillan Co., New York.

Killebrew. J.B. 1878. The grasses of Tennessee including cereals and forage plants. The American Co. Printers, Nashville, Tennessee.

Killebrew, J.B. 1898. Grasses and forage plants. Bulletin of the Agricultural Experiment Station of the University of Tennessee Vol. 11, Nos. 2, 3, 4. Knoxville.

Killebrew, J.B. and J.M. Safford, assisted by C.W. Carlton and H.L. Bentley. 1874. Introduction to the resources of Tennessee, first and second reports of the Bureau of Agriculture. Tavel, Eastman and Howell Printers, Nashville, Tennessee.

Knight, D. 1994. Mountains and Plains, The Ecology of Wyoming Landscapes. Yale University Press, New Haven, Connecticut.

Kowal, R.J. 1960. Southern pine beetle. Forest Pest Leaflet 49. U.S.D.A. Forest Service, Washington, D.C.

Krause, C. (ed.). 1992. Fiftieth Anniversary of Oak Ridge National Laboratory. Oak Ridge Laboratory Review 25(3,4): 1-282, 1-viii. Oak Ridge, Tennessee.

Krumpe, P.F., H.R. De Selm, and C.C. Amundsen. 1971. An ecological analysis of forest landscape perameters by multiband remote sensing. pp. 715-730. *In*: Proceedings of the Seventh International Symposium on Remote Sensing of Environmet. Institute of Science and Technology, University of Michigan, Ann Arbor, Michigan.

Kuchler, A.W. 1964. Manual to accompany the map, Potential Natural Vegetation of the Conterminous United States. American Geographical Society Special Publication No. 36, New York.

Lamson-Scribner, F. 1892. The grasses of Tennessee–Part I. University of Tennessee Agric. Expt. Sta. Bull. Vol. 5, No. 2. pp. 29-119, Knoxville, Tennessee.

Lamson-Scribner, F. 1894. Grasses of Tennessee–Part II. Tennessee Agric. Expt. Sta. Bull. Vol. 7, No. 1. Pp. 1-141, Knoxville, Tennessee.

Lebkuecher, J.G. and G.E. Hunter. 1991. A plant community analysis of Collins Gulf. J. Tennessee Acad. Sci. 66:31-36.

Lewis, T.M.N. and M. Kneberg. 1958. Tribes that slumber. The University of Tennessee Press, Knoxville, Tennessee.

Lillie, T.H. and J.D. Ripley. 1998. A strategy for implementing ecosystem management in the United States Air Force. Natural Areas J. 18:73-80.

Lindsey, A.A. (ed.). 1966. Natural features of Indiana. Indiana Acad. of Sci., Indianapolis, Indiana.

Livingston, B.E. and F. Shreve. 1921. The distribution of vegetation in the United States, as related to climatic conditions. Carnegie Institution of Washington.

Mackenzic, M.D. and P.S. White. 1998. Vegetation of the Great Smoky Mountains National Park, 1935-1938. Castanea 63:323-336.

Maddox, R.S. 1926. Tennesee. Pp. 347-349. *In*: V.E. Shelford (ed.). Naturalists Guide to the Americas. Williams and Wilkins Co., Baltimore, Maryland.

Martin, J.A. and B.H. Luebke. 1960. Types of farming in Tennessee. University of Tennessee Agric. Expt. Sta. Bull. 311, Knoxville, Tennessee.

Martin, W.H., S.G. Boyce, and A.C. Echternacht (eds.). 1993. Biodiversity of the Southeastern United States. Upland Terrestrial Communities. John Wiley & Sons, Inc., New York.

Martin, W.H., S.G. Boyce, and A.C. Echternacht (eds.). 1993. Biodiversity of the Southeastern United States. Lowland Terrestrial Communities. John Wiley & Sons, Inc., New York.

McCarthey, D.M. and C.W. Voigtlander (eds.). 1983. The first fifty years: changed lands, changed lives. Tennessee Valley Authority, Knoxville, Tennessee.

McGee, C.E. 1989. Converting low-quality hardwood stands to pine-hardwood mixtures. pp. 107-111. *In*: T.A. Waldrop (ed.), Proceedings of Pine-Hardwood Mixtures: A symposium on management and ecology of the type. Southeastern Forest Experiment Station Gen. Tech. Report SE-58. Asheville, North Carolina.

McKinney, L.E. and T.E. Hemmerly. 1984. Preliminary study of deciduous forests within the Inner Basin of Middle Tennessee. J. Tennessee Acad. Sci. 59:40-42.

McShea, W.J., H.B. Underwood, and J.H. Rappole (eds.). 1997. The science of overabundance. Smithsonian Institution Press, Washington, D. C.

Miller, F.H. 1941. Vegetation cover types of the Great Smoky Mountains National Park. [Map.] National Park Service, Gatlinburg, Tennessee.

Miller, N.A. and M.E.G. Holyfield. 1986. Old field succession on the loessal soil of the Third Chickasaw Bluff of West Tennessee. J. Tennessee Acad. Sci. 61:57-62.

Miller, S.G., S.P. Bratton, and J. Hadidian. 1992. Impacts of white-tailed deer on endangered and threatened vascular plants. Natural Areas Journal 12:67-74.

Mitchell, R.G., G.D. Amman, and W.E. Waters. 1970. Balsam wooly aphid. Forest Pest Leaflet 118. U.S.D.A. Forest Service, Washington, D. C.

Montgomery, M.E., M.L. McManus, and C.W. Berisford. 1989. The gypsy moth in pitch pine-oak mixtures: predictions of the south based on experiences in the north. pp. 43-49. *In*: T.A. Waldrop (ed.), Proceedings of Pine-Hardwood Mixtures: A symposium on management and ecology of the type. Southeastern Forest Experiment Station Gen. Tech. Report. SE-58. Asheville, North Carolina.

Moore, J.A., J.G. Bartlett, J.L. Boggs, M.J. Garazzi, L.S. Heath and S.G. McNulty. 2002. Abiotic factors. Pp. 429-452. *In*: D.N. Wear and J.G. Greis (eds.). Southern Forest Resource Assessment. Southern Research Station. Asheville, North Carolina.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley & Sons., Inc., New York.

Munns, E.N. 1938. The distribution of important forest trees of the United States. U.S.D.A. Misc. Publ. No. 287, Washington, D.C.

Neufeld, A.S., J.R. Renfro, W.D. Hacker, and D. Silsbee. No date. Ozone in Great Smoky Mountains National Park: Dynamics and effects on plants. Unpublished report. Uplands Research Laboratory, Great Smoky Mountains National Park, Gatlinburg, Tennessee.

Nodvin, S.C., J.S. Rigell, and S.M. Twigg. 1993. An indexed reference database of the Great Smoky Mountains, North Carolina and Tennessee. Technical Report NPS/SERGRS/NRTR-93/08. National Park Service, Washington, D.C.

Nordman, C. 2001. Rare plant list. Division of Natural Heritage. Tennessee Department of Environment and Conservation, Nashville, Tennessee.

Phillips, H.C. 1974. Lichens and ferns of Land Between the Lakes. Austin Peay State University, Clarksville, Tennessee.

Pittillo, J.D. and J.R. Wentworth (eds.). 1989. Vegetation of the Blue Ridge Province. Castanea 63(3).

Pyne, M. 2000. Biogeographic study of the barrens of the southeastern Highland Rim of Tennessee. The Nature Conservancy, Chapel Hill, North Carolina.

Quarterman, E. 1950. Major plant communities of Tennessee cedar glades. Ecology 31:234-254.

Quarterman, E. 1957. Early plant succession on abandoned cropland in the Central Basin of Tennessee. Ecology 38:300-309.

Quarterman, E. and R.L. Powell. 1978. Potential ecological/geological Natural Landmarks of the Interior Low Plateau. Report to the National Park Service. Vanderbilt University, Nashville, Tennessee.

Quarterman, E., M.P. Burbank, and D.J. Shure. 1993. Rock outcrop communities: Limestone, sandstone and granite. pp. 35-86. *In*: W.H. Martin, S.G. Boyce, and A.C. Echternacht (eds.), Biodiversity of southeastern United States. Upland Terrestrial Communities. John Wiley & Sons, Inc., New York.

Ramseur, G.S. 1986. The vascular flora of high mountain communities of the Southern Appalachians. J. Elisha Mitchell Sci. Soc. 76:82-112.

Reans, G.A. and P.C. Van Deusen. 1999. The southern annual forest inventory system. J. Agric. Biol. and Environ. Statistics 4:346-360.

Rehder, A. 1927. Manual of cultivated trees and shrubs. Macmillan Publishing Co., New York. Second edition, 1940.

Rehder, J.B. 1996. Mapping needle leaf forests in Great Smoky Mountains National Park. pp. 431-437. S. Morain and S.L. Baros (eds.), Raster Imagery in Geographic Information Systems. Onward Press, Sante Fe, New Mexico.

Robinson, B.L. and M.L. Fernald. 1908. Gray's New Manual of Botany. A handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada. Seventh edition. American Book Company, New York.

Romans, R.C. (ed.). 1977. Geobotany. Plenum Press, New York.

Romans, R.C. (ed.). 1981. Geobotany II. Plenum Press, New York.

Rooney, T.P. and W.J. Dress. 1997. Species loss over sixty-six years in the ground layer vegetation of Heart's Content, an old growth forest in Pennsylvania, U.S.A. Natural Areas Journal 17:297-305.

Rosson, J.F., Jr. 1999. An analysis of the temporal dynamics in tree species diversity for major taxa of two states in the Midsouth, USA. Ph.D. Diss., University of Tennessee, Knoxville, Tennessee.

Rucker, E. and T.E. Hemmerly. 1976. Host specificity of Mistletoe in Middle Tennessee I: Rutherford County. Castanea 41:31-33.

Safford, J.M. 1869. Geology of Tennessee. S. C. Mercer Printer, Nashville, Tennessee.

Sargent, C.S. 1884. Report on the Forests of North America (exclusive of Mexico). Department of Interior, Census Office. Government Printing Office, Washington, D.C.

Sargent, C.S. 1933. Manual of the trees of North America (exclusive of Mexico). Houghton Mifflin Co., Boston, Massachusetts.

Schibig, J. 1996. Twenty years of forest change at Radnor Lake Natural Area, Davidson County, Middle Tennessee. J. Tennessee Acad. Sci. 71:57-72.

Schlarbaum, S.E., F. Hebard, P.C. Spaine, and J.C. Kamalay. 1997. Three American Tragedies: chestnut blight, butternut canker, and Dutch elm disease. Pp. 45-54. *In*: K.O. Britton (ed.), Proceedings Exotic Pest Plant Council. Nashville, Tennessee.

Schweitzer, C.J. 2000. Forest statistics for East Tennessee, 1999. U.S.D.A. Forest Service Southern Research Station Resource Bull. SRS-51, Asheville, North Carolina.

Secretary of Agriculture. 1902. Message from the President of the United States transmitting a report of the Secretary of Agriculture in relation to the forests, rivers, and mountains of the Southern Appalachian Region. Government Printing Office, Washington, D. C.

Shanks, R.E. 1952. Checklist of the woody plants in Tennessee. J. Tennessee Acad. Sci. 27:27-50.

Shanks, R.E. 1954. Plotless sampling trials in Appalachian forest types. Ecology 35:237-244.

Shanks, R.E. 1958. Floristic regions of Tennessee. J. Tennessee Acad. Sci. 33:195-210.

Shanks, R.E. and F.H. Norris. 1950. Microclimatic variation in a small valley in eastern Tennessee. Ecology 31:532-539.

Shanks, R.E. and A.J. Sharp. 1963. Summer Key to Tennessee Trees. University of Tennessee Press, Knoxville. Also published in J. Tennessee Acad. Sci. 22: 114-133., 1947, and privately published 1950.

Shantz, H.L. and R. Zon. 1924. Natural vegetation. *In*: O.E. Baker (ed.), Atlas of American Agriculture. Washington, D.C., 1936 (Map dated 1923).

Sharp. A.J. 1939. Taxonomic and ecological studies of eastern Tennessee bryophytes. Amer. Midl. Naturalist 21:267-354 plus i-vii.

Sharp, A.J. 1955. Preliminary keys to the genera and species of Tennessee ferns. J. Tennessee Acad. Sci. 3:85-89.

Sharp, A.J. 1957. Vascular epiphytes in the Great Smoky Mountains. Ecology 38:654-655.

Sharp. A.J., R.E. Shanks, H.L. Sherman, and D.H. Norris. 1960. A preliminary checklist of dicots in Tennessee. Processed Report. The University of Tennessee, Knoxville.

Sharp, A.J., R.E. Shanks, J.K. Underwood, and E. McGilliard. 1956. A preliminary checklist of the monocots of Tennessee. Processed report. The University of Tennessee, Knoxville.

Shaver, J.M. 1933. A preliminary report on the plant ecology of Reelfoot Lake. J. Tennessee Acad. Sci. 8:48-54.

Shaver, J.M. 1934. Scott's spleenwort in Tennessee. Amer. Fern J. 24:39-42.

Shaver, J.M. and M. Dennison. 1928. Plant succession along Mill Creek. J. Tennessee Acad. Sci. 3:5-13.

Shaver, J.M. 1954. The ferns of Tennessee with the fern allies excluded. Bureau of publications, George Peabody College for Teachers, Nashville, Tennessee.

Small, J.K. 1913. Flora of the southeastern United States. Second edition, the Author, New York. First edition 1903.

Small, J.K. 1933. Manual of southeastern flora. Published by the author. Science Press Printing Co., New York.

Smalley, G.W. 1986. Site classification and evaluation for the interior uplands. U.S.D.A., Southern Forest Experiment Station and Southern Region Technical Publ. R8-TP9, Atlanta, Georgia.

Smith, D.K. 1984. A status report on bryophytes of the Southern Appalachian spruce-fir forests. pp. 131-138. *In*: P.S.

White (ed.), The Southern Appalachian Spruce-Fir Ecosystem: Its Biology and Threats. Research/Resources Management Report, SER-71, Atlanta, Georgia.

Smith, D.K., K.D. McFarland, and P.G. Davison. 1991. Development of a taxonomic/ecological database: report of the floristic richness of bryophytes, Great Smoky Mountains National Park. Report to the National Park Service, Cooperative Agreement CA-5460-5-8004, Subagreement No. 14. The University of Tennessee, Knoxville, Tennessee.

Smith, D.W. 1968. Vegetational changes in a five-county area of East Tennessee during secondary succession. M.S. Thesis, University of Tennessee, Knoxville, Tennessee.

Smith, G.F. and N.S. Nicholas. 1999. Post-disturbance spruce-fir forest stand dynamics at seven disjunct sites. Castanea 64:175-186.

Smith, L.R., E. Bridges, D. Durham, D. Eagar, A. Lovell, S. Pearsall, T. Smith, and P. Somers. 1983. The Highland Rim in Tennessee: Development of a community classification and identification of potential natural areas. Natural Heritage Program Tennessee Department of Conservation. Nashville, Tennessee.

Somers, P. (ed.). 1986. Symposium, Biota, ecology, and ecological history of cedar glades. ASB Bull. 33(4).

Southern Appalachian Man and the Biosphere Cooperative. 1996. The Southern Appalachian Assessment, Technical Reports. U. S. Department of Agriculture, Washington, D.C.

Springer, M.E. and J.A. Eldor. 1980. Soils of Tennessee. University of Tennessee Agric. Expt. Sta. Bull. 596.

Steed, R.M. 1979. Soil/site–forest cover relationship within the Hatchie River floodplain of West Tennessee. M.S. Thesis, University of Tennessee, Knoxville.

Stein, B.A., L.S. Kutner, and J.S. Adams (eds.). 2000. Precious Heritage. Oxford University Press, New York.

Sternitzke, A.S. 1955. Tennessee's timber economy. U.S.D.A. Forest Resource Report No. 9, Washington, D.C.

Stupka, A. 1964. Trees, shrubs and woody vines of Great Smoky Mountains National Park. The University of Tennessee Press, Knoxville, Tennessee.

Swanton, J.R. 1946. The Indians of the Southeastern United States. Smithsonian Inst. Bureau of Ethnology Bull. 137.

Tennessee Exotic Pest Plant Council. 1996. Tennessee Exotic Plant Management Manual. Friends of Warner Park. Nashville, Tennessee.

Tennessee Valley Authority Division of Forestry Relations. 1941. Forestry Data for the Tennessee Valley, Part I, Area Data for Valley Counties. Forestry Bulletin Series No. 3, Norris, Tennessee.

Tennessee Valley Authority Division of Forestry Relations. 1941. Areas characterized by general forest types in the Tennessee Valley. Map. Norris, Tennessee.

Tennessee Valley Authority Division of Forestry Relations. 1960. Forest inventory statistics for the Tennessee Valley. Forestry Bulletin No. 96, Norris, Tennessee.

Tennessee Valley Authority Hydrolic Data Branch. 1957. Intense storms summary, 1956, in Tennessee Valley region. Division of Water Control Planning, Knoxville, Tennessee.

Tennessee Valley Authority Hydrolic Data Branch. 1959. Mean precipitation in the Tennessee River Basin. Division of Water Control Planning Report No. 0-243A, Knoxville, Tennessee.

Tester, J.R. 1995. Minnesota's Natural Heritage. University of Minnesota Press, Minneapolis, Minnesota.

Thompson, F.R., III. 1996. Management of midwestern landscapes for the conservation of neotropical migratory birds. U.S.D.A. Forest Service North Central Forest Experiment Station General Technical Report NC-187, St. Paul, Minnesota.

Thor, E. and D.D. Summers. 1971. Changes in forest composition on Big Ridge Natural Study Area, Union County, Tennessee. Castanea 36:114-122.

Trani(Griep), M.K. 2002. Terrestrial ecosystems. Pp. 3-45. *In*: D.N. Wear and J.E. Greis (eds.). Southern Forest Resource Assessment. Southern Forest Research Station. Asheville, North Carolina.

Trimble, G.R., Jr. and E.H. Tryon. 1966. Crown encroachment into openings cut in Appalachian hardwood stands. J. Forest. (Washington) 64:104-108.

Tyndall, R.W. (ed.). 1994. Contributions of the Barrens Symposium, Old Dominion University, Virginia, April 15, 1993. Castanea 59(3).

Underwood, J.K., K.E. Rogers, and A.J. Sharp. 1973. The Grasses of Tennessee. Unpublished ms., The University of Tennessee, Knoxville, Tennessee.

United States Department of Agriculture Forest Service. 1981. An assessment of the forest and range land situation in the United States. Forest Resource Report No. 22, Washington, D.C.

United States Department of the Interior Geological Survey. 1970. National Atlas of the United States. Washington, D.C.

United States Fish and Wildlife Service. 2002. Endangered Species Bulletin, Vol. 32. Washington, DC.

Van Horn, G. S. 1981. The success of alien angiosperm species in Chickamauga Battlefield. J. Tennessee Acad. Sci. 56:1-4.

Vanderford, D.F. 1897. The soils of Tennessee. University of Tennessee Agricultural Experiment Station Bulletin Vol. 10, No. 3, Knoxville, Tennessee.

Vankat, J.L. 1979. The Natural Vegetation of North America. John Wiley & Sons, New York.

Walck, J.L., J.M. Baskin, C.C. Baskin, and S.W. Francis. 1996. Sandstone rockhouses of the eastern United States, with particular reference to the ecology and evolution of the endemic plant taxa. Bot. Rev. 62:311-362.

Waldrop, T.A., F.T. Lloyd, and J.A. Abercrombie, Jr. 1989. Fell and burn to regenerate pine-hardwood stands: an overview of research on stand development. pp. 75-82. *In*: T.A. Waldrop (ed.), Proceedings of Pine-Hardwood Mixtures: A symposium on management and ecology of the type. Southeastern Forest Experiment Station Gen. Tech. Report. SE-58. Asheville, North Carolina.

Ward, J.D. and P.A. Mistretta. 2002. Impact of pests on forest health. Pp. 403-428. *In*: D.N. Wear and J.G. Greis (eds.). National Forest Resource Assessment. Southern Research Station. Asheville, North Carolina.

Warden, J.C. 1989. Changes in the spruce-fir forest on Roan Mountain in Tennessee over the past fifty years as a result of logging. J. Tennessee Acad. Sci. 64:193-195.

Weakley, A.S., K.D. Patterson, S. Landoal, M. Pyne, and others (compilers). 1998. International classification of ecological communities: Terrestrial vegetation of the southeastern United States. The Nature Conservancy, Chapel Hill, North Carolina.

Wear, D.N. and P. Bolstad. 1998. Land-use changes in Southern Appalachian landscapes: Spacial analysis and forecast evaluation. Ecosystems 1:575-594.

Webb, S.L. 1986. Potential role of passenger pigeons and other vertebrates in the rapid Holocene migrations of nut trees. Quat. Research 26:367-375.

West, B.E. and J.C. Rennie. 1998. Landscape ecosystem classification for the mountain highlands of the Cherokee National Forest. pp. 67-73. *In*: T.A. Waldrop (ed.), Proceedings of the ninth biennial southern silvicultural research conference at Clemson University. U.S.D.A. Forest Service Southern Research Station, Asheville, North Carolina.

Wharton, M.C. 1972. Doctor women of the Cumberlands. Uplands Publishing, Pleasant Hill, Tennessee.

Wheat, R.M. and R.W. Dimmick. 1987. Forest communities and their relationship with land types on the western Highland Rim of Tennessee. pp. 377-383. *In*: R.L. Hay, F.W. Woods, and H. De Selm (eds.), Proceedings of the Central Hardwood Forest Conference VI. February 1987, Knoxville, Tennessee.

White, P.S. 1982. The flora of Great Smoky Mountains National Park: An annotated checklist of the vascular plants and a review of previous floristic work. Research/Resources Management Report SER-55, Atlanta, Georgia.

White, P.S. 1984. The Southern Appalachian spruce-fir ecosystem–its biology and threats. National Park Service–Southeast Region Research/Resources Management Series No. 71, Springfield, Virginia.

Whittaker, R.H. 1956. Vegetation of the Great Smoky Mountains. Ecol. Monogr. 26:1-80.

Wofford, B.E. 1989. Guide to the vascular plants of the Blue Ridge. The University of Georgia Press. Athens, Georgia.

Wofford, B.E. and E.W. Chester. 2002. Trees, shrubs, and woody vines of Tennessee. The University of Tennessee Press, Knoxville, Tennessee.

Wofford, B.E. and R. Kral. 1993. Checklist of the vascular plants of Tennessee. Sida Bot. Misc. No. 10.

Woods, F.W. 1952. Disease as a factor in the evolution of forest composition. J. Forest. (Washington) 51:871-873.

Woods, F.W. and R.E. Shanks. 1959. Natural replacement of chestnut by other species in the Great Smoky Mountains National Park. Ecology 40:349-361.

Zahner, R. and G.W. Smalley. 1989. Site quality: the ecological basis for pine-hardwood management decisions. pp. 59-63. *In*: T.A. Waldrop (ed.), Proceedings of Pine-Hardwood Mixtures: a symposium on management and ecology of the type. Southeastern Forest Experiment Station Gen. Tech. Report SE-58. Asheville, North Carolina.

THE VASCULAR FLORA OF LAND BETWEEN THE LAKES, KENTUCKY AND TENNESSEE: A THIRD CHECKLIST

EDWARD W. CHESTER

The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee 37044

ABSTRACT. Land Between the Lakes, a National Recreation Area in southwestern Kentucky and northwestern Middle Tennessee, has been botanically studied since 1964. A preliminary checklist in 1971 listed 799 species and lesser taxa. A second checklist in 1993 listed 1,310 species and lesser taxa; the current and third list includes 1,334 species and lesser taxa. Descriptive information on the area is given, as well as floristic analyses that include a numerical summary of the major taxonomic categories, a list of reported but excluded taxa, rare taxa, the woody and introduced components, and floristic affinities. The botanical literature of the area is referenced.

INTRODUCTION

One of the most unique physiographic features of southeastern United States occurs in southwestern central Kentucky and northwestern central Tennessee where the lower Cumberland and Tennessee rivers flow northward and nearly parallel (<20 km apart) for about 65 km. At the northern end of the parallel segments, the Cumberland turns westward, flowing to within four km of the Tennessee before the rivers diverge, continue northward, and empty into the Ohio River. Where the rivers are nearest to each other, about 25 air km south of their confluence with the Ohio, high dams on each river have resulted in extensive reservoirs. Kentucky Dam, a Tennessee Valley Authority (TVA) facility on the Tennessee River, was completed in 1944 and formed Kentucky Lake. Barkley Dam, a United States Army Corps of Engineers facility on the Cumberland River, was completed in 1966 and formed Barkley Lake. Also in 1966, the reservoirs were connected by a canal just south of the dams. The resulting interior peninsula, 13-16 km wide, 65 km long, and encompassing nearly 69,000 ha with 500 km of shoreline, was converted to public ownership in the early 1960s and named Land Between The Lakes (LBL). The TVA was granted stewardship in 1964 with the mandate to develop a National Demonstration Area for conservation, education, and recreation. The United States Department of Agriculture, Forest Service, assumed control in late 1999.

The vascular flora of LBL has been extensively studied since 1964. This paper (1) briefly describes the location, physical and vegetational setting, and history through TVA stewardship, pointing to conditions that have allowed the present flora to develop; (2) reviews the botanical literature referencing LBL; (3) notes the methods used to determine the known floristic composition; (4) provides floristic analyses, summarizing the major taxa categories, the woody flora, introduced species, and listed elements; (5) discusses floristic affinities; and (6) provides a third checklist of the known vascular flora.

Location and Physical Setting

Land Between The Lakes occupies parts of Stewart County, Tennessee, and Lyon and Trigg counties, Kentucky. It is bounded on the west by Kentucky Lake, on the east by Barkley Lake, and on the north by the canal; the southern boundary approximates Highway 79 between Dover and Paris

Landing. Kentucky Highway 453-Tennessee Highway 49 extends north-south through LBL where it is referred to as the "Trace" in reference to historic usage. United States Highway 68 bisects LBL east-west just north of midway. The area lies between 36°26'45" and 37°02'45" north latitude, and 87°52'25" and 88°13'35" west longitude.

LBL is at the western edge of the Western Highland Rim Subsection, Highland Rim Section, Interior Low Plateaus Physiographic Province of Fenneman (1938) and Quarterman and Powell (1978). The Mississippian Embayment of the Coastal Plain Province adjoins to the west, the Central (Nashville) Basin Section is to the east, The Southern Highland Rim Subsection is to the south, and the Pennyroyal Plain Subsection is to the north.

The topography is that of a maturely dissected plateau with narrow ridges, steep slopes, and ravines. The parallel river valleys and reservoirs are the major topographic features. Closely spaced tributaries, often intermittent or seasonal and mostly running east or west, butt against each other to form a narrow drainage divide that is somewhat closer to the Tennessee than to the Cumberland River. This divide, the Tennessee Ridge, was a Native American trail and probably a game trail before that; portions of the present "Trace" follow the divide. Elevations range from 107.9 m (the normal draw-down level of the reservoirs) to about 185 m. Slopes range from 0->25 percent in bottomlands and on rolling uplands to >50 percent above some streams and ravines; a few bluffs, especially along the Tennessee River, are perpendicular.

The bedrock is predominately Mississippian cherty limestones; surface exposure is uncommon except occasionally along the lakes and major streams. Cretaceous, Tuscaloosa white chert gravels occur over much of the uplands, often overlain by McNairy Sand. In addition, Tertiary-Quaternary brown gravels often overlie the Cretaceous materials and Pleistocene silty loess veneers many uplands. Glaciers did not reach the area and karst features, such as caves and sinkholes, are mostly lacking. Upland soils have developed in thin loess over gravel and chert, and are infertile, droughty, inferior for agriculture, and with excessive erosion unless protected. Bottomland soils have developed in alluvium derived from upland erosion and are fertile; most were in tilth before inundation. Harris (1988, 2002) presented a complete review of the LBL geology and soils.

Soils are within the Cumberland-Tennessee River Section, one of the 12 major Soil Association areas of Kentucky (Bailey and Winsor 1964). These soils generally developed in thin loess over gravel and chert. Most are low in fertility, are droughty, inferior for agriculture, and with excessive erosion unless protected. As described by Bailey and Winsor (1964) and Springer and Elder (1980), the principal soils are Brandon (upland, from loess over Coastal Plain material), Guinn (upland, from sandy-gravelly, Coastal Plain material), Bodine (upland, from cherty limestone), and Baxter (upland, from cherty and clayey limestone). In addition, bottomland soils have formed in alluvium derived from upland erosion and are generally a silt loam. These are (were) agriculturally productive and most were in tilth before construction of the dams.

The humid mesothermal climate (Thornthwaite 1948) is characterized by long warm summers and short mild winters with little or no water deficiency in any season. Evaporation is great in summer months, although thunderstorms are common and severe storms occasional, usually with heavy rains. The average temperature is 14.5°C; January is the coldest month (average 2.6°C) and July the warmest (average 25.4°C). Record temperatures for the period 1898-present were -29.4°C and 41.1°C. The growing season is about 191 days (mid-April to mid-late October). Soils normally freeze to a depth of several cm more than once each winter but rarely remain frozen for more than three days. Several snowfalls, averaging a total of 31 cm, occur each winter. Annual precipitation is126.8 cm; the wettest month is March (13.49 cm), and the driest is October (7.67 cm). Extreme precipitation years were 1930 (83.5 cm) and 1979 (200.1 cm). For a complete account of geology, climate, soils, and topography, see Harris (1988, 2002) and Close, Fralish, and Franklin (2002).

Vegetational Setting

Land Between The Lakes is within the Mississippian Plateau Section,Western Mesophytic Region, Eastern Deciduous Forest Formation of Braun (1950). The vegetation is transitional from the more mesic Mixed Mesophytic Region to the east and the more xeric Oak-Hickory Region to the west. There is no single climax type but a mosaic of types occurs, with local climatic, edaphic, and topographic factors determining specific conditions. Generally, the Western Rim plant life is more closely aligned to the Oak-Hickory Region than to the Mixed Mesophytic Region (Chester, Jensen, and Schibig 1995). As a result of topography and influences of the adjacent riverine systems, a number of habitat/community types occur in LBL.

Upland forests. Secondary forests of oaks, hickories, and several other hardwoods in various combinations dominate (Chester, Jensen, and Schibig 1995; Chester and Ellis 1989; Fralish and Crooks 1988, 1989; Schibig and Chester 1988). Xeric ridges and upper slopes are dominated by *Quercus coccinea*, *Q. marilandica*, *Q. prinus*, *Q. stellata*, and *Q. velutina*, although *Q. alba* is usually present. Common upland hickories are *Carya glabra*, *C. pallida*, and *C. tomentosa*. Occasional sprouts and stumps indicate the former importance of American chestnut (*Castanea dentata*). Other common species are *Amelanchier arborea*, *Nyssa sylvatica*, and *Oxydendrum arboreum*. Slope forests are usually dominated by *Quercus alba* but may include, in addition to many of the above species, *Acer saccharum*, *Carya ovalis*, *C. ovata*, *Liriodendron tulipifera*, *Prunus serotina*, *Q. falcata*, and *Q. rubra*. More mesophytic types occur on some north-facing slopes and in ravines, including the western form of the Mixed Mesophytic Forest in at least one case (Carpenter and Chester 1987, 1988), with a greater preponderance of *Acer saccharum*, *Aesculus glabra*, *Carya cordiformis*, *Fagus grandifolia*, *Liriodendron tulipifera*, *Nyssa sylvatica*, *Prunus serotina*, and *Quercus alba*.

Narrow ravines and streambanks include *Acer negundo*, *A. rubrum*, *A. saccharinum*, *Betula nigra*, *Carpinus caroliniana*, *Carya cordiformis*, *C. ovata*, *C. laciniosa*, *Celtis laevigata*, *C. occidentalis*, *Fraxinus americana*, *F. pennsylvanica*, *Juglans nigra*, *Liquidambar styraciflua*, *Platanus occidentalis*, *Populus deltoides*, *Salix nigra*, *Ulmus americana*, and *U. rubra*. Oaks of low grounds include *Quercus lyrata*, *Q. michauxii*, *Q. pagoda*, *Q. palustris*, and *Q. shumardii*.

With the exception of *Juniperus virginiana*, which is found throughout, native gymnosperms are limited. *Taxodium distichum* is occasional along Kentucky Reservoir (planted elsewhere), several stands of *Pinus virginiana* occur on dry promontories above Kentucky Lake, and one extensive area of *Pinus echinata* occurs in Stewart County (both species planted elsewhere).

Close, Fralish, and Franklin (2002), and Franklin, Fralish, and Close (2002) provided a review of forest communities. Jensen (2002) and Schibig (2002) discussed the importance of the genera

Quercus and *Carya* (respectively) in the LBL area.

Wetlands. Most wetlands result from or are directly influenced by fluctuating water levels of the reservoirs which flood natural depressions, old channels, and low bottomlands. Wetlands and moist-soil areas developed by TVA for waterfowl include subimpoundments of the reservoirs, waterholes, and pools formed by damming creeks. In addition, numerous old farm ponds, inland lakes, and areas flooded by beaver are often significant floristically. At least six vegetation types described by Carter and Burbank (1978) may be recognized: (1) vegetated open water; (2) vegetated flats [see Baskin, Baskin, and Chester (2002) for a review]; (3) shrub swamps; (4) remnant bottomland hardwood forests; (5) wet meadows; and (6) emergent marshes.

Grasslands. The Big Barrens of Kentucky extend slightly into Stewart and adjacent Montgomery County but not into LBL (Chester 1988a, DeSelm 1989). A few grasslands are maintained by periodic burning and/or clipping; the flora includes several prairie stalwarts, both grasses and forbs (examples listed later in the discussion of floristic affinities). Martin and Taylor (2002) discussed research on native grasslands in LBL.

Cultural communities. These are communities resulting from anthropogenic influences and include old lawns, ponds, meadows, fields, fencerows, orchards, roadsides, cut-over forests, and many other remnants of a landscape that, until 1964, was a small community-farming area. Also included are monoculture stands of *Pinus strobus*, *P. taeda*, *P. virginiana*, and *Taxodium distichum*, some pre-dating TVA management and ranging from <1-several ha.

History and Present Conditions

Archeological records show that several Native American cultural groups lived or hunted in the LBL area until slightly after European settlement (see Carstens and Merritt, 2002, for a review of LBL archaeology). Spanish explorers passed through the area as early as 1540 and developed an extensive fur trade with the Indians. By the late 1600s, French explorers were establishing trading posts on the rivers and the Long Hunters found an abundance of game, including bear, bison, deer, and elk, and used the area extensively in the 1700s. Settlements were established in the "Land Between The Rivers" by Europeans between 1779 and 1800, mostly by North Carolinians who assumed land grants in exchange for Revolutionary War services. All Indian occupation ended prior to 1800, but threats of attack from groups living west of the Tennessee River hindered settlement until about 1812. Even then settlement was slow with agriculture and lumbering basic to the economy. Ross (undated), who lived on the east bank of the Cumberland River opposite southern LBL, described the region in 1808 as " ...a wild, uninhabited district which had not yet attracted the attention of settlers and (which) was almost precisely in the same state it had been in for ages, ...a wild, rugged district lying west of us between the Cumberland and Tennessee Rivers, about 12 miles in width, an almost unbroken solitude, after which commenced the Indian territory extending to the Mississippi River."

An abundance of timber and mineral resources resulted in the area becoming a center for iron furnaces and rolling mills in the middle 1800s with a subsequent increase in population. By the 1870s most of the furnaces had closed due to depletion of both high-grade ore and timber required for charcoal to operate the furnaces and the population declined significantly [see Gildrie (2002) for

THE VASCULAR FLORA OF LAND BETWEEN THE LAKES, KENTUCKY AND TENNESSEE: A THIRD CHECKLIST

EDWARD W. CHESTER

The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee 37044

ABSTRACT. Land Between the Lakes, a National Recreation Area in southwestern Kentucky and northwestern Middle Tennessee, has been botanically studied since 1964. A preliminary checklist in 1971 listed 799 species and lesser taxa. A second checklist in 1993 listed 1,310 species and lesser taxa; the current and third list includes 1,334 species and lesser taxa. Descriptive information on the area is given, as well as floristic analyses that include a numerical summary of the major taxonomic categories, a list of reported but excluded taxa, rare taxa, the woody and introduced components, and floristic affinities. The botanical literature of the area is referenced.

INTRODUCTION

One of the most unique physiographic features of southeastern United States occurs in southwestern central Kentucky and northwestern central Tennessee where the lower Cumberland and Tennessee rivers flow northward and nearly parallel (<20 km apart) for about 65 km. At the northern end of the parallel segments, the Cumberland turns westward, flowing to within four km of the Tennessee before the rivers diverge, continue northward, and empty into the Ohio River. Where the rivers are nearest to each other, about 25 air km south of their confluence with the Ohio, high dams on each river have resulted in extensive reservoirs. Kentucky Dam, a Tennessee Valley Authority (TVA) facility on the Tennessee River, was completed in 1944 and formed Kentucky Lake. Barkley Dam, a United States Army Corps of Engineers facility on the Cumberland River, was completed in 1966 and formed Barkley Lake. Also in 1966, the reservoirs were connected by a canal just south of the dams. The resulting interior peninsula, 13-16 km wide, 65 km long, and encompassing nearly 69,000 ha with 500 km of shoreline, was converted to public ownership in the early 1960s and named Land Between The Lakes (LBL). The TVA was granted stewardship in 1964 with the mandate to develop a National Demonstration Area for conservation, education, and recreation. The United States Department of Agriculture, Forest Service, assumed control in late 1999.

The vascular flora of LBL has been extensively studied since 1964. This paper (1) briefly describes the location, physical and vegetational setting, and history through TVA stewardship, pointing to conditions that have allowed the present flora to develop; (2) reviews the botanical literature referencing LBL; (3) notes the methods used to determine the known floristic composition; (4) provides floristic analyses, summarizing the major taxa categories, the woody flora, introduced species, and listed elements; (5) discusses floristic affinities; and (6) provides a third checklist of the known vascular flora.

Location and Physical Setting

Land Between The Lakes occupies parts of Stewart County, Tennessee, and Lyon and Trigg counties, Kentucky. It is bounded on the west by Kentucky Lake, on the east by Barkley Lake, and on the north by the canal; the southern boundary approximates Highway 79 between Dover and Paris

Landing. Kentucky Highway 453-Tennessee Highway 49 extends north-south through LBL where it is referred to as the "Trace" in reference to historic usage. United States Highway 68 bisects LBL east-west just north of midway. The area lies between 36°26'45" and 37°02'45" north latitude, and 87°52'25" and 88°13'35" west longitude.

LBL is at the western edge of the Western Highland Rim Subsection, Highland Rim Section, Interior Low Plateaus Physiographic Province of Fenneman (1938) and Quarterman and Powell (1978). The Mississippian Embayment of the Coastal Plain Province adjoins to the west, the Central (Nashville) Basin Section is to the east, The Southern Highland Rim Subsection is to the south, and the Pennyroyal Plain Subsection is to the north.

The topography is that of a maturely dissected plateau with narrow ridges, steep slopes, and ravines. The parallel river valleys and reservoirs are the major topographic features. Closely spaced tributaries, often intermittent or seasonal and mostly running east or west, butt against each other to form a narrow drainage divide that is somewhat closer to the Tennessee than to the Cumberland River. This divide, the Tennessee Ridge, was a Native American trail and probably a game trail before that; portions of the present "Trace" follow the divide. Elevations range from 107.9 m (the normal draw-down level of the reservoirs) to about 185 m. Slopes range from 0->25 percent in bottomlands and on rolling uplands to >50 percent above some streams and ravines; a few bluffs, especially along the Tennessee River, are perpendicular.

The bedrock is predominately Mississippian cherty limestones; surface exposure is uncommon except occasionally along the lakes and major streams. Cretaceous, Tuscaloosa white chert gravels occur over much of the uplands, often overlain by McNairy Sand. In addition, Tertiary-Quaternary brown gravels often overlie the Cretaceous materials and Pleistocene silty loess veneers many uplands. Glaciers did not reach the area and karst features, such as caves and sinkholes, are mostly lacking. Upland soils have developed in thin loess over gravel and chert, and are infertile, droughty, inferior for agriculture, and with excessive erosion unless protected. Bottomland soils have developed in alluvium derived from upland erosion and are fertile; most were in tilth before inundation. Harris (1988, 2002) presented a complete review of the LBL geology and soils.

Soils are within the Cumberland-Tennessee River Section, one of the 12 major Soil Association areas of Kentucky (Bailey and Winsor 1964). These soils generally developed in thin loess over gravel and chert. Most are low in fertility, are droughty, inferior for agriculture, and with excessive erosion unless protected. As described by Bailey and Winsor (1964) and Springer and Elder (1980), the principal soils are Brandon (upland, from loess over Coastal Plain material), Guinn (upland, from sandy-gravelly, Coastal Plain material), Bodine (upland, from cherty limestone), and Baxter (upland, from cherty and clayey limestone). In addition, bottomland soils have formed in alluvium derived from upland erosion and are generally a silt loam. These are (were) agriculturally productive and most were in tilth before construction of the dams.

The humid mesothermal climate (Thornthwaite 1948) is characterized by long warm summers and short mild winters with little or no water deficiency in any season. Evaporation is great in summer months, although thunderstorms are common and severe storms occasional, usually with heavy rains. The average temperature is 14.5°C; January is the coldest month (average 2.6°C) and July the warmest (average 25.4°C). Record temperatures for the period 1898-present were -29.4°C and 41.1^{0}C. The growing season is about 191 days (mid-April to mid-late October). Soils normally freeze to a depth of several cm more than once each winter but rarely remain frozen for more than three days. Several snowfalls, averaging a total of 31 cm, occur each winter. Annual precipitation is126.8 cm; the wettest month is March (13.49 cm), and the driest is October (7.67 cm). Extreme precipitation years were 1930 (83.5 cm) and 1979 (200.1 cm). For a complete account of geology, climate, soils, and topography, see Harris (1988, 2002) and Close, Fralish, and Franklin (2002).

Vegetational Setting

Land Between The Lakes is within the Mississippian Plateau Section,Western Mesophytic Region, Eastern Deciduous Forest Formation of Braun (1950). The vegetation is transitional from the more mesic Mixed Mesophytic Region to the east and the more xeric Oak-Hickory Region to the west. There is no single climax type but a mosaic of types occurs, with local climatic, edaphic, and topographic factors determining specific conditions. Generally, the Western Rim plant life is more closely aligned to the Oak-Hickory Region than to the Mixed Mesophytic Region (Chester, Jensen, and Schibig 1995). As a result of topography and influences of the adjacent riverine systems, a number of habitat/community types occur in LBL.

Upland forests. Secondary forests of oaks, hickories, and several other hardwoods in various combinations dominate (Chester, Jensen, and Schibig 1995; Chester and Ellis 1989; Fralish and Crooks 1988, 1989; Schibig and Chester 1988). Xeric ridges and upper slopes are dominated by *Quercus coccinea*, *Q. marilandica*, *Q. prinus*, *Q. stellata*, and *Q. velutina*, although *Q. alba* is usually present. Common upland hickories are *Carya glabra*, *C. pallida*, and *C. tomentosa*. Occasional sprouts and stumps indicate the former importance of American chestnut (*Castanea dentata*). Other common species are *Amelanchier arborea*, *Nyssa sylvatica*, and *Oxydendrum arboreum*. Slope forests are usually dominated by *Quercus alba* but may include, in addition to many of the above species, *Acer saccharum*, *Carya ovalis*, *C. ovata*, *Liriodendron tulipifera*, *Prunus serotina*, *Q. falcata*, and *Q. rubra*. More mesophytic types occur on some north-facing slopes and in ravines, including the western form of the Mixed Mesophytic Forest in at least one case (Carpenter and Chester 1987, 1988), with a greater preponderance of *Acer saccharum*, *Aesculus glabra*, *Carya cordiformis*, *Fagus grandifolia*, *Liriodendron tulipifera*, *Nyssa sylvatica*, *Prunus serotina*, and *Quercus alba*.

Narrow ravines and streambanks include *Acer negundo*, *A. rubrum*, *A. saccharinum*, *Betula nigra*, *Carpinus caroliniana*, *Carya cordiformis*, *C. ovata*, *C. laciniosa*, *Celtis laevigata*, *C. occidentalis*, *Fraxinus americana*, *F. pennsylvanica*, *Juglans nigra*, *Liquidambar styraciflua*, *Platanus occidentalis*, *Populus deltoides*, *Salix nigra*, *Ulmus americana*, and *U. rubra*. Oaks of low grounds include *Quercus lyrata*, *Q. michauxii*, *Q. pagoda*, *Q. palustris*, and *Q. shumardii*.

With the exception of *Juniperus virginiana*, which is found throughout, native gymnosperms are limited. *Taxodium distichum* is occasional along Kentucky Reservoir (planted elsewhere), several stands of *Pinus virginiana* occur on dry promontories above Kentucky Lake, and one extensive area of *Pinus echinata* occurs in Stewart County (both species planted elsewhere).

Close, Fralish, and Franklin (2002), and Franklin, Fralish, and Close (2002) provided a review of forest communities. Jensen (2002) and Schibig (2002) discussed the importance of the genera

Quercus and *Carya* (respectively) in the LBL area.

Wetlands. Most wetlands result from or are directly influenced by fluctuating water levels of the reservoirs which flood natural depressions, old channels, and low bottomlands. Wetlands and moist-soil areas developed by TVA for waterfowl include subimpoundments of the reservoirs, waterholes, and pools formed by damming creeks. In addition, numerous old farm ponds, inland lakes, and areas flooded by beaver are often significant floristically. At least six vegetation types described by Carter and Burbank (1978) may be recognized: (1) vegetated open water; (2) vegetated flats [see Baskin, Baskin, and Chester (2002) for a review]; (3) shrub swamps; (4) remnant bottomland hardwood forests; (5) wet meadows; and (6) emergent marshes.

Grasslands. The Big Barrens of Kentucky extend slightly into Stewart and adjacent Montgomery County but not into LBL (Chester 1988a, DeSelm 1989). A few grasslands are maintained by periodic burning and/or clipping; the flora includes several prairie stalwarts, both grasses and forbs (examples listed later in the discussion of floristic affinities). Martin and Taylor (2002) discussed research on native grasslands in LBL.

Cultural communities. These are communities resulting from anthropogenic influences and include old lawns, ponds, meadows, fields, fencerows, orchards, roadsides, cut-over forests, and many other remnants of a landscape that, until 1964, was a small community-farming area. Also included are monoculture stands of *Pinus strobus*, *P. taeda*, *P. virginiana*, and *Taxodium distichum*, some pre-dating TVA management and ranging from <1-several ha.

History and Present Conditions

Archeological records show that several Native American cultural groups lived or hunted in the LBL area until slightly after European settlement (see Carstens and Merritt, 2002, for a review of LBL archaeology). Spanish explorers passed through the area as early as 1540 and developed an extensive fur trade with the Indians. By the late 1600s, French explorers were establishing trading posts on the rivers and the Long Hunters found an abundance of game, including bear, bison, deer, and elk, and used the area extensively in the 1700s. Settlements were established in the "Land Between The Rivers" by Europeans between 1779 and 1800, mostly by North Carolinians who assumed land grants in exchange for Revolutionary War services. All Indian occupation ended prior to 1800, but threats of attack from groups living west of the Tennessee River hindered settlement until about 1812. Even then settlement was slow with agriculture and lumbering basic to the economy. Ross (undated), who lived on the east bank of the Cumberland River opposite southern LBL, described the region in 1808 as " ...a wild, uninhabited district which had not yet attracted the attention of settlers and (which) was almost precisely in the same state it had been in for ages, ...a wild, rugged district lying west of us between the Cumberland and Tennessee Rivers, about 12 miles in width, an almost unbroken solitude, after which commenced the Indian territory extending to the Mississippi River."

An abundance of timber and mineral resources resulted in the area becoming a center for iron furnaces and rolling mills in the middle 1800s with a subsequent increase in population. By the 1870s most of the furnaces had closed due to depletion of both high-grade ore and timber required for charcoal to operate the furnaces and the population declined significantly [see Gildrie (2002) for a discussion of historic timber usage in LBL].

The Civil War heavily involved the area since the rivers were important transportation systems for both armies. Fort Henry on the Tennessee River within present-day LBL (mostly inundated) and Fort Donelson on the Cumberland River just outside LBL, were Confederate fortifications involved in major engagements; LBL served as an overland connector between the forts. After the war, guerilla bands roamed the area and the populace was faced with survival in an area torn by war, fear, hunger, crime, and such diseases as typhoid, malaria, and smallpox. Development was slow and many land grants fragmented into smaller units, some corporately-owned. No railroads entered the area, no cities were established, and farming, often of a subsistence type, predominated. By the turn of the twentieth century economic conditions were bleak, life extremely hard, and the people isolated. Sauer (1927) described the area as "A region dominated in landscape by forest, sparsely populated and little visited by outsiders, separated and isolated in its neighborhood life, divided in its outlook, little touched by progress. . ."

Major changes came to the area and its people after 1930 as a result of federal projects. The existing Honker and Hematite lakes were built by Work Progress Administration (WPA) forces in the middle 1930s. Kentucky Woodlands National Wildlife Refuge was developed by the United States Fish and Wildlife Service on the Cumberland River (Lyon and Trigg counties) in 1938. Kentucky Dam flooded the rich Tennessee River bottomlands in 1944, while Barkley Dam inundated most Cumberland River bottomlands in 1966. The sparse population consisted of about 950 families and somewhere between 2700 (Smith 1971) and 5000 people (Wallace 1988) when federal ownership for the entire peninsula was proposed in 1961. At that time there were few on-site doctors, no hospitals or public water-sewer systems, and only scattered communities had telephone service. Smith (1971) noted that "In short, the Land Between the Lakes area had remained as nearly untouched by America's industrializing, urbanizing trends as any area of comparable size in the eastern United States." By 1966 acquisition of the farms, country stores, churches, homes, corporately-owned woodlands, and other properties was complete. The wildlife refuge was moved southward and outside of LBL in 1962, becoming Cross Creeks National Wildlife Refuge. The history of LBL has been detailed by Smith (1971), Henry (1976), and Wallace (1988, 1992, 2002).

Presently, about 80 percent of LBL is forested, but all woodlands were disturbed to some degree prior to 1962 by cuttings, fires, and pasturing. Since 1962, TVA management has included rotational harvests ranging from selective to clear-cutting. A few small woodlands are relatively old or have other significant features and are protected: one is a National Natural Landmark, another is a Tennessee Natural Area, several are TVA Ecological Study Sites, and three are Society of American Foresters Natural Areas. Also, designation as a Biosphere Preserve resulted in protection for other sites (Forsythe 2002). Most non-forested lands show the results of various anthropogenic influences before 1962. Successional fields, old ponds, fences, roads, orchards, and gardens, as well as ancient iron-ore pits and furnaces are prominent features. Many homeplaces are yet well-marked by foundation stones and persisting introduced plant species.

Inland lakes include Bards (130 ha, Stewart County) and Energy (150 ha, Trigg County), both subimpoundments of Lake Barkley built in the 1960s, and Duncan (20 ha, Lyon County), formed when Duncan Creek was dammed in the 1970s. Many old fields and powerline rights-of-way are maintained by "bush-hogging" and area farmers lease some fields for corn, soybeans, and hay. There are developed and primitive campgrounds, hiking trails, an off-road vehicle area, visitor's center, nature center, picnic areas, wrangler's camp with barns and riding trails, and various educational, conservation, and demonstration areas, including a working 1850s-model farmstead. A herd of American bison is maintained in a fenced area exceeding 100 ha in Stewart County and there is a fenced Bison-Elk Prairie of about 300 ha in Trigg County. Wildlife management (deer, turkey, small game, waterfowl) has been a major objective and operations include food and cover plantings, waterholes, and moist-soil areas. Beaver, turkey and whitetail deer are commonplace and a breeding herd of European deer roam free in and around an environmental education area. Hunting, fishing, camping, hiking, and picnicing are major activities. Several hundred cemeteries, at various levels of maintenance, remain the only part of the area not under federal management.

HISTORY OF FLORISTIC STUDIES

Early published works including LBL were those of Kellerman (1959), who studied wetland plants of western Kentucky, and Thomas (1963), who compared three community types within the future LBL. During the planning stages of LBL, biologists at Austin Peay State University conducted preliminary surveys of the biota and published popular accounts for the tourist trade and for TVA's educational programs. Much of that research was conducted prior to 1970 and resulted in color guides to the ferns and lichens (Phillips 1974), spring wildflowers, summer and fall wildflowers, and trees and shrubs (Ellis and Chester 1971, 1973, 1980). Journal accounts of the flora began with an introduction by Riggins and Ellis (1966) and a checklist (**the first checklist**) of 799 taxa by Ellis, Wofford, and Chester (1971). Phillips (1970) published a list of lichens (updated by Dey and Eyer 1993), Clebsch (1974) reported on the bryophytes, and Chester, Schibig, and Jensen (1976) listed the woody flora. Floristic additions were made by Chester (1967, 1982, 1986a, 1988b), Chester and Souza (1986), Chester, Quick, and Mosley (1987), Chester and Holt (1989), Ramsey and Chester (1981), Schibig and Chester (1979), and Webb and Chester (1989). Rare plants were listed by Chester and Holt (1990), the pteridophyte flora by Noel, McReynolds, and Chester (1990), and the families Fagaceae and Juglandaceae detailed by Schibig, Jensen, and Chester (1990). The flora of Kentucky Reservoir dewatered flats was studied by Webb, Dennis, and Bates (1988) and Webb and Bates (1989); that of Lake Barkley flats was studied by Chester (1992). Baskin, Baskin, and Chester (2002) summarized several years of work on the ecology of mudflats. Jensen (1988, 1989) studied hybridization in LBL oaks and a pictorial guide to wildflowers was developed by Chester and Ellis (1995) and to wildflowers and woody plants (Chester and Ellis 2000). An updated checklist (**the second checklist**) of the vascular flora was given by Chester (1993).

Reports for state or federal agencies on significant sites and species include those of Quarterman and Powell (1978), Scott, Chester, and Snyder (1980), and DeSelm, Schmalzer, and Patrick (1982). The Bear Creek Natural Area, a National Natural Landmark and a Tennessee Natural Area, was studied by Carpenter and Chester (1987, 1988). The summary of four decades of Tennessee Valley Authority Stewardship of LBL (Chester and Fralish 2002) include chapters on 1) the vegetation and forest communities (Close, Fralish, and Franklin); 2) grasslands (Martin and Taylor); 3) oaks (Jensen); 4) hickories (Schibig); and mudflats (Baskin, Baskin, and Chester).

METHODS

Data for this checklist were obtained from literature reports, herbarium collections, and field work. All papers referencing the LBL flora were critically examined and voucher specimens verified. Literature reports without verifiable vouchers were excluded. Regional herbaria visited one-several times include the Athey Herbarium (now at MUR), APSC, EKY, KNK, KY, MEM (now at TENN), MTSU, MUR, TENN, TENN at Martin, TTU, TVA at Muscle Shoals, VDB (now at BRIT), and WKU (abbreviations are standards for herbaria or institutions). National herbaria were not consulted.

Several hundred collecting trips since 1967 have covered much of the area and led to more than 7,000 collections. No collections were taken from recent, obvious plantings but introduced taxa persisting around old homes, farms, and in cemeteries were collected. Special attention was given to locating state or federally-listed rare species. When combined with specimens collected prior to 1967 as vouchers for the preliminary checklist of Ellis et al. (1971), nearly 12,000 LBL specimens are housed at APSC. Identifications (many verified or annotated by experts) were from standard manuals, including Fernald (1950), Radford, Ahles, and Bell (1968), Cronquist (1980), Gleason and Cronquist (1991), and Isely (1990, 1998), or recent revisions and monographs (e.g., Argus 1986, Lelong 1984, Flora of North America Editorial Committee 1993, 1997, 2000). However, the checklist follows Wofford and Kral (1993) unless noted otherwise.

RESULTS AND DISCUSSION

The known LBL vascular flora consists of 1,334 species and lesser taxa within 606 genera and 144 families. A taxonomic summary is given in Table 1. Four families dominate: Asteraceae (164 taxa), Poaceae (143), Cyperaceae (85), and Fabaceae (78). These four families (<3 percent of all families) account for 470 (35.2 percent) of all taxa. Other large families include the: Rosaceae (53 taxa), Lamiaceae (45), Scrophulariaceae (34), Brassicaceae (32), Apiaceae and Ranunculaceae (27 each), Liliaceae (26), Polygonaceae (25), Fagaceae (24), Caryophyllaceae (20), Euphorbiaceae (19), Rubiaceae (18), Onagraceae (16), Orchidaceae (15), Juncaceae and Solanaceae (14 each), Asclepiaceae (13), Juglandaceae, Salicaceae, and Violaceae (12 each), Clusiaceae and Vitaceae (11 each), and the Convolvulaceae (10).

Carex is the largest genus with 47 taxa, followed by *Panicum* (25), *Quercus* (21), *Cyperus*, *Polygonum*, and *Solidago* (16 each), *Aster*, *Desmodium*, and *Eupatorium* (14 each), *Helianthus* and *Juncus* (12 each), *Viola* (11), and *Carya* and *Ranunculus* (10 each). As expected, the largest genera are those with species occurring in a number of habitat types, such as *Carex*, or those with several introduced taxa, such as *Eragrostis* and *Prunus*.

Table 1. Floristic summary of the Land Between The Lakes vascular flora.

Taxa Group	Families	Genera	Native Taxa	Introduced Taxa	Total
Ferns/Allies	14	22	31	0	31
Gymnosperms	3	5	4	6	10
Monocots	20	127	272	72	344
Dicots	107	452	712	237	949
TOTAL	144	606	1,019	315	1,334

Woody Flora

The woody flora consists of 203 taxa of trees, shrubs, and subshrubs, and 33 taxa of vines. These 236 taxa make up 17.7 percent of the total flora. This percentage is lower than that reported for other mid-south areas, e.g., 21 percent for the Great Smoky Mountains National Park (White 1982), and for Fort Donelson National Battlefield (Chester 1986b), and 25 percent for Shiloh National Military Park (Jones and White 1981). Sixty-six taxa (nearly 28 percent) are not native. Major tree/shrub genera are *Quercus* (21 taxa), *Carya* (10), *Crataegus* (8), *Prunus* (8), and *Pyrus* (including *Malus*) (7). Major woody vine genera are *Vitis* (8) and *Smilax* (4).

Introduced Taxa

The non-indigenous taxa mostly result from anthropogenic influences over the past 200 years. While further study and analysis will be required to completely categorize these taxa and to determine those that pose the most serious threats to native flora, several points can be made. The 315 non-indigenous taxa comprise 23.6 percent of the flora. This is higher than the 20 percent reported by White (1982) for the Great Smoky Mountains National Park and the 11.9 percent reported by Jones and White (1981) for Shiloh National Battlefield, but is about the same as that found in the heavily disturbed Fort Donelson National Battlefield (Chester 1986b). About 20 percent of the Tennessee flora is not native (Wofford and Kral 1993). Major families with introduced taxa are the Poaceae (44 taxa), Asteraceae (30), Fabaceae (27), Rosaceae (23), Brassicaceae (15), Lamiaceae (13), Liliaceae and Polygonaceae (11 each), Caryophyllaceae (10), Malvaceae, Scrophulariaceae and Solanaceae (7 each), Cucurbitaceae (5) and Oleaceae (4). Major introduced genera are *Trifolium* (7 taxa), *Polygonum* (6), *Prunus* and *Pyrus* (5 each), *Bromus*, *Rumex*, *Spiraea*, and *Setaria* (4 each), and *Allium*, *Artemesia*, *Cerastium*, *Eragrostis*, *Helianthus*, *Muscari*, *Poa*, *Philadelphus*, *Populus*, *Rosa*, *Rubus*, and *Vicia* (three each).

Based on origin and distribution data in Fernald (1950), most of the non-indigenous taxa are natives of Europe and the Old World; other origins include Asia, Eurasia, and Tropical America. A few species are native to another region of the United States (e.g., *Maclura pomifera*), and a few are native to other parts of Kentucky and/or Tennessee (e.g., *Pinus strobus*).

Several interesting species groups are included within these introductions. Old home sites, lawns, gardens, and orchards are recognized by the persistence of such herbs as *Cynodon dactylon*, *Hemerocallis fulva*, *Iris germanica*, *Lathyrus latifolius*, *Muscari* spp., *Narcissus* spp., and *Polygonum* spp.; common woody forms are *Albizia julibrissin*, *Euonymus fortunei*, *Forsythia* spp., *Hibiscus syriacus*, *Ligustrum* spp., *Paulownia tomentosa*, *Prunus persica*, *Pyrus communis*, *P. malus*, *Rosa* spp., *Spiraea* spp., and *Vinca* spp. A second group includes ornamentals mostly persisting from the original plantings, e.g., *Magnolia grandiflora*, *Picea abies*, *P. glauca*, and *Populus nigra*; some of these taxa may no longer exist in LBL. Another group includes species that were once utilized in crop production and are now naturalized and often weedy (*Dactylis glomerata*, *Festuca elatior*, *Kummerowia* spp., *Phleum pratense*, *Trifolium* spp., *Vicia* spp.). Other cultivars sometimes appear as waifs on reservoir shorelines or around camp sites (*Hibiscus esculentus*, *Lycopersicum esculentum*). A few species planted for erosion control and/or wildlife food have become serious pests (*Elaeagnus umbellata*, *Lespedeza cuneata*, *Pinus taeda*, *Pueraria montana* var. *lobata*, *Rosa multiflora*). The largest exotic group includes those species that were introduced by accident, by intention, or for unknown reasons and now thrive in disturbed habitats. Included are *Amaranthus* spp., *Lonicera japonica*, *Ranunculus sardous*, *Rumex crispus*, *Sorghum halepense*, and several dozen others.

Rare Elements

Land Between The Lakes is a significant preserve for rare plants of the western Interior Low Plateaus Province. Chester and Holt (1990) surveyed the listed vascular plants and that list is updated in Table 2 (Tennessee Natural Heritage Program 2003; Kentucky State Nature Preserves Commission 2000). Fifty-two species that are listed in Kentucky and/or Tennessee are known from at least one of the LBL counties. Several listed species are rather widespread (e.g., *Panax quinquefolius*) while others may be extirpated from LBL (e.g., *Lysimachia fraseri*, *Polytaenia nuttallii*). *Apios priceana* (Price's potato bean) is the only federal-listed species (threatened); this globally-rare species is known from at least three small populations in LBL. Obviously, future management and habitat manipulation within LBL should first consider the impact upon rare plants (and animals). Demographic studies, monitoring of presently-known sites, and continued searches for new sites are vital for all listed taxa.

Floristic Affinities

LBL includes a number of floristic elements. Species more characteristic of eastern highlands (i.e., an Appalachian element) include *Gaylussacia baccata*, *Halesia carolina*, *Itea virginica*, *Kalmia latifolia*, and *Pinus virginiana*. The Tennessee River may have been the migratory route for some or all of these. Species indicative of the "limestone flora" of central Tennessee include *Aristolochia tomentosa*, *Bumelia lycioides*, *Fraxinus quadrangulata*, *Lesquerella lescurii*, *Ptelea trifoliata*, *Quercus macrocarpa*, and *Ulmus serotina*. The Cumberland River has served as a migratory pathway for many of these taxa. Species characteristics of bottomland forests mostly found west of the Tennessee River include *Ampelopsis arborea*, *Brunnichia cirrhosa*, *Carya illinoinensis*, *Ilex decidua*, *Nyssa aquatica*, *Planera aquatica*, *Quercus lyrata*, *Q. michauxii*, *Q. nigra*, *Q. pagoda*, *Styrax americana*, *Taxodium distichum*, and *Vitis palmata*.

A grassland element occurs in various situations, especially in southern and middle LBL. There may be found such species as *Andropogon gerardi*, *Panicum virgatum*, *Schizachyrum scoparium*, *Sorghastrum nutans*, *Spartina pectinata* (rare), and *Tripsacum dactyloides*. Herbs more characteristic of barrens-grasslands include *Asclepias hirtella*, *A. verticillata*, *Dalea candidum*, *Echinacea pallida*, *Helianthus maximiliani*, *H. mollis*, *Lithospermum canescens*, *Ratibida pinnata*, *Salvia azurea*, and *Silphium* spp.

Yearly reservoir drawdowns in late summer-autumn expose extensive mudflats that provide habitat for numerous species not known from the area previously. These include *Fimbristylis vahlii*, *Hemicarpha micrantha*, *Leptochloa panicoides*, *Oldenlandia boscii*, and *O. uniflora*. The reservoirs also have provided a habitat for the introduction and naturalizations of such aquatic weeds as *Alternanthera philoxeroides*, *Ludwigia uruguayensis*, *Myriophyllum spicatum*, and *Najas minor*, and for the expansion of such native aquatics as *Azolla caroliniana* and *Zannichellia palustris*.

Table 2. State-listed taxa known from Land Between The Lakes based on Kentucky State Nature Preserves Commission (2000) and Tennessee Natural Heritage Program (2003).

Taxa	Status in KY[1]	Status in TN[1]	LBL Distribution[2]
Aesculus pavia L., Red Buckeye	T	-	S
Apios priceana Robin., Price's Potato Bean	E	E	S,T
Armoracia aquatica (Gray) Al-Sh. & Bates, Lake Cress	T	S	L,S,T
Asclepias purpurascens L., Purple Milkweed	-	T	L,S,T
Aster hemisphericus Alex., Prairie Aster	E	-	S,T
Aureolaria patula (Chapm.) Penn., False Foxglove	S	T	S
Baptisia bracteata Ell., Cream False Indigo	S	S	L,S,T
Cacalia suaveolens L., Sweet Indian Plantain	-	T	L,S,T
Carex comosa Boott, Bearded Sedge	H	T	S
Carex lacustris Willd., Lake-Margin Sedge	-	T	L,S,T
Castanea dentata (Marsh.) Borkh., American Chestnut	E	S	S,T
Ceanothus herbaceus Raf., Prairie Redroot	T	-[3]	L[4]
Cimicifuga rubifolia Kearney, Black Cohosh	T	T	S
Dalea candida Michx. ex Willd., White Prairie Clover	-	S	L,T
Echinacea pallida Nuttall, Pale Coneflower	-	T	L
Gymnopogon ambiguus (Michx.) BSP., Beardgrass	S	-	S,T
Halesia carolina L., Silverbell	T	-	L,S,T
Hedeoma hispidum Pursh, Rough Pennyroyal	T	-	L
Heteranthera dubia (Jacq.) MacM., Water Stargrass	S	-	L,T
Heteranthera limosa (Sw.) Willd., Mud Plantain	S	T	S,T
Hottonia inflata Ellis, Featherfoil	-	S	S
Hydrastis canadensis L., Golden Seal	-	S-CE	L,S,T
Iris brevicaulis Raf., Lamance Iris	-	E	S
Juglans cinerea L., White Walnut	S	T	S,T
Lesquerella lescurii (Gray) Watson, Nashville Mustard	S	-	S,T
Lilium michiganense Farw., Michigan Lily	-	T	L,S
Liparis loeselii Rich., Fen Orchid	T	E	S
Lysimachia fraseri Duby, Fraser's Loosestrife	E	T	S(PE)
Matelea carolinensis (Jacq.) Woodson, Carolina Anglepod	E	-	S
Muhlenbergia glabrifloris Scribn., Smooth-Flowered Muhly	S	S	L,T
Najas gracillima (Braun) Magnus, Slender Naiad	S	-	T
Nemophila aphylla (L.) Brumm., Nemophila	T	-	S
Oldenlandia uniflora L., One-Flowered Sweet-Ear	E	-	S,T
Panax quinquefolius L., Ginseng	-	S-CE	L,S,T
Paspalum boscianum Flugge, Bull-Grass	S	-	S
Phacelia ranunculacea (Nutt.) Const., Phacelia	S	S	S
Populus grandidentata Michx., Large-Tooth Aspen	-	S	S,T
Polytaenia nuttallii DC., Whitenymph	PE	T	T(PE)
Prenanthes barbata (T.&G.) Milstead, Bearded Rattlesnake Root	E	S	S

Continued next page

Table 2, Continued

Pyrus angustifolia Michx., Narrow-Leaf Crabapple	S	-	L,S,T
Ptilimnium capillaceum (Michx.) Raf., Mock Bishop's Weed	T	-	L,S,T
Ptilimnium nuttallii (DC.) Britt., Mock Bishop's Weed	E	-	L,S,T
Ranunculus flabellaris Raf., Yellow Water-Crowfoot	-	T	T
Sagittaria brevirostra M.&B., Shorted-Beaked Arrowhead	-	T	L,S
Sagittaria graminea Michx., Grass-Leaf Arrowhead	T	T	T
Salvia azurea Lam., Blue Sage	-	S	L,S,T
Silphium pinnatifidum Ell., Prairie Dock	S	T	L,S,T
Solidago buckleyi T. & G., Buckley's Goldenrod	S	-	L
Trepocarpus aethusae Nutt., Trepocarpus	T	-	L,S,T
Trifolium reflexum L., Buffalo Clover	E	E	T
Ulmus serotina Sarg., September Elm	S	-	L,S
Zanthoxylum americanum Mill., American Prickly Ash	-	S	T

[1]T = threatened; E = endangered; S = special concern (-CE = commercially exploited); PE = possibly extirpated; H = historic record only.
[2]S = Stewart County, TN; L = Lyon County, KY; T = Trigg County, KY.
[3]This taxon is not known from Tennessee
[4]See checklist for details.

Further study will be required to determine floristic affinities and changes resulting from such anthropogenic influences as the reservoirs and their annual fluctuation cycles, the withdrawal of agricultural practices from much of the area, the often over-abundant wildlife (especially beaver and deer), selective and clear-cutting of forests, and the maturation of some forests in the absence of human influences.

EXCLUDED TAXA

Previously reported taxa that are now excluded are listed in Table 2. Information is given for each in the following order: taxon, family, (counties and source of citation: L = Lyon County; S = Stewart County; T = Trigg County), and reason for exclusion.

Table 2. Reported but excluded taxa.

Agrimonia gryposepala Wallr., Rosaceae (L,S,T by Ellis, Wofford, and Chester1971). This rather rare, mostly mountain species is not known from LBL; specimens previously reported as *A. gryposepala* are assignable to other taxa.

Amorpha nitens F. E. Boynton, Fabaceae (L,S,T by Chester, Schibig, and Jensen (1976) and Chester (1993). This taxon is not separated from *A. fruticosa* by Wofford and Kral (1993).

Asclepias quadrifolia Jacq., Asclepiadaceae (S,T by Ellis, Wofford, and Chester1971). Dr. Ralph Thompson, Berea College, examined these specimens and decided that they were *A. variegata* L., even though some have 4-whorled leaves.

Aureolaria virginica (L.) Pennell, Scrophulariaceae (S by Ellis, Wofford, and Chester1971). There is no voucher for this report and I have not found the species in LBL.

Aster azureus Lindl., Asteraceae (L,S by Ellis, Wofford, and Chester 1971). Max Medley, University of Louisville, annotated these specimens as *A. shortii* Lindl.

Carex convoluta Mackenzie, Cyperaceae (S by Ellis, Wofford, and Chester 1971). I have followed Radford, Ahles, and Bell (1968) and assigned these questionable specimens to *C. rosea* Schk.

Carex striatula Michx., Cyperaceae (S by Carpenter and Chester 1987). I am not able, without doubt, to separate material on which this report is based from *C. laxiflora* Lam.; it is deleted pending examination by others more versed in this complex genus.

Carex virescens Muhl., Cyperaceae (S by Ellis, Wofford, and Chester 1971). Dr. Robert Kral, Vanderbilt University, pointed out that this material is the rare *C. shortiana* Dewey.

Carya texana Buckl., Juglandaceae (S by Fralish and Crooks 1989). Dr. Fralish (personal communication) later decided that this specimen was actually *C. pallida* (Ashe) Engl. & Graebn.

Celtis tenuifolia Nutt. var. *georgiana* (Small) Fernald and Schub., Ulmaceae (T by Ellis, Wofford, and Chester 1971; also mapped in T by Little 1977). We are within the range of this species and it is to be expected. However, I have seen no area material definitely assignable to it and neither has Dr. Kenneth Nicely (personal communication), Western Kentucky University, who has studied this group for a number of years.

Chrysopsis mariana (L.) Ell., Asteraceae (S by Ellis, Wofford, and Chester 1971). Based on a misidentification of *C. camporum* Greene material; *C. mariana* does not occur in this part of Tennessee (Semple and Chinnappa 1986).

Cirsium arvense (L.) Scop., Asteraceae (T by Thomas 1963). No vouchers were found at DHL to substantiate this report and I have seen no vouchers from LBL.

Cornus foemina Miller (*C. stricta* Lam.) (S,T by Chester, Schibig, and Jensen 1976, L,S,T by Chester 1993). Dr. Z. Murrell annotated these specimens as *C. amomum.*

Cornus obliqua Raf. (*C. purpusi* Koehne, *C. amomum* Mill. subsp. *obliqua* Wilson), (S,T by Chester, Schibig, and Jensen 1976 and Chester 1993). Dr. Z. Murrell annotated these specimens as *C. amomum.*

Cuscuta pentagona Engel., Convolvulaceae (S,T by Ellis, Wofford, and Chester 1971). I am not able to distinguish specimens on which this report was based from *C. campestris* Yuncker.

Cyperus odoratus L., Cyperaceae (L,S,T by Ellis, Wofford, and Chester 1971). All of our material is assignable to *C. ferruginescens* Boeckl. when keyed in most manuals (Fernald 1950, Radford, Ahles, and Bell 1968). However, *C. ferruginescens* should perhaps be considered part of *C. odoratus,* as suggested by Beal and Thieret (1986).

Desmodium ochroleucum M.A. Curtis, Fabaceae (S by Ellis, Wofford, and Chester 1971 and Chester 1993). Annotations by J. Raveill (VDB) in 1993 indicate that these specimens are probably of hybrid origin with *D. rotundifolium* involved in the parentage.

Eleocharis engelmannii Steud., Cyperaceae (S by Ellis, Wofford, and Chester 1971). I have followed Beal and Thieret (1986) and included this taxon under *E. obtusa* (Willd.) Schultes.

Eleocharis tenuis (Willd.) Schultes, Cyperaceae (S by Ellis, Wofford, and Chester 1971). This report was based on an immature plant of questionable affinity.

Fraxinus nigra Marsh., Oleaceae (T by Thomas 1963). No vouchers were found at DHL to substantiate this report and the species has not otherwise been reported from Kentucky (Little 1971, Meijer 1971).

Glyceria melicaria (Michx.) Hubb., Poaceae (T by Ellis, Wofford, and Chester 1971). Report based on a misidentification of *G. striata* (Lam.) Hitch. material, as determined by the late Dr. Ernest O. Beal, Western Kentucky University.

Heracleum lanatum Michx., Apiaceae (T by Thomas 1963). Primarily a mountain species previously reported only from Letcher County (Braun 1943). There are no vouchers for Trigg County at DHL and its presence in LBL is unlikely.

Hypericum densiflorum Pursh, Clusiaceae (T by Ellis, Wofford, and Chester 1971). I have seen no LBL material definitely assignable to this species.

Lespedeza violacea (L.) Pers., Fabaceae (L,S,T by Ellis, Wofford, and Chester 1971). Dr. Ralph L. Thompson, Berea College, annotated these vouchers as *L. repens* (L.) Barton.

Liatris aspera Michx., Asteraceae (L,S,T by Ellis, Wofford, and Chester 1971, L,S by Chester 1993). Milo Pyne pointed out that these specimens are *L. squarrosa* (L.) Michx.

Lilium canadense L., Liliaceae (L by Ellis, Wofford, and Chester 1971). Our specimens were identified as *L. canadense* L. by Dr. Robert G. Johnson, West Virginia University, in 1967. However, according to the treatment of Adams and Dress (1982), our material is *L. michiganense* Farwell.

Lilium superbum L., Liliaceae (S by Ellis, Wofford, and Chester 1971). Report based on a misidentification of *L. michiganense* Farwell material (see previous entry).

Lysimachia terrestris (L.) BSP., Primulaceae (S by Ellis, Wofford, and Chester 1971). Dr. Tom S. Cooperrider, Kent State University, determined these specimens to be the rare *L. fraseri* Duby.

Micranthemum umbrosum (Walt.) Blake, Scrophulariaceae (S by Ellis, Wofford, and Chester 1971). A misidentification of *Veronica* material, pointed out by Dr. John Thieret, Northern Kentucky University.

Oenothera tetragona Roth., Onagraceae (L,T by Ellis, Wofford, and Chester 1971). I am following Straley (1977) and combining this material with *O. fruticosa* L.

Paspalum circulare Nash, Poaceae (S by Ellis, Wofford, and Chester 1971). Specimens previously assigned here were annotated as *P. laeve* by Dr. Charles Allen, LSU-Eunice, in 1988.

Peltandra virginica (L.) Schott and Endl., Araceae (T by Thomas 1963). The report is not vouched at DHL, and I have not seen this species in LBL. However, it is widely distributed in western Kentucky (Beal and Thieret 1986) and may yet turn up in LBL.

Plantago major L., Plantaginaceae (L,S,T by Ellis, Wofford, and Chester 1971, T by Thomas 1963). The Ellis, Wofford, and Chester reports were based on misidentifications of *P. rugelii* material; the Thomas report is not vouched at DHL but probably also was based on *P. rugelii* specimens; *P. major* is not expected in LBL.

Poa chapmaniana Scribn., Poaceae (S by Carpenter and Chester 1987). These specimens appear to be *P. annua* L.

Psoralea psoralioides (Walt.) Cory var. *psoralioides,* Fabaceae (L,T by Ellis, Wofford, and Chester 1971). All of our material is nonglandular and hence belongs to the var. *eglandulosa* (Ell.) Freeman = *Orbexilum pedunculatum* (Miller) Rydb. var. *pedunculatum.*

Schrankia sp., Fabaceae (T by Thomas 1963). *Schrankia microphylla*, the common sensitive brier, occurs throughout the Southeast, including Kentucky (Braun 1943, Radford, Ahles, and Bell 1968) but I have not found it in LBL and this report is not vouched at DHL.

Smilax walteri Pursh, Liliaceae (S by Chester, Schibig, and Jensen 1976, T by Ellis, Wofford, and Chester 1971). Our specimens cannot be definitely assigned to this species and I am not including it. While certainly possible in LBL, its confirmed presence would represent a considerable disjunction to the northwest (Duncan 1975).

Stellaria aquatica (L.) Scop., Caryophyllaceae (S by Ellis, Wofford, and Chester 1971). A misidentification. However, this species is known from northern Kentucky (Beal and Thieret 1986) and could be a part of the LBL flora.

Thaspium barbinode (Michx.) Nutt., Apiaceae (T by Ellis, Wofford, and Chester 1971). Based on a specimen later identified as *T. pinnatifidum* (Buckl.) Gray by Dr. Anne H. Lindsey, University of North Carolina at Chapel Hill.

Thaspium pinnatifidum (Buckl.) Gray, Apiaceae (T by Chester 1986). Perpetuation of the error cited under *Thaspium barbinode* (see previous entry). The specimen is actually *Polytaenia nuttallii* DC.

Utricularia minor L., Lentibulariaceae (L by Kellerman 1959). Reported from Hematite Lake, which is actually in Trigg County. However, this northern species does not extend into Kentucky and the report is almost certainly an error, as pointed out by Beal and Thieret (1986). The common bladderwort of the Hematite area is *U. gibba* L.

Vernonia baldwinii Torrey, Asteraceae (T by Thomas 1963). A midwestern species (Cronquist 1980) known only from Carlisle County in extreme western Kentucky (Meijer 1972). While it may occur in LBL, it is excluded here in the absence of vouchers at DHL to substantiate the Thomas report.

Vernonia missurica Raf., Asteraceae (L,S by Ellis, Wofford, and Chester 1971). Dr. Samuel B. Jones, University of Georgia, determined the specimens on which these reports were based to be either *V. gigantea* (Walt.) Trel. ex Branner and Coville, or hybrids. However, *V. missurica* definitely is known from barrens in adjacent Montgomery County, Tennessee, to the east and was reported by Woods and Fuller (1988) from Calloway County, Kentucky, to the west and it may occur in LBL.

Viburnum molle Michx., Caprifoliaceae (T by Ellis, Wofford, and Chester 1971, and Chester, Schibig, and Jensen 1976). T. Weckman, Eastern Kentucky University, annotated these specimens as *V. dentatum* L.

Viburnum prunifolium L., Caprifoliaceae (L by Ellis, Wofford, and Chester 1971; L,T by Chester, Schibig, and Jensen 1976). T. Weckman, Eastern Kentucky University, annotated these specimens as *V. rufidulum* Raf.

Vitis riparia Michx., Vitaceae (S by Carpenter and Chester 1987). Dr. Michael Moore, University of Georgia, assigned these specimen to V. *vulpina* L.

SUMMARY

Land Between the Lakes is unique for several reasons, including its great size and public ownership, the fact that it is an interior peninsula interfacing with several physiographic regions, and its varied cultural and historical legacy. The area is about 80 percent forested, mostly with hardwood communities dominated by one or more of 20 species of native oaks. The area is a botanical crossroads, and the flora is large and diverse. While most of the flora is intraneous, floristic elements may be found from prairies and barrens to the north, west, and east, from the Coastal Plain to the south and west, from the more xeric oak-hickory forests westward and from the more mesic forests to the east. The Tennessee River has provided a migratory pathway for Appalachian elements, and the Cumberland River likewise has provided a pathway from the limestone floras of Middle Tennessee. The reservoirs have resulted in new habitats and as a consequence, the introduction of new species and the expansion of preimpoundment ones. Anthropogenic influences are great and more than one-fifth of the flora is introduced, yet many rare (listed) elements are present. Floristic studies over the past four decades indicate that the flora is dynamic; records are found regularly, and some species are of historic occurrence only. Future changes are inevitable and constant monitoring will be required to keep the checklist current for this significant vegetational-floristic region of middle America.

LITERATURE CITED

Abbott, J.R., R.L. Thompson, and R.A. Gelis. 2001. Vascular plants new to Kentucky. Sida 19:1199-1202.

Adams, R.M., and W.J. Dress. 1982. Nodding *Lilium* species of Eastern North America (Liliaceae). Baileya 21:165-188.

Argus, G.W. 1986. The genus *Salix* (Salicaceae) in the Southeastern United States. Systematic Botany Monographs 9:1-170.

Bailey, H.H., and J.H. Winsor. 1964. Kentucky Soils. Miscellaneous Publiscation 308. The University of Kentucky Agricultural Experiment Station, Lexington, Kentucky.

Baskin, C.C., J.M. Baskin, and E.W. Chester. 2002. Seed germination ecology of summer annual species of dewatered reservoir shorelines (mudflats), a temporally unpredictable habitat. Pp. 353-368. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Beal, E.O., and J.W. Thieret. 1986. Aquatic and wetland plants of Kentucky. Scientific and Technical Series Number 5. Kentucky Nature Preserves Commission, Frankfort, Kentucky.

Braun, E.L. 1950. Deciduous Forests of Eastern North America. Hafner Press, New York, New York.

Carpenter, J.S., and E.W. Chester. 1987. The vascular flora of the Bear Creek Natural Area, Stewart County, Tennessee. Castanea 2:112-128.

Carpenter, J.S., and E.W. Chester. 1988. A floristic and vegetational characterization of the Bear Creek Natural Area, Stewart County, Tennessee. Pp. 220-239. *In*: Snyder, D. H. (ed.). Proceedings of the First Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Carstens, K.C., and J.D. Merritt. 2002. The archaeology of Land Between The Lakes: A review. Pp. 69-80. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Carter, V., and J.H. Burbank. 1978. Wetland Classification System for the Tennessee Valley Region. Technical Note B24. Tennessee Valley Authority, Norris, Tennessee.

Chester, E.W. 1967. *Halesia carolina* L. in Kentucky, Indiana, and Ohio. Rhodora 9:380-382.

Chester, E.W. 1982. Some new distributional records for *Lesquerella lescurii* (Gray) Watson (Brassicaceae), including the first report from Kentucky. Sida 3:235-237.

Chester, E.W. 1986a. Additions to the known vascular flora of Land Between The Lakes, 1. New dicot records. Journal of the Tennessee Academy of Science 61:49-51.

Chester, E.W. 1986b. The Vascular Flora of Fort Donelson National Military Park, Stewart County, Tennessee. Research/Resources Management Report SER-80. United States Department of the Interior, National Park Service, Atlanta, Georgia.

Chester, E.W. 1988a. The Kentucky prairie barrens of northwestern Middle Tennessee: an historical and floristic perspective. Pp. 145-163. *In*: Snyder, D.H. (ed.). Proceedings of the First Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Chester, E.W. 1988b. Alligatorweed, *Alternanthera philoxeroides* (Mart.) Griseb. in Kentucky. Transactions of the Kentucky Academy of Science 9:140-142.

Chester, E.W. 1992. The vascular flora of Lake Barkley (lower Cumberland River) seasonally dewatered flats. Pp. 67-79. *In*: Snyder, D.H. (ed.). Proceedings of the Contributed Papers Sessions of the Fourth Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Chester, E.W. 1993. Vascular flora of Land Between The Lakes, Kentucky and Tennessee: an updated checklist. Journal of the Tennessee Academy of Science 68:1-14.

Chester, E.W., and W.H. Ellis. 1989. Plant communities of northwestern Middle Tennessee. Journal of the Tennessee Academy of Science 64:75-78.

Chester, E.W., and W.H. Ellis. 1995. Wildflowers of the Land Between The Lakes Region, Kentucky and Tennessee. Miscellanous Publication Number 11. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Chester, E.W., and W.H. Ellis. 2000. Wildflowers of the Land Between The Lakes Region, Kentucky and Tennessee. Second Edition. Miscellaneous Publication Number 15. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Chester, E.W., and J.S. Fralish (eds.). 2002. Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Chester, E.W., L.J. Schibig, and R.J. Jensen. 1976. The woody flora of Land Between The Lakes, Kentucky and Tennessee. Journal of the Tennessee Academy of Science 51:124-129.

Chester, E.W., R.J. Jensen, and J. Schibig. 1995. Forest communities of Montgomery and Stewart counties, northwestern Middle Tennessee. Journal of the Tennessee Academy of Science 70:82-91.

Chester, E.W., and K. Souza. 1986. Range extensions for the mosquito fern in Kentucky and Tennessee. Transactions of the Kentucky Academy of Science 47:137.

Chester, E.W., J.J. Quick, and D. Mosley. 1987. Two new adventive vascular species in the Tennessee flora. Journal of the Tennessee Academy of Science 62:77-78.

Chester, E.W., and S.E. Holt. 1989. The Uruguayian water-primose (*Ludwigia uruguayensis*) in Tennessee and Kentucky. Journal of the Tennessee Academy of Science 65:9-12.

Chester, E.W., and S.E. Holt. 1990. The rare vascular plants of Land Between The Lakes, Kentucky and Tennessee. Journal of the Tennessee Academy of Science 65:117-120.

Clebsch, A. 1974. Bryophytes of Land Between The Lakes, Kentucky-Tennessee. Castanea 39:295-339.

Close, D.D., J.S. Fralish, and S.B. Franklin. 2002. The climate, soil, and vegetation of Land Between The Lakes. Pp. 53-68. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Cronquist, A. 1980. Vascular flora of the Southeastern United States. Volume 1. Asteraceae. University of North Carolina Press, Chapel Hill, North Carolina.

DeSelm, H.R. 1989. The barrens of Tennessee. Journal of the Tennessee Academy of Science 64:89-95.

DeSelm, H.R. P.A. Schmalzer, and T.A. Patrick. 1982. Bear Creek, a Potential National Natural Landmark. Report to the United States National Park Service, Washington, D.C.

Dey, J.P., and S.B. Eyer. 1993. A revised checklist of macrolichens in the Land Between The Lakes Recreation Area of Kentucky and Tennessee. Pp. 161-174. *In*: Hamilton, S.W., E.W. Chester, and A.F. Scott (eds.). Proceedings of the Fifth Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Ellis, W.H., E. Wofford, and E.W. Chester. 1971. A preliminary checklist of the flowering plants of Land Between The Lakes. Castanea 36:229-246.

Ellis, W.H., and E.W. Chester. 1971. Spring Wildflowers of Land Between The Lakes. Tennessee Valley Authority, Golden Pond, Kentucky.

Ellis, W.H., and E.W. Chester. 1973. Summer and Fall Wildflowers of Land Between The Lakes. Tennessee Valley Authority, Golden Pond, Kentucky.

Ellis, W.H., and E.W. Chester. 1980. Trees and Shrubs of Land Between The Lakes. Tennessee Valley Authority, Golden Pond, Kentucky.

Fenneman, N.M. 1938. Physiography of Eastern United States. McGraw-Hill Book Co., New York, New York.

Fernald, M. L. 1950. Gray's Manual of Botany. Eighth Ed. American Book Co., New York, New York.

Flora of North America Editorial Committee. 1993. Flora of North America North of Mexico. Volume 2. Pteridophytes and Gymnosperms. Oxford University Press, New York, New York.

Flora of North America Editorial Committee. 1997. Flora of North America North of Mexico.Volume 3. Magnoliophyta: Magnoliidae and Hamamelidae. Oxford University Press, New York, New York.

Flora of North America Editorial Committee. 2000. Flora of North America North of Mexico. Volume 22. Magnoliophyta: Alismatidae, Arecidae, Commelinidae (in part), and Zingiberidae. Oxford University Press, New York, New York.

Forsythe, T.D. 2002. The "Land Between The Lakes Biosphere Reserve"-can it be a global model for sustainable development? Pp. 169-184. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Fralish, J.S., and F.B. Crooks. 1988. Forest communities of the Kentucky portion of Land Between The Lakes: a preliminary assessment. Pp. 164-175. *In*: Snyder, D.H. (ed.). Proceedings of the First Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Fralish, J.S., and F.B. Crooks. 1989. Forest composition, environment, and dynamics at Land Between The Lakes in Northwest Middle Tennessee. Journal of the Tennessee Academy of Science 3:107-111.

Franklin, S.B., J.S. Fralish, and D.D. Close. 2002. History, classification, and effects of disturbance on forest communities in Land Between The Lakes. Pp. 285-322. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Gildrie, R.P. 2002. Furnaces and crossties: Industrial wood usage in The Land Between The Lakes Region, 1843-1932. Pp. 81-94. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Gleason, H.A., and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. Second Edition. The New York Botanical Garden, Bronx, New York.

Harris, S.E., Jr. 1988. Summary review of geology of Land Between the Lakes, Kentucky and Tennessee. Pp. 26-83. *In*: Snyder, D.H. (ed.). Proceedings of the First Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Harris, S.E., Jr. 2002. Summary review of geology of Land Between The Lakes. Pp. 19-52. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Henry, J.M. 1976. The Land Between the Rivers. Tennessee Valley Authority, Golden Pond, Kentucky.

Isley, D. 1990. Vascular Flora of the Southeastern United States: Volume 3. Part 2, Leguminosae (Fabaceae). University of North Carolina Press, Chapel Hill, North Carolina.

Isely, D. 1998. Native and Naturalized Leguminosae (Fabaceae) of the United States (Exclusive of Alaska and Hawaii). Brigham Young University, Provo, Utah.

Jensen, R.J. 1988. Taxonomic implications of morphological variability among the red and black oaks of Land Between

The Lakes. Pp. 240-254. *In*: Snyder, D.H. (ed.). Proceedings of the First Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Jensen, R.J. 1989. The *Quercus falcata* Michx. complex in Land Between The Lakes, Kentucky and Tennessee. American Midland Naturalist 21:245-255.

Jensen, R.J. 2002. The oaks of Land Between The Lakes: Biodiversity and hybridization. Pp. 323-334. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Jones, R.L., and P.S. White. 1981. The Vascular Flora of Shiloh National Military Park, Hardin County, Tennessee. Research/Resources Management Report SER-50. United States Department of the Interior, National Park Service, Atlanta, Georgia.

Kellerman, C.D. 1959. A Survey of the Aquatic Plants of Western Kentucky. M.S. thesis, University of Louisville, Louisville, Kentucky.

Kentucky State Nature Preserves Commission. 2000. Rare and extirpated biota of Kentucky. Transactions of the Kentucky Academy of Science 61:115-132.

LeLong, M.G. 1984. New combinations for *Panicum* Subgenus *Panicum* and Subgenus *Dichanthelium* (Poaceae) of the southeastern Untied States. Brittonia 36:262-273.

Little, E.L., Jr. 1977. Atlas of United States Trees, Volume 4, Minor Eastern Hardwoods.Miscellaneous Publication Number 1342. U.S. Department of Agriculture, Washington, D.C.

Martin, W.H., and T.H. Taylor. 2002. Grasslands and grassland management in Land Between The Lakes. Pp. 267-284. *In*: Chester, E W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Meijer, W. 1971. Tree flora of Kentucky. Thomas Hunt Morgan School of Biological Sciences, University of Kentucky, Lexington, Kentucky.

Meijer, W. 1972. Composite Family (Asteraceae) in Kentucky. Thomas Hunt Morgan School of Biological Sciences, University of Kentucky, Lexington, Kentucky.

Naczi, R.F.C. 1999. *Carex planispicata*, a widespread and frequent new species of *Carex* Section *Griseae* (Cyperaceae) from the Eastern United States of America. Journal of the Kentucky Academy of Science 60:37-44.

Naczi, R.F.C., R. Kral, and C.T. Bryson. 2001. *Carex cumberlandensis*, a new species of Section *Careyanae* (Cyperaceae) from the Eastern United States of America. Sida 19:993-1014.

Noel, S.M., M.L. McReynolds, and E.W. Chester. 1990. The ferns and fern allies of Land Between The Lakes. Pp. 113-126. *In*: Hamilton, S.W., and M.L. Finley (eds.). Proceedings of the Third Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Phillips, H.C. 1970. An annotated list of foliose and fruticose lichens in Land Between The Lakes. Journal of the Tennessee Academy of Science 45:97-109.

Phillips, H.C. 1974. Lichens and Ferns of Land Between The Lakes. Tennessee Valley Authority, Golden Pond, Kentucky.

Quarterman, E., and R.L. Powell. 1978. Potential Ecological-Geological Natural Landmarks on the Interior Low Plateaus. United States Department of the Interior, National Park Service, Washington, D.C.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. University of North Carolina Press, Chapel Hill, North Carolina.

Ramsey, G.W., and E.W. Chester. 1981. The occurrence of *Cimicifuga rubifolia* Kearney in the Interior Low Plateaus Province of Tennessee. Castanea 46:100-101.

Riggins, R.I., and W.H. Ellis. 1966. A preliminary report on the vascular plants of Land Between The Lakes Park, Tennessee. Journal of the Tennessee Academy of Science 41:66.

Ross, J. Undated. Life and Times of Elder Reuben Ross. Grant, Faires, and Rodges, Philadelphia, Pennsylvania.

Sauer, C.O. 1927. Geography of the Pennyroyal. Kentucky Geological Survey, Series 6, Volume 25. Frankfort, Kentucky.

Schibig, J.L. 2002. The hickories of Land Between The Lkes: Biodiversity and the contribution of hickory taxa to area forest communities. Pp. 335-352. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Schibig, J.L., R.J. Jensen, and E.W. Chester. 1990. The Fagaceae and Juglandaceae of Land Between The Lakes: a review. Pp. 129-145. *In*: Hamilton, S.W., and M.L. Finley (eds.). Proceedings of the Third Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Schibig, J.L., and E.W. Chester. 1979. A note on the distribution of Styrax *americana* (Styracaceae) in Tennessee. Sida 8:213.

Schibig, J.L., and E.W. Chester. 1988. Vegetational and floristic characterization of a mixed hardwoods-shortleaf pine stand in Stewart County, Tennessee. Journal of the Tennessee Academy of Science 63:83-88.

Scott, A.F., E.W. Chester, and D.H. Snyder. 1980. A Study of Selected Potential Natural Areas in the Lower Cumberland River Basin of Tennessee. Division of Natural Heritage, Tennessee Department of Conservation, Nashville, Tennessee.

Semple, J.C., and C.C. Chinnappa. 1986. The cytogeography of *Chrysopsis mariana* (Compositae: Astereae): survey over the range of the species. Rhodora 88:261-266.

Smith, F.E. 1971. Land Between The Lakes, Experiment in Recreation. The University Press of Kentucky, Lexington, Kentucky.

Springer, M.E., and J.A. Elder. 1980. Soils of Tennessee. Bulletin 596. The University of Tennessee Agricultural Experiment Station, Knoxville, Tennessee.

Straley, G.B. 1977. Systematics of *Oenothera* Section *Kneiffia* (Onagraceae). Annals of the Missouri Botanical Garden 64:381-424.

Tennessee Natural Heritage Program. 2003. Rare Plant List. Division of Natural Heritage, Tennessee Department of Environment and Conservation, Nashville, Tennessee.

Thomas, W.L. 1963. Comparative Ecology of Three Contiguous Communities in the Cumberland River Valley in Western Kentucky. M.S. thesis, University of Louisville, Louisville, Kentucky.

Thornthwaite, C.W. 1948. An approach toward a rational classification of climate. Geographical Review 38:55-94.

Wallace, B.J. 1988. History of Land Between the Lakes. Pp. 84-144. *In*: Snyder, D.H. (ed.). Proceedings of the First Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Wallace, B.J. 1992. Between the Rivers: History of The Land Between The Lakes. Miscellaneous Publication Number 8. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Wallace, B.J. 2002. General History of The Land Between The Lakes prior to 1962. Pp. 3-18. *In*: Chester, E.W., and J.S. Fralish (eds.). Land Between The Lakes: Four Decades of Tennessee Valley Authority Stewardship. Miscellaneous Publication Number 16. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Webb, D.H., W.M. Dennis, and A.L. Bates. 1988. An analysis of the plant community of mudflats of TVA mainstream reservoirs. Pp. 177-198: *In*: Snyder, D.H. (ed.). Proceedings of the First Annual Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee.

Webb, D.H., and A.L. Bates. 1989. The aquatic vascular flora and plant communities along rivers and reservoirs of the Tennessee River System. Journal of the Tennessee Academy of Science 64:197-203.

Webb, D.L., and E.W. Chester. 1989. Distribution of the horned pondweed, *Zannichellia palustris* L. (Zannichelliaceae) in Tennessee and Kentucky. Transactions of the Kentucky Academy of Science 50:158-160.

White, P.S. 1982. The Flora of Great Smoky Mountains National Park: An Annotated Checklist of the Vascular Plants and a Review of Previous Floristic Work. Research/Resources Management Report SER-55. United States Department of the Interior, National Park Service, Atlanta, Georgia.

Wofford, B.E., and R. Kral. 1993. Checklist of the vascular plants of Tennessee. Sida, Botanical Misc. No. 10:1-66.

APPENDIX 1. THE THIRD CHECKLIST

The checklist is divided into four major groups with families arranged alphabetically with each: 1) Pteridophyta; 2) Gymnospermae; 3) Angiospermae, Monocotyledoneae; and 4) Spermatophyta: Angiospermae, Dicotyledoneae. Genera, species, and lesser taxa are then arranged alphabetically. Non-native taxa are indicated by an asterisk(*), based on the Wofford and Kral (1993) list. County distributions, based on vouchers at APSC or seen elsewhere and verified by the author, unless indicated otherwise, are give as L for Lyon County, S for Stewart County, and T for Trigg County.

PTERIDOPHYTA: FERNS AND FERN ALLIES

ASPLENIACEAE, Spleenwort Family

Asplenium platyneuron (L.) Britton Sterns & Poggenb., Ebony Spleenwort. Mesic to dry woodlands; throughout and often in large numbers (L,S,T).

Asplenium resiliens Kunze, Black-Stemmed Spleenwort. Bluffy woods; occasional to rare (L,S).

Asplenium rhizophyllum L. [*Camptosorus rhizophyllus* (L.) Link], Walking Fern. Bluffy woods; locally abundant (L,S,T).

Asplenium ruta-muraria L., Wall-Rue Spleenwort. Bluff faces above Kentucky Reservoir in Hillman Ferry Campground; very rare (L).

AZOLLACEAE, Water-Fern Family

Azolla caroliniana Willd., Mosquito Fern. Quite pools, beaver ponds; locally abundant (S,T).

BLECHNACEAE, Deer-Fern Family

Woodwardia areolata (L.) T. Moore, Chain-Fern. Wet woods; very rare (S).

DENNSTAEDTIACEAE, Bracken Family

Pteridium aquilinum (L.) Kuhn, Bracken Fern. Roadsides, dry open woods, cut-over forests and other disturbed sites; apparently both var. *latiusculum* (Desv.) Underw. ex A. Heller and var. *pseudocaudatum* (Clute) A. Heller occur in LBL (Flora North America 1993), but their status is unclear. Frequent and often in dense stands (L,S,T).

DRYOPTERIDACEAE, Wood Fern Family

Polystichum acrostichoides (Michx.) Schott, Christmas Fern. Mesic woods, especially on gully banks and along streams; probably our most abundant fern (L,S,T).

EQUISETACEAE, Horsetail Family

Equisetum arvense L., Field Horsetail. Known only from a few sandy streambanks but usually in large numbers when found (S,T).

Equisetum hyemale L. var. *affine* (Engelm.) A.A. Eaton, Scouring-Rush. Known only from sandy banks of Panther Creek and Lost Creek; very rare (S).

LYCOPODIACEAE, Club-Moss Family

Diphasiastrum digitatum (A. Braun) Holub [*Lycopodium digitatum* A. Braun, *L. flabelliforme* (Fern.) Blanch.], Ground Cedar, Running-Pine. Old fields, thickets, young forests; locally abundant (L,S,T).

OPHIOGLOSSACEAE, Adder's-Tongue Family

Botrychium biternatum (Sav.) Underw. [*B. tenuifolium* Underw., *B. dissectum* Spreng. var. *tenuifolium* (Underw.) Farwell], Southern Grape Fern. Low woods; scattered throughout (L,S,T).

Botrychium dissectum Spreng. [*B. obliquum* Muhl. ex Willd., *B. dissectum* Spreng. var. *obliquum* (Muhl.) Clute], Dissected Common Grape Fern. Low woods; frequent and highly variable. The forma *obliquum* Fern., given by Chester (1993), is not separated here in keeping with recent treatments (L,S,T).

Botrychium virginianum (L.) Sw., Rattlesnake Fern. Mesic slope and ravine forests; frequent (L,S,T).

Ophioglossum engelmannii Prantl, Limestone Adder's-Tongue. Open woods with limestone outcrops; very rare (T). This report is based on information from Mr. R. Athey (deceased) and is considered reliable although I have not seen a voucher.

Ophioglossum pycnostichum (Fernald) Löve & Löve [*O. vulgatum* L. var. *pycnostichum* Fernald], Southeastern Adder's-Tongue. Mesic, usually low woods; locally abundant (L,S,T).

OSMUNDACEAE, Royal Fern Family

Osmunda regalis L. var. *spectabilis* (Willd.) A. Gray, Royal Fern. Swampy woods and their borders; showy in a few sites but generally rare (L,T).

POLYPODIACEAE, Polypody Family

Polypodium polypodioides (L.) Watt var. *michauxianum* Weath., Resurrection Fern. Usually on trees but occasionally on rock-faces; scattered (S,T).

SELAGINELLACEAE, Spike-Moss Family

Selaginella apoda (L.) Spring, Meadow Spike-Moss. Seepage bluffs, spring and creek banks, muddy trails; occasional to rare (S,T).

SINOPTERIDACEAE, Maidenhair Family

Adiantum pedatum L., Common Maidenhair. Mesic wooded slopes and ravines; throughout but rarely abundant (L,S,T).

Cheilanthes lanosa (Michx.) D.C. Eaton, Hairy Lip Fern. Xeric bluffs; locally abundant (L,S,T).

Pellaea atropurpurea (L.) Link, Purple Cliffbrake. Bluffs and rocky woods; locally abundant (L,S).

THELYPTERIDACEAE, Marsh-Fern Family

Thelypteris hexagonoptera (Michx.) Weath., Broad Beech Fern. Mesic to dry woods; throughout, sometimes in stands (L,S,T).

Thelypteris palustris Schott var. *pubescens* (G. Lawson) Fernald, Marsh-Fern. Wet woods at Hematite Lake and swampy meadows around beaver ponds southward; rare (S,T).

WOODSIACEAE, Cliff Fern Family

Athyrium filix-femina (L.) Roth subsp. *asplenioides* (Michx.) Hulten [*A. asplenioides* (Michx.) Eaton], Southern Lady Fern. Highly variable, wet to mesic woods; throughout, often in large stands (L,S,T).

Cystopteris bulbifera (L.) Bernh., Bulblet Bladder Fern. Mesic bluffs in the south; very rare (S).

Cystopteris protrusa (Weath.) Blasdell [*C. fragalis* (L.) Bernh. var. *protrusa* Weath.], Southern Fragile Fern. Mesic to dry woods, bluffs; throughout, sometimes in large colonies (L,S,T).

Deparia acrostichoides (Sw.) M. Kato [*Athyrium thelypterioides* (Michx.) Desv.], Silvery Glade Fern. Mesic woods in southern sections only; very rare (S).

Diplazium pycnocarpon (Spreng.) M. Broun [*Athyrium pycnocarpon* (Spreng.) Tidestr.], Glade Fern. Base of wooded bluffs along lower Bear Creek; very rare (S).

Onoclea sensibilis L., Sensitive Fern. Wet woods, marshes, swampy sites throughout; abundant, often in dense stands (L,S,T).

Woodsia obtusa (Spreng.) Torr., Common Woodsia. Mesic to dry woods; throughout, often abundant (L,S,T).

SPERMATOPHYTA: GYMNOSPERMAE

CUPRESSACEAE, Cedar Family

**Juniperus chinensis* L., Juniper. Cultivars persist at a few homesites and cemeteries; very rare (L,S).

Juniperus virginiana L., Red Cedar. Old fields, fencerows, bluffs, and open forests; throughout, often in large numbers (L,S,T).

**Thuja orientalis* L., Oriental Arbor-Vitae. Cultivars persist at a few homesites and cemeteries; very rare (L,S,T).

PINACEAE, Pine Family

**Picea abies* (L.) Karst., Norway Spruce. Persisting at a few homesites and cemeteries; very rare (T).

**Picea glauca* (Moench) Voss, White Spruce. Persisting at a few homesites and cemeteries; very rare (L,S).

Pinus echinata Mill., Shortleaf or Yellow Pine. Native on a few ridges and slopes in Stewart County, persisting from plantings northward (L,S,T).

**Pinus strobus* L., White Pine. Planted throughout, a few trees predating TVA management (L,S,T).

**Pinus taeda* L., Loblolly Pine. Planted throughout, sometimes in plantations, and spreading. Many plantings predate TVA management (L,S,T).

Pinus virginiana Mill., Virginia or Scrub Pine. A few native stands occur on xeric sites, mostly on bluffs and slopes above the Tennessee River; also commonly planted (L,S,T).

TAXODIACEAE, Cypress Family

Taxodium distichum (L.) Rich., Bald Cypress. Occassional in coves and swampy ravines along the Tennessee River; planted in a few bottomlands of both river systems, with some plantings predating TVA management (L,S,T).

SPERMATOPHYTA: ANGIOSPERMAE-MONOCOTYLEDONEAE

AGAVACEAE, Century-Plant Family

Manfreda virginica (L.) Rose [*Agave virginica* L.], False Aloe, Rattlesnake Master. Open woods, xeric ridges, bluffs and cherty banks; occasional (L,S,T).

**Yucca flaccida* Haw. [*Y. filamentosa* L. var. *smalliana* (Fernald) Ahles, reported as *Y. filamentosa* L., in Ellis *et al.* (1971)], Beargrass, Spanish Bayonet. Persisting around old homesites and in cemeteries, and on roadsides where apparently naturalized; rare (L,S,T).

ALISMATACEAE, Water-Plantain Family

Alisma subcordatum Raf., Water-Plaintain. Pond margins, lakeshores, and other wet-swampy areas throughout; frequent (L,S,T).

Echinodorus cordifolius (L.) Griseb., Bur-Head. Swampy fields and marsh borders; occasional but sometimes in large numbers (L,S,T).

Sagittaria australis (J.G. Sm.) Small, Southern Arrowhead. Swampy meadows and woods, lakeshores; locally abundant (L,T).

Sagittaria brevirostra Mack. & Bush, Short-Beaked Arrowhead. Marshy areas; rare (L,S).

Sagittaria calycina Engelm. [*Lophotocarpus calycinus* (Engelm.) J.G. Smith], Arrowhead. Swampy fields and meadows, ponds margins, mudflats; often abundant (L,S,T).

Sagittaria graminea Michx., Grass-Leaf Arrowhead. Periodically appearing in one known site around and in a shallow pond, unknown otherwise; very rare (T).

Sagittaria latifolia Willd., Duck Potato. Swampy stream margins; very rare (S).

AMARYLLIDACEAE, Amaryllis Family

Hymenocallis occidentalis (Leconte) Kunth, Spider-Lily. Mesic to wet woodlands and thickets, often in clumps covering several square meters; frequent (L,S,T).

Hypoxis hirsuta (L.) Coville, Stargrass. Dry ridge and slope forests; rare but sometimes in large numbers (L,S,T).

**Leucojum aestivum* L., Summerflake. Persisting around homesites and on roadsides, especially on Silver Trail; rare (L,T).

**Lycoris radiata* (L'Hér.) Herb., Magic-Lily. Persisting at a homesite in Model; very rare (S).

**Narcissus poeticus* L., Poets' Narcissus. Persisting and slightly spreading around homesites and onto adjacent roadsides; locally abundant (L,S,T).

**Narcissus pseudonarcissus* L., Buttercup, Daffodil. Old homesites, roadsides, fencerows and cemeteries throughout; often spreading and in large stands; represented by various forms, some probably named cultivars (L,S,T).

ARACEAE, Arum Family

Acorus americanus (Raf.) Raf., Sweetflag. Swampy woods around the "Golden Pond" and in a few low wet meadows; very rare (S,T).

Arisaema dracontium (L.) Schott, Green Dragon. Ravine and streambank forests and thickets; occasional (L,S,T).

Arisaema triphyllum (L.) Schott, Jack-in-the-Pulpit. Low woods and thickets; frequent, sometimes in considerable numbers (L,S,T).

COMMELINACEAE, Spiderwort Family

**Commelina communis* L., Dayflower. Mesic fields and streambanks; locally abundant (L,S,T).

Commelina diffusa Burm. f., Diffuse Dayflower. Mesic thickets and muddy shores; occasional but sometimes abundant, as around the dewatered shores of Hematite Lake (L,S,T).

Commelina erecta L., Erect Dayflower. Around wooded springs and their branches; rare southward, unknown to the north (S).

Commelina virginica L., Virginia Dayflower. Mesic woods and thickets; occasional to rare (L,S,T).

Tradescantia subaspera KerGawl, Harsh Spiderwort. Mesic woods, bluffs and thickets; locally abundant (S,T).

Tradescantia virginiana L., Virginia Spiderwort. Mesic rocky woods and bluffs; rare (L,S,T).

**Zebrina pendula* Schwein., Common Zebrina. A waif collected once at a homesite in the 1960s but now presumed to be extirpated (L).

CYPERACEAE, Sedge Family

Bulbostylis capillaris (L.) C.B. Clarke, Bulbous-Styled Sedge. Low sandy fields; very rare (S).

Carex albicans Willd. ex Spreng. var. *albicans* [*Carex artitecta* Mack.], Covered Sedge. Dry slope and ridge forests; frequent (L,S,T).

Carex albursina E. Sheld., Pale Sedge. Rich rocky woods southward; rare (S).

Carex amphibola Steud., Ambiguous Sedge. Mesic woods, fields and thickets; frequent (L,S,T).

Carex annectens (E.P. Bicknell) E.P. Bicknell, Connected Sedge. Pond and swamp margins, wet fields and ditches; frequent, sometimes in large numbers (L,S,T).

Carex blanda Dewey, Charming Sedge. Rich wooded slopes and bluffs; frequent (L,S,T).

Carex caroliniana Schwein., Carolina Sedge. Mesic woods, low fields and thickets; infrequent (S,T).

Carex cephalophora Willd., Headed Sedge. Dry woods and bluffs; occasional (L,S).

Carex comosa Boott, Bearded Sedge. Swampy thickets formed by beaver; very rare but a large stand occurs in the one known site (S). The Trigg report by Ellis *et al.* (1971) is unconfirmed.

Carex complanata Torr. & Hook. [our material is the var. *hirsuta* Mack. = *C. hirsutella* (Mack.) Gleason], Flattened Sedge. Dry wooded ridges and slopes, fields and barrens; frequent (L,S,T).

Carex crinita Lam., Long-Haired Sedge. Wet woods, marshes, ditches; locally abundant but generally rare (L,S,T).

Carex crus-corvi Shuttlw. ex Kunze, Crow-Spur Sedge. Weedy bottomlands, ditches and around swamps; scattered but sometimes in large stands (L,S,T).

Carex cumberlandensis Naczi, Kral, & Bryson, Cumberland Sedge. Apparently rare in rich woods southward. Reported from S by Naczi, Kral, and Bryson (2001).

Carex digitalis Willd., Slender Sedge. Dry to mesic woods, swampy bottomlands; frequent (S,T).

Carex festucacea Willd., Fescue-Like Sedge. Mesic woods, swampy bottomlands; rare (L,S).

Carex flaccosperma Dewey [including var. *glaucodea* (Tuckerm.) Kuek. = *C. glaucodea* Tuckerm.], Flaccid-Fruited Sedge. Wet or mesic woodlands; rare (L,S,T).

Carex frankii Kunth, Frank's Sedge. Marshy soils throughout; often in stands (L,S,T).

Carex gracillima Schwein., Slender Sedge. Low woods, especially around Hematite Lake; rare (T).

Carex granularis Muhl. ex Willd., Granular Sedge. Wet fields and woods; rare (S,T).

Carex grayi J. Carey, Gray's Sedge. Mesic to swampy woodlands and thickets; frequent (L,S,T).

Carex intumescens Rudge, Swelled Sedge. Wet woods near the reservoirs; locally abundant (L,S.T).

Carex jamesii Schwein., James' Sedge. Rocky wooded slopes, bluffs; locally abundant (L,S,T).

Carex lacustris Willd., Lake-Margin Sedge. Swampy fields and woods near the reservoirs; rare but often in large stands when found (L,S,T).

Carex laxiflora Lam., Loose-Flowered Sedge. Rich wooded slopes; infrequent (L,S).

Carex leavenworthii Dewey, Leavenworth's Sedge. Lawns, roadsides, disturbed sites; occasional (S).

Carex louisianica Bailey, Louisiana Sedge. Swampy woods and thickets; locally abundant (L,S,T).

Carex lupuliformis Sartwell ex Dewey, Lupine-Like Sedge. Wet woods and swamp margins; rare (L). The Stewart report by Ellis *et al.* (1971) is undocumented.

Carex lupulina Willd., Hop-Like Sedge. Wetlands throughout, often in large stands (L,S,T).

Carex lurida Wahlenb., Sallow Sedge. Wet fields, swamps, ditches, pond margins; frequent, often abundant (L,S,T).

Carex meadii Dewey, Mead's Sedge. Dry rocky barrens to the north; very rare (L).

Carex muhlenbergii Schkuhr [including var. *enervis* Boott], Muhlenberg's Sedge. Dry to moist, open woods; frequent (L,S,T).

Carex nigromarginata Schwein., Black-Margined Sedge. Dry wooded ridges; locally abundant (S,T).

Carex normalis Mackenzie, Angled Sedge. Wet fields and swamps; occasional (L,S,T).

Carex oxylepis Torr. & Hook., Sharp-Scaled Sedge. Mesic rocky slope and ravine woods; rare (L,T).

Carex planispicata Naczi, Sedge. Bordering Hematite Lake; reported by Naczi (1999), based on an unnumbered Athey collection at SIU (T).

Carex picta Steud., Painted Sedge. Wooded slopes and ravines near Kentucky Reservoir; rare, but usually in stands when found (S,T).

Carex retroflexa Willd. [including the var. *texensis* (Torr.) Fernald = *C. texensis* (Torr.) Bailey], Reflexed Sedge. Dry woods and rocky slopes; occasional (L,S,T).

Carex rosea Willd., Rose-Like Sedge. Mesic wooded slopes, bluffs and ravines; frequent (L,S,T).

Carex scoparia Schkuhr, Broom-Like Sedge. Mesic to wet woods, mostly near Kentucky Reservoir; occasional (L,S,T).

Carex shortiana Dewey, Short's Sedge. Wet fields, ditches and low woods; rare (S,T).

Carex socialis Mohlenbr. and Schwegman. Social Sedge. Low woods; rare (S).

Carex squarrosa L., Spreading Sedge. Wet woods, swampy fields; frequent (L,S,T).

Carex stipata Muhl. ex Willd., Crowded Sedge. Wet woods and thickets; rare (S,T).

Carex stricta Lam., Erect Sedge. Wet meadows; very rare but in large numbers when found (S).

Carex swanii (Fernald) Mack., Swan's Sedge. Rich wooded slopes and bluffs; rare (S).

Carex tribuloides Wahl., Tribulus-Like Sedge. Swampy fields and woods; frequent (L,S,T).

Carex typhina Michx., Cat-Tail Sedge. Wet woodlands and meadows; rare (L,T). The Stewart report by Ellis *et al.* (1971) is undocumented.

Carex vulpinoidea Michx., Fox-Tail Sedge. Marshy areas, wet fields, ditches and pond margins; throughout, often in large numbers (L,S,T).

Cyperus aristatus Rottb., Aristate Sedge. Wet fields, mudflats; often abundant (L,S,T).

Cyperus bipartitus Torr. [*C. rivularis* Kunth], Streambank Sedge. Sandy streambanks, usually in shallow water; very rare (S).

Cyperus echinatus (L.) Wood [*C. ovularis* (Michx.) Torr.], Egg-Shaped Sedge. Mesic fields, meadows, disturbed sites; occasional (L,S,T).

Cyperus erythrorhizos Muhl., Red-Rooted Sedge. Mudflats, pond margins, wet fields; frequent (L,S,T).

Cyperus esculentus L. var. *esculentus*, Yellow Nut-Grass. A characteristic species of reservoir mudflats; less frequent in wet fields, ditches and around ponds (L,S,T).

**Cyperus esculentus* L. var. *sativus* Boeckl., Chufa. A variety with many tubers, planted for wildlife; not observed flowering or fruiting (S).

Cyperus ferruginescens Boeckl., Rusty Sedge. Mudflats, swampy fields, pond margins; scattered (L,S,T).

Cyperus filiculmis Vahl, Thread-Like Sedge. Sandy banks of Kentucky Reservoir; very rare (L,S).

Cyperus flavescens L., Yellowish Sedge. Sandy margins of springs and seeps; rare but usually in large numbers when found (S,T).

Cyperus flavicomus Michx. [*C. albomarginatus* Mart. & Schrad.], White-Margined Sedge. Reservoir mudflats; scattered but sometimes in large numbers (L,S,T).

**Cyperus iria* L., Iris-Like Sedge. Reservoir margins and low wet fields; locally abundant (S,T).

Cyperus lancastriensis Porter, Lancaster's Sedge. Mesic fields and meadows occasional (L,S,T).

Cyperus polystachyos Rottb. var. *texensis* (Torr.) Fernald, Texas Sedge. Sandy reservoir and spring margins; rare (L,S,T). The voucher for T is *Athey 2616* (MEM, now at TENN).

Cyperus pseudovegetus Steud. [including material previously referred to as *C. virens* Michx.], Green Sedge. Marshes, wet fields, ditches, pond margins; locally abundant (L,S,T).

Cyperus retrofractus (L.) Torr., Reflexed Sedge. Sandy margins of Kentucky Reservoir;very rare (L). The Stewart report by Ellis *et al.* (1971) is not documented.

Cyperus strigosus L., Strigose Sedge. Ditches, pond margins, swampy fields; throughout, (L,S,T).

Dulichium arundinaceum (L.) Britton, Three-Way Sedge. Shallow water or marshy spots around a few beaver ponds and embayments; rare (L,T).

Eleocharis acicularis (L.) Roem. & Schult., Needle-Shaped Spike-Rush. Forming dense mats on mudflats, especially on Kentucky Reservoir and northward on Lake Barkley, and some pond margins (L,S,T).

Eleocharis compressa Sull., Flattened Spike-Rush. Reservoir shorelines, wet fields, springs; rare (S).

Eleocharis erythropoda Steud., Red-Stemmed Spike-Rush. Sandy flats, streambank and reservoir margins; locally abundant (L,S,T).

Eleocharis obtusa (Willd.) Schult., Blount Spike-Rush. Mudflats, pond margins, ditches, other wet areas; frequent, often in large stands (L,S,T).

Eleocharis quadrangulata (Michx.) Roem.& Schult., Four-Angled Spike-Rush. Marshy shorelines of reservoirs and inland lakes; rare but sometimes in dense stands (L,S,T).

Fimbristylis autumnalis (L.) Roem. & Schult., Autumnal Fimbristylis. Abundant in reservoir and embayment mudflats, sometimes in wet fields, ditches and around ponds (L,S,T).

Fimbristylis vahlii (Lam.) Link, Vahl's Fimbristylis. Swampy fields and mudflats; abundant, especially around sandy outwashes (L,S,T).

Hemicarpha micrantha (Vahl) Britton, Small-Flowered Hemicarpha. Primarily a mudflat species where it is often abundant (L,S,T).

Kyllinga pumila Michx. [*Cyperus tenuiflorus* (Steud.) Dandy], Thin-Leaved Sedge. Wet fields, springs and seeps, reservoir margins; rare (L,S).

Rhynchospora capitellata (Michx.) Vahl, Small-Headed Rush. Marshy low fields and sandy stream banks; rare but sometimes in large numbers (L,S,T).

Rhynchospora corniculata (Lam.) A. Gray, Horned Rush. Marshy fields, most often around embayments and beaver ponds; locally abundant (L,S,T).

Scirpus americanus Pers., American Bulrush. Known only from marshy ground around Hematite Lake where it is abundant (T). Kellerman (1959) reported this species from Hematite Lake, Lyons (sic) County. However, Hematite Lake is totally within Trigg County.

Scirpus atrovirens Willd., Dark-Green Bulrush. Marshy fields, ditches, swamp borders, pond margins and similar sites; frequent, often in large clumps (L,S,T).

Scirpus cyperinus (L.) Kunth [*S. rubricosus* Fernald]. Red Bulrush. Marshes, swamp borders, pond margins; locally abundant (L,S,T).

Scirpus koilolepis (Steud.) Gleason, Hollow-Scaled Bulrush. Wet fields and meadows; occasional (L,S,T).

Scirpus pendulus Muhl. [*S. lineatus* Michx., misapplied, according to Beal and Thieret (1986)], Line-Scaled Bulrush. Marshes, swamps, pond margins, roadside ditches; frequent, often in dense (L,S,T).

Scirpus polyphyllus Vahl, Many-Leaved Bulrush. Spring branches, wet woodlands, ditches; rare (S).

Scirpus validus Vahl, Great or Soft-Stemmed Bulrush. Marshes made by beaver; very rare (S,T).

Scleria oligantha Michx., Nutrush. Rare in dry fields and barrens (L). This report is based on *Athey 4076* (Athey Herbarium, now at Murray State University, and VDB)

Scleria pauciflora Muhl. ex Willd., Few-Flowered Nutrush. Dry fields and barrens; occasional to rare (L,S,T). The voucher for L is *Athey 3154* (WKU).

DIOSCOREACEAE, Yam Family

**Dioscorea batatas* Dcne., Chinese Yam or Cinnamon Vine. Thickets and weedy roadsides, especially around old habitations; occasional (L,S,T).

Dioscorea villosa L., Wild Yam. Mesic woods, thickets and fencerows; occasional (L,S,T).

IRIDACEAE, Iris Family

**Belamcanda chinensis* (L.) DC., Blackberry Lily. Roadsides, fields, homesites; locally abundant (L,S,T).

**Gladiolus hortulanus* Bailey, Garden Gladiolus. A waif around old homesites during the original survey (1960s) but now presumed extirpated (S,T).

Iris brevicaulis Raf., Lamance Iris. Collected once from a swampy wood at the margin of Dry Fork Bay, Kentucky Reservoir; very rare, no recent observations (S).

Iris cristata Sol., Crested Dwarf Iris. Shaded outcrops, bluffs and rocky woods; occasional (L,S,T).

**Iris flavescens* DC., Yellow Iris. Persisting at homesites and cemeteries; rare (L,S,T).

**Iris germanica* L., Garden Iris. Persisting and vegetatively spreading around homesites and cemeteries, sometimes on roadsides; locally abundant (L,S,T).

Iris virginica L., Swampy embayment shorelines; locally abundant (S,T).

Sisyrinchium albidum Raf., White Blue-Eyed Grass. Dry and often cherty fields, banks and roadsides; frequent (L,S,T).

Sisyrinchium angustifolium Mill., Narrow-Leaf Blue-Eyed Grass. Mesic woods, fields and thickets; occasional (L,S,T).

JUNCACEAE, Rush Family

Juncus acuminatus Michx., Sharp-Sepaled Rush. Pond margins, creek banks, wet fields and meadows; frequent (L,S,T).

Juncus biflorus Elliott, Two-Flowered Rush. Ditches, wet fields, meadows, barrens; frequent (L,S,T).

Juncus brachycarpus Engelm., Short-Fruited Rush. Ditches, wet fields, meadows and barrens; locally abundant (L,S,T).

Juncus crassifolius Buch. [J. *validus* Cov.], Vigorous Rush. Sandy fields and creekbanks; rare. (S).

Juncus debilis Gray, Weak Rush. Low sandy woods and fields; rare, no recent collections (T).

Juncus diffusissimus Buckley, Diffuse Rush. Wet fields and meadows, ditches; rare but sometimes in large numbers (L,S,T).

Juncus effusus L., Soft Rush. Pond edges, swamps, ditches, and around other areas with standing water; frequent, clumped (L,S,T).

Juncus marginatus Rostk., Margined Rush. Ditches, pond margins, wet fields and meadows, marshes; abundant (L,S,T).

Juncus nodatus Coville, Noded Rush. Pond margins, wet fields by reservoirs; rare (L,T).

Juncus scirpoides Lam., Scirpus-Like Rush. Ditches and wet fields; very rare (S).

Juncus secundus P. Beauv., One-Sided Rush. Fields, meadows and barrens; very rare (S).

Juncus tenuis Willd., Path Rush. Homesites, trails, old roads and other disturbed sites; the most abundant rush in LBL (L,S,T).

Luzula bulbosa (A.W. Wood) Rydb., Bulb-Bearing Woodrush. Open dry fields, woods and cemeteries; locally abundant (L,S).

Luzula echinata (Small) F.J. Herm., Woodrush. Mesic woods throughout; frequent (L,S,T).

LEMNACEAE, Duckweed Family

Lemna minor L. [including *L. perpusilla* Torr.], Duckweed. Ponds, pools, sluggish streams and bay-heads; locally abundant (L,S,T).

Lemna valdiviana Phil., Valdivia Duckweed. Quiet cool springs and branches; rare but in large quantities when found (S).

Spirodela polyrhiza (L.) Schleid., Water Flaxseed, Greater Duckweed. Ponds, beaver swamps, sluggish bay-heads and streams; locally abundant (S,T).

Wolffia papulifera C.H. Thompson, Water-Meal. Clean ponds; abundant when found but generally rare. Some of our material may be assigned to other species when critically examined by specialists (S,T).

Wolffiella floridana (Donn.Sm.) C.H. Thompson, Florida Water-Meal. Collected once in Hematite Lake; very rare (T).

LILIACEAE, Lily Family

Allium canadense L., Wild Onion. Mesic fields and meadows, low woods; frequent (L,S,T).

**Allium cepa* L., Common Onion. A multiplying cultivar persists and spreads around a few old gardens; very rare (L,T).

**Allium sativum* L., Garden Garlic. Persisting in old gardens and fencerows; very rare (S).

**Allium vineale* L., Field Garlic. Roadsides, lawns, fields and meadows; a weedy species (L,S,T).

**Asparagus officinale* L., Garden Asparagus. Old homesites, gardens and roadsides; occasional (L,S,T).

Camassia scilloides (Raf.) Cory, Wild Hyacinth. Low woods and bluffs; rare (L,S).

Chamaelirium luteum (L.) A. Gray, Blazing Star. Rich wooded slopes southward; rare (S).

**Convallaria majalis* L., Lily-of-the-Valley. Persisting around an old homesite; very rare (S).

Disporum lanuginosum (Michx.) G. Nicholson, Yellow Mandarin. Rich wooded slopes; rare but in quantities when found (S,T).

Erythronium albidum Nutt., White Dog's-Tooth Violet. Very rare in mesic woods (L). The Stewart report by Ellis *et al.* (1971) is not vouchered.

Erythronium americanum KerGawl, Yellow Adder's-Tongue. Locally abundant in rich moist woods southward, rare to the north (S,T).

**Hemerocallis fulva* L., Orange Day-Lily. Persisting and vegetativity spreading from old plantings around homesites, in cemeteries, and sometimes on roadsides; infrequent (S,T).

**Hyacinthus orientalis* L., Common or Garden Hyacinth. Persisting in cemeteries and around old homesites; rare (L,S,T).

Lilium michiganense Farw., Michigan Lily. Mesic woods and roadsides; very rare (L,S).

**Muscari botryoides* (L.) Mill., Grape-Hyacinth. Old homesites and garden; very rare (L).

**Muscari comosum* Mill., Hairy Grape-Hyacinth. Old homesites, gardens and fields; rare (T).

**Muscari racemosum* L., Racemose Grape-Hyacinth. Old homesites; very rare (L).

Nothoscordum bivalve (L.) Britton, False Garlic. Rocky woods and bluffs; rare (L,T).

**Ornithogalum umbellatum* L., Star-of Bethlehem. Old homesites, fields; occasional (S,T).

Polygonatum biflorum (Walter) Elliott [*P. canaliculatum* (Muhl.) Pursh], Solomon's Seal. Mesic slopes, ravines and bluffs; frequent (L,S,T).

Smilacina racemosa (L.) Desf., False Spikenard. Rich woods; frequent (L,S,T). Including the var. *cylindrata* Fernald reported by Ellis *et al.* (1971).

Stenanthium gramineum (Ker) Morong, Featherbells. Not vouchered, but reliably reported from Lyon County by Scott Gunn (personal communication).

Trillium cuneatum Raf., Purple Trillium. A few rich woods and bluffs southward but unknown from the north; very rare (S).

Trillium flexipes Raf., White Trillium. Abundant along Bear Creek but otherwise unknown; rare (S).

Trillium recurvatum Beck, Recurved Trillium. Scattered throughout in rich woods (L,S,T).

Uvularia grandiflora Sm., Bellwort. Rich wooded slopes; locally abundant (L,S,T).

NAJADACEAE, Naiad Family

Najas gracillima (A. Braun) Magnus, Slender Naiad. Known only from one spring-pond in the Golden Pond area; very rare (T).

Najas guadalupensis (Spreng.) Magnus, Guadalupe Naiad. Bays and shallow water of Kentucky Reservoir and the inland lakes; abundant and often a pest (L,S,T).

Najas minor All., Small Naiad. Shallow water of Kentucky Reservoir and the inland lakes; abundant, weedy (L,S,T).

ORCHIDACEAE, Orchis Family

Aplectrum hyemale (Muhl. ex Willd.) Nutt., Puttyroot. Rich woods, mostly on alluvium; occasional (L,S,T).

Corallorhiza odontorhiza (Willd.) Nutt., Autumn Coralroot. Low thin woods; very rare (S,T).

Corallorhiza wisteriana Conrad, Wister's Coralroot. Low rich woods; very rare (T). This report is based on *Athey 4007* (VDB).

Cypripedium calceolus L. var. *pubescens* (Willd.) Correll, Yellow Lady's Slipper. Rich, mesic to dry woods and thickets; rare (S,T).

Galearis spectabilis (L.) Raf. [*Orchis spectabilis* L.], Showy Orchis. Low rich woods and thickets; very rare (L,T). The voucher for T is *Athey 4008* (VDB).

Goodyera pubescens (Willd.) R. Br., Rattlesnake Plantain. Mixed pine-oak woods on dry slopes and ridges; very rare (S).

Liparis lilifolia (L.) Rich., Lily-Leaved Twayblade. Rich mesic woods; very rare (L,S,T).

Liparis loeselii (L.) Rich., Fen Orchid or Bog Twayblade. Known only from a boggy meadow formed by beaver activity; very rare (S).

Platanthera peramoena (A. Gray) A. Gray [*Habenaria peramoena* Gray], Purple Fringeless Orchid. Rich woods, thickets, low fields and barrens; rare but sometimes in quantities (L,S,T).

Spiranthes cernua (L.) Rich., Nodding Ladies' Tresses. Fields, mesic woods; occasional (L,S,T).

Spiranthes gracilis (Bigelow) Beck, Slender Ladies' Tresses. Barrens, thin dry woods; rare (S).

Spiranthes grayi Ames [*S. tuberosa* Raf.], Little Ladies' Tresses. Thin dry woods; very rare (S,T).

Spiranthes ovalis Lindl., Lesser Ladies' Tresses. Rich mesic woodlands, usually on alluvium. Our material is var. *erostellata* Catling (Catling 1983); very rare (S).

Spiranthes vernalis Engelm. & A. Gray, Spring Ladies' Tresses. Wet fields; very rare (S).

Tipularia discolor (Pursh) Nutt., Cranefly Orchid. Slope and ridge forests; occasional (L,S,T).

POACEAE, Grass Family

Agrostis elliottiana Schult., Elliott's Bentgrass. Fields, meadows, roadsides; locally abundant (S,T).

**Agrostis gigantea* Roth [*A.alba* L.], Redtop. Roadsides, fields, disturbed lands; frequent (L,S,T).

Agrostis hyemalis (Walt.) BSP. [including *A. scabra* Willd.], Ticklegrass, Hairgrass. Mesic fields and thickets; occasional to rare (S).

Agrostis perennans (Walt.) Tuck., Upland Bent. Woodlands and roadsides; frequent (L,S,T).

**Aira elegantissima* Schur [*A. elegans* Willd.], Elegant Hairgrass. Old fields, dry roadsides, disturbed sites; rare but sometimes in large stands (S).

Alopecurus carolinianus Walt., Carolina Foxtail. Low fields, wet meadows; abundant (L,S,T).

Andropogon gerardi Vit., Big Bluestem. Barrens and fields; occasional (L,S,T).

Andropogon gyrans Ashe [*A. elliottii* Chapm.], Elliott's Broom Sedge. Bluffs, barrens, dry fields; locally abundant (L,S,T).

Andropogon ternarius Michx., Silver Broom Sedge. Fields, open woods, barrens; occasional (L,S,T).

Andropogon virginicus L., Broom Sedge. Old fields, thickets, cut-over woods; abundant and one of our most conspicuous grasses (L,S,T).

**Anthoxanthum aristatum* Boiss., Sweet Vernal Grass. Weedy roadsides; recently introduced and first reported by Abbott, Thompson, and Gelis (2001).

Aristida dichotoma Michx. Poverty Grass. Dry banks, fields and barrens; frequent, (L,S,T).

Aristida longespica Poir. var. *longespica*, Spiked Needlegrass. Dry fields, banks, barrens; frequent, often in dense stands (L,S,T).

Aristida longespica Poir. var. *geniculata* (Raf.) Fernald, Geniculate Spiked Needlegrass. Fields barrens; very rare (S).

Aristida oligantha Michx., Few-Flowered Needlegrass. Dry fields, barrens, eroded lands; frequent, often conspicuous (L,S,T).

Aristida purpurascens Poir., Purple Needlegrass. Fields, barrens, roadsides; locally abundant (L,S,T).

**Arthraxon hispidus* (Thunb.) Makino, Joint-Grass. Mesic to wet fields, thickets and ditches; scattered but sometimes in large stands (L,S,T).

Arundinaria gigantea (Walt.) Muhl., Cane. Thin woods on streambanks and in bottomlands, usually in dense stands; locally abundant (L,S,T).

**Arundo donax* L., Giant Reed. Persisting and slightly spreading at a few old homesites; rare (S,T).

**Avena sativa* L., Cultivated Oats. Waif on strawed roadsides and in waste areas; rare (S,T).

Brachyelytrum erectum (Schreb.) Beauv., Short Huskgrass. Slope woods; locally abundant (L,S,T).

**Bromus commutatus* Schrad. [including *B. racemosus* L.], Racemose Brome Grass. Fields, roadsides, disturbed sites; frequent and often in large numbers (L,S,T).

**Bromus inermis* Leyss., Hungarian Brome Grass. Clumped on roadsides and in fields; rare (T).

**Bromus japonicus* Thunb., Japanese Brome. Roadsides and fields; locally abundant (L,S,T).

Bromus pubescens Muhl. ex Willd. [*B. purgans* L.], Woodland Brome Grass. Mesic woodlands, especially in ravines and on streambanks; occasional (L,S,T).

**Bromus tectorum* L., Brome Grass. Roadsides, fields, disturbed sites; frequent to abundant (L,S,T).

Cenchrus incertus Curtis, Sandbur. Collected once in an open, sandy, lawn-like area by Kentucky Reservoir at Gray's Landing; very rare (S).

Chasmanthium latifolium (Michx.) Yates [*Uniola latifolia* Michx.], Wild Oats. Mesic to wet fields and woods; frequent and often in dense stands (L,S,T).

Cinna arundinacea L., Wood Reedgrass. Swampy fields and woods, wet barrens; occasional (L,S,T).

**Cynodon dactylon* (L.) Pers., Bermuda Grass. A lawn grass spreading vegetatively to roadsides, around old homes and in cemeteries; occasional but matted when found (L,S,T).

**Dactylis glomerata* L., Orchard Grass. A forage and hay crop, self-seeding onto roadsides, in fields and disturbed sites; frequent (L,S,T).

Danthonia spicata (L.) Beauv., Poverty Grass. Dry woods, banks, eroded fields and other dry open areas; abundant (L,S,T).

Diarrhena americana Beauv., Diarrhena. Shaded river banks, bluffs and woods; rare (L,T).

Diarrhena obovata (Gleason) Bran.[*D. americana* Beauv. var. *obovata* Gleason], Obovate Diarrhena. Rare in rocky woods (L).

**Digitaria ischaemum* (Schreb.) Muhl., Smooth Crab Grass. Cultivated fields, picnic grounds, reservoir shorelines and other disturbed sites; frequent, often in dense stands (L,S,T).

**Digitaria sanguinalis* (L.) Scop., Hairy Crab Grass. Disturbed sites and cultivated fields;throughout, often in dense stands (L,S,T).

**Echinochloa crusgalli* (L.) Beauv., Barnyard Grass. Wet fields, ditches, swamp borders, around ponds; locally abundant (L,S,T).

**Echinochloa frumentacea* (Roxb.) Link, Japanese Millet. Planted in wildlife plots, especially in bottomlands, and often self-seeding (L,S,T).

Echinochloa muricata (Beauv.) Fernald, Barnyard Grass. Low fields; rare (S).

**Eleusine indica* (L.) Gaertn., Goose Grass, Yard Grass. Fields, roadsides, old yards, disturbed soils; scattered, locally abundant (L,S,T).

Elymus hystrix L. [*Hystrix patula* Moench], Bottlebrush Grass. Streambanks, mesic bluff and slope forests where there are outcrops; locally abundant (L,S,T).

Elymus villosus Muhl., Hairy Wild Rye. Open woods, bluffs and thickets; occasional to rare (L,S).

Elymus virginicus L. var. *virginicus*, Virginia Wild Rye, Terrell Grass. Fields, barrens, thickets, disturbed sites; frequent (L,S,T).

Elymus virginicus L. var. *glabriflorus* (Vasey) Bush. With the typical variety (L,S,T).

Elymus virginicus L. var. *submuticus* Hook. Rare, probably not distinct from the typical variety (S).

Eragrostis capillaris (L.) Nees, Lace Grass. Roadsides, fields; locally abundant (L,S,T).

**Eragrostis cilianensis* (All.) Mosher [*E. megastachya* (Koel.) Link], Stink-Grass. Open wet fields, meadows, reservoir margins and other disturbed sites; frequent, often matted (L,S,T).

**Eragrostis curvula* (Schrad.) Nees, Weeping Love Grass. Planted on a few roadsides for erosion control; clumped (L,S,T).

Eragrostis frankii Meyer, Frank's Love Grass. Open roadsides, banks, fields; occasional, sometimes in large numbers (L,S,T).

Eragrostis hirsuta (Michx.) Nees, Hairy Love Grass. Dry fields and rocky riverbanks; rare (L,S,T).

Eragrostis hypnoides (Lam.) BSP., Creeping Love Grass. Mudflats, wet fields, pond margins; carpet-forming (L,S,T).

**Eragrostis pilosa* (L.) Beauv., Pilose Love Grass. Alluvial flats and other moist disturbed sites; frequent, often in dense stands (L,S,T).

Eragrostis spectabilis (Pursh) Steud., Tumble Grass. Dry fields, roadsides; frequent (L,S,T).

Erianthus alopecuroides (L.) Ell., Wooly Beardgrass. Fields, roadsides, disturbed sites; frequent, often in large stands (L,S,T).

Erianthus giganteus (Walt.) Muhl., Giant Beardgrass. Under power lines, in fields, and on roadsides; locally abundant (L,S,T).

**Festuca elatior* L. [*F. arundinacea* Schreb.], Tall or Meadow Fescue. Naturalized throughout in fields, meadows, on roadsides and in disturbed soils (L,S,T).

**Festuca rubra* L., Red Fescue. Sparingly naturalized in disturbed soils; occasional (L,S,T).

Festuca subverticillata (Pers.) Alex. [F. *obtusa* Biehler], Obtuse Fescue. Mesic woods, most often in streambank or bottomland forests; frequent (L,S,T).

Glyceria striata (Lam.) Hitchc., Manna-Grass. Wet woods, swamps, marshes, ditches; throughout, often in stands (L,S,T).

Gymnopogon ambiguus (Michx.) BSP., Beardgrass. Old fields and barrens; very rare (S,T).

**Holcus lanatus* L., Velvet Grass. Fields, meadows, roadsides; infrequent (L,S,T).

Hordeum pusillum Nutt., Little Barley. Fields, meadows, roadsides, disturbed sites; frequent (L,S,T).

**Hordeum vulgare* L., Common Barley. Waif on strawed roadcuts and reservoir banks; rare (L,S,T).

Leersia oryzoides (L.) Sw., Rice Cutgrass. Marshes, wet meadows; locally abundant (L,S,T).

Leersia virginica Willd., Virginia Cutgrass. Mesic woods and thickets; frequent (L,S,T).

Leptochloa filiformis (Lam.) Beauv., Feathergrass. Open reservoir banks, cultivated bottomlands, disturbed sites; infrequent (L,S).

Leptochloa panicoides (Pres.) Hitchc. [*Diplachne halei* Nash], Meadow Grass. Mudflats and swampy fields and thickets by the reservoirs; locally abundant (L,S,T).

**Lolium multiflorum* Lam., Italian Ryegrass. Roadsides, fields; locally abundant (L,S,T).

**Lolium perenne* L., Common Ryegrass. Roadsides, fields, disturbed soils; rare (L,S).

Melica mutica Walt., Melic Grass. Mesic rocky woodlands and bluffs; occasional (L,S,T).

Melica nitens (Scribn.) Nutt., Shining Melic Grass. Open woods on limestone outcrops; very rare (T). This report is based on an unnumbered collection by Mr. Raymond Athey (Athey Herbarium, now at MUR).

**Microstegium vimineum* (Trin.) Cam.[*Eulalia viminea* (Trin.) Ktze.], Japanese Grass. Bottomland woods and thickets, ditches, wet fields; frequent, often forming large mats (L,S,T).

**Miscanthus sinensis* Anderss., Chinese Plumegrass. Homesites; rare (S,T).

Muhlenbergia capillaris (Lam.) Trin., Hairgrass. Dry open woods and fields; rare (S,T).

Muhlenbergia frondosa (Poir.) Fernald, Leafy Muhly. Wooded bluffs and streambanks; rare (L,S).

Muhlenbergia glabriflora Scribn., Smooth-Flowered Muhly. Bluffy woods, fields; rare (L,T).

Muhlenbergia schreberi Gmel., Nimble-Will. Mesic weedy sites throughout; abundant (L,S,T).

Muhlenbergia sobolifera (Muhl.) Trin., Sprouting Muhly. Slopes, ridges, bluffs; frequent (L,S,T).

Muhlenbergia sylvatica Torr., Woodland Muhly. Mesic wooded bluffs, roadbanks and low woods; locally abundant northward, rare to the south (L,S,T).

Muhlenbergia tenuiflora (Willd.) BSP., Slender-Flowered Muhly. Rich woods; infrequent (S,T).

Panicum acuminatum Swartz var. *acuminatum* [*P. lanuginosum* Ell.], Woolly Panic Grass. Open woods, thickets and fields; abundant (L,S,T).

Panicum acuminatum Swartz var. *lindheimeri* (Nash) Lelong [*P. lindheimeri* Nash], Lindheimer's Panic Grass. Mesic fields and barrens; rare (S,T).

Panicum acuminatum Swartz var. *longiligulatum* (Nash) Lelong [*P. longiligulatum* Nash], Long-Liguled Panic Grass. Mesic to dry, open woods, fields and barrens; frequent (L,S,T).

Panicum anceps Michx., Two-Edged Panic Grass. Moist to dry fields, roadsides, thickets, disturbed lands; throughout, often abundant (L,S,T).

Panicum angustifolium Ell., Narrow-Leaved Panic Grass. Old fields and barrens; generally rare but sometimes in large stands (S,T).

Panicum boscii Poir., Bosc's Panic Grass. Bluffs, dry thin woods, roadsides; frequent (L,S,T).

Panicum capillare L. var. *capillare,* Witch-Grass. Fields, roadsides, disturbed areas; frequent and showy in autumn (L,S,T).

Panicum capillare L. var. *sylvaticum* Torr. [*P. philadelphicum* Bernh. ex Trin.], Philadelphia Panic Grass. Moist fields and woods; rare (T).

Panicum clandestinum L., Hidden Panic Grass. Woods, thickets and fields; frequent (L,S,T).

Panicum commutatum Schult. var. *commutatum*, Changeable Panic Grass. Open woods, thickets and fields; frequent (L,S,T).

Panicum depauperatum Muhl., Impoverished Panic Grass. Dry woods and banks; occasional (L,S,T).

Panicum dichotomiflorum Michx., Forked-Flowered Panic Grass. Bottomlands, ditches, mudflats, pond margins; frequent, often in dense stands (L,S,T).

Panicum dichotomum L. var. *dichotomum*, Forking Panic Grass. Dry thin woods, thickets and fields; abundant (L,S,T).

Panicum dichotomum L. var. *ramulosum* (Torr.) Lelong [*P. microcarpon* Muhl.], Small-Fruited Panic Grass. Low woods and fields, barrens; infrequent but sometimes in large stands (L,S,T).

Panicum flexile (Gatt.) Scribn., Pliant Panic Grass. Fields and roadsides; locally abundant (L,S,T).

Panicum laxiflorum Lam., Loose-Flowered Panic Grass. Woods, fields; abundant (L,S,T).

Panicum linearifolium Scribn., Linear-Leaved Panic Grass. Dry cherty woods, fields and banks; infrequent northward, rare to the south (L,S,T).

**Panicum miliaceum* L., Browntop Millet. Planted in wildlife plots and sometimes self-seeding and spreading to adjacent fields and roadsides; abundant when found (L,T).

Panicum polyanthes Schult., Many-Flowered Panic Grass. Dry woods and fields; frequent, (L,S,T).

Panicum ravenelii Scribn. & Merr., Ravenel's Panic Grass. Dry woods and fields; occasional (L,S,T).

Panicum rigidulum Bosc ex Nees var. *rigidulum* [*P. agrostoides* Spreng.], Agrostis-Like Panic Grass. Swampy fields and mudflats, pond margins; throughout, often dense (L,S,T).

Panicum rigidulum Bosc ex Nees var. *elongatum* (Pursh) Lelong [*P. stipitatum* Nash; *P. agrostoides* Spreng. var. *elongatum* (Pursh) Scribn.], Stipitate Panic Grass. With the typical variety (L,S,T).

Panicum scoparium Lam., Broom-Like Panic Grass. Swampy woods, wet meadows and fields; locally abundant (L,S,T).

Panicum sphaerocarpon Ell., Round-Fruited Panic Grass. Dry woods and fields; occasional (L,S,T).

Panicum virgatum L., Switchgrass. Fields, roadsides, barrens; locally abundant (L,S,T).

Paspalum boscianum Flugge, Bull-Grass. Weedy bottomlands southward; very rare (S).

**Paspalum dilatatum* Poir., Dallis-Grass. Moist meadows, fields, lawns and picnic grounds; throughout and often in stands (L,S,T).

Paspalum dissectum L., Divided Knotgrass. Drawdown zones or emergent wetlands of reservoirs and inland lakes; rare but usually plentiful when found (L,S,T).

Paspalum distichum L., Knotgrass. Reservoir shorelines; throughout, locally abundant (L,S,T).

Paspalum floridanum Michx., Florida Knotgrass. Moist fields and meadows; scattered but sometimes in large stands (L,S,T).

Paspalum laeve Michx. [*P. circulare* Nash], Smooth Knotgrass. Mesic fields, meadows, thickets and disturbed sites; throughout (L,S,T).

Paspalum pubiflorum Rupr., Hairy-Flowered Knotgrass. Lawns, fields, meadows, disturbed sites; locally abundant (L,S,T).

Paspalum repens Berg. [*P. fluitans* (Ell.) Kunth], Repent Knotgrass. Wet fields, thickets, reservoir margins and streambanks; locally abundant (L,S,T).

Paspalum setaceum Michx. var. *muhlenbergii* (Nash) Banks, Bristle-Like Knotgrass. Wet meadows and fields; scattered but locally abundant (L,S,T).

Phalaris arundinacea L., Reed Canary Grass. Marshy to mesic bottomlands and forest borders of Lake Barkley; rare (L,S,T).

**Phleum pratense* L., Timothy. Naturalized, fields, on roadsides and in disturbed sites; frequent (L,S,T).

**Poa annua* L., Low Speargrass, Annual Bluegrass. Fields, disturbed areas; locally abundant (L,S,T).

Poa autumnalis Muhl., Autumnal Bluegrass. Low woods; rare but sometimes in large numbers (L,T).

**Poa compressa* L., Canadian Bluegrass. Woods, thickets and trailsides; locally abundant (L,S,T).

**Poa pratensis* L., Kentucky Bluegrass. Mesic fields, meadows, roadsides, old lawns; frequent, often in dense stands (L,S,T).

Poa sylvestris Gray, Woodland Bluegrass. Wooded streambanks and bluffs; occasional (L,S,T).

Schizachyrium scoparium (Michx.) Nash [*Andropogon scoparius* Michx.], Little Bluestem. Bluffs, barrens and fields; frequent, often in dense stands (L,S,T).

**Secale cereale* L., Common Rye. Waif on newly seeded and strawed roadbanks; rare (S).

**Setaria faberii* Herrm., Tall Foxtail. A weed of disturbed and cultivated lands (L,S,T).

**Setaria italica* (L.) Beauv., German or Hungarian Millet. Planted for wildlife and hay and self-seeding on roadsides and in fields; often abundant (L,S,T).

Setaria parviflora (Poir.) Kerg. [*S. geniculata* (Lam.) Beauv.], Bent Bristly Foxtail. Fields, roadsides, meadows and barrens; frequent, often in large stands (L,S,T).

**Setaria pumila* (Poir.) Roem. & Schult. [*S. lutescens* (Wigel.) Hubb.; *S. glauca* (L.) Beauv.], Glaucous Foxtail. Fields, meadows and roadsides; frequent and often in large stands (L,S,T).

**Setaria viridis* (L.) Beauv., Green Foxtail. Roadsides, fields and barrens; abundant (L,S,T).

Sorghastrum nutans (L.) Nash, Indian Grass. Barrens, dry fields, under power lines; infrequent but usually in stands when found (L,S,T).

**Sorghum halepense* (L.) Pers., Johnson Grass. Cultivated fields mostly; abundant (L,S,T).

**Sorghum vulgare* Pers., Sorghum, Sudex, Milo. Waif on roadsides and riverbanks; also planted for wildlife and hay (L,S,T).

Spartina pectinata Link, Cord Grass. Wet fields along Kentucky Reservoir; very rare (T).

Sphenopholis nitida (Biehl.) Scribn., Shining Wedge Grass. Mesic to dry woods; frequent (L,S,T).

Sphenopholis obtusata (Michx.) Scribn. var. *obtusata,* Blunt Wedge Grass. Mesic to dry woods and barrens; occasional (S,T).

Sphenopholis obtusata (Michx.) Scribn. var. *major* (Torr.) Erdman [*S. intermedia* (Rydb.) Rydb.], Intermediate Wedge Grass. Mesic, usually low woods; occasional (L,S,T).

Sporobolus asper (Michx.) Kunth, Dropseed. Dry fields and barrens with limestone outcrops; very rare (L). This report is based on *Athey 4527* (MEM).

**Sporobolus indicus* (L.) Br. [*S. poiretii* (Roem. & Schult.) Hitchc., Smut Grass. Weedy fields, disturbed lands; rare (T).

Sporobolus vaginiflorus (Torr.) Wood, Poverty-Grass. Dry fields, disturbed sites; rare but in abundance when found (L,S,T).

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

Tripsacum dactyloides (L.), Gama-Grass. Fields and thickets, mostly near the reservoirs, especially Kentucky Lake; locally abundant in large dense stands (L,S,T).

**Triticum aestivum* L., Common Wheat. Commonly planted for wildlife and sparingly self-seeding or appearing as a waif on roadsides and reservoir margins (L,S,T).

Vulpia octoflora (Walt.) Rydb. [*Festuca octoflora* Walt.], Eight-Flowered Fescue. Barrens, dry fields, banks; frequent (L,S,T).

**Zea mays* L., Corn. Commonly planted and sometimes self-seeding or appearing as a waif on roadsides and reservoir margins (L,S,T).

PONTEDERIACEAE, Pickerelweed Family

**Eichhornia crassipes* (Mart.) Solms, Water-Hyacinth. Shallow bays (sometimes flowering) and washing ashore on Kentucky Reservoir shorelines (S,T).

Heteranthera dubia (Jacq.) MacM., Water Stargrass. Abundant in and around Hematite Lake, Long Creek below Hematite Dam, and Honker Lake (L,T).

Heteranthera limosa (Swartz) Willd., Mud Plantain. Kentucky Reservoir mudflats and one small pond; rare (S,T).

Heteranthera reniformis Ruiz & Pavon, Kidney-Leaved Mud Plantain. Springs, branches, ponds, muddy shores, ditches; scattered but usually in masses when found (L,S).

POTAMOGETONACEAE, Pondweed Family

**Potamogeton crispus* L., Curly-Leaved Pondweed. Rooted in shallow water and floating in deeper areas of Kentucky Reservoir; rare (S,T).

Potamogeton diversifolius Raf., Diverse-Leaved Pondweed. Upland ponds, beaver ponds, shallow reservoir embayments; locally abundant (L,S,T).

Potamogeton foliosus Raf., Leafy Pondweed. Ponds, beaver pools; locally abundant (S,T).

Potamogeton nodosus Poir. [*P. americanus* C. & S.], Knotty Pondweed. Embayments, stranded on reservoir mudflats, inland lakes; locally abundant (L,S,T).

Potamogeton pusillus L., Small Pondweed. Beaver ponds, heads of quiet reservoir bays; locally abundant, becoming weedy in Kentucky Reservoir (L,S,T).

SMILACACEAE, Catbrier Family

Smilax bona-nox L., China-Brier. Mesic thickets, fence rows, fields; frequent (L,S,T).

Smilax glauca Walt., Sawbrier. Old fields, fence rows and other disturbed lands; frequent (L,S,T).

Smilax herbacea L. [our material is the var. *pulverulenta* (Michx.) Gray], Carrion-Flower. Low fields and thickets; occasional to rare (S,T).

Smilax hispida Muhl. [*S. tamnoides* L.], Bristly Greenbrier. Low woods, thickets and fencerows; frequent, especially southward (S,T).

Smilax rotundifolia L., Common Greenbrier. Mesic thickets and woodlands; frequent (L,S,T).

SPARGANIACEAE, Bur-Reed Family

Sparganium americanum Nutt., American Bur-Reed. Swampy creekbanks, beaver marshes; rare (L,S).

TYPHACEAE, Cat-Tail Family

Typha latifolia L., Common Cat-Tail. Shallow ponds, swamp margins, roadsides ditches; scattered throughout, usually in large colonies when found (L,S,T).

ZANNICHELLIACEAE, Horned Pondweed Family

Zannichellia palustris L., Horned Pondweed. Shallow water of Kentucky Reservoir embayments; locally abundant (L,S,T). The voucher for L is *Webb 5363* (TENN).

SPERMATOPHYTA: ANGIOSPERMAE-DICOTYLEDONAE

ACANTHACEAE, Acanthus Family

Dicliptera brachiata (Pursh) Spreng., Dicliptera. Bottomland woods and thickets; rare, southern areas only (S).

Justicia americana (L.) Vahl, Water Willow. Shallow water and muddy shores, mostly around embayments; frequent and often in dense stands (L,S,T).

Ruellia caroliniensis (J.F. Gmel.) Steud., Carolina Wild Petunia. Open woodlands, fields, thickets and roadsides; frequent (L,S,T).

Ruellia strepens L., Smooth Wild Petunia. Mesic woodlands, fields and thickets; occasional (L,S,T).

ACERACEAE, Maple Family

Acer negundo L., Box Elder. Moist woods, fields and thickets; frequent (L,S,T).

Acer rubrum L., Red Maple. Low woods, bottomlands and other mesic sites throughout; frequent (L,S,T). Including the var. *trilobum* Koch reported by Ellis *et al.* (1971) and Chester *et al.* (1976).

Acer saccharinum L., Silver or Water Maple. A characteristic and often dominant species of bottomland and streambank forests, especially southward (L,S,T).

Acer saccharum Marsh., Sugar Maple. General in mesic woodlands; old plantings are a frequent indicator of former homesteads; abundant (L,S,T). Including the var. *schneckii* Rehder reported by Ellis *et al.* (1971) and Chester *et al.* (1976).

AMARANTHACEAE, Amaranth Family

**Alternanthera philoxeroides* (Mart.) Griseb., Alligatorweed. Open marshy shores of Kentucky Reservoir bays; locally abundant (L,S,T).

**Amaranthus hybridus* L., Pigweed, Wild Beet. A weed of cultivated ground and waste places; locally abundant (L,S,T).

Amaranthus rudis J.D. Saur, [*A. tamariscinus* Nutt., *Acnida tamariscina* (Nutt.) Wood], Water Hemp. Sandy flats and banks along Kentucky Reservoir; frequent (L,S,T).

**Amaranthus spinosus* L., Spiny Amaranth. Cultivated fields, pastures and other disturbed sites; occasional (S,T).

Amaranthus tuberculatus (Moq.) Sauer [*Acnida altissima* Ridd.], Water Hemp. Mudflats of the reservoirs and their bays, cultivated bottomlands; frequent, sometimes very plentiful (L,S,T).

**Gomphrena globosa* L., Globe Amaranth. A waif persisting at an old homesite; very rare if not extirpated (S).

Iresine rhizomatosa Standl., Bloodleaf. Swampy bottomland woods and thickets along Lake Barkley; very rare (T).

ANACARDIACEAE, Cashew Family

Rhus copallina L., Shining or Winged Sumac. A characteristic species of old fields, thickets and fencerows; abundant (L,S,T).

Rhus glabra L., Smooth Sumac. In the same habitats as previous species; abundant (L,S,T).

Toxicodendron radicans (L.) Kuntze [*Rhus radicans* L.], Poison Ivy. In various habitats from fields to forests and disturbed sites; abundant (L,S,T).

ANNONACEAE, Custard-Apple Family

Asimina triloba (L.) Dunal, Pawpaw. A constant and often abundant understory member of mesic woods, especially in low sites (L,S,T).

APIACEAE, Parsley Family

**Anethum graveolens* L., Common Dill. Persisting and spreading from cultivation at the (formerly) Empire Farm; rare, probably extirpated (T).

Angelica venenosa (Greenway) Fern., Angelica. Roadbanks, open woods and forest borders; locally abundant (L,S,T).

Chaerophyllum procumbens (L.) Crantz, Chervil. Alluvial thickets and fields along Barkley Reservoir; rare (S).

Chaerophyllum tainturieri Hook., Rough Chervil. Thickets, fields, roadsides and other cultural sites; locally abundant (L,S,T).

Cicuta maculata L., Water Hemlock. Wet fields, ditches and borders of swamps and marshes; occasional (L,S,T).

**Conium maculatum* L., Poison Hemlock. Open road sides, Tharpe area; rare (S).

Cryptotaenia canadensis (L.) DC., Honewort. Cultural sites, roadsides, fields, mesic woods; occasional (L,S,T).

**Daucus carota* L., Wild Carrot, Queen Anne's Lace. Fields, roadsides, cultural sites; frequent (L,S,T).

Erigenia bulbosa (Michx.) Nutt., Harbinger-of-Spring. Rich, mesic forested slopes and bluffs in early spring; occasional (L,S,T).

Eryngium prostratum Nutt., Prostrate Eryngo. Wet fields, shorelines of embayments and ditches; locally abundant (L,S,T).

Eryngium yuccifolium Michx., Rattlesnake Master. Dry banks, fields and barrens; rare (L,S,T).

Osmorhiza longistylis (Torr.) DC., Anise-Root. Mesic slope and ravine forests; occasional (L,S,T).

Oxypolis rigidior (L.) Raf., Cowbane. Wet fields and ditches; very rare (T).

Polytaenia nuttallii DC., Prairie Parsley. Dry, upland forest borders; not seen in over 30 years and possibly extirpated (T).

Ptilimnium capillaceum (Michx.) Raf., Hair-Like Mock Bishop's Weed. Sandy shores of both reservoirs; locally abundant (L,S,T).

Ptilimnium costatum (Ell.) Raf., Ribbed Mock Bishop's Weed. Sandy shores of Kentucky Lake; locally abundant (L,S).

Ptilimnium nuttallii (DC.) Britt., Nuttall's Mock Bishop's Weed. Sandy shores of Kentucky Lake; locally abundant (L,S,T).

Sanicula canadensis L., Canada Black Snakeroot. Mesic to dry woodlands; frequent (L,S,T).

Sanicula odorata (Raf.) Pryer & Phillippe [*S. gregaria* Bickn.], Black Snakeroot. Mesic woods southward; rare (S).

Sanicula smallii Bickn., Small's Black Snakeroot. Low woods; rare (S,T).

Sium sauve Walt., Water Parsnip. Marshy areas at heads of a few bays; rare (S,T).

Thaspium trifoliatum (L.) Gray var. *trifoliatum*, Meadow Parsnip. Woods, barrens and fields; occasional (L,S,T).

Thaspium trifoliatum (L.) Gray var. *flavum* Blake, Yellow Meadow Parsnip. Dry woods, barrens and fields; occasional (L,S).

**Torilis arvensis* (Huds.) Link [*T. japonica* (Houtt.) DC.], Hedge Parsley. Roadsides and cultural sites, especially around old homes; occasional (L,S,T).

Trepocarpus aethusae Nutt. ex DC., Sandy shores and wet woods at heads of Kentucky Lake bays; occasional, sometimes in large stands (L,S,T).

Zizia aptera (Gray) Fern., Wingless Golden Alexanders. Wooded streambanks, ravines and moist shaded roadsides; occasional (L,S,T).

Zizia aurea (L.) Koch, Golden Alexanders. Wooded streambanks; rare (S). The Lyon and Trigg reports by Ellis *et al.* (1971) are not vouchered.

APOCYNACEAE, Dogbane Family

Amsonia tabernaemontana Walt., Bluestar, Blue Dogbane. Mesic thickets and open woods, especially on streambanks; occasional (L,S,T).

Apocynum cannabinum L., Indian Hemp. Roadsides, fields, thickets and disturbed lands; frequent and often in dense stands (L,S,T).

**Vinca major* L., Large Periwinkle. Persisting around old homesites; very rare (S).

**Vinca minor* L., Common Periwinkle. Persisting and spreading around old homesites and in cemeteries; locally abundant (L,S,T).

AQUIFOLIACEAE, Holly Family

Ilex decidua Walt., Deciduous Holly. Frequent along streams, around embayments and the lakeshores; rarely in ravine and moist-slope forests (L,S,T).

Ilex opaca Ait., American Holly. Native in a few ravine and slope forests and perisisting at homesites; rare (S,T).

ARALIACEAE, Ginseng Family

**Acanthopanax sieboldianus* Makino, Spiny Panax. This shrub, with spiny, arching branches, persists at an old homesite (L).

Aralia spinosa L., Devil's Walking Stick. A species of dry woods, forest borders, road and trailsides; frequent (L,S,T).

**Hedera helix* L., English Ivy. Persisting and spreading slightly around homesites and in cemeteries; rare (L,S,T).

Panax quinquefolius L., Ginseng. Mesic slope and ravine woods; occasional (L,S,T).

ARISTOLOCHIACEAE, Birthwort Family

Aristolochia serpentaria L., Virginia Snakeroot. Mesic wooded slopes, ravines and bluffs; occasional (L,S,T).

Aristolochia tomentosa Sims, Dutchman's Pipe Vine. A high climbing vine in thickets and woods along Barkley Lake; rare and known only from southern portions (S,T).

Asarum canadense L., Wild Ginger. Mesic woods and bluffs; locally abundant (L,S,T).

ASCLEPIADACEAE, Milkweed Family

Asclepias amplexicaulis Smith, Clasping-Leaf Milkweed. Dry woods and fields; occasional (L,S,T).

Asclepias hirtella (Pennell) Woods., Hairy Milkweed. Dry roadsides and barrens; very rare (S).

Asclepias incarnata L., Swamp Milkweed. Open wet fields, swamps, marshes and ditches; sometimes abundant (L,S,T).

Asclepias perennis Walt., Smooth-Seeded Milkweed. Swampy woods and shorelines along the Tennessee River and its embayments; occasional (L,S,T).

Asclepias purpurascens L., Purple Milkweed. Mesic woods, thickets and fields; locally abundant (L,S,T).

Asclepias syriaca L., Common Milkweed. Mesic fields, roadsides, meadows and barrens; abundant when found (L,S,T).

Asclepias tuberosa L., Butterfly Weed. Fields, barrens and roadsides; frequent (L,S,T).

Asclepias variegata L., Variegated Milkweed. Fields, barrens and roadsides; frequent (L,S,T).

Asclepias verticillata L., Horsetail Milkweed. Dry fields and open woods; occasional (L,S,T).

Cynanchum laeve (Michx.) Pers. [*Ampelamus albidus* (Nutt.) Britton], Honeyvine. Fencerows and thickets; occasional but sometimes forming extensive colonies (L,S,T).

Matelea carolinensis (Jacq.) Woods. [*Gonolobus carolinensis* (Jacq.) Schultes], Carolina Angle-Pod. Mesic thickets and fencerows; rare (S,T).

Matelea gonocarpa (Walt.) Shinners [*Gonolobus gonocarpos* (Walt.) Perry], Climbing Milkweed, Angle-Pod. Mesic thickets and fencerows; frequent, often forming large colonies (L,S,T).
Matelea obliqua (Jacq.) Woods. [*Gonolobus shortii* Gray], Short's Angle-Pod. Thickets; very rare (T).

ASTERACEAE, Composite Family

Achillea millefolium L.,Yarrow. Fields, roadsides and other disturbed sites; frequent (L,S,T).
Ambrosia artemesiifolia L., Common Ragweed. Fields, roadsides and thickets; frequent (L,S,T).
Ambrosia bidentata Michx., Twice-Toothed Ragweed. Dry fields, roadsides and barrens; locally abundant (L,S,T).
Ambrosia trifida L., Great Ragweed, Buffalo Weed. Bottomland fields and thickets, mesic disturbed sites; locally abundant (L,S,T).
Antennaria plantaginifolia (L.) Rich., Plantain-Leaved Pussy Toes. Dry banks and roadsides, open dry woods; abundant (L,S,T).
Antennaria solitaria Rydb., Solitary Pussy Toes. Dry open woods and banks; rare (S,T).
**Anthemis cotula* L., Mayweed. Roadsides, fields, old barnyards; becoming rare (L,S,T).
**Arctium minus* (Hill) Bernh., Common Burdock. Fields and thickets, especially around old homes and barnyards; occasional (L,S,T).
**Artemesia annua* L., Wormwood. Fields, homesteads, thickets; occasional (L,S,T).
**Artemesia ludoviciana* Nutt., White Sage. Persisting and spreading by rhizomes around homesites; very rare (S,T).
**Artemesia vulgaris* L., Common Mugwort. Spreading around a few homesites; very rare (S).
Aster cordifolius L., Heart-Leaved Aster. Bluffy woods and rocky slopes; occasional to rare (L,S,T).
Aster dumosus L., Bushy Aster. Dry fields, woods and roadsides; frequent (L,S,T).
Aster hemisphericus Alex., Hemispherical Aster. Dry cherty banks and fields; locally abundant southward but becoming rare and eventually absent to the north (S,T).
Aster lateriflorus (L.) Britt., Lateral-Flowered Aster. Dry forest borders, weedy fields and bluffs; occasional (L,S,T).
Aster linariifolius L., Toadflax Aster. Dry fields and dry open woods; rare (L,S,T). The voucher for S is *Kral 5227* (VDB - now at BRIT).
Aster novae-angliae L., New England Aster. Dry open woods, fields and thickets; very rare (S).
Aster oblongifolius Nutt., Oblong-Leaf Aster. Dry woods and bluffs; very rare (S).
Aster ontarionis Wieg., Ontario Aster. Mudflats and swampy fields along the reservoirs; rare (L).
Aster patens Ait., Spreading Aster. Dry open fields and woods; frequent (L,S,T).
Aster pilosus Willd., Pilose Aster. Old fields, thickets, dry woods and banks; frequent (L,S,T).
Aster sagittifolius Willd., Arrow-Leaf Aster. Mesic woodlands, bluffs, fields; occasional (L,S,T).
Aster shortii Lindl., Short's Aster. Mesic woods and bluffs; occasional (L,S,T).
Aster simplex Willd., Simple Aster. Mudflats and swampy thickets along the reservoirs; locally abundant (L,S,T).
Aster undulatus L., Undulate Aster. Fields, barrens, dry open woods; locally abundant (L,S,T).
Astranthium integrifolium (Michx.) Nutt., Western Daisy. Dry roadbanks and open woods; locally abundant to the south but rare or absent northward (S,T).
Bidens aristosa (Michx.) Britt., Tickseed Sunflower. Mesic fields, thickets and barrens; occasional, sometimes abundant (L,S,T).
Bidens bipinnata L., Spanish-Needles. Fields, roadsides, thickets, disturbed land; occasional (L,S,T).
Bidens cernua L., Nodding Sticktights. Mudflats, swampy fields and thickets; occasional but sometimes in dense stands (L,S,T).
Bidens discoidea (Torr. & Gray) Britt., Discoid Sticktights. On logs and stumps exposed by falling water of embayments and swamps; locally abundant (L,S,T).
Bidens frondosa L. [including *B. vulgata* Greene], Leafy Sticktights. Wet fields and thickets; frequent (L,S,T).

Bidens polylepis Blake, Scaled Sticktights. Mesic fields and thickets; locally abundant (L,S,T).

Bidens tripartita L. [*B. comosa* (Gray) Wieg.], Three-Parted Sticktights. Mudflats, swampy fields, pond margins; occasional (L,S,T).

Boltonia diffusa Ell., Diffuse Boltonia [previously reported as *B. asteroides* (L.) L'Her., but Dr. A. Cronquist placed our material under *B. diffusa*]. Wet fields, reservoir margins, mudflats, swampy thickets; locally abundant (L,S,T).

Cacalia atriplicifolia L., Pale Indian Plantain. Mesic fields and thickets, usually in bottomlands; locally abundant (L,S,T).

Cacalia muhlenbergii (Schulz-Bip.) Fern., Great Indian Plantain. Mesic fields and thickets, usually in bottomlands; locally abundant but less frequently encountered than the previous species (L,S,T).

Cacalia suaveolens L., Sweet Indian Plantain. Mesic fields, thickets and woods, usually in bottomlands; rare (L,S,T).

**Carduus nutans* L., Nodding or Musk Thistle. Roadsides and fields; rare but a potentially troublesome weed (S,T).

**Centaurea cyanus* L., Bachelor's Buttons. Persisting in cemeteries and on roadsides; rare (S).

**Centaurea maculosa* Lam., Spotted Star-Thistle. Roadsides, homesites and cemeteries; rare (L,T).

**Chrysanthemum leucanthemum* L., Oxeye Daisy. Fields and roadsides; abundant (L,S,T).

**Chrysanthemum parthenium* (L.) Bernh., Feverfew. Persisting in a cemetery; very rare (T).

Chrysopsis camporum Greene, Prairie Golden Aster. Dry roadsides, fields and barrens; locally abundant southward but unknown from the north (S).

**Chrysopsis pilosa* Nutt., Pilose Golden Aster. Open weedy fields and roadsides; very rare (S,T).

**Cichorium intybus* L., Chicory. Roadside weed; infrequent (L,S,T).

Cirsium altissimum (L.) Spreng., Tall Thistle. Fields, cultural sites, open woods; frequent (L,S,T).

Cirsium carolinianum (Walt.) Fern. & Schub., Carolina Thistle. Margins of dry woods; very rare (L).

Cirsium discolor (Muhl.) Spreng., Two-Colored Thistle. Fields, roadsides, cultural sites; frequent and probably the most abundant thistle in LBL (L,S,T).

**Cirsium vulgare* (Savi) Tenore, Bull/Common Thistle. Roadsides, fields; infrequent (L,S,T).

Conyza canadensis (L.) Cronquist [*Erigeron canadensis* L.], Horseweed. Mesic fields, thickets and cultural sites; locally abundant. A dominant species of bottomland fields in early successional stages (L,S,T).

Conyza ramosissima Cronquist, Divergent Fleabane. Old lawns and gravel driveways; very rare (S).

**Coreopsis lanceolata* L., Lance-Leaved Tickseed. Persisting and spreading around homesteads to fields and roadsides; locally abundant (S,T).

Coreopsis major Walt., Large Tickseed. Dry open woods and fields; frequent southward but becoming rare to the north (L,S,T).

**Coreopsis tinctoria* Nutt., Tickseed. Shorelines, fields, roadsides; locally abundant (L,S,T).

Coreopsis tripteris L., Tall Tickseed. Moist fields and thickets; frequent (L,S,T).

**Cosmos bipinnatus* Cav., Cosmos. Self-seeding in cemeteries; rare (S).

**Dahlia rosea* Cav., Common Dahlia. Persisting in a cemetery; very rare (S).

Echinacea pallida Nutt., Pale Coneflower. Dry roadsides near and adjacent to Silver Trail; rare (L).

Echinacea purpurea (L.) Moench, Purple Coneflower. Dry woods; very rare, not collected since the 1960s (T).

Eclipta alba (L.) Hassk., Yerba-De-Tago. Wet thickets and ditches, swampy areas; frequent (L,S,T).

Elephantopus carolinianus Willd., Carolina Elephant's Foot. Mesic fields, disturbed and cultural sites; locally abundant (L,S,T).

Erechtites hieracifolia (L.) Raf. ex DC., Fireweed. Disturbed and cut-over woodlands; locally abundant (L,S,T).

Erigeron annuus (L.) Pers., Daisy Fleabane. Fields, roadsides and disturbed sites; abundant (L,S,T).

Erigeron philadelphicus L., Philadelphia Fleabane. Fields, roadsides and other cultural sites; occasional (L,S,T).

Erigeron pulchellus Michx., Robin's Plantain. Woodland borders and dry open woods; rare but in patches when found (S,T).

Erigeron strigosus Muhl. ex Willd., Daisy Fleabane. Fields, roadsides and other cultural sites; frequent (L,S,T).

Eupatorium album L., White Thoroughwort. Dry fields and roadsides; rare (S,T).

Eupatorium altissimum L., Tall Thoroughwort. Dry fields and roadsides; infrequent to the south, very rare northward (S,T). The voucher for T is *Athey 4470* (formerly MEM, now at TENN).

Eupatorium aromaticum L., Aromatic Thoroughwort. Fields and meadows; rare (S,T).

Eupatorium capillifolium (LaM.) Small, Dog-Fennell. Disturbed woods; very rare (S).

Eupatorium coelestinum L., Mist Flower, Ageratum. Mesic fields, disturbed sites; abundant (L,S,T).

Eupatorium fistulosum Barratt, Joe Pye Weed. Mesic fields and thickets, usually in bottomlands; locally abundant (L,S,T).

Eupatorium hyssopifolium L., Hyssop-Leaved Thoroughwort. Fields and barrens; throughout, often abundant (L,S,T).

Eupatorium incarnatum Walt., Flesh-Colored Thoroughwort. Ditches, wet fields and woods, mesic bluffs; rare (L,S,T).

Eupatorium perfoliatum L., Perfoliate Thoroughwort, Boneset. Wet fields and thickets; occasional but sometimes in large numbers (L,S,T).

Eupatorium purpureum L., Sweet Joe Pye Weed. Mesic fields, thickets and forest borders, most often in bottomlands; locally abundant (L,S,T).

Eupatorium rotundifolium L., Rough-Leaved Thoroughwort. Fields; occasional (L,S,T).

Eupatorium rugosum Houtt., White Snakeroot. Low woods, streambanks and ravines; abundant throughout (L,S,T).

Eupatorium serotinum Michx., Late-Flowering Thoroughwort. Fields, barrens and cultural sites; occasional (L,S,T).

Eupatorium sessilifolium L., Upland Boneset. Dry fields, barrens and open woods; rare (L,S,T).

Euthamia graminifolia (L.) Nutt. [*Solidago graminifolia* (L.) Salisb.], Grass-Leaved Goldenrod. Fields and barrens; occasional (L,S,T).

**Galinsoga quadriradiata* Ruiz & Pavon [*G. ciliata* (Raf.) Blake], Ciliate Galinsoga. Weedy areas at the Wrangler's Camp; very rare (T).

Gnaphalium obtusifolium L., Catfoot. Fields, barrens and open woods; frequent (L,S,T).

Gnaphalium purpureum L., Purple Catfoot. Fields, barrens and thickets; frequent (L,S,T).

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

Helenium autumnale L., Autumnal Sneezeweed. Wet meadows formed by beaver dams; rare (S).

Helenium flexosum Raf., Flexous Sneezeweed. Swampy fields and meadows; frequent (L,S,T).

Helianthus angustifolius L., Narrow-Leaved Sunflower. Fields, roadsides and barrens; locally abundant (L,S,T).

**Helianthus annuus* L., Common Sunflower. Usually planted for wildlife; locally abundant (S,T).

Helianthus atrorubens L., Red Sunflower. Barrens and fields; rare southward (S).

Helianthus divaricatus L., Spreading Sunflower. Roadsides, fields and dry woods; frequent (L,S,T).

Helianthus hirsutus Raf., Hairy Sunflower. Fields, roadsides; frequent, often abundant (L,S,T).

**Helianthus x laetiflorus* Pers., Beautifully-Flowered Sunflower. Old homesites, where apparently persisting and spreading from rhizomes; rare (T). The Stewart report from Ellis *et al.* (1971) is not vouchered.

**Helianthus maximilianii* Schrad., Maximilian's Sunflower. Persisting from plantings, sometimes on roadsides; generally rare but sometimes in large stands (L,S,T).

Helianthus microcephalus Torr. & Gray, Small Wood Sunflower. Open woods, fields, and roadsides; frequent (L,S,T).

Helianthus mollis Lam., Soft Sunflower. Fields and barrens; rare but sometimes in stands (L,T).

Helianthus occidentalis Riddell, Western Sunflower. Barrens and fields; rare (T).
Helianthus strumosus L., Smooth Sunflower. Weedy fields and thickets; locally abundant (L,S,T).
Helianthus tuberosus L., Jerusalem Artichoke. Along open water-courses; locally abundant (S,T).
Heliopsis helianthoides (L.) Sweet, Oxeye. Low fields, thickets and open woods; occasional (L,S,T).
Hieracium gronovii L., Hawkweed. Dry woods, banks and fields; frequent (L,S,T).
**Hypochoeris radicata* L., Cat's Ear. Open disturbed sites; very rare (S).
**Iva annua* L. [*I. ciliata* Willd.], Marsh Elder. Fields, especially around cultivated bottomlands; frequent and often in dense stands (L,S,T).
Krigia biflora (Walt.) Blake, Two-Flowered Dwarf Dandelion. Open woods, cemeteries and fields; abundant (L,S,T).
Krigia dandelion (L.) Nutt., Potato Dandelion. Fields, cemeteries and roadsides; frequent (L,S,T).
Krigia oppositifolia Raf. [*Serinia oppositifolia* (Raf.) Ktze.], Opposite-Leaved Dwarf Dandelion. Weedy fields, usually in sandy bottomlands; locally abundant (L,S,T).
Krigia virginica (L.) Willd., Virginia Dwarf Dandelion. Sandy fields and roadbanks; rare (L,S,T).
Kuhnia eupatorioides L., False Boneset. Fields, barrens, open oak woods; rare (L,S,T).
Lactuca canadensis L., Canadian Wild Lettuce. Fields, roadsides and waste lands; frequent (L,S,T).
Lactuca floridana (L.) Gaertn., Florida Wild Lettuce. Mesic fields, roadsides and open woods; occasional (L,S,T).
**Lactuca saligna* L., Willow-Leaved Wild Lettuce. Road shoulders and fields; rare (L,S,T).
**Lactuca serriola* L. [*L. scariola* L.], Prickly Wild Lettuce. Fields, roadsides, thickets; occasional (L,S,T).
Liatris spicata (L.) Willd., Spicate Blazing Star. Fields and barrens; rare (L).
Liatris squarrosa (L.) Michx., Spreading Blazing Star. Dry fields, banks, barrens; frequent (L,S,T).
Liatris squarrulosa Michx. [*L. scabra* (Greene) K. Schum.]. Rough Blazing Star. Dry fields, roadbanks and barrens; frequent and sometimes abundant, especially northward (L,S,T).
**Matricaria matricarioides* (Less.) Porter, Pineapple Weed. Open road shoulders, Highway 68; rare (T).
Melanthera nivea (L.) Small [*M. hastata* Michx.], Hastate-Leaved Melanthera. Thickets and wet woods along Kentucky Reservoir; rare (S,T).
Mikania scandens (L.) Willd., Climbing Hempweed. Forming dense thickets along a few Kentucky Reservoir bays; generally rare (S,T).
Parthenium integrifolium L., Wild Quinine. Dry fields, barrens, roadsides and open oak woods; frequent (L,S,T).
Pluchea camphorata (L.) DC., Camphor Weed. Swampy fields and thickets, mostly along the reservoirs; abundant (L,S,T).
Polymnia canadensis L., Canadian Leafcup. Mesic woods and bluffs in the south only; rare (S).
Polymnia uvedalia L., Bearsfoot. Mesic woods and bluffs, forest borders; occasional (L,S,T).
Prenanthes altissima L., Tall Rattlesnake Root. Mesic woods, fields and thickets;occasional (L,S,T).
Prenanthes barbata (Torr. & Gray) Milstead, Rattlesnake Root. Fields, barrens southward; rare (S).
Pyrrhopappus carolinianus (Walt.) DC., False Dandelion. Mesic fields, ditches, streambanks and roadsides; frequent (L,S,T).
Ratibida pinnata (Vent.) Barnh., Prairie Coneflower. Dry fields and barrens; rare but sometimes in large numbers (L,T).
Rudbeckia fulgida Ait., Shining Coneflower. Low fields and thickets in the south; rare (S).
Rudbeckia hirta L., Black-Eyed Susan. Fields, roadsides and barrens; abundant (L,S,T).
Rudbeckia laciniata L., Laciniate Coneflower. Low woods and thickets; occasional (L,S,T).
Rudbeckia triloba L., Lobed-Leaved Coneflower. Low fields and thickets, especially along creeks; abundant (L,S,T).
Senecio anonymus Wood [*S. smallii* Britton], Small's Groundsel. Weedy roadsides and fields; rare (S,T).
Senecio aureus L., Golden Ragwort. Swampy woods and streambanks; locally abundant, especially southward (S,T).

Senecio glabellus Poir., Butterweed. Fallow bottomlands, wet fields and meadows; abundant (L,S,T).
Senecio obovatus Muhl., ex Willd., Obovate Groundsel. Mesic bluffs and outcrops; rare (T).
Sericocarpus linifolius (L.) BSP [*Aster solidagineus* Michx.], White-Topped Aster. Dry fields, banks and open woods; frequent (L,S,T).
Silphium astericus L., Rosinweed. Dry fields and barrens; very rare (T).
Silphium integrifolium Michx., Entire-Leaved Rosinweed. Fields, roadsides; occasional (L,S,T).
Silphium perfoliatum L., Cup-Leaved Rosinweed. Low fields and thickets; rare (S,T).
Silphium pinnatifidum Ell. [*S. terebinthinaceum* Jacq. var. *pinnatifidum* (Ell.) Gray], Prairie Dock. Low fields and thickets, barrens; occasional (L,S,T). .
Silphium trifoliatum L., Three-Leaved Rosinweed. Dry open woods and fields southward; rare, identification tentative (S).
Solidago altissima L. [*S. canadensis* L.], Tall Goldenrod. Mesic fields, roadsides, barrens, waste lands; frequent (L,S,T).
Solidago bicolor L., Whiterod. Dry oak-hickory woods and bluffs; rare (S).
Solidago buckleyi Torr. & Gray, Buckley's Goldenrod. Mesic forest borders northward; rare (L).
Solidago caesia L., Bluestem Goldenrod. Mesic woods, especially on outcrops, bluffs and gully banks; occasional (L,S,T).
Solidago erecta Pursh, Erect Goldenrod. Fields, roadsides, barrens and dry woods; frequent (L,S,T).
Solidago flexicaulis L., Zig-Zag Goldenrod. Mesic slopes and bluffs; rare (S,T).
Solidago gigantea Ait., Large Goldenrod. Mesic fields, roadsides and disturbed lands; frequent, often in large stands (L,S,T).
Solidago hispida Muhl., Hispid Goldenrod. Fields, roadsides and dry woods; occasional (L,S,T).
Solidago juncea Ait., Early Goldenrod. Fields, roadsides; frequent, sometimes plentiful (L,S,T).
Solidago nemoralis Ait., Gray Goldenrod. Fields, barrens, roadbanks, open woods; abundant (L,S,T).
Solidago odora Ait., Sweet Goldenrod. Old fields and barrens; rare (S,T).
Solidago patula Muhl., Spreading Goldenrod. Low woodlands of Barnes Hollow and around Hematite Lake; rare (T).
Solidago rugosa Mill., Rugose Goldenrod. Mesic to dry woods, thickets, barrens and forest borders; occasional (L,S,T).
Solidago speciosa Nutt., Showy Goldenrod. Fields, open woods, cherty roadsides; rare (L,S,T).
Solidago sphacelata Raf., Blighted Goldenrod. Bluffs and rocky woods; rare (S,T).
Solidago ulmifolia Muhl. ex Willd., Elm-Leaved Goldenrod. Dry woods; occasional (L,S,T).
**Sonchus asper* (L.) Hill, Spiny-Leaved Sow-Thistle. Old homesites and roadsides; rare (S,T).
**Tagetes erecta* L., Common Marigold. Planted and apparently self-seeding in cemeteries; rare (S,T).
**Taraxacum officinale* Weber, Common Dandelion. Lawns, fields, picnic areas; frequent (L,S,T).
Verbesina alternifolia (L.) Britt. [*Actinomeris alternifolia* (L.) DC.], Wing-Stem. Bottomland thickets and streambanks; frequent and often plentiful southward, occasional northward (L,S,T).
Verbesina helianthoides Michx., Helianthus-Like Crownbeard. Fields, barrens and dry open woods; locally abundant, especially northward (L,S,T).
Verbesina virginica L., Tickweed or Frostweed. Fields, thickets, forest borders; abundant (L,S,T).
Vernonia gigantea (Walt.) Trel., Tall Ironweed. Low fields and thickets; abundant (L,S,T).
**Xanthium strumarium* L., Cocklebur. Cultivated fields, mudflats; abundant (L,S,T).

BALSAMINACEAE, Touch-Me-Not Family

Impatiens capensis Meerb., Spotted Touch-Me-Not. Creekbanks, mesic woods and thickets; locally abundant (L,S,T).
Impatiens pallida Nutt., Pale Touch-Me-Not. Mesic thickets, especially along streams, but much less frequent than the previous species and unknown northward; rare (S). The Trigg report from Ellis *et al.* (1971) is not vouchered.

BERBERIDACEAE, Barberry Family

**Berberis thunbergii* DC., Barberry. Persisting from homesite plantings; very rare (T).

Caulophyllum thalictroides (L.) Michx., Blue Cohosh. Known only from rich woods along Bear Creek; very rare (S).

Podophyllum peltatum L., Mayapple. Forests throughout; often plentiful (L,S,T).

BETULACEAE, Birch Family

Alnus serrulata (Ait.) Willd., Common Alder. Lakeshores, swampy areas, creekbanks and around springs and branches; locally abundant (L,S,T).

Betula nigra L., River or Black Birch. Streambanks, swamps, reservoir shorelines; scattered throughout, sometimes abundant (L,S,T).

Carpinus caroliniana Walt., Blue Beech. A rather constant understory species of ravine, streambank and mesic slope forests; frequent (L,S,T).

Corylus americana Walt., Hazelnut. Roadsides and logging-road thickets, mesic open woodlands; locally abundant (L,S,T).

Ostrya virginiana (Mill.) K. Koch, Hop Hornbeam. A constant understory shrub or small tree in slope and ravine forests (L,S,T). Including var. *lasia* Fernald reported by Chester *et al.* (1976).

BIGNONIACEAE, Bignonia Family

Bignonia capreolata L., Cross-Vine. Mesic woodlands, thickets and fencerows, especially in bottomlands; occasional (L,S,T).

Campsis radicans (L.) Seem., Trumpet Creeper. Often weedy in fields, fencerows and thickets, especially in bottomlands; frequent (L,S,T).

**Catalpa speciosa* (Ward.) Engelm., Catalpa. Persisting from plantings in old lawns and in cemeteries; slightly spreading into fields and woodlands; occasional (L,S,T).

BORAGINACEAE, Borage Family

Cynoglossum virginianum L., Wild Comfrey. Wooded slopes and ravines; occasional (L,S,T).

Hackelia virginiana (L.) Johnston, Stickweed. Wooded slopes and bluffs; occasional to rare (L,S,T).

**Heliotropium indicum* L., Turnsole. Wet fields and meadows, mudflats, swamp and reservoir margins; frequent (L,S,T).

**Lithospermum arvense* L., Corn Gromwell. Dry fields and roadsides; locally abundant (L,S,T).

Lithospermum canescens (Michx.) Lehm., Hoary Puccoon. Dry upland woods and barrens; rare (L,T). The voucher for T is *Athey 3976* (Athey Herbarium, now at Murray State University).

Lithospermum latifolium Michx., American Gromwell. Mesic bluffy woods; rare (L,T).

Mertensia virginica (L.) Pers., Bluebells. Rich mesic woods, usually on alluvium; locally abundant southward, rare northward (L,S,T).

Myosotis macrosperma Engelm., Large-Seeded Scorpion Grass. Fields, roadsides and other disturbed sites; frequent (L,S,T).

Myosotis verna L., Scorpion Grass. Fields, roadsides, other disturbed sites; often abundant, especially in fallow cultivated fields (L,S,T).

BRASSICACEAE, Mustard Family

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

Arabis canadensis L., Canada Rock Cress. Mesic woodlands and bluffs; occasional to rare (L,S,T).

Arabis laevigata (Muhl.) Poir., Smooth Rock Cress. Mesic woodlands, especially around outcrops and bluffs; occasional (L,S,T).

Armoracia lacustris (Gray) Al-Shehb. & Bates [*A. aquatica* (Eat.) Wieg.], Lake Cress. Swamps, often in shallow water, and adjacent marshy woods; sometimes in clean streams at bay heads and in shallow embayments of Kentucky Reservoir; locally abundant (L,S,T).

**Barbarea vulgaris* R. Browne, Yellow Rocket, Winter Cress. Mesic fields, meadows, roadsides, other disturbed sites; locally abundant (L,S,T).

**Brassica juncea* (L.) Coss., Leaf Mustard. Persisting after cultivation; once widely planted in gardens and around tobacco plantbeds for spring greens but not seen in over 20 years (T).

**Brassica rapa* L., Common Turnip. Fields, meadows, roadsides and other disturbed sites (formerly a common garden plant); occasional (L,S,T).

**Capsella bursa-pastoris* (L.) Medic., Shepherd's Purse. Fields, meadows, roadsides and disturbed soils; occasional (L,S,T).

**Cardamine hirsuta* L., Bitter Cress. Lawns, fields, meadows and disturbed soils; frequent, often abundant (L,S,T).

Cardamine parviflora L., Small-Flowered Bitter Cress. Fields, meadows, lawns and other disturbed sites; locally abundant (L,S,T).

Cardamine pensylvanica Muhl., Pennsylvania Bitter Cress. Fields and disturbed sites; rare (L,S,T).

Cardamine rhomboidea (Pers.) DC. [*C. bulbosa* (Schreb.) BSP.], Spring Cress. Springy woods, wet meadows and streambanks; locally abundant (L,S,T).

Dentaria diphylla Michx. [*Cardamine diphylla* (Michx.) A. Wood], Two-Leaved Toothwort, Pepper-Root. Rich mesic woods and bluffs; rare (S).

Dentaria heterophylla Nutt.[*Cardamine angustata* Schulz], Various-Leaved Toothwort, Rich woods; scattered (S,T).

Dentaria laciniata Muhl. [*Cardamine concatenata* (Michx.) Ahles], Toothwort. Wooded ravines, slopes and bluffs; frequent (L,S,T).

Draba brachycarpa Nutt., Short-Fruited Whitlow Grass. Roadsides, lawns, fields and disturbed soil; locally abundant (L,S,T).

**Draba verna* L., Whitlow Grass. Same habitats and often with the previous species (L,S,T).

**Erysimum repandum* L., Treacle Mustard. Gravel road shoulders on Highway 68 where a large stand was first observed in 1988; very rare (T).

Iodanthus pinnatifidus (Michx.) Steud., Purple Rocket. Low mesic woodlands and footslopes; generally rare but often in quantities when found (L,S,T).

**Lepidium campestre* R. Browne, Cow-Cress. Fields, roadsides and disturbed sites; rare (S,T).

Lepidium densiflorum Schrad., Dense Peppergrass. Fields, meadows and roadsides; occasional to rare (S). The Trigg report from Ellis *et al.* (1971) is not vouchered.

Lepidium virginicum L., Peppergrass, Poor-Man's Pepper. Fields, roadsides and waste sites; occasional (L,S,T).

Lesquerella lescurii (Gray) Watson, Nashville Mustard. Meadows and fallow bottomlands along Lake Barkley; very rare (S,T).

**Nasturtium officinale* R. Browne, Water Cress. Known from a few springs, spring branches and creeks southward; rare (S).

**Raphanus raphanistrum* L., Wild Radish. Appearing in newly-planted small-grain fields; rare (S,T).

Rorippa palustris (L.) Besser [*R. islandica* (Oeder) Borbas], Yellow Cress. Rare on reservoir shorelines (L,S). Our material is subsp. *glabra* (O.E. Schultz) Stuckey var. *fernaldiana* (Butt. & Abbe) Stuckey.

Rorippa sessiliflora (Nutt.) Hitchc., Sessile-Flowered Yellow Cress. Wet fields and meadows, mudflats; abundant (L,S,T).

**Rorippa sylvestris* (L.) Besser, Creeping Yellow Cress. Wet thickets and roadsides; rare (L,T).

Sibara virginica (L.) Rollins, Arabis-Spelled-Backward. Fallow bottomland fields and disturbed soils; locally abundant southward but becoming rare to the north (L,S,T).

**Sisymbrium officinale* (L.) Scop., Hedge Mustard. Thickets and disturbed weedy sites; rare (S,T).

**Thlaspi arvense* L., Penny Cress. Sandy road shoulders; rare but sometimes in large stands (T).

**Thlaspi perfoliatum* L., Perfoliate-Leaved Penny Cress. Locally abundant in a few sites along major highways but generally rare (T).

BUXACEAE, Box Family

Pachysandra procumbens Michx., Allegheny Spurge. Mesic slopes and ravines southward, especially along Bear Creek, where it is abundant; otherwise unknown (S).

CABOMBACEAE, Fanwort Family

Brasenia schreberi Gmelin, Water-Shield. Hematite Lake and a few woodland ponds; in dense stands when found but generally rare (L,T).

CACTACEAE, Cactus Family

Opuntia humifusa Raf., Prickly Pear. Xeric open woods and bluffs, mostly along Kentucky Reservoir; rare (L,S,T).

CALLITRICHACEAE, Water-Starwort Family

Callitriche deflexa A. Browne, Deflexed Water-Starwort. Rocks and mud around and in springs, spring branches, and fields; probably common but rarely collected (S).

Callitriche heterophylla Pursh, Diverse-Leaved Water-Starwort. Fresh ponds and sluggish pools and streams; locally abundant (L,S,T).

CAMPANULACEAE, Bluebell Family

Campanula americana L., American Bellflower. Mesic woods and thickets, usually in bottomlands; occasional, sometimes in large numbers (L,S,T).

Lobelia cardinalis L., Cardinal Flower. Swamps, marshes, wet fields and woods; frequent, sometimes in large numbers. (L,S,T).

Lobelia inflata L., Indian Tobacco. Fields, open woods, and disturbed sites; occasional (L,S,T).

Lobelia puberula Michx., Downy Lobelia. Dry, usually sandy or cherty fields and roadsides; occasional, locally abundant (L,S,T).

Lobelia siphilitica L., Great Blue Lobelia. Mesic to wet fields and thickets; generally are (L,S).

Lobelia spicata Lam., Spiked Lobelia. Sandy or cherty roadsides, fields and barrens; ccasional, sometimes abundant (L,T).

Specularia perfoliata (L.) DC., Venus' Looking Glass. Mesic fields, roadsides and disturbed sites; frequent (L,S,T).

CANNABACEAE, Hemp Family

**Humulus lupulus* L., Common Hops. Persisting in the 1960s, now presumed extirpated (S).

CAPPARACEAE, Caper Family

**Cleome houtteana* Raf. [*C. spinosa* Jacq.], Spider-Flower. Waif on roadsides, old homesites, and on the lakeshores; rare (L,S,T).

Polanisia dodecandra (L.) DC., Clammyweed. Sandy, dewatered shores of the reservoirs; rare but in abundance along the canal (L). This, and the next taxon, need clarification.

**Polanisia trachysperma* Torr. & Gray, Clammyweed. Sandy shores along the reservoirs; occasional, locally abundant (S,T).

CAPRIFOLIACEAE, Honeysuckle Family

**Lonicera* x *bella* Zabel, Bush Honeysuckle. Persisting around homesites; very rare (S,T).

**Lonicera japonica* Thunb., Japanese Honeysuckle. Thickets, fencerows, fields and disturbed sites; a noxious weed throughout (L,S,T).

Lonicera sempervirens L., Trumpet or Coral Honeysuckle. Thickets and fencerows; rare (S,T).

Sambucus canadensis L., Elderberry. Mesic thickets, fields, and fencerows; frequent (L,S,T).

Symphoricarpos orbiculatus Moench, Coralberry, Buckbush. Fields, thickets, disturbed sites; frequent, often in stands (L,S,T).

Triosteum angustifolium L., Horse Gentian. Dry woods and thickets; rare (L,T).

Viburnum dentatum L., Arrow Wood. Rich woods near Hematite Lake; very rare, no recent observations (T). Previously reported as *V. molle* Michx.

Viburnum rufidulum Raf., Rusty Blackhaw. Rocky woods, bluffs and thickets; frequent (L,S,T). Includes specimens previously reported as *V. prunifolium* L.

CARYOPHYLLACEAE, Pink Family

**Agrostemma githago* L., Corn-Cockle. Adventive around homesites in early LBL days but now possibly extirpated (S).

Arenaria patula Michx., Spreading Sandwort. Sandy road shoulders and fields; rare but plentiful when found (T).

**Arenaria serpyllifolia* L., Thyme-Leaved Sandwort. Sandy fields, meadows and roadsides; rare but plentiful when found (L,S,T).

**Cerastium brachypetalum* Pers., Short-Petaled Mouse-Ear Chickweed. Fallow fields, sunny meadows, lans and roadsides; locally abundant (L,S,T).

Cerastium brachypodum (Engelm.) Robins. [*C. nutans* Raf. var. *brachypodum* Engelm.], Short-Stalked Mouse-Ear Chickweed. Moist sunny banks, creekbanks; rare (T).

**Cerastium glomeratum* Thuillier [*C. viscosum* L.], Sticky Mouse-Ear Chickweed. Mat-forming in lawns, fallow fields and disturbed sites; abundant (L,S,T).

**Cerastium holosteoides* Fries var. *vulgare* (Hart.) Hylander [*C. vulgatum* L.], Common Mouse-Ear Chickweed. Lawns, meadows, cemeteries and disturbed sites; locally abundant (L,S,T).

Cerastium nutans Raf., Nodding Mouse-Ear Chickweed. Mesic fields and meadows; locally abundant (S,T). The Lyon report from Ellis *et al.* (1971) is not vouchered.

**Dianthus armeria* L., Deptford Pink. Dry fields and roadsides; occasional (L,S,T).

**Holosteum umbellatum* L., Jagged Chickweed. Lawns, roadsides, picnic areas; locally abundant (L,T).

**Lychnis alba* Mill., White Cockle or Campion. Formerly adventive around homesites, now possibly extirpated (L).

Paronychia canadensis (L.) Wood, Forked Chickweed. Dry woods and thickets; occasional (L,S,T).

Paronychia fastigiata (Raf.) Fern., Fastigiate Forked Chickweed. Dry woods, reservoir banks; locally abundant (L,S,T).

Sagina decumbens (Ell.) Torr. & Gray, Pearlwort. Fields, old roads, roadsides; rare (L).

**Saponaria officinalis* L., Soapwort, Bouncing Bet. Creekbanks, mesic roadsides and fields; occasional southward, rare to the north (L,S,T).

Silene antirrhina L., Sleepy Catchfly. Fields, roadsides, disturbed areas; frequent (L,S,T).

Silene stellata (L.) Ait. f.., Starry Campion. Rich rocky woods and thickets; frequent (L,S,T).

Silene virginica L., Fire Pink. Rich woods and thickets; infrequent (L,S,T).

**Stellaria media* (L.) Cyrillo, Common Chickweed. Old lawns, cemeteries and other open disturbed sites; frequent and often matted in stands (L,S,T).

Stellaria pubera Michx., Giant or Star Chickweed. Rich rocky woods; occasional southward, rare to the north (S,T).

CELASTRACEAE, Staff-Tree Family

Celastrus scandens L., Bittersweet. No voucher seen but reliably reported from Stewart County by Scott Gunn (personal communication).

Euonymus americanus L., Strawberry Bush. Mesic woodlands, especially in ravines and on streambanks; occasional southward, rare to the north (L,S,T). Heavily browsed by deer.

Euonymus atropurpureus Jacq., Wahoo. Along lakeshores, in ravines, on bluffs and in streambank woods; occasional to rare (L,S,T).

Euonymus fortunei (Turcz.) Hand.-Maz., Climbing Euonymus. Persisting and spreading around old homesite plantings; rare (L,S).

CERATOPHYLLACEAE, Hornwort Family

Ceratophyllum demersum L., Coontail. Quiet embayments and swamps; becoming weedy in many Kentucky Resevoir bays; often very abundant (L,S,T).

CHENOPODIACEAE, Goosefoot Family

Chenopodium album L., Lamb's Quarters. Disturbed lands such as old homesites, picnic grounds and shorelines; occasional (L,S,T).

Chenopodium ambrosioides L., Mexican Tea. Same habitats and often with the previous species; occasional (L,S,T).

CISTACEAE, Rockrose Family

Lechea tenuifolia Michx., Narrow-Leaved Pinweed. Dry, often eroded, cherty or sandy fields and banks; locally abundant (L,S,T).

Lechea villosa Ellis, Hairy Pinweed. Dry to mesic open woods and banks; occasional to rare but sometimes in stands (L,S,T).

CLUSIACEAE, St. John's-Wort Family

Hypericum denticulatum Walt., Coppery St. John's-Wort. Dry, cherty fields, roadsides and woods; frequent (L,S,T).

Hypericum drummondii (Grev. & Hook.) Torr. & Gray, Nits-and Lice. Sandy roadsides, fields and barrens; frequent, often in stands (L,S,T).

Hypericum gentianoides (L.) BSP, Orange-Grass or Pinweed. Sandy fields and slopes; very rare (T).

Hypericum hypericoides (L.) Crantz [*Ascyrum hypericoides* L.], St. Andrew's Cross. Occasional in slope, ravine and shoreline forests (L,S,T).

Hypericum mutilum L., Slender St. John's-Wort. Marshes, wet meadows, ditches, pond margins, reservoir shorelines; frequent, often weedy (L,S,T).

Hypericum perforatum L., Common St. John's-Wort. Dry fields, roadsides; occasional (L,S,T).

Hypericum prolificum L. [*H. spathulatum* (Spach.) Steud.], Shrubby St. John's-Wort. Dry to low woods, mostly near the lakeshores; frequent, often in dense stands (L,S,T).

Hypericum punctatum Lam., Dotted St. John's-Wort. Roadsides, fields, thickets and disturbed areas throughout; some of our material may be assignable to subspecific taxa (L,S,T).

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 (L,S,T).

Triadenum tubulosum (Walt.) Gleason [*Hypericum tubulosum* Walt.], Marsh St. John's-Wort. Wet woods and thickets around embayments and swamps; abundant (L,S,T).

Triadenum walteri (Gmel.) Gleason [*H. tubulosum* Walt. var. *walteri* (Gmel.) Lott.], Walter's St. John's-Wort. Wet woods at heads of bays, swampy fields and thickets; abundant (L,S,T).

CONVOLVULACEAE, Morning-Glory Family

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

Convolvulus arvensis L., Field Bindweed. Sandy roadsides, fields and thickets; rare but sometimes mat-forming (T).

Cuscuta compacta Juss., Compact Dodder. Wet thickets, fields and woods; locally abundant (L,S,T).

Cuscuta campestris Yuncker [including *C. pentagona* Engelm.]. Prairie Dodder. Fields, meadows and thickets throughout, often in large stands (L,S,T).

Cuscuta cuspidata Engelm., Cuspidate Dodder. Wet thickets, swampy fields; occasional to rare (L,S,T).

Cuscuta gronovii Willd., Gronovius' Dodder. Thickets and weedy fields; occasional (L,S).

**Ipomoea coccinea* L., Red Morning-Glory. Sandy thickets along Kentucky Reservoir; rare (T).

**Ipomoea hederacea* L., Ivy-Like Morning-Glory. Fields and thickets, most often in and around areas of cultivation; frequent (L,S,T).

Ipomoea lacunosa L., White Morning-Glory. Mudflats, fields and thickets; locally abundant (L,S,T).

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

CORNACEAE, Dogwood Family

Cornus amomum Mill., Swamp Dogwood, Red Willow. Lakeshores, swampy thickets and fields, shrub swamps; frequent and often in dense stands(L,S,T).

Cornus drummondii Meyer, Rough-Leaved Dogwood. Edges of low woods; very rare (T).

Cornus florida L., Flowering Dogwood. A constant understory component of slope and ridge forests, also in fields, thickets and fencerows; frequent (L,S,T).

CRASSULACEAE, Orpine Family

Sedum pulchellum Michx., Stonecrop. Sandy road shoulders and fields; very rare (S).

**Sedum sarmentosum* Bunge, Yellow Stonecrop. Persisting from cultivation around homesites and in cemeteries; very rare (S,T).

Sedum ternatum Michx., Stonecrop. Mesic shaded outcrops and bluffs; rare but often in large colonies when found (L,S,T).

CUCURBITACEAE, Gourd Family

**Citrullus vulgaris* Schrad., Watermelon. Waif around trash piles, campsites and reservoir shoreline; rare (L,S,T).

**Cucumis melo* L., Canteloupe. Waif on sandy reservoir shorelines and around campsites; rare (L,S).

**Cucumis sativus* L., Cucumber. Waif around campgrounds and on reservoir shorelines;rare (T).

**Cucurbita pepo* L., Pumpkin. Waif on reservoir shorelines and around campsites; rare (T).

**Lagenaria vulgaris* Seringe, Gourd. Formerly persisting, by self-seeding, around homesites but now known only as a shoreline waif (T).

Melothria pendula L., Creeping Cucumber. Bottomland woods and thickets, especially near the reservoirs; locally abundant (L,S,T).

Sicyos angulatus L., Bur Cucumber. Mesic thickets, especially around shorelines, often covering large areas; frequent (L,S,T).

DIPSACACEAE, Teasel Family

**Dipsacus fullonum* L. [*D. sylvestris* Huds.], Common Teasel. Dry roadsides, fields and reservoir banks; rare but usually in large numbers when found (S,T).

EBENACEAE, Ebony Family

Diospyros virginiana L., Common Persimmon. Fields, woodlands, fencerows and reservoir shorelines throughout; frequent (L,S,T). Including the var. *pubescens* (Pursh) Dippel (Chester *et al.* 1976).

ELAEAGNACEAE, Oleaster Family

**Elaeagnus umbellata* Thunb., Autumn Olive. Commonly planted around waterholes and at various other sites for wildlife food, spreading (L,S,T).

ERICACEAE, Heath Family (including PYROLACEAE)

Chimaphila maculata (L.) Pursh, Spotted Wintergreen. Slope and ridge forests southward; very rare (S).

Gaylussacia baccata (Wang.) K. Koch, Black Huckleberry. Xeric ridge forests; locally abundant (S,T).

Kalmia latifolia L., Mountain Laurel. Rocky slopes and bluffs above or near Kentucky Reservoir; scattered but usually plentiful when found (S,T).

Monotropa hypopithys L., Pinesap, False Beechdrops. Dry to mesic slope forests; very rare (S,T).

Monotropa uniflora L., Indian Pipe, Corpse-Plant. Rich low woods; generally rare but sometimes in large numbers (S,T).

Oxydendrum arboreum (L.) DC., Sourwood. Dry ridge and slope forests; abundant southward but becoming scarce to the north (L,S,T).

Vaccinium arboreum Marsh., Farkleberry, Sparkleberry. Dry woodlands; frequent (L,S,T).

Vaccinium pallidum Ait. [*V. vacillans* Torr.], Sugar Huckleberry. Dry ridge and slope forests; locally abundant southward, more rare to the north (S,T).

Vaccinium stamineum L., Deerberry, Squaw Huckleberry. Dry ridge and slope forests; scattered but locally abundant (L,S,T).

EUPHORBIACEAE, Spurge Family

Acalypha ostryaefolia Ridd., Three-Seeded Mercury. Cultivated fields, disturbed sites, reservoir shorelines; occasional, sometimes in large numbers (L,S,T).

Acalypha rhomboidea Raf., Rhombic-Leaved Three-Seeded Mercury. Fields, roadsides, disturbed sites; frequent (L,S,T).

Acalypha virginica L., Virginia Three-Seeded Mercury. Fields, roadsides, dry woods, disturbed sites; frequent, often in large numbers (L,S,T).

Croton capitatus Michx., Hogwort, Wooly Croton. Dry roadbanks, barrens, reservoir margins; locally abundant (L,S,T).

Croton glandulosus L. var. *septentrionalis* Muell.-Arg., Sand Croton. Fields, roadsides, barrens; occasional (L,S,T).

Croton monanthogynus Michx., Prairie Tea. Fields, roadsides, barrens, disturbed sites; frequent, out most common Croton (L,S,T).

Crotonopsis elliptica Willd., Rushfoil. Dry cherty fields and roadbanks; rare (L,S).

Euphorbia commutata Engelm., Wood Spurge. Mesic outcrops and bluffs southward; very rare (S).

Euphorbia corollata L., Flowering Spurge. Fields, roadsides and barrens; frequent, often in showy numbers (L,S,T).

**Euphorbia cyparissias* L., Cypress Spurge. Persisting around an old homesite at Golden Pond, otherwise unknown (T).

Euphorbia dentata Michx., Spurge, Wild Poinsettia. Roadsides and fields; rare (S,T).

Euphorbia heterophylla L., Painted-Leaf. Collected once from bluffs near the high-water line of Kentucky Reservoir, Hillman Ferry; very rare (L).

Euphorbia humistrata Engelm. Spreading Purslane. Sandy reservoir margins; rare (T).

Euphorbia maculata L., Eyebane. Fields, waste sites; frequent (L,S,T).

**Euphorbia marginata* Pursh, Snow-on-the-Mountain. Persisting around homesites; rare (S).

Euphorbia supina Raf., Milk Purslane. Sandy fields, disturbed sites, reservoir and embayment shorelines; frequent (L,S,T).

Phyllanthus caroliniensis Walt., Phyllanthus. Sandy shorelines of reservoirs, embayments and streams; occasional (L,S,T).

**Ricinus communis* L., Castor Bean. Formerly self-seeding in old gardens and lawns; now probably extirpated (S).

Tragia cordata Michx., Cordate-Leaved Tragia. Mesic thickets and woods; rare (L,S).

FABACEAE, Legume or Pulse Family

**Albizia julibrissin* Durazz., Mimosa. Persisting and spreading around former habitations and in cemeteries; frequent (L,S,T).

Amorpha fruticosa L., False Indigo. Around the lakeshores and in swampy woods; frequent (L,S,T). This genus is in need of evaluation.

Amorpha glabra Desf. Ex Poir, Shining False Indigo. Lakeshore thickets; rare (S).

Amphicarpaea bracteata (L.) Fern., Hog Peanut. Woodlands and thickets; locally abundant (L,S,T).

Apios americana Medic., American Potato Bean. Thickets along creeks, around swamps and the lakeshores; locally abundant (L,S,T).

Apios priceana Robinson, Price's Potato Bean. Open woods and thickets; very rare (S,T).

Astragalus canadensis L., Canada Milk Vetch. Open woods and thickets along the Tennessee River; very rare (S).

Baptisia alba (L.) Vent. var. *macrophylla* (Lairsey) Isely [*B. leucantha* T. & G.; *B. lactea* (Raf.) Thieret], White False Indigo. Open woods and thickets, usually mesic; occasional (L,S,T).

Baptisia bracteata Elliott var. *glabrescens* (Lairsey) Isely [*B. leucophaea* Nuttall], Cream False Indigo. Roadsides, forest borders and fields, usually upland; occasional northward (L,S,T).

Cercis canadensis L., Redbud. A characteristic understory species of mesic forests, and often in old fields; frequent (L,S,T).

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

Chamaecrista nictitans (L.) Moench [*Cassia nictitans* L.], Wild Sensitive Senna. Mesic roadbanks, fields and meadows; infrequent but sometimes in stands (L,S,T).

Clitoria mariana L., Spoon-Flower, Butterfly Pea. Mesic to dry woods, thickets and roadsides; occasional to rare (L,S,T).

**Coronilla varia* L., Crown Vetch. Planted on many roadbanks for erosion control and forming extensive, vegetative colonies; locally abundant (L,S,T).

Crotalaria sagittalis L., Arrow Crotalaria. Barrens, roadsides and dry fields; occasional (L,S,T).

Dalea candida Michx. ex Willd. [*Petalostemum candidum* (Willd.) Michx.], White Prairie Clover. Dry open woods and barrens northward; very rare (L,T).

Desmanthus illinoensis (Michx.) MacM. ex Robins. & Fern., Prairie Mimosa. Barrens, fields and reservoir shorelines; rare (L,S,T).

Desmodium canescens (L.) DC., Hoary Tick Clover. Weedy fields and barrens; frequent, often in large numbers (L,S,T).

Desmodium ciliare (Muhl. ex Willd.) DC., Ciliate Tick Clover. Fields and roadsides; occasional (L,S,T).

Desmodium glabellum (Michx.) DC. Smooth Tick Clover. Open woods and fields; rare (T).

Desmodium glutinosum (Muhl. ex Willd.) A. Wood, Glutinous Tick Clover. Mesic woodlands; rare but usually in large numbers when found (L,S,T).

Desmodium laevigata (Nutt.) DC., Long-Leaved Tick Clover. Mesic fields; occasional (L,T).

Desmodium marilandicum (L.) DC., Maryland Tick Clover. Weedy fields, roadsides and barrens; occasional, sometimes plentiful (L,S,T).

Desmodium nudiflorum (L.) DC., Naked-Stemmed Tick Clover. Moist to dry woodlands, usually on slopes; occasional (L,S,T).

Desmodium nuttallii (Schlind.) Schub., Nuttall's Tick Clover. Dry fields; rare (S).

Desmodium paniculatum (L.) DC., Panicled Tick Clover. Fields and roadsides; occasional (L,S,T).

Desmodium pauciflorum (Nutt.) DC., Few-Flowered Tick Clover. Mesic woods; occasional (L,S,T).

Desmodium perplexum Schub. [*D. paniculatum* (L.) DC. var. *dillenii* (Darl.) Isely], Perplexing Tick Clover. Fields, barrens, disturbed sites; occasional but sometimes in large numbers (L,S,T).

Desmodium rotundifolium DC., Prostrate Tick Clover. Dry woodlands; occasional (L,S,T).

Desmodium sessilifolium (Torr.) Torr. & Gray, Sessile-Leaved Tick Clover. Fields and barrens; rare (L,S,T).

Desmodium viridiflorum (L.) DC. Shining Tick Cover. Dry woods and fields; occasional (L,S,T).

Dioclea multiflora (Torr. & Gray) Mohr, Dioclea. Mostly on rocky slopes above the Tennessee River; locally abundant (L,S,T).

Galactia volubilis (L.) Britt., Downy Milk Pea. Dry thickets, fields and roadsides; occasional, sometimes forming large masses (L,S,T).

Gleditsia triacanthos L., Honey-Locust. Disturbed woods, fields, fencerows, low woods, reservoir and embayment shorelines; frequent (L,S,T).

**Glycine max* (L.) Merrill, Soybean. Cultivated, especially in bottomlands southward; also frequently appearing in fields and on roadsides (L,S,T).

**Gymnocladus dioica* (L.) K. Koch, Kentucky Coffee Tree. Perhaps native in LBL but all known trees are persisting from homesite plantings; very rare (S,T).

**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 (L,S,T).

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

**Lathyrus hirsutus* L., Rough Pea. Weedy fields and thickets, most often in low ground;rare but sometimes in large quantites (L,S,T).

**Lathyrus latifolius* L., Perennial Sweet Pea. Climbing in fields, fencerows and thickets around old homesteads; locally abundant (L,S,T).

**Lespedeza bicolor* Turcz., Bicolor Lespedeza. A shrub planted for wildlife food and cover; locally abundant (L,S,T).

Lespedeza capitata Michx., Headed Lespedeza. Known only from the Neville Creek hill prairie; very rare (S).

**Lespedeza cuneata* (Dumont) G. Don, Sericea Lespedeza. Spreading from plantings, especially on roadsides; abundant (L,S,T).

Lespedeza hirta (L.) Hornem., Hairy Bush Clover. Dry fields, open woods, roadsides; frequent, sometimes in large numbers (L,S,T).

Lespedeza intermedia (S. Watson) Britt., Intermediate Bush Clover. Dry wooded slopes and ridges; occasional (L,S,T).

Lespedeza procumbens Michx., Trailing Bush Clover. Dry fields, roadsides, cemeteries, old lawns; abundant (L,S,T).

Lespedeza repens (L.) Bart., Creeping Bush Clover. Dry fields and roadsides; frequent, often abundant (L,S,T).

Lespedeza virginica (L.) Britt., Virginia or Slender Bush Clover (including some material probably of hybrid origin). Dry fields, barrens, roadsides and open woods; occasional (L,S,T).

**Lotus corniculatus* L., Birdsfoot Trefoil. Planted on exposed roadbanks; very rare (L).

**Medicago lupulina* L., Black Medic. Cemeteries, roadsides, old lawns, other disturbed sites; locally abundant (L,S,T).

**Medicago sativa* L., Alfalfa. Waif on roadsides and in disturbed lands; very rare (L,S).

**Melilotus alba* Medic., White Sweetclover. Roadsides, fields, disturbed sites; frequent (L,S,T).

**Melilotus officinalis* (L.) Pallas, Yellow Sweetclover. Roadsides, fields, meadows, disturbed sites; frequent, often in large numbers (L,S,T).

Orbexilum pedunculatum (Mill.) Rydb. var. *pedunculatum* [*Psoralea psoralioides* (Walt.) Cory var. *eglandulosa* (Ell.) Freeman], Sampson's Snake Root. Dry fields, woods, barrens; locally abundant (L,S,T).

Phaseolus polystachios (L.) BSP., Wild Bean. Mesic thickets and fencerows; rare (S,T).

**Pueraria montana* (Lour.) Meritt var. *lobata* (Willd.) Maesen & S. Almeida. [*P. lobata* (Willd.) Ohwi], Kudzu Vine. Forming extensive stands around old plantings (L,S,T).

**Robinia hispida* L., Rose or Bristly Locust. Persisting and spreading around old homes, sometimes into fields and onto roadsides; locally abundant (L,S,T).

Robinia pseudoacacia L., Black Locust. Fields, fencerows, homesites, disturbed woods; locally abundant (L,S,T).

Senna marilandica (L.) Link [*Cassia marilandica* L.], Wild Senna. Mesic fields, thickets and other disturbed sites; occasional (L,S,T).

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

Strophostyles helvula (L.) Ell., Yellow Wild Bean. Fields, barrens, thickets; locally abundant (L,S,T).

Strophostyles leiosperma (Torr. & Gray) Piper, Smooth Wild Bean. Sandy fields, mostly near Kentucky Reservoir; locally abundant (L,S,T).

Strophostyles umbellata (Muhl. ex Willd.) Britt., Umbelled Wild Bean. Fields, barrens, roadsides, disturbed sites; frequent (L,S,T).

Stylosanthes biflora (L.) BSP., Pencil Flower. Fields, barrens, roadsides, disturbed sites; occasional, sometimes in large numbers (L,S,T).

Tephrosia virginiana (L.) Pers., Goat's-Rue. Dry woods and fields; frequent (L,S,T).

**Trifolium arvense* L., Rabbitfoot Clover. Sandy fields by Kentucky Reservoir; very rare, no recent collections (T).

**Trifolium campestre* Schreb. [*T. procumbens* L.], Hop Clover. Fields, roadsides, homesteads, disturbed sites; frequent, usually dense when found (L,S,T).

**Trifolium dubium* Sibth., Low Hop Clover. Old lawns, fields, cemeteries and roadsides; often abundant (L,S,T).

**Trifolium hybridum* L., Alsike Clover. Roadsides and other disturbed areas; rare (L,S).

**Trifolium incarnatum* L., Crimson Clover. Cultivated, sometimes persisting (L,S,T).

**Trifolium pratense* L., Red Clover. Fields, roadsides, homesteads, disturbed sites; frequent (L,S,T).

Trifolium reflexum L., Buffalo Clover. Collected once from a wooded gully bank; very rare (T).

**Trifolium repens* L., White Clover. Fields, roadsides, homesteads, disturbed sites; abundant (L,S,T).

**Vicia angustifolia* (Bauhin) L. [*V. sativa* L. ssp. *nigra* in Isely (1990)], Narrow-Leaved Vetch. Fields, roadsides, thickets; locally abundant (L,S,T).

Vicia caroliniana Walt., Carolina Vetch. Rich wooded slopes and bluffs; rare (S).

**Vicia dasycarpa* Tenore [*V. villosa* Roth. ssp. *varia* (Host) Corbiere in Isely (1990)], Winter Vetch. Fields, roadsides, old homesites; locally abundant (L,S,T).

**Vicia villosa* Roth., Hairy Vetch. Fields, roadsides, fencerows; locally abundant (L,S,T).

Wisteria frutescens (L.) Poir., American Wisteria. Thickets along the lakeshores and embayments; frequent, often forming dense stand (L,S,T).

FAGACEAE, Beech Family

Castanea dentata (Marsh.) Borkh., American Chestnut. Stump sprouts and small trees are occasionally found in ridge and slope forests (S,T).

**Castanea mollissima* Blume, Chinese Chestnut. Specimens appearing to be hybrids and planted by the U.S. Fish and Wildlife Service during their management of the former Kentucky Woodlands National Wildlife Refuge persist in Trigg County.

Fagus grandifolia Ehrh., American Beech. Mesic, mostly north-facing slope forests; occasional and sometimes very abundant southward, more rare northward (L,S,T).

**Quercus acutissima* Carr., Sawtooth Oak. Planted for wildlife food in Barnes Hollow and along the Trace, especially in Trigg County (T).

Quercus alba L., White Oak. Slope and ridge forests throughout; probably the most often-encountered tree in LBL (L,S,T).

Quercus bicolor Willd., Swamp White Oak. Low woods; very rare (L,T).

Quercus coccinea Muenchh., Scarlet Oak. Dry upland woods; scattered throughout but rarely abundant (L,S,T).

Quercus falcata Michx., Southern Red Oak, Spanish Oak. A characteristic species of dry woods, fencerows and fields; abundant (L,S,T). Including var. *triloba* (Michx.) Nutt. reported by Chester *et al.* (1976).

Quercus imbricaria Michx., Shingle Oak. Along streams, the lakeshores and in mesic woods; frequent (L,S,T).

Quercus lyrata Walt., Overcup Oak. Along mainstream and embayment shorelines of the reservoirs, especially Kentucky Lake; occasional (L,S,T).

Quercus macrocarpa Michx., Mossycup/Bur Oak. Low woods along Barkley Reservoir; rare (S).

Quercus marilandica Muenchh., Blackjack Oak. General in dry ridge and slope woodlands (L,S,T).

Quercus michauxii Nutt., Swamp Chestnut, Basket or Cow Oak. Bottomland forests, streambanks; occasional (L,S,T).

Quercus muehlenbergii Engelm., Chinkapin Oak. Slopes and upper terraces where limestone is exposed; occasional (L,S,T).

Quercus nigra L., Water Oak. Bottomland forests along the Tennessee River; very rare and perhaps extirpated (S). The report from Trigg County on the Cumberland River (Thomas 1963) is unsubstantiated.

Quercus pagoda Raf. [*Q. falcata* Michx. var *pagodaefolia* Ell.], Cherrybark Oak. A characteristic species of lower slope, terrace and reservoir-margin forests; frequent and often abundant (L,S,T).

Quercus palustris Muenchh., Pin Oak. Along the lakeshores and in low woods; rare. Also sometimes persisting from old lawn planting (L,S,T).

Quercus phellos L., Willow Oak. Mesic woods, especially along the Tennessee River, and sometimes in wet upland sites; rare (L,S,T).

Quercus prinus L. [*Q. montana* Willd], Chestnut Oak. A characteristic species of dry ridge and slope forests; abundant (L,S,T).

Quercus rubra L., Northern Red Oak. Mesic slope forests; occasional, rarely abundant (L,S,T).

Quercus shumardii Buckl. var. *shumardii,* Shumard Red Oak. Mostly in bottomland forests, especially within the Cumberland drainage; occasional (L,S,T).

Quercus shumardii Buck. var. *schneckii* Sarg., Schneck's Red Oak. With the typical variety, rare (S).

Quercus stellata Wang., Post Oak. Characteristic of dry ridge and slope forests; abundant (L,S,T).

Quercus velutina L., Black Oak. Dry ridge and slope woods throughout; usually abundant (L,S,T).

FUMARIACEAE, Fumitory Family

Corydalis flavula (Raf.) DC., Yellow Corydalis. Low woods; locally abundant (L,S,T).

Dicentra cucullaria (L.) Bernh., Dutchman's Breeches. Mesic outcrops and bluffs; rare (L,S,T).

GENTIANACEAE, Gentian Family

Bartonia paniculata (Michx.) Muhl., Screw-Stem. Low woods along Kentucky Reservoir; rare (S,T).

Frasera caroliniensis Walt., [*Swertia caroliniensis* (Walt.) Ktze.] American Columbo. Mesic to dry wooded slopes, sometimes in fields and meadows; locally abundant (L,S,T).

Gentiana villosa L., Sampson's Snakeroot. Open dry woods; no recent collections and very rare if still present (S). This report is based on *Shanks 2196* (TENN).

Obolaria virginica L., Pennywort. Mesic or dry woodlands; rare and known mostly from the south (S,T). The voucher for T is *Athey 4005* (Athey Herbarium, now at Murray State University).

Sabatia angularis (L.) Pursh, Rose Pink. Open roadsides, fields and barrens; frequent, sometimes abundant (L,S,T).

GERANIACEAE, Geranium Family

Geranium carolinianum L., Wild Cranesbill. Roadsides, fields and disturbed sites; occasional, sometimes abundant (S,T).

**Geranium dissectum* L., Dissected Cranesbill. Roadsides and disturbed sites; rare (T).

Geranium maculatum L., Wild Geranium. Rich mesic woodlands and bluffs; infrequent but sometimes in large numbers (L,S,T).

Geranium molle L., Dovesfoot Cranesbill. Weedy gravel shoulders along major highways; generally rare but sometimes weedy (S,T).

HALORAGACEAE, Water-Milfoil Family

Myriophyllum aquaticum (Vellozo) Verdcourt [*M. brasiliense* Camb.], Water Feather, Parrot's Feather. Abundant in Crooked Creek beaver swamps at head of Energy Lake (T); The Lyon report from Ellis *et al.* (1971) is unconfirmed.

Myriophyllum spicatum L., Eurasian Milfoil. Often eed in Kentucky Reservoir bays; less frequently encountered in the Cumberland system (L,S,T).

HAMAMELIDACEAE, Witch-Hazel Family

Liquidambar styraciflua L., Sweetgum. Wet woodlands, streambank and bottomland forests, wet fields; frequent, often in large quantities (L,S,T).

HIPPOCASTANACEAE, Buckeye Family

Aesculus glabra Willd., Ohio Buckeye. In a few streambanks, ravine and bluff forests southward but becoming rare and eventually unknown northward: rare (S,T).

Aesculus pavia L., Red Buckeye. Alluvial woodlands in the south, especially along Bear Creek; very rare (S).

HYDROPHYLLACEAE, Waterleaf Family

Hydrophyllum appendiculatum Michx., Appendaged Waterleaf. Slope and ravine forests; rare (S,T).

Hydrophyllum canadense L., Canadian Waterleaf. Know only from the Bear Creek Natural Area where it is abundant in mesic woodlands (S).

Hydrophyllum macrophyllum Nutt., Large-Leaved Waterleaf. Generally rare except in mesic woods of the Bear Creek Natural Area where it is abundant (L,S,T).

Nemophila aphylla (L.) Brummitt, Nemophila. Wooded ravines and streambanks, old homesites and trails; locally abundant southward, unknown northward (S).

Phacelia bipinnatifida Michx., Scorpion Weed. Mesic wooded slopes, bluffs and ravines; locally abundant (L,S).

Phacelia ranunculacea (Nutt.) Const., Ranunculus-Leaved Phacelia. Floodplain of Barkley Reservoir between Bear and Cow creeks; very rare (S).

JUGLANDACEAE, Walnut Family

Carya carolinae-septentrionalis (Ashe) Engelm. & Graebn., Southern Shagbark or Carolina Hickory. Mesic to dry slope forests; rare (S,T). *C. ovata* K. Koch var. *australis* (Ashe) Little in FNA (1997).

Carya cordiformis (Wang.) K. Koch, Bitternut Hickory. Footslopes, ravines, streambank forests; frequent southward, less often seen to the north (L,S,T).

Carya glabra (Mill.) Sweet, Pignut Hickory. Dry slope and ridge forests, fields, fencerows; frequent, sometimes abundant (L,S,T).

Carya illinoinensis (Wang.) K. Koch, Pecan. Persisting from plantings at homesites and orchards but native in low woods along both reservoirs; rare (L,S,T).

Carya laciniosa (Michx. f.) Loud., Big Shellbark Hickory, Kingnut. Bottomland, ravine and streambank forests; occasional in the south, rare northward (L,S,T).

Carya ovalis (Wang.) Sarg. var. *ovalis*. Sweet Pignut, Red Hickory. Slope and ridge forests, fields and fencerows; frequent (L,S,T). Included under *C. glabra* (Mill.) Sweet in FNA (1997).

Carya ovalis (Wang.) Sarg. var. *obcordata* (Muhl.) Sarg., Obcordate Sweet Pignut. With the typical variety but rare (S). See note under *C. ovalis* var. *ovalis*.

Carya ovata (Mill.) K. Koch, Shagbark, Scalybark, or Shellbark Hickory. Slope and low forests, fields, fencerows; frequent (L,S,T).

Carya pallida (Ashe) Engelm. & Graebn., Pale or Sand Hickory. Dry ridge and slope forests, mostly northward; occasional (L,S,T).
Carya tomentosa Nutt., Mockernut or White-Heart Hickory. Dry woodlands, fencerows and fields throughout; frequent (L,S,T).
Juglans cinerea L., Butternut, White Walnut. Ravine and streambank forests; very rare (S,T).
Juglans nigra L., Black Walnut. Mesic slope, bottomland and ravine forests; frequent. Also frequently persisting from old plantings (L,S,T).

LAMIACEAE, Mint Family

Agastache nepetoides (L.) Kuntze, Giant Hyssop. Mesic thickets, roadsides and along forest borders; occasional (L,S,T).
**Ajuga reptans* L., Carpet Bugleweed. Persisting at an old homesite; very rare (L).
Blephilia ciliata (L.) Benth., Wood-Mint. Mesic woods and thickets; occasional (L,S,T).
Blephilia hirsuta (Pursh) Benth., Hairy Wood-Mint. Mesic woods and thickets; occasional (L,S,T).
Collinsonia canadensis L., Horse-Balm. Mesic wooded slopes, thickets; locally abundant (L,S,T).
Cunila origanoides Britt., Dittany. Dry woods, fields and barrens; frequent (L,S,T).
**Glechoma hederacea* L., Ground Ivy. Persisting around a few homesites and in cemeteries, sometimes in alluvial woods; rare but usually mat-forming when found (L,S,T).
Hedeoma hispidum Pursh, Rough Pennyroyal. Dry sandy fields; very rare (L).
Hedeoma pulegioides (L.) Pers., American Pennyroyal. Dry woods, fields and barrens; locally abundant (L,S,T).
**Lamium amplexicaule* L., Henbit. Homesites, picnic areas, meadows and roadsides; frequent, often very abundant in early spring (L,S,T).
**Lamium purpureum* L., Dead Nettle. Same habitats and often with the previous species (L,S,T).
**Leonurus cardiaca* L., Motherwort. Roadsides, homesites, other disturbed areas; rare (S,T).
Lycopus americanus Muhl., Water Horehound. Swamp margins, streambanks, ditches, wet meadows and woods; occasional (L,S,T).
Lycopus rubellus Moench, Stalked Water Horehound. Wet soil in swampy woods; occasional northward, especially along Kentucky Reservoir bays (L,T).
Lycopus virginicus L., Bugleweed. Wet woods and meadows; locally abundant (L,S,T).
**Marrubium vulgare* L., Common Horehound. Persisting at a homesite; possibly extirpated (S).
**Mentha piperita* L., Peppermint. Springs, branches, around homesites; locally abundant (S,T).
**Mentha spicata* L., Spearmint. Spring branches and creekbanks; rare but often in large stands (S).
Monarda fistulosa L., Wild Bergamot. Mesic woods, fields, bluffs and barrens; frequent (L,S,T).
**Nepeta catarica* L., Catnip. Collected once at an old homesite; probably extirpated (T).
**Perilla frutescens* (L.) Britt., Beefsteak Plant. Disturbed woods, thickets and fields; frequent and often in large numbers (L,S,T).
**Physostegia virginiana* (L.) Benth., False Dragonhead. Roadsides, old homesites; rare (L,S,T). The voucher for L is *Athey 2181* (formerly MEM, now at TENN).
**Prunella vulgaris* L., Heal-All. Fields, lawns, roadsides and meadows; frequent (L,S,T).
Pycnanthemum incanum (L.) Michx., Gray Mountain Mint. Fields, roadsides, forest borders; frequent (L,S,T).
Pycnanthemum muticum (Michx.) Pers., Mountain Mint. Low fields and woods; infrequent (L,S).
Pycnanthemum pilosum Nutt., Hairy Mountain Mint. Dry fields; locally abundant (L,S,T).
Pycnanthemum pycnanthemoides (Leaven.) Fern., Mountain Mint. Dry fields, roadsides and open woods; frequent and often abundant but may not be distinct from *P. incanum* (L,S,T).
Pycnanthemum tenuifolium Schrad., Slender Mountain Mint. Fields, roadsides, thickets; frequent and often abundant (L,S,T).
Pycnanthemum virginianum (L.) Dur. & Jack., Virginia Mountain Mint. Fields and barrens; occasional (L,S,T).

Salvia azurea Lam. [*S. pitcheri* Torr.], Blue Sage. Dry fields, barrens and forest borders; locally abundant (L,S,T).

Salvia lyrata L., Lyre-Leaved Sage. Fields, meadows, old lawns; locally abundant (L,S,T).

**Satureja hortensis* L., Summer Savory. Once persisting at a homesite but probably extirpated (L). This report is based on *Athey 438* (Athey Herbarium, now at Murray State University).

Scutellaria elliptica Muhl., Hairy Skullcap. Mosit fields, woods and roadsides; frequent (L,S,T).

Scutellaria incana Biehl., Downy Skullcap. Moist woods and fields; locally abundant (L,S,T).

Scutellaria integrifolia L., Entire-Leaved Skullcap. Moist thickets, fields and woods along Kentucky Reservoir and its bays; frequent (L,S,T).

Scutellaria lateriflora L., Mad-Dog Skullcap. Swampy fields, ditches and marsh borders; locally abundant (L,S,T).

Scutellaria nervosa Pursh, Veiny Skullcap. Mesic, usually alluvial woods; rare but sometimes in large numbers (L,S,T).

Scutellaria ovata Hill, Heart-Leaved Skullcap. Moist to wet fields, roadsides and woods; locally abundant (L,S,T).

Scutellaria parvula Michx. [including vars. *australis* Fassett and *leonardii* (Epling) Fernald], Small Skullcap. Dry woods and thickets; frequent, sometimes abundant (L,S,T).

Stachys tenuifolia Willd. var. *tenuifolia,* Smooth Hedge Nettle. Wet woods, fields, meadows; occasional (L,S,T).

Stachys tenuifolia Willd. var. *perlonga* Fern. Swampy woods; rare but probably more abundant than records indicate due to confusion with the typical variety (L).

Synandra hispidula (Michx.) Baill., Synandra. Mesic wooded ravines adjacent to lower Bear Creek where it is abundant (S).

Teucrium canadense L., American Germander. Wet soil of ditches, fields and disturbed sites; often abundant (L,S,T).

Trichostema brachiatum L. [*Isanthus brachiatus* (L.) BSP.], Isanthus. Dry roadsides and disturbed sites; locally abundant northward but rare to the south (L,S,T).

Trichostema dichotomum L., Blue Curls. Fields and barrens; occasional but sometimes in showy numbers (L,S,T).

LAURACEAE, Laurel Family

Lindera benzoin (L.) Blume, Spicebush. Ravine, lower slope and streambank forests; frequent and often abundant (L,S,T). Most of our material has some lower-leaf pubescence, indicative of var. *molle* (Palmer & Steyerm.) Rehd.

Sassafras albidum (Nutt.) Nees, Sassafras. Fields, roadsides, fencerows, disturbed forests; abundant (L,S,T). Including var. *molle* (Raf.) Fern. reported by Chester *et al.* (1976).

LENTIBULARIACEAE, Bladderwort Family

Utricularia gibba L., Humped Bladderwort. Long Creek, Hematite Lake, a few old mining pits in the Hematite area and a few ponds; abundant when found (S,T).

LINACEAE, Flax Family

Linum medium (Planch.) Britton, Flax. Dry fields, roadsides, open woods; occasional to rare (L,S,T).

Linum striatum Walt., Striate Flax. Open woods and fields; rare (S,T).

Linum virginianum L., Virginia Flax. Open fields and banks; rare (L,S,T).

LOGANIACEAE, Logania Family

Polypremum procumbens L., Prostrate Polypremum. Fallow, sandy fields; very rare (T).

Spigelia marilandica L., Indian Pink. Mesic woodlands, fields, roadsides, thickets; occasional, sometimes in large numbers (L,S,T).

LYTHRACEAE, Loosestrife Family

Ammannia coccinea Rothb., Long-Leaved Ammannia. Mudflats, pond and swamp margins; occasional but sometimes plentiful (L,S,T).

Cuphea petiolata (L.) Koehne, Clammy Cuphea or Waxweed. Low woods, thickets and disturbed sites; locally abundant (S,T).

**Lagerstroemia indica* L., Crepe Myrtle. Persisting around a few old homesites; very rare (L,S).

Lythrum alatum Pursh, Winged Loosestrife. Wet meadows, roadsides and barrens; rare (S,T).

Rotala ramosior (L.) Koehne, Tooth-Cup. Mudflats and open pond and swamp margins; usually abundant (L,S,T).

MAGNOLIACEAE, Magnolia Family

Liriodendron tulipifera L., Tulip Tree or Yellow Poplar. An important timber tree of mesic slopes and ravines; also frequently found in successional fields (L,S,T).

**Magnolia grandiflora* L., Evergreen Magnolia. Persisting from old plantings; very rare (L,S).

MALVACEAE, Mallow Family

**Abutilon theophrasti* Medic., Velvet-Leaf, Buttermold Plant. Fields, roadsides, old barnyards and homesites; locally abundant (L,S,T).

**Althaea rosea* Cav., Hollyhock. Persisting at old homesites; very rare (S).

**Anoda cristata* (L.) Schlecht., Crested Anoda. Gravel road shoulders, cultivated fields, waste places; rare (T).

**Hibiscus esculentus* L., Common Okra. Waif in a trash dump; very rare (L).

Hibiscus militaris Cav., Halberd-Leaved Rose Mallow. Swamps and marshes, embayment shorelines; often abundant (L,S,T).

Hibiscus moscheutos L., Swamp Rose Mallow, Swamp Cotton. Swamps, marshes, around embayments; often abundant (L,S,T).

**Hibiscus syriacus* L., Rose-of-Sharon. Persisting around old homesites and in cemeteries, sometimes spreading to fields and roadsides; rare (L,S,T).

**Sida rhombifolia* L., Rhombic-Leaf Sida. Weedy disturbed sites; rare (T).

**Sida spinosa* L., Prickly Sida. Fields, roadsides and disturbed sites; frequent and sometimes abundant (L,S,T).

MELASTOMACEAE, Melastoma Family

Rhexia mariana L., Maryland Meadow Beauty. Colony-forming in wet meadows; very rare (L).

Rhexia virginica L., Virginia Meadow Beauty. Weedy bottomlands, pond and swamp margins; locally abundant (L,S,T).

MENISPERMACEAE, Moonseed Family

Calycocarpum lyoni (Pursh) Gray, Cupseed. Rich woods and thickets; occasional to rare (L,S,T).

Cocculus carolinus (L.) DC., Red-Berried Moonseed, Snailseed. Low fencerows and thickets, mesic woodlands, especially along reservoir and embayments shorelines; occasional (L,S,T).

Menispermum canadense L., Moonseed, Yellow Parilla. Rich woods and thickets; rare (L,S,T).

MENYANTHACEAE, Buckbean Family

**Nymphoides peltata* (Gmelin) Kuntze, Yellow Floating Heart. Recently introduced into some ponds; abundant when found (S).

MOLLUGINACEAE, Carpet-Weed Family

Mollugo verticillata L., Carpetweed. Sandy fields, roadsides, reservoir shorelines, cultivated fields; locally abundant (L,S,T).

MORACEAE, Mulberry Family

*_Broussonetia papyrifera_ (L.) Vent., Paper Mulberry. Persisting and spreading slightly around a few homesites and cemeteries; rare (T).

*_Maclura pomifera_ (Raf.) Schneid., Osage Orange, Bois D'Arc. Lowland fencerows, thickets and streambanks; occasional (L,S,T).

*_Morus alba_ L., White Mulberry. Persisting around homesites and in a few old orchards; rare (S,T).

Morus rubra L., Red Mulberry. An understory shrub or small tree in mesic woodlands; frequent (L,S,T).

NELUMBONACEAE, Water-Sheild Family

Nelumbo lutea (Willd.) Pers., Yellow Nelumbo. A troublesome weed in Hematite Lake, Crooked Creek beaver swamp and parts of Duncan Bay; rare otherwise (L,S,T).

NYCTAGINACEAE, Four-O'Clock Family

*_Mirabilis nyctaginea_ (Michx.) MacM., Four-O'Clock, Umbrella-Wort. Bluffs of Kentucky Reservoir at Hillman Ferry; very rare (L).

NYMPHAEACEAE, Water-Lily Family

Nuphar luteum (L.) Sibth. & Smith ssp. _macrophyllum_ (Small) Beal, Spatter-Dock, Yellow Pond Lily. Abundant in one pond and expected in sluggish pools of Barkley Reservoir (S).

*_Nymphaea odorata_ Ait., Fragrant Water-Lily, Pond-Lily. Once abundant in a pond on Blue Springs Road but extirpated before 1975 and now unknown from LBL (S).

NYSSACEAE, Sour-Gum Family

Nyssa aquatica L., Cotton-Gum, Water Tupelo. Low woods along Kentucky Reservoir; rare (S,T).

Nyssa sylvatica Marsh., Black-Gum. Throughout in almost all woodlands and often in fields, fencerows and thickets (L,S,T).

OLEACEAE, Olive Family

*_Forsythia viridissima_ Lindl., Yellowbells, Forsythia. Persisting at homesites and in cemeteries; scattered throughout (S,T). Including _Forsythia suspensa_ (Thunb.) Vahl. reported by Chester _et al._ (1976).

Fraxinus americana L., American or White Ash. Mesic woodlands, fields and fencerows; frequent (L,S,T). Including the var. _biltmoreana_ Beadle reported by Ellis _et al._ (1971) and Chester _et al._ (1976), following Hardin (1974).

Fraxinus pennsylvanica Marsh., Green Ash. Streambank and bottomland forests where it is a successional species; also a dominant member of many lowland forests (L,S,T). Including the var. _subintegerrima_ (Vahl.) Fernald reported by Ellis _et al._ (1971) and Chester _et al._ (1976), following Hardin (1974).

Fraxinus quadrangulata Michx., Blue Ash. Mesic woods and bluffs along Lake Barkley; rare (S).

*_Ligustrum obtusifolium_ Sieb. & Zucc., Privet. Persisting at a few old homesites; very rare (L,S).

*_Ligustrum vulgare_ L. [_L. sinense_ Lour.], Privet. Persisting and sometimes spreading around old homesites and cemeteries; occasional (L,S,T).

*_Syringa vulgaris_ L., Lilac. Persisting at homesites and cemeteries; rare (L,S,T).

ONAGRACEAE, Evening Primrose Family

Circaea lutetiana ssp. _canadensis_ (L.) Asch. & Mag. [_C. quadrisulcata_ (Max.) Franch. & Sav. var. _canadensis_ (L.) Hara], Enchanter's Nightshade. Mesic woods, especially along creeks and around springs; infrequent (L,S,T).

Epilobium coloratum Biehler, Willow-Herb. Gravel-sandy creek beds and wet meadows rare (L,S,T).

Gaura biennis L., Biennal Gaura. Dry fields, barrens and roadsides; rare (S,T).

Gaura filipes Spach, Slender-Stalked Gaura. Fields and barrens; rare (S).

Jussiaea decurrens (Walt.) DC. [*Lugwigia decurrens* Walt.], Decurrent Primrose-Willow. Wet fields, marshes, pond margins, mudflats; frequent (L,S,T).

Jussiaea leptocarpa Nutt. [*Ludwigia leptocarpa* (Nutt.) Hara], Slender-Fruited Primrose Willow. Swamps and sandy river banks, mudflats; rare (S).

Jussiaea repens L. var. *glabrescens* Kuntze [*Ludwigia peploides* var. *glabrescens* (Kuntze) Shinners], Smooth Primrose-Willow. Low swamps and marshes; abundant and mat-forming when found (S,T).

**Jussiaea uruguayensis* Camb. [*Ludwigia uruguayensis* (Camb.) Hara], South American Primrose-Willow. Bear Creek bottomlands where it is abundant in shallow swamps and marshes; rare northward (L,S).

Ludwigia alternifolia L. var. *alternifolia,* Seedbox. Wet fields, ditches, streambanks, swampy thickets; frequent, sometimes in large stands (L,S,T).

Ludwigia alternifolia L. var. *pubescens* Palmer & Steyerm., Hairy Seedbox. Same habitats as the typical variety but not as frequently encountered (S).

Ludwigia palustris (L.) Ellis var. *americana* (DC.) Fern. & Grisc., Marsh Purslane. In mud around ponds, swamps, marshes and river banks; locally abundant (L,S,T).

Oenothera biennis L., Biennal Evening Primrose. Fields, roadsides, open woods, other disturbed sites; frequent (L,S,T).

Oenothera fruticosa L. [including material reported as *Q. tetragona* Roth. by Ellis *et al.* (1971), based on Straley (1977)], Shrubby Sundrops. Barrens, dry fields, roadbanks, open woods; frequent, sometimes in large numbers (L,S,T).

Oenothera laciniata Hill, Ragged Evening Primrose. Fields and other disturbed sites; locally abundant (L,S,T).

Oenothera speciosa Nutt., Showy Evening Primrose. Adventive around homesites and on roadsides; no recent collections (S).

Oenothera villosa Thunb., Hairy Evening Primrose. Reported from Trigg County by Dietrich, Wagner, and Raven (1997), based on Forrester 02243 at UNCC and APSC. Weedy fields, apparently rare.

OROBANCHACEAE, Broom-Rape Family

Conopholis americana (L.) Wallr., Squaw-Root. Mesic wooded slopes; rare but usually in large quantities when found (L,S).

Epifagus virginiana (L.) Bart., Beech-Drops. Mesic woods under American beech, hence more common in southern sections; locally abundant (S,T).

OXALIDACEAE, Wood-Sorrel Family

Oxalis grandis Small, Giant Wood Sorrel. Mesic sites such as low woodlands and shaded bluffs; generally rare (S,T).

Oxalis stricta L., Yellow Wood Sorrel. Fields, meadows, old lawns; abundant (L,S,T).

Oxalis violacea L., Violet Wood Sorrel. Dry open woodlands; locally abundant (L,S,T).

PAPAVERACEAE, Poppy Family

**Eschscholtzia californica* Cham., California Poppy. Collected once in a cemetery; very rare (S).

**Papaver rhoeas* L., Corn Poppy. Collections from the 1960s were persisting from cultivation; now presumed extirpated (L).

Sanguinaria canadensis L., Bloodroot, Red Puccoon. Mesic woodlands, outcrops and bluffs; rare but usually in numbers when found (L,S,T).

Stylophorum diphyllum (Michx.) Nutt., Celadine Poppy, Wood Poppy. Know only from one mesic woods near Barkley Reservoir; very rare (S).

PASSIFLORACEAE, Passion-Flower Family

Passiflora incarnata L., Passion-Flower, Maypops. Thickets, fencerows and other disturbed sites; frequent (L,S,T).

Passiflora lutea L., Small Passion-Flower. Mesic thickets and woodlands; occasional (L,S,T).

PHRYMACEAE, Lopseed Family

Phryma leptostachya L., Lopseed. Mesic slope and alluvial woodlands; occasional (L,S,T).

PHYTOLACCACEAE, Pokeweed Family

Phytolacca americana L., Pokeweed. Roadsides, fields, fencerows, disturbed woodlands; occasional and sometimes abundant (L,S,T).

PLANTAGINACEAE, Plantain Family

Plantago aristata Michx., Bracted Plantain. Fields, roadsides, disturbed sites; bundant (L,S,T).

**Plantago lanceolata* L., Buckhorn, Lance-Leaved Plantain. Old lawns, fields and disturbed sites; often abundant (L,S,T).

Plantago pusilla Nutt., Small Plantain. Sandy fields, roadsides, cemeteries; locally abundant (L,T).

Plantago rugelii Dcne., Rugel's Plantain. Mesic fields, old lawns, roadsides and other disturbed sites; often abundant (L,S,T).

Plantago virginica L., Virginia or Hoary Plantain. Fields, especially cultivated bottomlands, and disturbed open lands throughout; often abundant (L,S,T).

PLATANACEAE, Plane-Tree Family

Platanus occidentalis L., Sycamore. General along streams, around ponds and in moist to wet woodlands and fields; frequent (L,S,T).

POLEMONIACEAE, Phlox Family

Phlox divaricata L., Blue or Common Phlox. Alluvial and lower-slope woods; frequent, sometimes in large stands (L,S,T).

Phlox glaberrima L., Swamp or Smooth Phlox. Low woodlands, fields and thickets; generally rare but abundant in a few sites (L,S,T).

Phlox paniculata L., Fall or Garden Phlox. Mesic fields and thickets; locally abundant (L,S,T).

Phlox pilosa L. ssp. *pilosa*, Hairy Phlox. Dry roadsides, fields and thickets, sometimes in open woods; locally abundant (L,S,T).

Phlox pilosa L. ssp. *deamii* Levin. Dry roadsides; known only from Lyon county, apparently rare.

**Phlox subulata* L., Moss-Pink. Persisting and slightly spreading around a few cemeteries and homesites; locally abundant (S,T).

Polemonium reptans L., Greek Valerian, Jacob's Ladder. Mesic woodlands, especially on streambanks; generally rare but sometimes in large stands (L,S,T).

POLYGALACEAE, Milkwort Family

Polygala incarnata L., Pink Milkwort. Roadbanks, ditches, fields and disturbed sites; rare (S,T).

Polygala sanguinea L., Field Milkwort. Fields, roadsides, barrens; occasional to rare (L,S,T).

Polygala verticillata L., Whorled Milkwort. Roadsides, fields, barrens; occasional (L,S,T).

POLYGONACEAE, Buckwheat Family

Brunnichia cirrhosa Gaertn., Ladies' Eardrops. Climbing in thickets along the reservoirs and their embayments; frequent on Kentucky Lake, occasional to rare on Barkley (L,S,T).

**Fagopyrum esculentum* Moench, Buckwheat. Planted in wildlife plots and self-seeding (S,T).

Polygonum amphibium L., Scarlet Smartweed. Wet fields, thickets and ditches along the shorelines and at heads of Tennessee River embayments; frequent, often in large, dense stands; not common on the Cumberland River (L,S,T).

**Polygonum aviculare* L., Knotweed. Gravel and dirt driveways, fields; locally abundant (L,S,T).

**Polygonum cespitosum* Blume var. *longisetum* (DeBry.) Stewart, Bristled Smartweed. Mesic or wet fields, ditches, thickets and woodlands; abundant (L,S,T).

**Polygonum cuspidatum* Sieb. & Zucc., Japanese Knotweed. Persisting at a few homesites and appearing as a waif on riverbanks: rare (L,S).

Polygonum erectum L., Erect Knotweed. Old lawns, meadows, disturbed sites; occasional (S,T).

Polygonum hydropiper L., Water Pepper. Wet fields around marshes, wet woods and fields; abundant (L,S,T).

Polygonum hydropiperoides Michx., Mild Water Pepper. Swamps, marshes, wet woods and fields; abundant (L,S,T).

Polygonum lapathifolium L., Dock-Leaved Smartweed. Mesic fields, roadsides and disturbed sites; frequent (L,S,T).

**Polygonum orientale* L., Princes Feather. Waif on lakeshores and persisting around homesites; very rare, no recent collections (T).

Polygonum pensylvanicum L., Pinkweed. Mesic fields, ditches and shorelines; abundant (L,S,T).

**Polygonum persicaria* L., Lady's Thumb. Fields, roadsides, disturbed sites; occasional (L,S,T).

Polygonum punctatum Ell., Water Smartweed. Wet fields, woods, marshes; abundant (L,S,T).

**Polygonum sachalinense* Schmidt, Giant Knotweed. Persisting at a few old homesites; very rare (T).

Polygonum sagittatum L., Arrow-Leaved Tearthumb. Wet fields, marshes and bayhead thickets; locally abundant (L,S,T).

Polygonum scandens L., Climbing False Buckwheat. Old fencerows, thickets, disturbed sites, most often in mesic places; locally abundant (L,S,T).

Polygonum setaceum Baldwin, Bristly Smartweed. Swamps, low woods; locally abundant (L,S,T).

**Rumex acetosella* L., Sheep Sorrel. Fields, meadow, old lawns, disturbed sites; often abundant and weedy (L,S,T).

Rumex altissima Wood, Pale Dock. Open swampy banks of Kentucky Reservoir; rare (S,T).

**Rumex conglomeratus* Murr., Clustered-Flowered Dock. Swampy areas and beaver marshes around bayheads; rare (S).

**Rumex crispus* L., Curly or Yellow Dock. Fields, meadows, other disturbed sites; frequent, often weedy (L,S,T).

**Rumex obtusifolius* L., Bitter Dock. Wet woods, streambank and swamp borders; rare (S,T).

Rumex verticillatus L., Swamp Dock. Streambanks, swamps, marshes, often in shallow water; occasional southward, rare to the north (S,T).

Tovara virginiana (L.) Raf., Jumpseed. Mesic slope and ravine woods; frequent (L,S,T).

PORTULACACEAE, Purslane Family

Claytonia virginica L., Spring Beauty. Mesic woodlands and thickets, especially in bottomlands, cemeteries and old homesites; locally abundant (L,S,T).

**Portulaca oleracea* L., Purslane. Recently disturbed soils and cultivated fields; rare (L,S,T).

PRIMULACEAE, Primrose Family

**Anagallis arvensis* L., Scarlet Pimpernel. Wet thickets, fields and woods; generally rare but sometimes in large stands (L,T).

Dodecatheon meadia L., Shooting Star. Mesic wooded bluffs to the south where it is locally abundant; rare to the north (S).

Hottonia inflata Ell., Featherfoil. Known only from one slough near Lake Barkley in southern LBL; very rare (S).

Lysimachia ciliata L., Fringed Loosestrife. Wet fields, ditches, marsh borders and other wet areas; occasional (L,S,T).

Lysimachia fraseri Duby, Fraser's Loosestrife. Mesic woodlands; not seen in over 30 years and possibly extirpated (S).

Lysimachia hybrida Michx., Hybrid Loosestrife. Thickets along Kentucky Reservoir; rare (L,T).

Lysimachia lanceolata Walt., Lance-Leaved Loosestrife. Mesic to wet fields, thickets and marsh borders; occasional (L,S,T).

**Lysimachia nummularia* L., Moneywort. Wet fields, ditches and low woods; generally rare but sometimes forming an extensive ground-cover (L,S,T).

Samolus parviflorus Raf., Brookweed, Water Pimpernel. Springs, branches, seepage areas; occasional southward, rare to the north (L,S,T).

RANUNCULACEAE, Crowfoot Family

Actaea pachypoda Ell., Doll's-Eye. Rich mesic forests, usually on alluvium; rare, southward only (S).

Anemone virginiana L., Tall Anemone. Mesic woodlands and thickets, roadsides; occasional (L,S,T).

Aquilegia canadensis L., Columbine. Wooded outcrops and bluffs; very rare (L).

Cimicifuga racemosa (L.) Nutt., Black Cohosh, Black Snakeroot. Rich wooded slopes, sometimes in cut-over woodlands; locally abundant (L,S,T).

Cimicifuga rubifolia Kearney, Black Cohosh. Mesic slopes southward; rare (S).

Clematis viorna L., Leatherflower. Mesic thickets, weedy fields and disturbed sites; rare (L,S,T).

Clematis virginiana L., Virgin's Bower. Thickets and weedy fields; occasional (L,S,T).

**Consolida ambigua* (L.) Ball & Heywood [*Delphinium ajacis* L.], Rocket Larkspur. Roadsides, disturbed sites, old homesites; rare (S,T).

Delphinium tricorne Michx., Dwarf Larkspur. Mesic woods and bluffs; occasional (L,S,T).

Enemion biternatum Raf. [*Isopyrum biternatum* (Raf.) Torr. & Gray], False Rue Anemone. Mesic woods, thickets and outcrops; occasional but usually in large stands when found (L,S,T).

Hepatica nobilis Mill. var. *acuta* (Pursh) Steyerm. [*H. acutiloba* DC.], Liverleaf. Mesic outcrops and bluffs; locally abundant southward, rare to the north (S).

Hydrastis canadensis L., Goldenseal, Yellow Puccoon. Rich woods of ravines and slopes; rare but sometimes in large stands (L,S,T).

Myosurus minimus L., Mousetail. Fallow bottomlands in early spring; locally abundant (L,S,T).

**Paeonia lactiflora* Pall., Peony. Persisting in cemeteries and at homesites; occasional, perhaps represented by more than one taxon (L,S,T).

Ranunculus abortivus L., Small-Flowered Crowfoot. Idle fields, especially bottomlands, and disturbed sites; locally abundant (L,S,T).

Ranunculus carolinianus DC., Carolina Buttercup. Swampy open woods in Cumberland River bottomlands; rare (L).

Ranunculus fascicularis Muhl., Early Buttercup. Dry, thinly-wooded slopes and ridges; rare (S,T).

Ranunculus flabellaris Raf., Yellow Water Crowfoot. Long Creek west of Hematite Lake; rare (T).

Ranunculus hispidus Michx., Hispid Buttercup. Dry slope and ridge forests; occasional (L,S,T).

Ranunculus micranthus Nutt., Tiny-Flowered Buttercup. Slope and ridge forests; occasional (L,S,T).

**Ranunculus parviflorus* L., Small-Flowered Crowfoot. Idle bottomland fields, ditches; locally abundant (S,T).

Ranunculus pusillus Poir., Low Spearwort. Idle bottomland fields; locally abundant (S,T).

Ranunculus recurvatus Poir., Recurved Buttercup. Streambanks, mesic woods; occasional (L,S,T).

**Ranunculus sardous* Crantz, European Crowfoot. Mesic or wet fields, meadows, ditches; locally abundant (L,S,T).

Thalictrum dioicum L., Early Meadow Rue. Mesic slopes with outcrops and bluffs; very rare (T).

Thalictrum revolutum DC., Waxy Meadow Rue. Mesic fields and woods; occasional (L,S,T).

Thalictrum thalictroides (L.) Eames & Boivin [*Anemonella thalictroides* (L.) Spach.], Rue Anemone. Rich woods, thickets and shaded roadsides; occasional (L,S,T).

RHAMNACEAE, Buckthorn Family

Ceanothus americanus L., New Jersey Tea. Dry woodlands, roadsides and woodland borders; occasional (L,S,T).

Ceanothus herbaceous Raf., Prairie Redroot. Voucher not seen, but reported by Scott Gunn (personal communication) from Lyon County.

Rhamnus caroliniana Walt., Carolina Buckthorn, Indian Cherry. Mesic woodlands, fencerows and thickets, usually on limestone outcrops; occasional to rare (L,S,T).

ROSACEAE, Rose Family

Agrimonia parviflora Ait., Small-Flowered Harvest Lice. Low thickets, weedy fields and woods; occasional (L,S,T).

Agrimonia pubescens Wallr., Hairy Harvest Lice. Mesic woodlands and thickets; occasional southward, rare to the north (L,S,T).

Agrimonia rostellata Wallr., Beaked Harvest Lice. Woodlands throughout; frequent (L,S,T).

Amelanchier arborea (Michx. f.) Fern., Serviceberry. A characteriestic small tree of dry woodlands in the south but becoming rare northward (L,S,T).

Aruncus dioicus (Walt.) Fern. var. *dioicus*, Goat's-Beard. Mesic fields and thickets, forest borders; occasional to rare (S,T). The Lyon report from Ellis *et al.* (1971) is not vouchered.

Aruncus dioicus (Walt.) Fern. var. *pubescens* (Rydb.) Fern. [*A. pubescens* Rydb.], Hairy Goat's-Beard. Same habitats as the typical variety and perhaps more common (L,S).

**Chaenomeles lagenaria* (Loisel.) Koidz., Flowering Quince. Persisting at homesites and in cemeteries; occasional (L,S,T).

Crataegus calpodendron (Ehrh.) Medicus, Pear Hawthorn. Mesic woodlands and thickets; occasional to rare (L,S,T).

Crataegus collina Chapmn., Hill Hawthorn. Dry woods and thickets; occasional (L,S,T)

Crataegus crus-galli L., Cockspur Hawthorn. Dry woodlands and fields; occasional to rare (L,S,T).

Crataegus mollis (Torr. & Gray) Scheele, Downy Hawthorn. Low woods, thickets, and shorelines; occasional (L,S,T).

Crataegus phaenopyrum (L. f.) Medic., Washington Hawthorn. Mesic woodlands, fields, thickets and reservoir margins; occasional (L,S,T).

Crataegus pruniosa (Wendl.) K. Koch, Frosted Hawthorn. Mesic to wet woods and thickets; rare (T).

Crataegus spathulata Michx., Little-Hip Hawthorn. Low woods, thickets, old pastures; rare (T).

Crataegus viridis L., Green Haw. Low woods, reservoir and swamp margins; occasional (L,S,T).

**Duchesnea indica* (Andr.) Focke, Indian Strawberry. Old lawns and cemeteries; very rare (T).

Fragaria virginiana Duchesne, Strawberry. Fields, roadsides and old homesites, possibly including cultivar remnants; rare but abundant when found (L,S,T).

Geum canadense Jacq., Canada or White Avens. Mesic fields, thickets and woods; frequent (L,S,T).

Geum vernum (Raf.) Torr. & Gray, Vernal Avens. Mesic fields, thickets and weedy disturbed sites; frequent (L,S,T).

Gillenia stipulata (Muhl.) Baill., American Ipecac. Woods, thickets and roadsides; frequent (L,S,T).

Potentilla norvegica L., Five-Finger. Roadsides, fields, disturbed land; occasional (L,S,T).

**Potentilla recta* L., Upright Five-Finger. Fields and weedy disturbed sites; occasional (L,S,T).

Potentilla simplex Michx., Old-Field Cinquefoil. Fields and weedy disturbed sites; frequent (L,S,T).

Prunus americana Marsh., American Plum. Small tree in many dry woodlands, especially after disturbance; occasional (L,S,T).

Prunus angustifolia Marsh., Chickasaw Plum. Forming dense thickets in some old fields, fencerows and disturbed sites; occasional (L,S,T).

Prunus avium L., Sweet Cherry. Persisting in an old orchard; very rare (L).
Prunus cerasus L., Sour Cherry. Persisting at an old homesite; very rare (T).
Prunus domestica L., Cultivated Plum. Persisting, old orchards and around homesites; rare (L,S,T).
Prunus persica (L.) Batsch, Common Peach. Persisting in old orchards and at homesites, spreading onto roadsides; frequent (L,S,T).
Prunus serotina Ehrh., Wild Black Cherry. A constant member of mesic to dry slope forests and in fencerows and fields; frequent (L,S,T).
Prunus triloba Lindl., Flowering Almond. Small shrub persisting and slightly spreading in cemeteries and around old homes; rare (L,S,T).
Pyrus angustifolia Ait. [*Malus angustifolia* (Ait.) Michx.], Narrow-Leaved Crabapple. Dry woods, fields and roadsides; frequent, especially northward (L,S,T).
Pyrus calleryana Dcne., Bradford Pear. Planted and persisting (S).
Pyrus communis L., Common Pear. Persisting at old home and orchard sites; occasional (L,S,T).
Pyrus coronaria L. [*Malus coronaria* (L.) Mill.] Wild Sweet Crab Apple. Dry woods, fields and thickets; occasional northward, rare to the south (L,S,T).
Pyrus malus L. [*Malus pumila* Mill.], Common Apple. Persisting at many old home and orchard sites and sometimes appearing on roadsides and around camps; occasional (L,S,T).
Pyrus prunifolia Willd. [*Malus prunifolia* (Willd.) Borkh.], Cultivated Crab. Know only from one heavily-bearing tree persisting at a Golden Pond homesite (T).
Pyrus sieboldii Reg. [*Malus sieboldii* (Reg.) Rehd.], Toringo Crab. Frequently planted along the Trace and in campgrounds, apparently for wildlife food (L,S,T).
Rosa carolina L., Carolina Rose. Barrens, weedy fields and thickets; occasional (L,S,T).
Rosa multiflora Thunb., Multiflora Rose. Widely spreading from old plantings; a locally abundant and often noxious weed in fields, thickets and fencerows (L,S,T).
Rosa odorata (Andr.) Sweet, Cultivated Rose. Persisting in cemeteries and around homes; it is probable that several taxonomic entities are involved; rare (T).
Rosa palustris Marsh., Swamp Rose. Thickets in open swamps and marshes; rare (T).
Rosa setigera Michx., Prairie Rose. Fields, thickets, roadsides; frequent, often abundant (L,S,T).
Rosa wichuraiana Crepin., Rambling Rose. Persisting at homes, in cemeteries and in fencerows; often forming dense stands (other cultivar elements probably included); occasional (L,S,T).
Rubus argutus L., Common Blackberry. Fields and roadsides, often in dense stands; frequent (L,S,T).
Rubus bifrons Vest, European Blackberry. Persisting and apparently naturalized (S).
Rubus flagellaris Willd., Dewberry. Fields, roadbanks and open disturbed woods; frequent (L,S,T).
Rubus occidentalis L., Black Raspberry. Spreading around some homesites and orchards, sometimes appearing on roadsides and in fields and woods; occasional (L,S,T).
Rubus phoenicolasius Maxim., Wineberry. Persisting at a few homesites; very rare (S).
Spiraea prunifolia Sieb. & Zucc., Bridal-Wreath. Adventive around homesites and in cemeteries; locally abundant (L,S,T).
Spiraea salicifolia L., Willow-Leaved Spiraea. Persisting at an old homesite; very rare (S).
Spiraea thunbergii Sieb. & Zucc., Thunberg's Bridal-Wreath. Same as the previous species but not as frequently encountered (L,T).
Spiraea vanhouttei Zabel, Vanhoutt's Bridal-Wreath. Same; frequent (L,S,T).

RUBIACEAE, Madder Family

Cephalanthus occidentalis L., Buttonbush. Swampy thickets, especially around the lakeshores and bays; often in very dense stands (L,S,T).
Diodia teres L., Poor-Joe, Buttonweed. Dry fields, disturbed sites; locally abundant (L,S,T).
Diodia virginiana L., Virginia Buttonweed. Wet fields, meadows, ditches; locally abundant (L,S,T).
Galium aparine L., Cleavers, Bedstraw. Homesites and many other weedy, disturbed areas; locally abundant in the south, rare northward (L,S,T).

Galium circaezans Michx., Wild Licorice. Moist woods and fields; occasional (L,S,T).
Galium concinnum Torr. & Gray, Shining Bedstraw. Mesic to swampy fields, thickets and woods, mostly near the reservoirs; rare (L,S,T).
Galium obtusum Biegel., Obtuse Bedstraw. Woodlands, especially along the lakeshores; rare (S,T).
**Galium pedemontanum* Ell., Piedmont Bedstraw. Sunny banks, lawns and fields; locally abundant, sometimes weedy (L,S,T).
Galium pilosum Ait., Hairy Bedstraw. Fields, open and cut-over woods; locally abundant (L,S,T).
Galium tinctorium L., Swamp Bedstraw. Marshes, wet fields and thickets; locally abundant (L,S,T).
Galium triflorum Michx., Sweet-Scented Bedstraw. Mesic woods; occasional (L,S,T).
Houstonia caerulea L., Bluets. Lawns, meadows, fields, cemeteries; locally abundant (L,S,T).
Houstonia purpurea L., Purple Bluets. Dry woodlands, roadbanks, disturbed sites; frequent (L,S,T).
Houstonia pusilla Schoepf [*H. patens* Ell.], Small Bluets. Fields, meadows, lawns, cemeteries and roadsides, frequent (L,S,T).
Oldenlandia boscii (DC.) Chap. [*Hedyotis boscii* DC.], Bosc's Sweet-Ear. Dewatered flats on Kentucky Reservoir; often abundant (L,S,T).
Oldenlandia uniflora L. [*Hedyotis uniflora* (L.) Lam.], One-Flowered Sweet-Ear. Dewatered Flats on Kentucky Reservoir; rare (S,T).
**Sherardia arvensis* L., Field Madder. Old lawns and roadsides; rare (S,T).
Spermacoce glabra Michx., Buttonweed. Wet meadows, fields, lakeshores; rare (L,S,T).

RUTACEAE, Rue Family

Ptelea trifoliata (L.) Raf., Wafer Ash. Rich woodlands, bluffs and fencerows; rare (S,T).
Xanthoxylum americanum Mill., American Prickly Ash. Thickets and open woods with limestone outcrops; very rare (T). This report is based on *Athey 4002* (Athey Herbarium - now at Murray State University, and VDB - now at BRIT).

SALICACEAE, Willow Family

**Populus alba* L., White or Silver Poplar. Old homesites and cemeteries where extensive colonies often result from root sprouts; scattered (L,S,T).
**Populus canescens* (Ait.) Sm., White Poplar. Spreading from root sprouts around a few old homesites; rare (S).
Populus deltoides Bartr., Cottonweed. Reservoir shorelines, around embayments and ponds and in bottomland and streambank forests; frequent (L,S,T).
Populus grandidentata Michx., Big-Toothed Aspen. Mesic slope forests; rare (S,T).
**Populus nigra* L. var *italica* Muenchh., Lombardy Popular. Collected once from a homesite which has since been cleared; this species may no longer occur in LBL (T).
**Salix babylonica* L., Weeping Willow. Persisting at a few old homesites and cemeteries but not reproducing; rare (S,T).
Salix caroliniana Michx., Carolina or Ward's Willow. Wet fields, streambanks and roadsides ditches; occasional to rare (L,S,T).
Salix exigua Nutt. [*S. interior* Rowlee], Sandbar Willow. Reservoir and embayment margins along Kentucky Reservoir; rare (L,S,T).
Salix humilis Marsh. var. *humilis*, Upland Willow. Wet fields, roadsides, ditches and barrens; occasional (L,S,T).
Salix humilis Marsh. var. *microphylla* (Anderss.) Fern. [*S. tristis* Ait.], Dwarf Upland Willow, Sage Willow. Dry upland woods and forest borders; rare (T).
Salix nigra Marsh., Black Willow. Reservoir and embayment shorelines, stream and pond margins, swamps; this is by far our most abundant willow (L,S,T).
Salix sericea Marsh., Silky Willow. Wet fields, thickets and ditches; locally abundant southward, such as the Crockett Creek area, but rare to the north (S,T).

SANTALACEAE, Sandalwood Family

Comandra umbellata (L.) Nutt., Bastard Toadflax. Dry oak woods and borders; very rare (S).

SAPINDACEAE, Soapberry Family

**Cardiospermum halicacabum* L., Balloon Vine. Mesic thickets, mostly along reservoir margins; frequent, often in dense stands (L,S,T).

SAPOTACEAE, Sapodilla Family

Bumelia lycioides (L.) Gaertn., Southern Buckthorn. Mesic woodlands, fencerows, thickets, usually around bluffs and outcrops; rather rare (L,S,T).

SAURURACEAE, Lizard's-Tail Family

Saururus cernuus L., Lizard's-Tail. Marshes, swamps, shallow water of inlake lakes and embayments; locally abundant (L,S,T).

SAXIFRAGACEAE, Saxifrage Family

Heuchera americana L., American Alumroot. Mesic woods and thickets, outcrops and bluffs; occasional, sometimes in large numbers (L,S,T).

Heuchera villosa Michx., Hairy Alumroot. Mesic woods and thickets, especially on outcrops and bluffs; sometimes abundant southward, rare northward (S,T).

Hydrangea arborescens L., Hydrangea. Streambanks, bluffs, outcrops; locally abundant (L,S,T).

Itea virginica L., Virginia Willow. Swampy woods and thickets near reservoirs; very rare (T).

Penthorum sedoides L., Ditch Stonecrop. Swamps, wet fields, pond margins; occasional (L,S,T).

**Philadelphus coronarius* L., Mock-Orange. Persisting in a few cemeteries and around old homesites; rare (L,T).

**Philadelphus inodorus* L., Odorless Mock-Orange. Perhaps native on pre-impoundment slopes and bluffs, but known only from cultivation (persisting) at old homesites; very rare (S).

**Philadelphus pubescens* Loisel., Hairy Mock-Orange. Persisting around homesites and in cemeteries; perhaps native on a few Cumberland River bluffs (L,S,T).

Ribes missouriense Nutt., Missouri Gooseberry. Mesic thickets along upper Elbow Creek, Golden Pond; very rare (T).

SCROPHULARIACEAE, Figwort Family

Agalinis fasciculata Ell. [*Gerardia fasciculata* Ell.], Fascicled Foxglove. Dry successional fields; locally abundant (L,S).

Agalinis purpurea (L.) Penn. [*Gerardia purpurea* L.] Purple Foxglove. Fields, roadsides, thickets; locally abundant (L,S,T).

Agalinis tenuifolia (Vahl) Raf. [*Gerardia tenuifolia* Vahl.], Slender Foxglove. Roadsides, fields, disturbed sites; frequent and often abundant (L,S,T).

Aureolaria flava (L.) Farw. [*Gerardia flava* L.], Yellow False Foxglove. Dry oak woods and bluffs; locally abundant (L,S,T).

Aureolaria patula (Chapm.) Penn. [*Gerardia patula* (Chapm.) Gray], False Foxglove. Mesic limestone footslopes; very rare (S).

Aureolaria pectinata (Nutt.) Benth. [*Gerardia pectinata* L.], Pectinate False Foxglove. Dry thin woods, bluffs and banks; locally abundant southward but becoming rare to the north (S,T).

Bacopa rotundifolia (Michx.) Wettst., Round-Leaved Water-Hyssop. Ponds, ditches, dewatered shorelines; rare but sometimes in large colonies (L,S,T).

Buchnera americana L., American Blue-Hearts. Dry roadsides, open woods, barrens; rare (L,S,T). The voucher for L is *Athey 4173* (formerly MEM, now at TENN).

**Chaenorrhinum minus* (L.) Lange, Dwarf Snapdragon. Sometimes abundant on gravel road shoulders, mostly along Highway 68, but otherwise unknown (T).

Chelone glabra L., Turtlehead. Wet to mesic woods and thickets; locally abundant (S,T).

Conobea multifida (Michx.) Benth. [*Leucospora multifida* (Michx.) Nutt.], Clefted Conobea. River banks, pond margins, mudflats; locally abundant (L,S,T).

Gratiola neglecta Torr., Hedge-Hyssop. Pond margins, wet fields, ditches, mudflats; abundant (L,S,T).

Gratiola virginiana L., Virginia Hedge Hyssop. Shallow pond margins, muddy shores; rare (L,S).

**Kickxia elatine* (L.) Dum., Canker-Root. Rocky embankments along Barkley Lake; very rare (S).

Lindernia anagallidea (Michx.) Penn., False Pimpernell. Pond margins, reservoir mudflats; frequent, often in large numbers (L,S,T).

Lindernia dubia (L.) Penn., False Pimpernell. Pond margins, wet fields, ditches, mudflats; frequent, often in large numbers (L,S,T).

Mimulus alatus Ait., Winged Monkey Flower. Marshes, wet meadows, creekbanks, ditches and low woods; frequent (L,S,T).

Mimulus ringens L. Ringed Monkey Flower. Bottomlands swamps of Barkley Reservoir; rare but sometimes in large numbers (L,T).

**Paulownia tomentosa* (Thunb.) Steud., Princess or Empress Tree. Persisting at homesites and in cemeteries and sometimes spreading to fields and roadsides; occasional (L,S,T).

Pedicularis canadensis L., Common Lousewort, Wood-Betony. Mesic woods and thickets; rare to occasional (L,S,T)

Penstemon australis Small, Southern Beard-Tongue. Mesic woodlands and fields; rare (S).

Penstemon calycosus Small, Large-Calyxed Beard-Tongue. Mesic woods, bluffs, meadows, fields and roadsides; frequent (L,S,T).

Penstemon digitalis Nutt., Beard-Tongue. Roadsides and open woods; rare (T).

Penstemon hirsutus (L.) Willd., Hirsute Beard-Tongue. Roadsides, bluffs, thickets and fields, usually in drier sites; rare (L).

Penstemon laevigatus Sol., Smooth Beard-Tongue. Mesic fields and open woodlands; frequent (L,S,T).

Penstemon tenuiflorus Penn., Slender-Flowered Beard-Tongue. Dry bluffs, fields and forest borders; frequent (L,S,T).

Scrophularia marilandica L., Carpenter's-Square. Mesic woods, bluffs and thickets; frequent (L,S,T).

Seymeria macrophylla Nutt. [*Dasistoma macrophylla* (Nutt.) Raf.], Mullein Foxglove. Woodlands, both mesic and dry, especially around outcrops; frequent, often clumped (L,S,T).

**Verbascum blattaria* L., Moth-Mullein. Fields, roadsides, waste lands; frequent (L,S,T).

**Verbascum thapsus* L., Common Mullein. Same habitats as the previous species; sometimes in stands, especially along shorelines and in cut-over woods (L,S,T).

**Veronica arvensis* L., Common Speedwell. Open fields, roadsides, present and former lawns; abundant throughout (L,S,T).

Veronica peregrina L., Neckweed. Fallow bottomland fields, wet meadows; abundant (L,S,T).

**Veronica serpyllifolia* L., Thyme-Leaved Speedwell. Cemeteries, lawns, fields; rare (L,S).

Veronicastrum virginicum (L.) Farw., Culver's-Root. Mesic to dry woods and thickets; infrequent but sometimes in stands (L,S,T).

SIMAROUBACEAE, Quassia Family

**Ailanthus altissima* (Mill.) Swingle, Tree-of-Heaven. Adventive around homesites, cemeteries and on roadsides; occasional but sometimes in stands (L,S,T).

SOLANACEAE, Nightshade Family

**Datura stramonium* L., Jimsonweed. Edges of cultivated fields, cultural sites, open disturbed areas; occasional (L,S,T).

**Lycospersicon esculentum* Mill., Tomato. Waif, reservoir margins, campgrounds; rare (L,S,T).

**Ulmus pumila* L., Siberian Elm. Broken, diseased remnants of lawn and cemetery plantings still persist in a few places; rare (L,S,T).

Ulmus rubra Muhl., Red or Slippery Elm. Mesic woodlands, especially in bottomlands and along streams; also in fencerows and fields; frequent (L,S,T).

Ulmus serotina Sarg., September Elm. Woods and mesic bluffs along the Cumberland River; very rare (L,S).

URTICACEAE, Nettle Family

Boehmeria cylindrica (L.) Sw., False Nettle, Bog-Hemp. Swamps, wet fields, creekbanks and wet woods; frequent (L,S,T).

Laportea canadensis (L.) Wedd., Wood-Nettle. Wet woods and thickets, swamp borders; locally abundant (L,S,T).

Parietaria pensylvanica Muhl., Pellitory. Open rocky woods and bluffs; locally abundant (L,S,T).

Pilea pumila (L.) Gray, Clearweed. Mesic to wet woods, especially on bluffs and around outcrops; occasional but often plentiful (L,S,T).

Urtica chamaedryoides Pursh, Nettle. Cumberland River woodlands and bluffs; rare (L,S).

VALERIANACEAE, Valerian Family

Valeriana pauciflora Michx., Valerian. Abundant in rich alluvial woods along or near Bear Creek but otherwise unknown (S).

**Valerianella locusta* Betcke [*V. olitoria* (L.) Poll.], Corn-Salad. Low fields, river banks; rare but usually in showy numbers when found (L,S,T).

Valerianella radiata (L.) Dufr., Corn-Salad. Fields, roadsides, thickets; locally abundant (L,S,T).

VERBENACEAE, Vervain Family

**Callicarpa americana* L., Beauty-Berry. Persisting from landscape plantings; very rare (T).

Lippa lanceolata Michx. [Phyla lanceolata (Michx.) Greene], Fog-Fruit. Wet fields, swamp and reservoir margins; locally abundant (L,S,T).

Verbena bracteata Lag. & Rodr., Bracted Vervain. Collected more than 20 years ago on a sandy roadside; possibly extirpated (T).

**Verbena brasiliensis* Vellozo, Brazilian Vervain. Known only from a sandy disturbed area near Kentucky Reservoir; very rare (T).

Verbena hastata L., Blue Vervain. Wet fields, thickets and open woods; locally abundant (L,S,T).

**Verbena hybrida* Voss, Hybrid Vervain. Persisting and adventive around homesites and in cemeteries; rare (L,S,T).

Verbena simplex Lehm., Narrow-Leaved Vervain. Roadsides, fields; frequent (L,S,T).

Verbena urticifolia L. var. *urticifolia*, White Vervain. Fields, woodlands; frequent (L,S,T).

Verbena urticifolia L. var. *leiocarpa* Perry & Fern., Smooth White Vervain. With the typical variety but rare (S).

VIOLACEAE, Violet Family

Hybanthus concolor (Forst.) Spreng., Green Violet. Rich rocky woods; infrequent but sometimes in large numbers (L,S,T).

Viola cucullata Aiton, Hooded Violet. Moist open woodlands, wet meadows; rare (S).

Viola missouriensis Greene [*V. sororia* Willd. var. *missouriensis* Greene, after McKinney 1986], Missouri Violet. Alluvial woods; rare (S,T).

Viola pedata L., Pansy-Violet, Bird-Foot Violet. Dry sunny banks and open woods; frequent, often in large stands (L,S,T).

Viola priceana Pollard, Confederate Violet. Low woods and meadows, old lawns; rare but sometimes in large numbers, especially around homesites (S).

**Nicandra physalodes* (L.) Pers., Apple-of-Peru. Cultivated fields, roadsides, old homesites, disturbed lands; occasional (L,S).

**Nicotiana tabacum* L., Tobacco. Formerly a major cash crop with sprouts and "plantbeds" persisting until frost; unknown now except for a few plants grown at the Homeplace (S).

**Petunia violacea* Lindl., Petunia. Old homesites and cemeteries; rare (L,S).

Physalis angulata L., Angled Ground Cherry. Cultivated fields, reservoir shorelines, disturbed sites; frequent (L,S,T).

Physalis cordata Mill. [*P. pubescens* var. *glabra* (Michx.) Waterfall], Cordate-Leaved Ground Cherry. Cultivated fields; rare (S).

Physalis heterophylla Nees, Variable-Leaved Ground Cherry. Roadsides, fields, cemeteries and other open disturbed sites; frequent (L,S,T).

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 (L,S,T).

Physalis pubescens L., Pubescent Ground Cherry. Weedy fields, sandy reservoir shorelines; frequent and often in large numbers (L,S,T).

Physalis virginiana Mill., Virginia Ground Cherry. Fields and disturbed sites; occasional (L,S,T).

**Solanum americanum* Mill., American Nightshade. Fields and other open disturbed sites; frequent, often in large numbers (L,S,T).

Solanum carolinense L., Horse-Nettle. Fields, homesites, meadows and other such disturbed sites; frequent, often in large numbers (L,S,T).

**Solanum sarachoides* Sendtner, Hairy Nightshade. Sandy shores of Kentucky Reservoir; rare (S,T).

STAPHYLEACEAE, Bladdernut Family

Staphylea trifolia L., Bladdernut. Wooded streambanks and ravines, and on rocky slopes and bluffs; throughout but infrequent (L,S,T).

STYRACACEAE, Storax Family

Halesia carolina L., Carolina Silverbell. Ravines and north-facing slopes of Kentucky Reservoir embayments; scattered and rarely abundant (L,S,T).

Styrax americana Lam., American Snowbell or Storax. Swampy thickets along Kentucky Reservoir and its embayments; often abundant (L,S,T).

Styrax grandifolia Ait., Big-Leaf Snowbell or Storax. Known only from a small grove under a pine canopy in the Devil's Backbone area; very rare (S).

TILIACEAE, Linden Family

Tilia heterophylla Vent., White Basswood. Mesic woods and creekbanks; locally abundant, especially on north-facing slopes of Kentucky Reservoir embayments (L,S,T). Taxonomy of our native basswoods is unclear.

ULMACEAE, Elm Family

Celtis laevigata Willd., Sugarberry. Low woodlands, fencerows, old fields, homesites, especially around outcrops; frequent (L,S,T).

Celtis occidentalis L., Hackberry. Along streams, in lowland forests and on mesic slopes; occasional (L,S,T).

Planera aquatica (Walt.) Gmel., Water-Elm. Shoreline of Kentucky Reservoir; rare (S).

Ulmus alata Michx., Winged Elm. Woods, old fields, fencerows and roadsides; abundant (L,S,T).

Ulmus americana L., American Elm. Bottomland, streambank, mesic slope and bluff forests; frequent. Sometimes persisting from old lawn plantings (L,S,T).

Viola pubescens Ait. var. *eriocarpa* (Schwein.) Russell [*V. pensylvanica* Michx., *V. eriocarpa* Schwein.], Yellow Violet. Rich slope and ravine forests; locally abundant (L,S,T).

**Viola rafinesquii* Greene, Field Pansy. Lawns, meadows, roadbanks and other open disturbed sites; frequent, often in large numbers (L,S,T).

Viola sagittata Ait., Arrow-Leaved Violet. Mesic open woods and meadows; rare (S,T).

Viola sororia Willd., Meadow Violet. Low woods, meadows, old lawns, fields; frequent, often very abundant (L,S,T). Reported as *Viola papilionacea* Pursh, by Ellis *et al.* (1971). Following McKinney (1987), this common woodland and meadow violet should be called *V. sororia* Willd.

Viola striata Ait., Cream Violet. Rich wooded slopes and ravines; locally abundant southward, rare to the north (S,T).

Viola triloba Schwein. var. *dilatata* (Ell.) Brainerd [*V. palmata* L. forma *dilatata* Brainerd *sensu* McKinney 1987], Dilated Three-Lobed Violet. Dry woods, thickets; infrequent (L,S,T).

Viola triloba Schwein. var. *triloba* [*V. palmata* L. forma *palmata sensu* McKinney 1987], Three-Lobed Violet. Slope and ridge forests, thickets; infrequent (L,S,T).

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 (L,S,T).

VITACEAE, Grape Family

Ampelopsis arborea (L.) Koehne, Pepper-Vine. Mesic thickets, especially around old dwellings (persisting from plantings) and along the Tennessee River where it may be native (L,S,T).

Ampelopsis cordata Michx., Heart-Leaf Ampelopsis. Mesic fencerows and thickets, especially in bottomlands; locally abundant (L,S,T).

Parthenocissus quinquefolia (L.) Planch., Virginia Creeper. Woodlands, fencerows, thickets and disturbed sites throughout; abundant (L,S,T).

Vitis aestivalis Michx., Summer Grape. Woodlands and fencerows throughout; frequent, thicket-forming or a high climber (L,S,T).

Vitis cinerea (Engelm. in Gray) Engelm. ex Millard var. *baileyana* (Munson) Comeaux, Bailey's Downy Grape. Bottomland fencerows and thickets; occasional (L,S,T).

Vitis cinerea (Engelm.) Engelm. ex Mill. var. *cinerea*, Downy Grape. Very rare in low woods (L).

Vitis labrusca L., Fox Grape. Very rare in low thickets (T).

**Vitis labruscana* Bailey, Cultivated Grape. Rarely persisting in old orchards and homesteads (L,T).

Vitis palmata Vahl, Red Grape. Sandy thickets near the outer edges of the Kentucky Reservoir fluctuation zone; locally abundant (L,S,T).

Vitis rotundifolia Michx., Muscadine Grape. Both dry and wet woodlands throughout; frequent, thicket-forming or sometimes trailing on the forest floor (L,S,T).

Vitis vulpina L., Frost Grape. Mesic woods, fencerows and thickets; frequent, forming thickets or high-climbing (L,S,T).

CHECKLIST OF THE VASCULAR PLANTS OF HANCOCK BIOLOGICAL STATION, MURRAY STATE UNIVERSITY, CALLOWAY COUNTY, KENTUCKY

RALPH L. THOMPSON

Hancock Biological Station, Murray State University, Murray, Kentucky 42071

ABSTRACT. A floristic survey was made of the Hancock Biological Station, Murray State University, throughout the growing seasons of 1998-2002. The 31.6 ha tract lies 23 km from Murray, Kentucky, in northeastern Calloway County within the Jackson Purchase Region of western Kentucky. The station adjoins Kenlake State Resort Park to the north and Kentucky Lake shoreline to the east. The vegetation is an excellent example of upland Oak-Hickory Forest. Plant habitats represent four main categories: dry and dry-mesic oak-hickory forests, early to mid-successional areas, culturally-disturbed areas, and wet areas. Vascular plants include 560 specific and infraspecific taxa in 320 genera from 110 families; 463 are native and 97 are exotic species. Taxonomic representation is: one Lycopodiophyta, one Equisetophyta, eight Polypodiophyta, four Pinophyta, and 546 Magnoliophyta. The largest families in species richness are the Asteraceae (73), Poaceae (67), Fabaceae (41), and Cyperaceae (34). Life forms are made up of 131 annuals, 16 biennials, 310 perennials, and 103 woody taxa.

INTRODUCTION

Hancock Biological Station (HBS), the biological field station of Murray State University, Murray, Kentucky, was established in 1966 from the efforts of Dr. Hunter M. Hancock, the late emeritus professor and chair of biology, to provide year-around research in aquatic and terrestrial biology. HBS is situated in northeastern Calloway County within the Rushing Creek Quadrangle at latitude 36°44'04" N, and longitude 88°11'00" W within the Jackson Purchase Region of western Kentucky. The station is 23 km northeast of Murray, Kentucky, and borders Kenlake State Resort Park to the north and adjoins the Kentucky Lake shoreline to the east. HBS consists of 31.6 ha of predominantly Oak-Hickory Forest with open fields formerly used for farming and pasture.

Hancock Biological Station is a member of the Organization of Biological Field Stations, an association of 180 field stations in North America and Central America, which is concerned with field facilities for biological research and education (Organization of Biological Field Stations 2003). The HBS and the nearby Land Between The Lakes have been designated as an Experimental Ecological Reserve by the National Science Foundation and the Institute of Ecology. The HBS is one of three research facilities forming the support base for the Center for Reservoir Research, which conducts research on basic and applied aspects of reservoir ecology. A group of educational institutions constituting the Ecological Consortium of Mid-America utilize HBS for summer undergraduate and graduate teaching and as a base of operation for field trips and research throughout the year (Murray State University 2003).

The HBS was one of six principal collecting sites in a floristic study of Calloway County by Woods (1983). That county flora was published after additional collections (Woods and Fuller 1988). The objectives of this paper are to present a complete annotated checklist of the vascular flora specifically at HBS and to include all the collectors and collections since 1966.

THE ENVIRONMENTAL CONTEXT

Hancock Biological Station lies within the Jackson Purchase Physiographic Region or the Mississippi Embayment Section of the East Gulf Coastal Plain based on Fenneman (1938). Keys et al. (1995) place the area west of the Tennessee River (the Kentucky Lake impoundment) as belonging to the Deep Loess Hills and Bluffs Subsection of the Upper Gulf Coastal Plain Section of the Eastern Broadleaf Forest Province. Based on geology, soils, and vegetation present at HBS, the site is representative of the Loess Plains of the Mississippi Valley Loess Plains (Woods et al. 2002). Elevations at HBS range from 110 m along the Kentucky Lake shoreline to 137 m at the northwestern station entrance.

The geology of HBS includes alluvium, loess, and cherty limestone of the Quaternary, Cretaceous, and Mississippi Systems (Seeland and Wilshire 1965). Silt, sand, and cherty gravel alluvium of the Pleistocene and Recent of the Quaternary System is found in coves next to Kentucky Lake. Shallow, silty loess from the Pleistocene of the Quaternary System covers the dominant cherty limestone of the Fort Payne Formation of the Mississippian System. A very small area of the Kentucky Lake shoreline has clay, clayey silts, and gravels of the Tuscaloosa Formation of Upper Cretaceous Series.

The Brandon-Bodine Association is the main soil association mapped where HBS is situated (Humphrey et al. 1973). This soil association is found on sloping to very steep well-drained to excessively drained, silty and cherty uplands. The Brandon series on 6-30 percent side slopes and ridges are acid to strongly acid, well-drained soils developed in 0.6-1.2 m of loess. These soils consist of about 23 cm of brown silty loams, 25.4-68.5 cm of yellowish-red, silty clay loams, and 71.1-127 cm of Coastal Plains gravel. Bodine series are acid to strongly acid, well-drained to excessively drained, residual cherty limestone soils from the Fort Payne Formation on 12-60 percent side slopes near Kentucky Lake. These soils are brown, cherty silt loams from 2.5-12.7 cm, yellowish-brown, cherty silt loams from 15.2-55.9 cm, and yellowish-red, very cherty, silty clay loams from 58.4-157 cm deep.

The forest vegetation in the Jackson Purchase Region is predominantly Oak-Hickory Forest (Küchler 1964, Bryant and Held 2001, Woods et al. 2002). Braun (1950) included the Mississippi Embayment Section (Jackson Purchase Region) in her Western Mesophytic Forest Region based on mixed mesophytic vegetation of the western loess bluffs. However, Braun (1950) noted that except for this reason, she would have placed the vegetation in her Oak-Hickory Forest Region.

The dominant vegetation of HBS is clearly mixed Oak-Hickory Forest with dry oak-hickory and dry-mesic oak-hickory forests present. Dry oak-hickory forest stands have *Quercus stellata*, *Q. marilandica*, and *Carya glabra* on upper, open south-trending slopes, and ridgecrests. Other important trees are *Acer rubrum*, *Nyssa sylvatica*, *Carya tomentosa*, *Quercus velutina*, *Ulmus alata*, *Amelanchier arborea*, and *Vaccinium arboreum*. The more extensive dry-mesic oak-hickory forest stands include *Quercus alba* as the major dominant. Other important trees include *Quercus falcata*, *Q. velutina*, *Q. stellata*, *Q. rubra*, *Carya ovata*, *C. tomentosa*, *Prunus serotina*, *Ulmus rubra*, and *Cornus florida* on lower side slopes, sloping terrain, and cove valleys.

Plant habitats at HBS fall under four main categories: oak-hickory forests, early and mid-successional areas, culturally-disturbed areas, and wet areas. A discussion of each plant habitat and its associated species is the focus of a future paper. Several plant habitats present in the annotated checklist include: dry and dry-mesic oak-hickory forests, early and mid-successional old-fields and forest edges, a burned old-field restoration prairie, a powerline corridor cut, a riparian forest, shrub swamps, an emergent wetland, a wetland meadow, cove floodplains, a ponded borrow pit and depression pits, the Kentucky Lake shoreline, a station wetland complex, the mowed and unmowed station yard, station gravel trails and roads, the roadsides of Emma Drive and Watersport Road.

Climate in the Jackson Purchase Region is humid, temperate continental type with warm to hot summers and cool to moderately cold winters. In Murray, from 1961-1990, the mean annual temperature was 14.7° C with January, the coldest month, at 1.3° C, and July, the warmest month, at 26.1° C. The length of the growing season is 211 days from the median first frost on October 30 and the median last freeze on April 4. Mean precipitation is 136 cm per year with October, the driest month, at 9.0 cm, and December, the wettest month, at13.3 cm (Western Kentucky University 2001).

METHODS

A floristic survey was conducted during the growing seasons from March-November 1998 through 2002. Plants were identified using Mohlenbrock (1986) and Gleason and Cronquist (1991). Nomenclature of families and species follows Gleason and Cronquist (1991). Plants were collected in duplicate with the master set deposited into the Murray State University Herbarium (MUR) and the second set placed in the Berea College Herbarium (BEREA), Berea, Kentucky. Plant habitats were delineated through extensive field reconnaissance and field collections in conjunction with site topographic-moisture features, present vegetation, dominant and associated species, and cultural disturbances.

The annotated checklist is organized into an alphabetical family sequence and then within each family alphabetically by genus and species. The scientific name of each taxon is followed by a common name and the habitat where the species was observed and collected. A relative abundance value of rare, infrequent, occasional, frequent, or abundant throughout HBS follows with the life-form designation. Relative abundance values follow Thompson and Jones (2001). Plant collectors and their collection numbers for each species end each entry of the checklist. All collections of herbarium specimens on file at MUR and BEREA are listed since the first 1966 collection. An asterisk (*) preceding the scientific name indicates an exotic or non-indigenous taxon. A lower case (o) indicates a new Calloway County record based on herbarium holdings at MUR. A dagger (†) represents a planted or cultivated taxon (Appendix 1).

RESULTS AND DISCUSSION

A total of 560 specific and infraspecific taxa in 320 genera from 110 families were documented from all collections made from HBS (Table 1). Taxonomic division representation is: one Lycopodiophyta, one Equisetophyta, eight Polypodiophyta, four Pinophyta, and 546 Magnoliophyta (144 Liliopsida, 402 Magnoliopsida). Ninety-seven (17.3%) were exotic or non-indigenous taxa (Table 1). Twenty-three species were deliberately planted or cultivated.

Table 1. Taxonomic distribution of vascular plants at the Hancock Biological Station.

Division	Family	Genera	Species	Native	Exotic
Equisetophyta	1	1	1	1	0
Lycopodiophyta	1	1	1	1	0
Polypodiophyta	4	7	8	8	0
Pinophyta	3	3	4	4	0
Magnoliophyta	101	308	546	449	97
Liliopsida	15	69	143	116	28
Magnoliopsida	86	239	403	333	69
TOTALS	110	320	560	463	97

In species richness, the largest families are the Asteraceae (73), Poaceae (67), Fabaceae (41), Cyperaceae (34), Lamiaceae (20), Rosaceae (15), and Scrophulariaceae (15). Life forms consist of 131 annuals, 16 biennials, 310 perennials, and 103 woody taxa. Woody taxa are composed of 65 trees, 19 shrubs, and 19 vines (Appendix 1).

Woods (1983) listed 912 species, 428 genera, and 119 families from his masters thesis. Woods and Fuller (1988) increased those numbers to 1018 species, 462 genera, and 129 families after additional collections were added to MUR. The 560 specific and infraspecific taxa account for 55.0% of the total Calloway County flora, based on Woods and Fuller (1988). Thirty-five new Calloway County records were documented that were not present at MUR or in Woods and Fuller (1988). The 560 taxa comprised 17.2% of the 3254 vascular plants recorded for Kentucky by Medley (1993).

Twenty individuals have collected a total of 795 vascular plant specimens at HBS since 1966 (Appendix 2). A total of 560 species have been collected among those 795 specimens. Thirty-nine species had been collected more than twice (Appendix 1). Thompson collected and recollected 552 (98.6%) of the 560 species which accounted for 69.4% of the total collections (Appendix 2).

ACKNOWLEDGMENTS

Special thanks are extended to Dr. Ross C. Clark, Eastern Kentucky University, for verification of woody plants, and to Dr. Robert F.C. Naczi, Delaware State University, for identification and verification of the Cyperaceae.

LITERATURE CITED

Braun, E.L. 1950. Deciduous forests of eastern North America. Macmillan Publishing Co., New York, New York.

Bryant, W.S. and M.E. Held. 2001. An ordination of the plant communities of the Jackson Purchase Region of Kentucky. Pp. 11-18. *In*: Chester, E.W. and A.F. Scott (eds.): 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.

Fenneman, N.M. 1938. Physiography of eastern United States. McGraw-Hill Book Co., New York, New York.

Gleason, H.A. and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada, Second Edition. The New York Botanical Garden, Bronx, New York.

Humphrey, M.E. , F.L. Anderson, R.A. Hayes, and J.D. Sims. 1973. Soil survey of Calloway and Marshall Counties, Kentucky. U.S.D.A., Soil Conservation Service, Washington, D.C.

Keys, Jr., J., C. Carpenter, S. Hooks, F. Lienig, W.H. McNab, W.E. Russell, and M.L. Smith. 1995. Ecological units of the eastern United States-first approximation (map and booklet of map unit tables). U.S. Department of Agriculture, Forest Service, Atlanta, Georgia.

Western Kentucky University. 2001. Kentucky climate summary, 1961—1990: Murray. Accessed at: <http://www.kyclim.wku.edu/kcc/html/kyclimate.html>

Küchler, A.W. 1964. Potential natural vegetation of the conterminous United States. Map and accompanying manual. Amer. Geographical Soc. Publ. No. 36. New York, New York.

Medley, M.E. 1993. An annotated catalog of the known or reported vascular flora of Kentucky. Ph.D. dissertation, University of Louisville, Louisville, Kentucky.

Mohlenbrock, R. H. 1986. Guide to the vascular flora of Illinois. Revised and enlarged edition. Southern Illinois University Press, Carbondale, Illinois.

Murray State University. 2003. Hancock Biological Station facilities and information. Accessed at: <http://www.mursuky.edu/qacd/cos/hbs/hbs/htm>

Organization of Biological Field Stations. 2003. Organization of Biological Field Stations home page. Accessed at: <http://www.obfs.org/regions/nc.html>

Seeland, D.A. and H.G. Wilshire. 1965. Geologic map of part of the Rushing Creek Quadrangle, Map GQ-445. U.S. Geological Survey, Washington, D.C.

Thompson, R.L. and R.L. Jones. 2001. Woody plants of Rock Creek Research Natural Area and watershed uplands, Laurel County, Kentucky. Castanea 66:275-287.

Woods, A.J., J.M. Omernik, W.H. Martin, G.J. Pond, W.M. Andrews, S.M. Call, J.A. Comstock, and D.D. Taylor. 2002. Ecoregions of Kentucky (color poster with map, descriptive text, summary tables, and photographs). U.S. Geological Survey, Reston, Virginia.

Woods, M. 1983. The vascular flora of Calloway County, Kentucky. M.S. thesis, Murray State University, Murray, Kentucky.

Woods, M. and M.J. Fuller. 1988. The vascular flora of Calloway County, Kentucky. Castanea 53:88-109.

APPENDIX 1

VASCULAR PLANTS OF HANCOCK BIOLOGICAL STATION, MURRAY STATE UNIVERSITY, CALLOWAY COUNTY, KENTUCKY

Key to notations:

[*] Exotic species throughout Kentucky.
[†] Planted native or exotic species at HBS.
[o] Calloway County distributional records.

EQUISETOPHYTA

EQUISETACEAE (Horsetail Family)

†*Equisetum hyemale* L. (Scouring Rush). Planted in station wetland complex. Infrequent; perennial. *Thompson 98-87*

LYCOPODIOPHYTA

LYCOPODIACEAE (Clubmoss Family)

Lycopodium digitatum Dillen. (Southern Ground-cedar). Early successional old-field woods near Boy Scout Trail. Rare; perennial. *Thompson 99-318*

POLYPODIOPHYTA

ASPLENIACEAE (Spleenwort Family)

Asplenium platyneuron (L.) BSP. (Ebony Spleenwort). Dry-mesic oak-hickory forest, south peninsula on north hillside. Infrequent; perennial. *Thompson 98-98*; *Woods 815*

Polystichum acrostichoides (Michx.) Schott. (Christmas Fern). Dry-mesic oak-hickory forest, south peninsula hillside. Occasional; perennial. *Thompson 99-227*; *Woods 739*

Thelypteris hexagonoptera (Michx.) Weatherby (Broad-beech Fern). Dry-mesic oak-hickory forest, valley bottom at Watersport Road cove. Rare; perennial. *Thompson 01-230*

Woodsia obtusa (Spreng.) Torr. (Blunt Cliff-fern). Dry oak-hickory forest, north peninsula on east-trending cliffside at Kentucky Lake. Infrequent; perennial. *Thompson 98-190*

DENNSTAEDITIACEAE (Bracken Fern Family)

Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw. (Bracken Fern). Dry oak-hickory forest, openings. Frequent; perennial. *Thompson 99-237*; *Woods 513*

ONOCLEACEAE (Sensitive Fern Family)

†*Onoclea sensibilis* L. (Sensitive Fern). Planted in station wetland complex. Infrequent; perennial. *Thompson 02-213*

OPHIOGLOSSACEAE (Adder's Tongue Family)

Botrychium dissectum Spreng. var. *obliquum* (Muhl.) Clute (Dissected Grapefern). Dry-mesic oak-hickory forest, boat dock cove valley. Infrequent; perennial. *Thompson 98-718*

B. virginianum (L.) Swartz. (Rattlesnake Fern). Dry-mesic oak-hickory forest, north-trending hillside near boat dock cove. Infrequent; perennial. *Thompson 99-154*

PINOPHYTA

CUPRESSACEAE (Cedar Family)

Juniperus virginiana L. (Eastern Red Cedar). Dry oak-hickory forest and mid-successional old-fields. Occasional; canopy tree. *Thompson 98-101*; *Woods 400*

PINACEAE (Pine Family)

†*Pinus taeda* L. (Loblolly Pine). Dry oak-hickory forest, pine plantation north of Boy Scout Trail. Occasional, canopy tree. *Thompson 00-157*

†*P. virginiana* P. Mill. (Virginia Pine). Planted in station yard near washhouse. Rare; canopy tree. *Thompson 99-423*

TAXODIACEAE (Cypress Family)

Taxodium distichum (L.) Rich. (Bald Cypress). Riparian forest, Kentucky Lake gravel shoreline at north peninsula. Rare; canopy tree. *Thompson 98-406*; *Fuller 3003*

MAGNOLIOPHYTA

ACANTHACEAE (Acanthus Family)

Justicia americana (L.) M. Vahl (American Water Willow). Kentucky Lake gravel shoreline Pacer Point cove. Abundant; perennial. *Thompson 99-309*; *Woods 803*

Ruellia caroliniensis (Walter) Steudel (Wild Petunia). Dry oak-hickory forest, woodland edges. Occasional; perennial. *Thompson 98-71*; *Hunter and Austin 1824*

ACERACEAE (Maple Family)

Acer negundo L. (Box-elder). Riparian forest, north peninsula cove floodplain of Kentucky Lake. Occasional; canopy tree. *Thompson 98-110*; *Woods 1187*

A. rubrum L. (Red Maple). Dry and dry-mesic oak-hickory forests, mid-successional old-fields and south peninsula hillsides. Frequent; canopy tree. *Thompson 99-29*; *Beck 46A*

A. saccharinum L. (Silver Maple). Riparian forest, Kentucky Lake by boat dock cove floodplain. Occasional; canopy tree. *Thompson 99-02*; *Woods 1188*

A. saccharum Marshall (Sugar Maple). Dry-mesic oak-hickory forest, north peninsula valley. Infrequent; canopy tree. *Thompson 02-226*; *Obourn 10*; *Woods 1191*

AGAVACEAE (Agave Family)

Agave virginica L. (False Aloe). Dry oak-hickory forest, south peninsula south-trending cherty hillside opening. Rare; perennial. *Thompson 98-344*

†*Yucca filamentosa* L. (Spanish Bayonet). Planted in station yard near washhouse. Rare; perennial.*Thompson 02-224*

AMARANTHACEAE (Pigweed Family)

**Alternanthera philoxeroides* (Mart.) Griseb. (Alligator-weed). Emergent wetland, Pacer Point cove, Kentucky Lake. Abundant; perennial. *Thompson 01-241*; *Alverson s.n.*

Amaranthus rudis Sauer (Water Hemp). Kentucky Lake gravel shoreline at boat dock cove. Occasional; annual. *Thompson 99-451*; *Fuller 3005*; *Hildebrandt s.n.*

**A. retroflexus* L. (Redroot Rough Pigweed). Kentucky Lake gravel shoreline along north peninsula. Rare; annual. *Thompson 99-449*

A. tuberculatus (Moq.) Sauer (Water Hemp). Kentucky Lake gravel shoreline at boat dock cove. Infrequent; annual. *Fuller 3000*

ANACARDIACEAE (Sumac Family)

Rhus copallina L. (Winged Sumac). Early successional burned old-field restoration prairie and mid-successional old-fields. Frequent; small tree. *Thompson 98-324*; *Woods 897*; *Beck 52A*; *Hunter and Austin 1802*

R. glabra L. (Smooth Sumac). Mid-successional old-fields and woodland edge of powerline corridor north of Emma Drive. Occasional; small tree. *Thompson 98-111*

Toxicodendron radicans (L.) Kuntze (Poison Ivy). Dry and dry-mesic oak-hickory forests, ubiquitous. Abundant; woody vine. *Thompson 02-209*

ANNONACEAE (Custard Apple Family)

Asimina triloba (L.) Duval (Pawpaw). Dry-mesic oak-hickory forest, north peninsula cove valley. Frequent; small tree. *Thompson 98-415*

APIACEAE (Carrot Family)

Angelica venosa (Greenway) Fern. (Hairy Angelica). Early successional burned old-field restoration prairie. Rare; perennial. *Thompson 98-426*

Chaerophyllum tainturieri Hook. (Rough Chervil). Early successional powerline corridor north Emma Drive. Frequent; annual. *Thompson 99-110*

Cicuta maculata L. (Water-hemlock). Kentucky Lake gravel and sand shoreline at boat dock cove. Occasional; perennial. *Thompson 98-440*

**Daucus carota* L. (Wild Carrot). Early successional roadside of Emma Drive. Frequent; biennial. *Thompson 01-219*; *Woods 751*

Eryngium prostratum Nutt. (Spreading Eryngo). Mowed yard of station wetland complex. Infrequent; perennial. *Thompson 98-366*; *Fuller 3002*

Sanicula canadensis L. (Black Snakeroot). Dry-mesic oak-hickory forest, south peninsula hillside near boat dock cove. Occasional; biennial. *Thompson 99-274*; *Woods 736*

**Torilis arvensis* (Huds.) Link (Field Hedge-parsley). Ruderal area by gravel pile near Wolfson Drive and workshop. Infrequent; annual. *Thompson 98-383*

Trepocarpus aethusae Nutt. (Trepocarpus). Kentucky Lake wooded cove floodplains. Occasional; annual. *Thompson 01-209*; *Hunter and Austin 1796*; *Woods 704*

APOCYNACEAE (Dogbane Family)

Amsonia tabernaemontana Walter (Common Bluestar). Dry-mesic oak-hickory forest, open area adjacent to boat dock cove. Rare; perennial. *Thompson 99-308*; *Woods 405*

Apocynum cannabinum L. (Indian Hemp). Mid-successional roadside edge of Emma Drive. Occasional; perennial. *Thompson 98-01*; *Hunter and Austin 1814*

†**Vinca minor* L. (Lesser Periwinkle). Unmowed yard by radioactive waste building north of Emma Drive. Occasional; woody vine. *Thompson 01-214*

AQUIFOLIACEAE (Holly Family)

Ilex decidua Walter (Swamp Holly). Dry-mesic oak-hickory forest, north peninsula floodplain by Kentucky Lake. Rare; small tree. *Thompson 02-236*

ARACEAE (Arum Family)

Arisaema dracontium (L.) Schott (Green Dragon). Dry-mesic oak-hickory forest, valley west of Wolfson House driveway. Rare; perennial. *Thompson 01-226*

ARALIACEAE (Ginseng Family)

Aralia spinosa L. (Devil's Walking Stick). Dry-mesic oak-hickory forest, valley west of Wolfson House driveway. Rare; small tree. *Thompson 98-210*

†*Hedera helix* L. (English Ivy). North wall of washhouse. Infrequent; woody vine. *Thompson 98-56*

ARISTOLOCHIACEAE (Birthwort Family)

Aristolochia serpentaria L. (Virginia-snakeroot). Dry-mesic oak-hickory forest, north-trending cherty hillside near boat dock cove. Rare; perennial. *Thompson 99-338*

ASCLEPIADACEAE (Milkweed Family)

Asclepias amplexicaule J.E. Smith (Clasping Milkweed). Early successional burned old-field restoration prairie. Rare; perennial. *Thompson 99-232*; *Beck 33A*

A. perennis Walter (Smooth-seeded Milkweed). Emergent wetland, Pacer Point cove floodplain of Kentucky Lake. Rare; perennial. *Thompson 99-386*

A. syriaca L. (Common Milkweed). Dry oak-hickory forest, woodland edge west of main laboratory building. Rare; perennial. *Thompson 98-168*

A. tuberosa L. (Butterfly Weed). Early successional burned old-field restoration prairie. Infrequent; perennial. *Thompson 01-178*; *Beck 61A*; *Hunter and Austin 1814*; *Woods 741*

A. variegata L. (White Milkweed). Dry-mesic oak-hickory forest, north-trending hillside near boat dock and roadside of Watersport Road. Infrequent; perennial. *Thompson 98-44*

Ampelamus albidus (Nutt.) Britton (Blue-vine). Dry-mesic oak-hickory, opening adjacent to boat dock at Kentucky Lake. Rare; perennial. *Thompson 98-567*

o*Matelea gonocarpa* (Walter) Shinners (Common Angle-pod). Roadside thicket along Watersport Road at junction with Pacer Point. Rare; perennial. *Thompson 98-134*

ASTERACEAE (Composite Family)

**Achillea millefolium* L. (Common Yarrow). Early successional burned old-field restoration prairie. Infrequent; perennial. *Thompson 00-166*; *Hunter and Austin 1783; Woods 526*

Ambrosia artemisiifolia L. (Common Ragweed). Disturbed gravel area by glasshouse mesocosm and old-field by ponded borrow pit. Frequent; annual. *Thompson 01-150*

A. trifida L. (Giant Ragweed). Early successional old-field by ponded borrow pit north of Emma Drive. Occasional; annual. *Thompson 98-431*

Antennaria plantaginifolia (L.) Rich. (Plantain Pussy-toes). Dry oak-hickory forest, cherty openings. Occasional; perennial. *Thompson 99-28*; *Woods 403*

Aster dumosus L. (Bushy Aster). Early successional old-field north of Emma Drive by ponded borrow pit. Occasional; perennial. *Thompson 01-619*

A. lateriflorus (L.) Britton (Calico Aster). Dry-mesic oak-hickory forest, woodland opening adjacent to boat dock. Infrequent; perennial. *Thompson 01-617*

o*A. ontarionis* Wieg. (Bottomland-aster). Kentucky Lake gravel shoreline at Pacer Point cove. Occasional; perennial. *Thompson 01-611*

A. patens Aiton var. *patens* (Clasping-leaved Aster). Dry oak-hickory forest, in north peninsula cherty openings. Occasional; perennial. *Thompson 01-633*

A. pilosus Willd. (Hairy White Aster). Early successional old-field by ponded borrow pit north of Emma Drive. Frequent; perennial. *Thompson 01-615*

A. solidagineus Michx. (Narrow-leaved White-topped Aster). Dry oak-hickory forest, cherty openings along Watersport Road and early successional burned old-field restoration prairie. Occasional; perennial. *Thompson 01-245*; *Hunter and Austin 1785*; *Woods 756*

Bidens bipinnata L. (Spanish-needles). Disturbed area around station yard. Rare; annual. *Woods 818*

B. frondosa L. (Common Beggar's Ticks). Wetland meadow at Pacer Point. Frequent; annual. *Thompson 01-601*

o*B. polylepis* S.F. Blake (Ozark Tickseed-sunflower). Wet roadside ditch south of Emma Drive. Rare; annual. *Thompson 99-435*

B. vulgata Greene (Tall Beggar's Ticks). Wetland meadow, Pacer Point. Infrequent; annual. *Thompson 01-608*

Boltonia asteroides (L.) L'Her. (False Aster). Early successional old-field north of Emma Drive and west of ponded borrow pit. Infrequent; perennial. *Thompson 98-690*

**Chrysanthemum leucanthemum* L. (Ox-eye Daisy). Roadside on Emma Drive near station entrance gate. Infrequent; perennial. *Thompson 99-82*

**Cichorium intybus* L. (Chicory). Mowed roadside at edge of asphalt along Emma Drive Rare; perennial. *Thompson 98-384*

Cirsium discolor (Muhl.) Spreng. (Field Thistle). Early successional powerline corridor along Emma Drive. Infrequent; perennial. *Thompson 98-570*

o**Cirsium vulgare* (Savi) Tenore (Bull Thistle). Early successional powerline corridor by Emma Drive. Rare; biennial. *Thompson 98-583*

Conyza canadensis (L.) Cronq. (Horseweed). Wolfson House gravel driveway and disturbed gravel area by glasshouse mesocosm. Occasional; annual. *Thompson 99-442*

*Coreopsis lanceolat*a L. (Long-stalked Tickseed). Early successional old-field roadside ditch on south side of Emma Drive. Occasional; perennial. *Thompson 99-179*

C. major Walter (Woodland Tickseed). Dry oak-hickory forest, cherty embankment off Watersport Road. Occasional; perennial. *Thompson 01-120*

C. tinctoria Nutt. (Plains Tickseed). Early successional old-field between Emma Drive and ponded borrow pit. Rare; annual. *Thompson 01-222*; *Adams 39*; *Beck 57B*

C. tripteris L. (Tall Tickseed). Dry oak-hickory forest, south peninsula open area. Infrequent; perennial. *Thompson 98-552*

**Eclipta prostrata* (L.) L. (Yerba-de-tajo). Emergent wetland, Pacer Point and Kentucky Lake shoreline. Rare; annual. *Thompson 98-662*

Elephantopsis carolinianus Willd. (Carolina Elephantopsis). Dry-mesic oak-hickory forest, boat dock floodplain of Kentucky Lake . Infrequent; perennial. *Thompson 98-707*

Erechitites hieraciifolia (L.) Raf. (Fireweed). Early successional old-field next to ponded borrow pit north of Emma Drive. Infrequent; annual. *Thompson 01-614*

Erigeron annuus (L.) Pers. (Daisy Fleabane). Roadside of Emma Drive and powerline corridor.Frequent; annual. *Thompson 01-105; Woods 617*

E. philadelphicus L. (Philadelphia Fleabane). Mowed yard around workshop and washhouse. Infrequent; perennial. *Thompson 99-35*

E. strigosus Muhl. (Rough Fleabane). Early successional old-field and powerline cut along Emma Drive. Frequent; annual. *Thompson 00-160*; *Beck 68C*; *Woods 51*

Eupatorium coelestinum L. (Blue Mistflower). Wetland meadow, Pacer Point adjacent to Kentucky Lake. Infrequent; perennial. *Thompson 01-634*; *Wagamen 16*

E. fistulosum Barratt (Joe-pye Weed). Early successional burned old-field restoration prairie. Occasional; perennial. *Thompson 98-550*

E. perfoliatum L. (Perfoliate-leaved Boneset). Early successional old-field near Boy Scout Trail. Occasional; perennial. *Thompson 99-419*

E. rugosum Houtt. (White Snakeroot). Dry-mesic oak-hickory forest, Pacer Point valley. Frequent; perennial. *Thompson 01-607*

E. serotinum Michx. (Late Boneset). Roadside wet ditch of Emma Drive. Occasional; perennial. *Thompson 01-603*

E. sessilifolium L. (Upland Boneset). Dry oak-hickory forest, open area near station wetland complex. Rare; perennial. *Thompson 98-587*

Euthamia graminifolia (L.) Nutt. (Flat-topped Goldenrod). Early successional old-field near Boy Scout Trail. Infrequent; perennial. *Thompson 99-411*

Gnaphalium obtusifolium L. (Old Field Balsam). Early successional powerline corridor parallel to north of Emma Drive. Infrequent; annual. *Thompson 98-639*

G. purpureum L. (Purple Cudweed). Early successional old-field near ponded borrow pit. Occasional; annual. *Thompson 02-204; Hunter and Austin 1784*; *Woods 515*

Helenium flexuosum Raf. (Southern Sneezeweed). Seasonal ponded depression pit south of Emma Drive. Rare; perennial. *Thompson 98-594*

Helianthus augustifolius L. (Narrow-leafed Sunflower). Early successional old-field adjacent to ponded borrow pit. Infrequent; perennial. *Thompson 01-625*

H. divaricatus L. (Woodland Sunflower). Mid-successional old-field and wooded edge by Boy Scout Trail. Infrequent; perennial. *Thompson 98-405*;

H. hirsutus Raf. (Hairy Sunflower). Dry oak-hickory forest, south peninsula open area above Kentucky Lake. Occasional; perennial. *Thompson 99-412; Beck 59C*

H. microcephalus Torr. & A. Gray (Small-headed Sunflower). Dry oak-hickory forest, open area adjacent to boat dock cove. Occasional; perennial. *Thompson 98-548*

Heliopsis helianthoides (L.) Sweet (Sunflower-everlasting). Dry-mesic oak-hickory forest, north peninsula embankment at Kentucky Lake. Rare; perennial. *Thompson 98-395*

Hieracium gronovii L. (Hairy Hawkweed). Dry oak-hickory forest, south peninsula south-trending hillside. Occasional; perennial. *Thompson 98-623*

Krigia biflora (Walt.) S.F. Blake (Orange Dwarf dandelion). Dry-mesic oak-hickory forest, opening near boat dock cove. Occasional; perennial. *Thompson 99-51*

K. dandelion (L.) Nutt. (Colonial Dwarf Dandelion). Dry oak-hickory forest, wooded edge north of Wolfson House. Infrequent; perennial. *Thompson 99-60*; *Woods 508*

K. virginica (L.) Willd. (Virginia Dwarf Dandelion). Mowed yard at the workshop and washhouse. Occasional; annual. *Thompson 99-81*

Lactuca canadensis L. (Canada Wild Lettuce). Early successional powerline corridor north of Emma Drive. Infrequent; biennial. *Thompson 98-347*

L. floridana (L.) Gaertn. (Florida Blue Lettuce). Roadside thicket along Watersport Road at junction with Pacer Point. Infrequent; biennial. *Thompson 98-545*

**L. serriola* L. (Prickly Lettuce). Roadside of Watersport Road. Rare; biennial. *Thompson 99-312*

Liatris spicata (L.) Willd. (Sessile Blazing Star). Dry oak-hickory forest, cherty opening north of loblolly pine plantation. Infrequent; perennial. *Thompson 99-427*

L. squarrulosa Michx. (Southern Blazing Star). Dry oak-hickory forest, cherty opening north of loblolly pine plantation. Occasional; perennial. *Thompson 98-520*; *Beck 42A*

o*Matricaria matricarioides* (Less.) Porter (Pineapple Weed). Roadside of Emma Drive at junction with faculty cabins trail. Rare; annual. *Thompson 99-244*

Mikania scandens (L.) Willd. (Climbing Hempweed). Shrub swamp thicket, at boat dock floodplain. Rare; perennial. *Thompson 98-686*; *Hemberger 04*

Parthenium integrifolium L. (Wild Quinine). Early successional burned old-field prairie. Infrequent; perennial. *Thompson 01-121; Hunter and Austin 1794*

Pluchea camphorata (L.) DC. (Camphor weed). Boat dock cove and Pacer Point cove floodplains. Rare; perennial. *Thompson 99-460*

Pyrrhopappus caroliniensus (Walter) DC. (Carolina False Dandelion). Roadside junction of Emma Drive and Watersport Road. Infrequent; perennial. *Thompson 99-283*

Rudbeckia hirta L. (Black-eyed Susan). Early successional burned old-field restoration prairie. Occasional; biennial. *Thompson 98-67; Beck 60B*; *Hunter and Austin 1805*; *Woods 50*

Senecio glabellus Poir. (Yellowtop Groundsel). Kentucky Lake gravel shoreline at north peninsula cove floodplain. Frequent; annual. *Thompson 99-03*; *Woods 55*

Solidago caesia L. (Blue-stemmed Goldenrod). Dry-mesic oak-hickory forest, north peninsula hillside. Occasional; perennial. *Thompson 98-706*

S. canadensis L. (Canada Goldenrod). Early succcessional old-field near ponded borrow pit north of Emma Drive. Frequent; perennial. *Thompson 01-610*; *Beck 76A*

S. erecta Pursh (Erect Goldenrod). Dry oak-hickory forest cherty opening adjacent to Watersport Road. Occasional; perennial. *Thompson 01-622*

S. juncea Aiton (Stiff Goldenrod). Early successional old-field north of Emma Drive. Frequent; perennial. *Thompson 99-328*; *Beck 75A; Hunter and Austin 1820*; *Woods 184*

S. missouriensis Nutt. (Missouri Goldenrod). Early successional old-field south of Emma Drive. Occasional; perennial. *Thompson 98-619*; *Beck 76B*

S. nemoralis Aiton (Old-field Goldenrod). Early successional old-field north of loblolly pine plantation. Occasional; perennial. *Thompson 98-643*

S. odora Aiton (Licorice-goldenrod). Early successional burned old-field restoration prairie. Occasional; perennial. *Thompson 01-612*

**Sonchus asper* (L.) Hill (Common Sow Thistle). Inside wire enclosure of water treatment station. Rare; annual. *Thompson 98-456*; *Woods 817*

**Taraxacum officinale* Weber (Common Dandelion). Mowed station yard inside Emma Drive circle. Frequent; perennial. *Thompson 99-12*

Verbesina helianthoides Michx. (Yellow Crownbeard). Early successional powerline corridor. Occasional; perennial. *Thompson 00-163; Hunter and Austin 1795*; *Woods 747*

Vernonia gigantea (Walt.) Trel. (Tall Ironweed). Early successional burned old-field restoration prairie. Occasional; perennial. *Thompson 01-604*

Xanthium strumarium L. (Common Cocklebur). Kentucky Lake gravel shoreline at Pacer Point. Frequent; annual. *Thompson 98-657*

BALSAMINACEAE (Jewelweed Family)

Impatiens capensis Meerb. (Spotted Jewelweed). Pacer Point cove floodplain and station wetland complex. Occasional; annual. *Thompson 98-432*; *Woods 805*

BERBERIDACEAE (Barberry Family)

Podophyllum peltatum L. (May-apple). Dry-mesic oak-hickory forest, valley west of Wolfson House driveway. Occasional; perennial. *Thompson 99-20*; *Woods 436*

BETULACEAE (Birch Family)

Alnus serrulata (Aiton) Willd. (Smooth Alder). Shrub swamp, boat dock cove floodplain. Occasional; shrub. *Thompson 99-445*; *Beck 38A*; *Hunter and Austin 1800*

Betula nigra L. (River Birch). Riparian forest, Kentucky Lake gravel shoreline. Occasional; canopy tree. *Thompson 99-242*

Corylus americana Walter (American Hazelnut). Dry-mesic oak-hickory forest, north-trending south peninsula cherty hillside. Rare; shrub. *Thompson 98-224*

o*Ostrya virginiana* (P. Mill.) K. Koch (Eastern Hop Hornbeam). Mid-successional old-field and forest edge along Boy Scout Trail. Infrequent; small tree. *Thompson 01-224*

BIGNONIACEAE (Bignonia Family)

Bignonia capreolata L. (Cross-vine). Riparian forest, north peninsula and Pacer Point cove floodplain. Frequent; woody vine. *Thompson 98-163*

Campsis radicans (L.) Seeman (Trumpet Creeper). North peninsula east-trending rocky cliffs at Kentucky Lake. Occasional; woody vine. *Thompson 01-204*

BORAGINACEAE (Borage Family)

Cynoglossum virginianum L. (Wild Comfrey). Dry-mesic oak-hickory forest, valley bottom at Watersport Road cove. Rare; perennial. *Thompson 02-234*

Myosotis macrosperma Engelm. (Large-seeded Scorpion-grass). Early successional powerline corridor off Emma Drive. Infrequent; annual. *Thompson 99-183*

BRASSICACEAE (Mustard Family)

**Arabidopsis thaliana* (L.) Heynh. (Mouse-ear Cress). North peninsula east-trending cliffside next to Kentucky Lake. Occasional; annual. *Thompson 99-73*

**Capsella bursa-pastoris* (L.) Medic. (Shepherd's Purse). Unmowed station yard adjacent to Wolfson House driveway. Rare; annual. *Thompson 99-41*

Cardamine concatenata (Michx.) O. Schwartz (Cut-leaf Toothwort). Dry-mesic oak-hickory forest, trail to burned old-field restoration prairie. Infrequent; perennial. *Thompson 99-18; Woods 399*

**C. hirsuta* L. (Hairy Bittercress). Mowed station yard along Emma Drive and Emma Drive circle. Abundant; annual. *Thompson 99-16*

C. parviflora L. (Dry-land Bittercress). North peninsula east-trending cliffside by Kentucky Lake. Infrequent; annual. *Thompson 99-98*; *Abbott 12476*; *Fuller 3007*

C. pensylvanica Muhl. (Pennsylvania Bittercress). Kentucky Lake gravel shoreline by boat dock cove. Infrequent; annual. *Thompson 99-05*

Draba brachycarpa Nutt. (Short-fruited Whitlow-grass). Mowed station yard by workshop. Rare; annual. *Thompson 99-33*

o**D. verna* L. (Whitlow-grass). Mowed station yard by workshop and washhouse. Frequent; annual. *Thompson 99-13*

Lepidium virginicum L. (Wild Peppergrass). Unmowed and mowed station yard along trail to washhouse and faculty cabins. Infrequent; annual. *Thompson 00-167*

Rorippa sessiliflora (Nutt.) A.S. Hitchc. (Marsh Yellowcress). Emergent wetland, Pacer Point at Kentucky Lake shoreline. Occasional; annual. *Thompson 99-45*; *Abbott 12483*

**Sisymbrium officinalis* (L.) Scop. (Hedge-mustard). Wolfson House gravel driveway. Rare; annual, silique. *Thompson 99-175*

CAMPANULACEAE (Bluebell Family)

Campanula americana L. (American Bellflower). Roadside thicket along Watersport Road at junction with Pacer Point. Rare; annual. *Thompson 98-325*

Lobelia inflata L. (Indian Tobacco). Gravel trail leading to Schnautz House. Infrequent; annual. *Thompson 99-336*

L. puberula Michx. (Downy Lobelia). Early successional burned old-field restoration prairie. Infrequent; perennial. *Thompson 01-621*

L. spicata Lam. (Spiked Lobelia). Abandoned old-field along Emma Drive. Rare; perennial. *Hunter & Austin 1807*

Triodanis perfoliata (L.) Nieuwl. var. *biflora* (Ruiz & Pavon) Bradley (Venus' Looking Glass). North peninsula east cliffside bordering Kentucky Lake. Infrequent, annual. *Thompson 98-69*; *Woods 57*

T. perfoliata (L.) Nieuwl. var. *perfoliata* (Venus' Looking Glass). Unmowed and mowed station yard along Emma Drive. Frequent; annual. *Thompson 00-165*; *Woods 518*

CAPRIFOLIACEAE (Honeysuckle Family)

**Lonicera japonica* Thunb. (Japanese Honeysuckle). Dry and dry-mesic forest and powerline corridor, ubiquitous. Abundant; woody vine. *Thompson 98-3*

Sambucus canadensis L. (Common Elderberry). Dry mesic oak-hickory forest, north peninsula cliffside and Kentucky Lake. Infrequent; shrub. *Thompson 01-164; Beck 71A*

Symphoricarpos orbiculatus Moench. (Coral-berry). Mid-successional old-field and powerline corridor along Emma Drive. Infrequent; shrub. *Thompson 98-375*

Viburnum rufidulum Raf. (Rusty Black-haw). Dry oak-hickory forest, between main laboratory building next to Kentucky Lake. Infrequent; small tree. *Thompson 99-111*

CARYOPHYLLACEAE (Pink Family)

**Arenaria serpyllifolia* L. (Thyme-leaf Sandwort). Trail to faculty cabins by workshop. Frequent; annual. *Thompson 01-101*

**Cerastium brachypetalum* Pers. (Short-petaled Mouse-ear Chickweed). Mowed station yard edge of Emma Circle Drive. Rare; annual. *Thompson 99-104* o*C. nutans* Raf. (Nodding Mouse-ear Chickweed). East-trending cliffline of North peninsula by Kentucky Lake. Rare; annual. *Thompson 99-52*; *Abbott 12475*

o**C. viscosum* L. (Clammy Mouse-ear Chickweed). Mowed station yard and Emma Drive powerline corridor. Frequent; annual. *Thompson 99-56*

**C. vulgatum* L. (Common Mouse-ear Chickweed). Mowed station yard near washhouse. Infrequent; perennial. *Thompson 98-66*

**Dianthus armeria* L. (Deptford Pink). Roadside at junction of Watersport Road and Emma Drive. Infrequent; annual. *Thompson 00-151*

Silene antirrhina L. (Sleepy Catchfly). North peninsula clifftop above Kentucky Lake. Rare; annual. *Thompson 99-138*

S. stellata (L.) Aiton f. (Starry Campion). Dry-mesic oak-hickory forest, roadside thicket along Watersport Road at junction with Pacer Point. Rare; perennial. *Thompson 98-414*

S. virginica L. (Virginia Fire Pink). Dry-mesic oak-hickory forest, trail to burned old-field. restoration prairie. Infrequent; perennial. *Thompson 99-22*

**Stellaria media* (L.) Villars (Common Chickweed). Unmowed station yard by washhouse. Frequent; annual. *Thompson 99-53*

CHENOPODIACEAE (Goosefoot Family)

**Chenopodium album* L. (Lamb's Quarters). Disturbed gravel area by glasshouse mesocosm. Rare; annual. *Thompson 01-168*

CISTACEAE (Rockrose Family)

Lechea mucronata Raf. (Hairy Pinweed). Dry oak-hickory forest, cherty embankment of Watersport Road. Rare; perennial. *Thompson 98-511*

o*L. tenuifolia* Michx. (Narrow-leaved Pinweed). Dry oak-hickory forest, south peninsula cherty hillside above Kentucky Lake. Frequent; perennial. *Thompson 01-218*

CLUSIACEAE (St. John's Wort Family)

Hypericum denticulatum Walter (Coppery St. Johns-wort). Early successional old-field north of Emma Drive. Occasional; perennial. *Thompson 99-332*; *Hunter and Austin 1782*

H. drummondii (Grev. & Hook.) Torr. & A. Gray (Drummond's St. Johns-wort). Dry oak-hickory forest, cherty roadside embankment on Watersport Road. Rare; annual. *Thompson 98 493*; *Woods 186*

H. hypericoides (L.) Crantz (St. Andrew's-cross). Dry-mesic oak-hickory forest, woodland opening adjacent to boat dock. Infrequent; shrub. *Thompson 01-184*

H. mutilum L. (Marsh St. Johns-wort). Emergent wetland and wetland meadow, Pacer Point by Kentucky Lake. Occasional; annual. *Thompson 99-390*

H. prolificum L. (Shrubby St. Johns-wort). Dry-mesic oak-hickory forest, Pacer Point valley along creek. Rare; shrub. *Thompson 99-314*

H. punctatum Lam. (Dotted St. Johns-wort). Early successional old-field and powerline cut. Occasional; perennial. *Thompson 01-199*; *Hunter and Austin 1788*

H. stragulum P. Adams & Robs. (St. Peter's-wort). Early successional burned old-field restoration prairie and south peninsula hillside. Occasional; shrub. *Thompson 98-409*

COMMELINACEAE (Spiderwort Family)

**Commelina communis* L. (Asiatic Day-flower). Unmowed yard beside main laboratory building. Occasional; annual. *Thompson 02-233*

**C. diffusa* Burm. f. (Creeping Day-flower). Kentucky Lake gravelly shoreline at Pacer Point. Infrequent; annual. *Thompson 98-671*

C. virginica L. (Virginia Day-flower). Boat dock cove floodplain. Infrequent; perennial. *Thompson 98-669*

CONVOLVULACEAE (Morning-glory Family)

Calystegia sepium (L.) R. Br. (Hedge-bindweed). North peninsula hillside thicket by Kentucky Lake. Infrequent; perennial. *Thompson 99-379*

o**Ipomoea hederacea* Jacq. (Ivy-leaved Morning-glory). Kentucky Lake gravel shoreline just off north peninsula east cliffside. Rare; annual. *Thompson 99-439*

Ipomoea lacunosa L. (White Morning-glory). Kentucky Lake gravel shoreline by boat dock. Frequent; annual. *Thompson 98-665*; *Woods 1061*

CORNACEAE (Dogwood Family)

Cornus amomum P. Mill. (Silky Dogwood). Shrub swamp, Pacer Point cove and boat dock cove floodplains. Infrequent; shrub. *Thompson 01-117*; *Woods 735*

C. florida L. (Flowering Dogwood). Dry-mesic oak-hickory forest, south peninsula and north peninsula hillsides. Occasional; subcanopy tree. *Thompson 99-26; Beck 51B*; *Green B-3*; *McLemore 98*; *Woods 401*

Nyssa aquatica L. (Swamp Tupulo). Riparian forest, north peninsula cove. Rare; canopy tree. *Thompson 02-151*

Nyssa sylvatica Marshall (Blackgum). Mid-successional old-fields, dry and dry-mesic oak-hickory forest. Abundant; canopy tree. *Thompson 01-119*; *Beck 49A*; *Woods 807*

CUCURBITACEAE (Melon Family)

o*Melothria pendula* L. (Creeping Cucumber). Climbing on chain link fence surrounding boathouse compound. Rare; annual. *Thompson 98-604*

Sicyos angulatus L. (Bur-cucumber). Dry-mesic oak-hickory forest, cove floodplain at Kentucky Lake below Rafinesque House. Rare; annual. *Thompson 01-643*

CUSCUTACEAE (Dodder Family)

Cuscuta pentagona Engelm. (Field Dodder). Early successional old-field and powerline corridor. Occasional; annual. *Thompson 99-302*

CYPERACEAE (Sedge Family)

Carex albicans Willd. (Blunt-scaled Oak Sedge). Dry-mesic oak-hickory forest, northeast-trending hillside adjacent to boat dock cove. Occasional; perennial. *Thompson 99-159; Abbott 12484*

C. blanda Dewey (Common Wood Sedge). Dry-mesic oak-hickory forest, north peninsula cove valley. Occasional; perennial. *Thompson 99-162*

o*C. caroliniana* Schwein. (Carolina Sedge). Dry-mesic oak-hickory forest, valley west of boat dock cove. Rare; perennial. *Thompson 99-123*

C. cephalophora Muhl. (Short-headed Bracted Sedge). Unmowed station yard near fence boathouse compound fence. Infrequent; perennial. *Thompson 99-120*

†*C. crinata* Lam. (Fringed Sedge). Planted in station wetland complex. Infrequent; perennial. *Thompson 99-149*

C. debilis Michx. (Southern Weak Sedge). Dry-mesic oak-hickory forest, boat dock cove floodplain. Occasional; perennial. *Thompson 99-158*

C. digitalis Willd. (Narrow-leaved Wood Sedge). Dry-mesic oak-hickory forest, north peninsula valley. Occasional; perennial. *Thompson 99-163; Abbott 12486*

C. frankii Kunth (Bristly Cattail Sedge). Wetland meadow, Pacer Point adjacent to creek and Kentucky Lake. Rare; perennial. *Thompson 98-271*

C. glaucodea Tuckerman (Blue Sedge). Wet roadside ditch of Emma Drive just west of Watersport Road and swale across Boy Scout Trail. Rare; perennial. *Thompson 98-19*

C. grayi Carey (Common Bur Sedge). North peninsula and boat dock cove floodplains. Occasional; perennial. *Thompson 98-94*; *Woods 522*

C. hirsutella Mack. (Hairy Green Sedge). Early successional burned old-field restoration prairie. Frequent; perennial. *Thompson 01-134; Woods 609*

C. laxiflora Lam. (Beech Wood Sedge). Dry-mesic oak-hickory forest, Pacer Point north-trending hillside and valley. Infrequent; perennial. *Thompson 99-153*

†*C. lupulina* Muhl. (Common Hop Sedge). Wetland meadow, Pacer Point by Kentucky Lake and planted in wetland complex. Occasional; perennial. *Thompson 01-233*

C. lurida Wahlenb. (Yellow-green Sedge). Wet roadside ditch near station entrance gate by Emma Drive. Rare, perennial. *Thompson 99-213*

C. muhlenbergii Schk. (Muhlenberg's Sedge). Dry oak-hickory forest, cherty openings above Kentucky Lake. Frequent; perennial. *Thompson 01-130; Woods 509*

C. nigromarginata Schwein. (Black-margined Sedge). Dry-mesic oak-hickory forest, north peninsula ridgecrest. Infrequent, perennial. *Thompson 99-96; Abbott 12485*

C. retroflexa Muhl. (Curly-styled Wood Sedge). Dry-mesic oak-hickory forest, ridgecrests and hillsides. Occasional; perennial. *Thompson 99-161*; *Abbott 12486*

C. tribuloides Wahl. (Short-bracted Sedge). Wetland meadow, Pacer Point at Kentucky Lake and station wetland complex. Rare; perennial. *Thompson 01-215*

C. typhina Michx. (Common Cattail Sedge). Emergent wetland, Pacer Point adjacent to woodland edge and Kentucky Lake. Infrequent; perennial. *Thompson 01-232*

C. vulpinoidea Michx. (Fox Sedge). Established in station wetland complex. Rare; perennial. *Thompson 98-75*

Cyperus echinatus (L.) Wood (Globe-flatsedge). Wetland meadow, Pacer Point and ponded borrow pit at Emma Drive. Infrequent; perennial. *Thompson 01-236*; *Woods 748*

C. esculentus L. (Yellow Nutsedge). Emergent wetland and wetland meadow, Pacer Point by Kentucky Lake shoreline. Rare; perennial. *Thompson 99-444*

C. pseudovegetus Steud. (Green Nutsedge). Wetland meadow, Pacer Point at woodland edge and Kentucky Lake. Rare; perennial. *Thompson 01-238*

C. squarrosus L. (Recurved Nutsedge). Kentucky Lake gravel shoreline at Pacer Point cove. Abundant; annual. *Thompson 99-436*

C. strigosus L. (False Nut-sedge). Wetland meadow, Pacer Point and ponded borrow pit north of Emma Lake. Infrequent; perennial. *Thompson 01-234*

o*Eleocharis acicularis* (L.) Roem. & Schultes (Needle Spikerush). Kentucky Lake gravel shoreline at Pacer Point cove. Abundant; perennial. *Thompson 99-455*

E. ovata (Roth) Roem. & Schultes (Blunt Spikerush). Ponded borrow pit north of Emma Drive and seasonal ponded depression pit. Infrequent; annual. *Thompson 98-444*

Fimbristylis autumnalis (L.) Roem. & Schultes (Fimbristylis). Emergent wetland and wetland meadow, Pacer Point. Abundant; perennial. *Thompson 99-380*

Rhynchospora corniculata (Lam.) A. Gray var. *interior* Fern. (Beakrush). Emergent wetland, Pacer Point and Kentucky Lake. Rare; perennial. *Thompson 99-376*

†*Scirpus atrovirens* Willd. (Dark-green Bulrush). Planted in station wetland complex. Rare; perennial. *Thompson 99-214*

S. cyperinus (L.) Kunth (Wool Grass). Small ponded depression pits and ponded borrow pit north of Emma Drive. Infrequent; perennial. *Thompson 98-554*

†*S. validus* Vahl (Great Bulrush). Planted in station wetland complex. Rare; perennial. Thompson 98-522

Scleria pauciflora Mulh. (Carolina Stone-rush). Early successional burned old-field restoration prairie. Occasional; perennial. *Thompson 99-235*

S. triglomerata Michx. (Tall Stone-rush). Early successional burned old-field restoration prairie. Frequent; perennial. *Thompson 98-137*

DIOSCOREACEAE (Yam Family)

**Dioscorea batatas* Decne. (Cinnamon-vine). Established in station wetland complex. Rare; perennial vine. *Thompson 99-250*

D. villosa L. (Wild Yam). Dry-mesic oak-hickory forest, hillsides and valleys. Occasional; perennial vine. *Thompson 01-220; Woods 616*

EBENACEAE (Ebony Family)

Diospyros virginiana L. (Common Persimmon). Mid-successional old-fields and dry-mesic oak-hickory forest. Occasional; canopy tree. *Thompson 98-130*; *Woods 893*

ELAEAGNACEAE (Russian Olive Family)

**Elaeagnus umbellata* Thunb. (Autumn Olive). Roadside border on south side of Emma Drive west of washhouse. Rare; small tree. *Thompson 99-32*

ERICACEAE (Heath Family)

Vaccinium arboreum Marshall (Sparklebush). Dry oak-hickory forest, cherty opening north of loblolly pine plantation. Frequent; small tree. *Thompson 00-156*

V. stamineum L. (Deerberry). Dry oak-hickory forest, south peninsula cherty embankment next to Watersport Road. Occasional; shrub. *Thompson 01-216*; *Woods 512*

EUPHORBIACEAE (Euphorbia Family)

Acalypha rhomboidea Raf. (Rhomboid-leaved Copperleaf). Disturbed gravel area by glasshouse mesocosm. Rare; annual. *Thompson 99-463*

A. virginica L. (Virginia Copperleaf). Kentucky Lake gravel shoreline east side of north peninsula. Frequent; annual. *Thompson 98-561*

Croton glandulosus L. var. *septentrionalis* (L.) Muell. Arg. (Sand Croton). Early successional powerline corridor north of Emma Drive. Infrequent; annual. *Thompson 98-711*

C. monoanthogynus Michx. (Prairie Tea). Early successional powerline corridor north of Emma Drive. Occasional; anuual. *Thompson 98-370, 98-621*

Euphorbia corollata L. (Flowering Spurge). Dry oak-hickory forest, open areas adjacent to Kentucky Lake. Occasional; perennial. *Thompson 98-356*

E. maculata L. (Spotted Spurge). Mowed station yard at edge of asphalt of Emma Drive circle. Frequent; annual. *Thompson 99-431*

E. nutans Lagasca (Eyebane Spurge). Disturbed gravel area by glasshouse mesocosm. Occasional; annual. *Thompson 98-684*; *Woods 376*

Phyllanthus caroliniensis Walter (Phyllanthus). Kentucky Lake gravel shoreline near boat dock cove. Rare; annual. *Thompson 99-443*

FABACEAE (Pea Family)

**Albizia julibrissin* Durazz. (Mimosa). Roadside and powerline cut along Emma Drive. Occasional; tree. *Thompson 01-165*

Amorpha fruticosa L. (False Indigo). Cherty embankment along Kentucky Lake shoreline at boat dock bridge. Infrequent; shrub. *Thompson 99-224*

Cercis canadensis L. (Eastern Redbud). Dry-mesic oak-hickory forest, woodland edge along Boy Scout Trail and faculty cabins trail. Occasional; subcanopy tree. *Thompson 99-31*

Chamaecrista fasciculata (Michx.) Greene (Partridge Pea). Early successional old-field north of Emma Drive. Occasional; annual. *Thompson 98-596*; *Wagaman 23*; *Woods 892*

C. nicitans (L.) Moench. (Wild Sensitive Plant). Early successional old-field south of Emma Drive. Infrequent; annual. *Thompson 98-584*

Clitoria mariana L. (Butterfly-pea). Dry oak-hickory forest, south peninsula hillside above bank of Kentucky Lake. Infrequent; perennial. *Thompson 00-321* o**Coronilla varia* L. (Crown-vetch). Unmowed station yard at side of main laboratory building and station wetland complex. Occasional; perennial. *Thompson 01-128*

Crotalaria sagittalis L. (Rattlebox). Early sucessional burned old-field restoration prairie. Rare; annual. *Thompson 99-325*

Desmodium glabellum (Michx.) DC. (Smooth Tick-trefoil). Mid-successional old-field near Boy Scout Trail. Occasional; perennial. *Thompson 98-692*

o*D. glutinosum* (Muhl.) A. Wood (Clustered Tick-trefoil). Dry-mesic oak-hickory forest, north peninsula east-trending hillside. Rare; perennial. *Thompson 98-398*

D. marilandicum (L.) DC. (Maryland Tick-trefoil). Dry-mesic oak-hickory forest, open area near station wetland complex. Infrequent; perennial. *Thompson 98-588*

D. nudiflorum (L.) DC. (Naked Tick-trefoil). Dry-mesic oak-hickory forest, east-trending hillside adjacent to boat dock cove. Occasional; perennial. *Thompson 99-320*

D. paniculatum (L.) DC. (Panicled Tick-trefoil). Early successional old-field between Emma Drive and ponded borrow pit. Occasional; perennial. *Thompson 98-651*

D. rotundifolium DC. (Round-leaved Tick-trefoil). Dry oak-hickory forest, south peninsula ridgecrest Rare; perennial. *Thompson 98-571*

o*Dioclea multiflora* (T. & G.) C. Mohr. (Milk Pea). Dry oak-hickory forest, clifftop east of station wetland complex and Kentucky Lake. Rare; perennial vine. *Thompson 98-303*

Galactia volubilis (L.) Britton (Hairy Milk-pea). Mid-successional powerline corridor near workshop. Infrequent; perennial vine. *Thompson 99-326*; *Woods 981*

Gleditsia triacanthos L. (Honey-locust). Dry-mesic oak-hickory forest, south hillside east of boat dock and south of station wetland complex. Rare; canopy tree. *Thompson 98-326*

**Lespedeza cuneata* (Dum. Cours.) G. Don (Sericea Lespedeza). Early successional old-fields along Emma Drive. Abundant; perennial. *Thompson 01-635*; *Woods 898*

L. hirta (L.) Hornem. (Hairy Lespedeza). Dry oak-hickory forest, south peninsula cherty openings. Infrequent; perennial. *Thompson 01-618*; *Woods 971*

L. intermedia (S. Wats.) Britton (Wand Lespedeza). Early successional old-field north of loblolly pine plantation. Occasional; perennial. *Thompson 98-703*

L. procumbens Michx. (Downy Trailing Lespedeza). Early successional old-field on south side of Emma Drive. Frequent; perennial. *Thompson 98-699*

L. repens (L.) Barton (Smooth Trailing Lespedeza). Early successional old-field and Emma Drive powerline corridor. Occasional; perennial. *Thompson 99-202*; *Beck 50B*

o**L. stipulacea* Maxim. (Korean Lespedeza). Mowed station yard and Emma Drive circle. Abundant; annual. *Thompson 98-379*; *Woods 977*

**L. striata* (Thunb.) Hook. & Arnott. (Japanese Lespedeza). Mowed station yard and Emma Drive circle. Abundant; annual. *Thompson 01-636*

L. virginica (L.) Britton (Virginia Lespedeza). Early successional burned old-field restoration prairie. Infrequent; perennial. Thompson 98-626; *Woods 980*

†o**Lotus corniculatus* L. (Bird's-foot Trefoil). Planted in early successional old-field by ponded borrow pit north of Emma Drive. Rare; perennial. *Thompson 01-203*

**Medicago lupulina* L. (Black Medic). Mowed station yard and Emma Drive circle. Occasional; annual. *Thompson 01-152*

**Melilotus alba* Medic. (White Sweetclover). Unmowed road shoulder south of Emma Drive. Infrequent; biennial. *Thompson 01-221*

**M. officinalis* (L.) Pallas (Yellow Sweetclover). Disturbed gravel area by glasshouse mesocosm. Rare; biennial. *Thompson 02-239*

Orbexilum pedunculatum (Miller) Rydb. (Sampson's Snakeroot). Dry oak-hickory forest, opening off Watersport Road. Occasional; perennial. *Thompson 98-18*; *Woods 619*

Robinia pseudoacacia L. (Black Locust). Dry-mesic oak-hickory forest, open north peninsula above Kentucky Lake Occasional; tree. *Thompson 99-91*

Strophostyles leiosperma (T. & G.) Piper (Woolly Bean). Early successional old-field south of Emma Drive. Rare; perennial. *Thompson 98-595*; *Beck 62A*; *Woods 896.*

Stylosanthes biflora (L.) BSP. (Pencil-flower). Mid-successional oak-hickory forest along Boy Scout Trail. Infrequent; perennial *Thompson 99-234; Woods 50*

Tephrosia virginiana (L.) Pers. (Hoary Pea). Dry oak-hickory forest, north peninsula cherty openings. Occasional; perennial *Thompson 01-124*; *Beck 55B*; *Hunter and Austin 1790.*

**Trifolium campestre* Schreber (Yellow Hop-clover). Mowed roadside of Emma Drive near station entrance gate. Rare; annual. *Thompson 98-46*

**T. dubium* Sibth. (Little Hop-clover). Mowed station yard surrounded by Emma Drive circle. Abundant; annual. *Thompson 01-102*

†**T. pratense* L. (Red Clover). Planted in early successional old-field between Emma Drive and ponded borrow pit. Occasional; perennial. *Thompson 02-237*; *Beck 32B*

**T. repens* L. (White Clover). Mowed station yard around main laboratory building and Emma Drive circle. Abundant; perennial. *Thompson 01-139*

**Vicia dasycarpa* Tenore (Woolly-pod Vetch). Early successional old-field edge by ponded borrow pit. Rare; annual. *Thompson 01-253*

**V. sativa* L. (Common Vetch). Unmowed station yard at edge of station wetland complex. Rare; annual. *Thompson 99-215*

Wisteria frutescens (L.) Poir. (Atlantic Wisteria). Riparian forest, boat dock cove and north peninsula cove floodplains. Occasional; woody vine. *Thompson 98-412*

FAGACEAE (Beech Family)

Fagus grandifolia Ehrh. (American Beech). Dry-mesic oak-hickory forest, off south hillside by gravel road to boat dock. Infrequent; canopy tree. *Thompson 99-290*; *Woods 972*

Quercus alba L. (White Oak). Dry-mesic oak-hickory forest, north and south peninsula hillsides and valleys. Abundant; canopy tree. *Thompson 98-540*; *Beck 73B*; *Woods 985*

o*Q. coccinea* Muenchh. (Scarlet Oak). Dry-mesic oak-hickory forest, beside gravel road to boat dock. Rare; canopy tree. *Thompson 98-369*

Q. falcata Michx. (Southern Red Oak). Dry-mesic oak-hickory forest, north and south peninsula ridgetops. Frequent; canopy tree. *Thompson 98-564*; *Beck 21A*; *Woods 1192*

Q. imbricaria Michx. (Shingle Oak). Dry-mesic oak-hickory forest, woodland border south of Emma Drive. Infrequent; canopy tree. *Thompson 98-449*; *Hunter and Austin 1810*; *Woods 73*

Q. lyrata Walter (Overcup Oak). Riparian forest, Kentucky Lake at boat dock cove and near north peninsula cove. Rare; canopy tree. *Thompson 99-424*

Q. marilandica Muenchh. (Black-jack Oak). Dry oak-hickory forest, south and north peninsula cherty openings and ridgetops. Frequent; canopy tree. *Thompson 99-200*; *Adams 09*; *Beard 05*; *Beck 29A*; *Hunter and Austin 1800*; *Woods 1190*

Q. muehlenbergii Engelm. (Chinkapin Oak). Dry-mesic oak-hickory forest, north peninsula hillside. Rare; canopy tree. *Thompson 98-41*

Q. rubra L. (Northern Red Oak). Dry-mesic oak-hickory forest, north and south peninsulas. Abundant; canopy tree. *Thompson 98-345*

Q. shumardii Buckley (Shumard's Oak). Mowed station yard inside Emma Drive circle. Rare; canopy tree. *Thompson 98-603*; *Adams 08*; *Beck 24A; Hunter and Austin 1808*

Q. stellata Wangenh. (Post-oak). Dry oak-hickory forest, south and north peninsula cherty openings and ridgetops. Frequent; canopy tree *Thompson 98-123*; *Beck 26B*; *Woods 984*

Q. velutina Lam. (Black Oak). Dry oak-hickory forest, south and north peninsula ridgecrests and hillsides. Abundant; canopy tree *Thompson 02-231*; *Beck 27B*

GENTIANACEAE (Gentian Family)

Sabatia angularis (L.) Pursh (Marsh Rose Pink). Early successional old-field moist ditch adjacent to Emma Drive. Infrequent; biennial. *Thompson 99-324*; Beck 43B

GERANIACEAE (Geranium Family)

Geranium carolinianum L. (Carolina Cranesbill). Early successional old-field and powerline corridor north of Emma Drive. Occasional; annual. *Thompson 99-116*; *Woods 520*

HALORAGACEAE (Water-milfoil Family)

**Myriophyllum spicatum* L. (European Water-milfoil). Submergent in coves. Infrequent; perennial. *Fuller 3004*

HAMAMELIDACEAE (Witch-hazel Family)

Liquidambar styraciflua L. (Sweetgum). Riparian forest, Pacer Point valley along creek. Occasional; canopy tree. Thompson 98-192; *Obourn 08*

HIPPOCASTANACEAE (Horse Chestnut Family)

Aesculus pavia L. (Red Buckeye). Dry oak-hickory forested edge south of main laboratory building and Emma Drive. Rare; subcanopy tree. *Thompson 99-334*; *Abbott 12474*

HYDRANGEACEAE (Hydrangea family)

Hydrangea cinerea Small (Wild Hydrangea). East cliffside thicket of North peninsula, gully above Kentucky Lake. Infrequent; shrub. *Thompson 01-207*

IRIDACEAE (Iris Family)

Iris cristata Aiton (Dwarf Crested Iris). Dry-mesic oak-hickory forest, valley hillside east of Watersport Road and Pacer Point. Infrequent; perennial. *Thompson 99-69*; *Woods 444*

†**I. pseudoacorus* L. (Yellow Flag). Planted in station wetland complex. Rare; perennial. *Thompson 99-147*

†*I. virginica* L. (Southern Blue Flag). Boat dock cove floodplain and planted in station wetland complex. Infrequent; perennial. *Thompson 99-148*; *Woods 623*

Sisyrinchium angustifolium P. Mill. (Narrow-leaved Blue-eyed Grass). Mid-successional old field along Boy Scout Trail. Occasional; perennial. *Thompson 99-84; Woods 56*

JUGLANDACEAE (Walnut Family)

o*Carya cordiformis* (Wangenh.) K. Koch (Bitternut Hickory). Dry-mesic oak-hickory forest, south peninsula south-trending hillside. Rare; canopy tree. *Thompson 99-218*

C. glabra (Mill.) Sweet (Smooth Pignut Hickory). Dry oak-hickory forest, south and north peninsula hillsides. Abundant; canopy tree. *Thompson 02-223*; *Woods 975*

C. ovata (Mill.) K. Koch (Shagbark Hickory). Dry-mesic oak-hickory forest, south and north peninsula hillsides and valleys. Abundant; canopy tree. *Thompson 98-231*; *Beard 01*; *Beck 37C*; *Kozusnicek 06*; *Woods 970*

C. pallida (Ashe) Engler & Graebn. (Pale Hickory). Dry-mesic oak-hickory forest, north peninsula hillside by faculty cabins. Infrequent; canopy tree. *Thompson 98-197*

C. tomentosa (Poir.) Nutt. (Mockernut Hickory). Dry-mesic oak-hickory forest, north and south peninsulas. Abundant; canopy tree. *Thompson 02-230; Beck 70B*; *Woods 979*

JUNCACEAE (Rush Family)

Juncus acuminatus Michx. (Sharp-pointed Rush). Ponded borrow pit just north of Emma Drive. Infrequent; perennial. *Thompson 98-143*

o*J. biflorus* Ell. (Two-flowered Rush). Wet roadside ditch bordering Emma Drive. Occasional; perennial. *Thompson 01-225*

J. brachycarpus Engelm. (Short-headed Rush). Ponded borrow pit adjacent to Emma Drive. Infrequent; perennial. *Thompson 98-256*

J. diffusissiimus Buckley (Spreading Rush). Wet roadside ditch near station entrance gate along Emma Drive. Rare; perennial. *Thompson 99-287*

J. effusus L. var. *solutus*. Fern. & Wieg. (Common Rush). Ponded borrow pit adjacent to Emma Drive. Infrequent; perennial. *Thompson 02-202*

J. marginatus Rostk. (Marginated Rush). Wet roadside ditch near station entrance gate along Emma Drive. Occasional; perennial. *Thompson 98-153; Woods 745*

J. tenuis Willd. var. *tenuis* (Slender Path-rush). Trails to student and faculty cabins by mowed station yard. Abundant; perennial. *Thompson 99-245*

Luzula bulbosa (A. Wood) Rydb. (Wood Rush). Dry-mesic oak-hickory forest, openings and unmowed station yard edges. Frequent; perennial. *Thompson 99-86; Abbott 12481*

LAMIACEAE (Mint Family)

Cunila origanoides (L.) Britton (Maryland Dittany). Dry oak-hickory forest, south-trending cherty hillsides. Occasional; perennial. *Thompson 98-717*

Hedeoma pulegioides (L.) Pers. (American Pennyroyal). Dry wooded area along Kentucky Lake. Rare; annual. *Woods 819*

**Lamium amplexicaule* L. (Henbit). Mowed station yard by faculty cabins trail and workshop. Infrequent; annual. *Thompson 99-11*

**L. purpureum* L. (Purple Dead-nettle). Mowed station yard inside Emma Drive circle near main laboratory building. Infrequent; annual. *Thompson 99-14*

Lycopus virginicus L. (Virginia Bugleweed). Wetland meadow, Pacer Point. Rare; perennial. *Thompson 98-682*

†**Mentha x piperita* L. (Peppermint). Planted in station wetland complex. Rare; perennial. *Thompson 00-322*

Monarda fistulosa L. (Wild Bergamot). Mid-successional old-field powerline corridor along Emma Drive. Infrequent; perennial. *Thompson 01-170*

**Perilla frutescens* (L.) Britton (Beefsteak Plant). Roadside along Watersport Road near Pacer Point. Rare; annual. *Thompson 98-710*

**Prunella vulgaris* L. (Self-heal). Wooded picnic area near boat dock. Occasional; perennial. *Thompson 98-64*; *Beck 35A*

Pycnanthemum pycnanthemoides (Leavenw.) Fern. (Hoary Mountain Mint). Early successional burned old-field restoration prairie. Infrequent; perennial. *Thompson 01-623*; *Woods 895*

P. tenuifolium Schrad. (Slender Mountain Mint). Early successional old-field and powerline corridor. Occasional; perennial. *Thompson 99-285; Beck 48B*; *Woods 744*

o*P. virginianum* Durand & Jackson (Virginia Mountain Mint). Early successional burned old-field restoration prairie. Rare; perennial. *Thompson 98-519*

Salvia lyrata L. (Lyrate-leaved Wild Sage). Wooded picnic area near boat dock. Occasional; perennial. *Thompson 99-151*

Scutellaria elliptica Muhl. (Elliptic-leaved Skullcap). Dry-mesic oak-hickory, opening on south hillside adjacent to boat dock cove. Occasional; perennial. *Thompson 00-158*

S. incana Biehler (Downy Skullcap). Dry-mesic oak-hickory forest, valley leading to boat dockcove floodplain. Infrequent; perennial. *Thompson 98-294*; *Woods 810*

S. integrifolia L. (Large-flowered Skullcap). Dry-mesic oak-hickory forest, south-trending hillside near Kentucky Lake. Infrequent; perennial. *Thompson 99-167*

S. ovata Hill (Heart-leaved Skullcap). Dry-mesic oak-hickory forest, east-trending hillside east of Schnautz House. Infrequent; perennial. *Thompson 98-93*; *Woods 737*

S. parvula Michx. (Little Skullcap). Dry oak-hickory forest, cherty opening east of Watersport Road. *Thompson 99-87*; *Abbott 12479*; *Woods 510*

Stachys tenuifolia Willd. (Smooth Hedge-nettle). Roadside ditch off Watersport Road by creek crossing. Rare; perennial. *Thompson 00-320*

Teucrium canadense L. (American Germander). North peninsula eastside cliff and Kentucky Lake gravel shoreline. Rare; perennial. *Thompson 98-208*; *Adams 06*

LAURACEAE (Laural Family)

Sassafras albidum (Nutt.) Nees (White Sassafras). Dry oak-hickory forest, south peninsula hillside and field borders. Occasional; canopy tree. *Thompson 98-223; Beard 02*; *Beck 39A*; *Kozusnicek 07*; *Obourn 09*; *Winstead 02*

LILIACEAE (Lily Family)

o*Allium canadense* L. (Wild-onion). Roadside ditch of Watersport Road. Occasional; perennial. *Thompson 99-240*

**A. vineale* L. (Field-garlic). Early successional powerline corridor north along Emma Drive. Infrequent; perennial. *Thompson 02-207*

Chamaelirium luteum (L.) A. Gray (Devil's Bit). Dry-mesic oak-hickory forest, valley west of Watersport Road. Rare; perennial. *Thompson 99-208*

†**Hemerocallis fulva* (L.) L. (Orange Day-lily). Planted in station yard and station wetland complex. Infrequent; perennial. *Thompson 99-258*

Hypoxis hirsuta (L.) Cov. (Yellow Star-grass). Dry oak-hickory forest, open embankment along Watersport Road. Infrequent; perennial. *Thompson 99-77*; *Woods 514*

†**Narcissus pseudo-narcissus* L. (Daffodil). Persisting from an old planting in woods west of Wolfson House driveway. Infrequent; perennial. *Thompson 99-17*

Polygonatum biflorum (Walt.) Ell. (True Solomon's Seal). Dry-mesic oak-hickory forest, east-trending hillside near from boat dock. Infrequent; perennial. *Thompson 98-09; Woods 511*

Smilacina racemosa (L.) Desf. (False Solomon's Seal). Dry-mesic oak-hickory forest, valley leading to north peninsula cove. Occasional; perennial. *Thompson 99-272*

o*Uvularia sessilifolia* L. (Sessile-leaved Bellwort). Dry-mesic oak-hickory forest, valley leading to north peninsula cove. Occasional; perennial. *Thompson 01-229*

LINACEAE (Flax Family)

Linum medium (Planchon) Britton (Common Yellow Flax). Early successional burned old-field restoration prairie. Occasional; perennial. *Thompson 01-153*

LOGANIACEAE (Logania Family)

Spigelia marilandica L. (Indian Pinkroot). Roadside thicket east of Watersport Road and Pacer Point cove by creek. Infrequent; perennial. *Thompson 01-112*

LYTHRACEAE (Loosestrife Family)

Ammannia coccinea Rottb. (Long-leaved Ammannia). Kentucky Lake gravel shoreline at Pacer Point. Rare; annual. *Thompson 98-659*

Rotala ramosior (L.) Koehne (Tooth-cup). Emergent wetland, Pacer Point and Kentucky Lake. Abundant; annual. *Thompson 99-383; Fuller 3009*

MAGNOLIACEAE (Magnolia Family)

Liriodendron tulipifera L. (Yellow Poplar). Dry-mesic oak-hickory forest, between boat dock cove and burned old-field restoration prairie. Rare; canopy tree. *Thompson 98-293*

MALVACEAE (Mallow Family)

Hibiscus laevis All. (Smooth Rose-mallow). Emergent wetland, Kentucky Lake shoreline at north peninsula cove and Pacer Point cove. Occasional; perennial. *Thompson 99-387*

**Sida spinosa* L. (Prickly Sida). Kentucky Lake gravel shoreline near boat dock. Rare; annual. *Thompson 98-539*

MARANTACEAE (Prayer Plant Family)

†*Thalia dealbata* Roscoe (Powder Thalia). Planted in station wetland complex. Rare; perennial. *Thompson 98-716*

MELASTOMATACEAE (Melastome Family)

Rhexia virginica L. (Wing-stem Meadow-beauty). Dry wooded area on shore of Kentucky Lake. Rare; perennial. *Woods 821*

MENISPERMACEAE (Moonseed Family)

Cocculus carolinus (L.) DC. (Carolina Snailseed). Roadside thicket in valley by Pacer Point and Watersport Road. Infrequent; woody vine. *Thompson 98-496*

MOLLUGINACEAE (Carpet-weed Family)

**Mollugo verticillata* L. (Carpet-weed). Kentucky Lake gravel shoreline near boat dock and disturbed gravel area by greenhouse mesocosm. Occasional; annual. *Thompson 01-162*

MONOTROPACEAE (Indian Pipe Family)

Monotropa hypopithys L. (Pine Sap) Dry oak-hickory forest, south of Emma Drive near student cabins. Rare; perennial. *Thompson 98-217*; *Hunter and Austin 1837*

MORACEAE (Mulberry Family)

Maclura pomifera (Raf.) C.K. Schneider (Osage-orange). Western edge of Emma Drive circle by washhouse and student cabin trail. Rare; canopy tree. *Thompson 01-169*

Morus rubra L. (Red Mulberry). Dry-mesic oak-hickory forest, west of Emma Drive circle. Occasional; canopy tree. *Thompson 98-195*; *Woods 808*

NAJADACEAE (Water-nymph Family)

Najas guadalupensis (Spreng.) Magnus (Southern Water-nymph). Kentucky Lake submergent at north peninsula cove. Frequent; perennial. *Thompson 99-457*; *Fuller 3001*

OLEACEAE (Olive family)

Fraxinus americana L. (White Ash). Dry-mesic oak-hickory forest, on north peninsula west-trending hillside. Infrequent, canopy tree. *Thompson 98-382*

F. pennsylvanica Marshall (Green Ash). Kentucky Lake shoreline at north peninsula. Rare; canopy tree. *Thompson 98-357*

†**Ligustrum sinense* L. (Chinese Privet). Wooded edge between boathouse compound and unmowed station yard near Emma Drive circle. Rare; shrub. *Thompson 99-393*

ONAGRACEAE (Evening-Primrose Family)

Ludwigia alternifolia L. (Square-pod Seedbox). Wet roadside ditch of Emma Drive near station entrance gate. Rare; perennial. *Thompson 98-516*

L. decurrens Walter (Wingstem Water-primrose). Emergent wetland, Pacer Point and Kentucky Lake. Rare; perennial. *Thompson 99-381*

Oenothera biennis L. (Common Evening-primrose). Early successional powerline corridor north of Emma Drive. Occasional; biennial. *Thompson 01-630*

O. fruticosa L. (Southern Sundrops). Early successional burned old-field restoration prairie. Infrequent; perennial. *Thompson 98-202*

O. speciosa Nutt. (White Evening-primrose). Early successional old-field at edge on south side of Emma Drive. Rare; perennial. *Thompson 98-02*

ORCHIDACEAE (Orchid Family)

Spiranthes cernua (L.) Rich. (Nodding Ladies'-tresses). Early successional old-field next to ponded borrow pit north of Emma Drive. Rare; perennial. *Thompson 98-641; Beyer s.n.*; *Sparks 53*

S. lacera (Raf.) Raf. (Slender Ladies'-tresses). Unmowed station yard near washhouse. Rare; perennial. *Thompson 98-611*

S. vernalis Engelm. & A. Gray (Spring Ladies'-tresses). Wet ditch border along Emma Drive. Rare; perennial. *Thompson 98-212*

Tipularia discolor (Pursh) Nutt. (Crane-fly Orchid). Dry-mesic oak-hickory forest, southwest of student cabins. Rare; perennial. *Thompson 98-526*

OXALIDACEAE (Oxalis Family)

Oxalis dillenii Jacq. (Southern Yellow Sorrel). Early successional powerline corridor by Emma Drive and disturbed area by glasshouse mesocosm. Occasional; perennial. *Thompson 01-108*; *Abbott 12482*; *Beck 63A*; *Hengst 130*

O. stricta L. (Yellow Wood Sorrel). Edge of tree line surrounding old trailer. Rare; perennial. *Woods 531*

O. violacea L. (Violet Wood Sorrel). Dry oak-hickory forest, open embankment east side of Watersport Road. Infrequent; perennial. *Thompson 99-80*

PASSIFLORACEAE (Passion Flower Family)

Passiflora incarnata L. (Maypops). Wooded thicket at junction of Wolfson House driveway and Schnautz House. Rare; perennial vine. *Thompson 00-325*; *Adams 82*; *Beck 44D; Hunter and Austin 1818*

P. lutea L. var. *glabriflora* Fern. (Yellow Passion-flower). Dry-mesic oak-hickory forest, Kentucky Lake and boat dock cove hillside. Perennial vine. *Thompson 98-373*

PHYTOLACCACEAE (Pokeweed Family)

Phytolacca americana L. (American Pokeweed). Woodland thicket at south edge of station wetland complex. Infrequent; perennial. *Thompson 01-113*; *Beck 40B*; *Woods 804*

PLANTAGINACEAE (Plantain Family)

Plantago aristata Michx. (Bracted Plantain). Abandoned gravel road west of Emma Drive by powerline corridor. Infrequent; annual. *Thompson 01-223*; *Woods 743*

**P. lanceolata* L. (English Plantain). Mowed station yard near main laboratory building and Emma Drive circle. Frequent; perennial. *Thompson 98-74*

P. rugelii Dcne. (Rugel's Plantain). Mowed station yard inside Emma Drive circle and washhouse. Frequent; perennial. *Thompson 98-180*

P. virginica L. (Virginia Plantain). Abandoned gravel road west of Emma Drive by powerline corridor. Occasional; annual. *Thompson 99-126*; *Woods 517*

PLATANACEAE (Plane Tree Family)

Platanus occidentalis L. (American Sycamore). Riparian forest, Kentucky Lake gravel shoreline. Occasional; canopy tree. *Thompson 98-201*; *Woods 1194*

POACEAE (Grass Family)

**Agrostis gigantea* Roth. (Redtop). Established in station wetland complex. Infrequent; perennial. *Thompson 00-326*

**A. stolonifera* L. (Creeping Bent). Early successional powerline corridor in ditch along Emma Drive. Infrequent; perennial. *Thompson 99-133*

Alopecurus carolinianus Walter (Carolina Foxtail). Embankment above Kentucky Lake gravel shoreline at Pacer Point cove. Rare; annual. *Thompson 99-47*

Andropogon ternarius Michx. (Silver Bluestem). Early successional old-fields north and south side of Emma Drive. Occasional; perennial. *Thompson 01-626*

A. virginicus L. (Broom-sedge). Early successional old-fields north and south of Emma Drive. Occasional; perennial. *Thompson 01-637*

Aristida dichotoma Michx. (Churchmouse Triple-awn). Early successional old-field by ponded borrow area. Frequent; annual. *Thompson 01-642*

A. longespica Poir. (Slimspike Triple-awn). Early successional old-field by ponded borrow pit. Occasional; annual. *Thompson 01-640*

o*Brachiaria platyphylla* (Griesb.) Nash (Broadleaf Signal Grass). Early successional old-field by ponded borrow area. Rare; perennial. *Thompson 01-605*

Brachyelytrum erectum (Schreb.) P. Beauv. (Short Huskgrass). Dry-mesic oak-hickory forest, valley hillsides by boat dock cove. Occasional; perennial. *Thompson 98-181*

**Bromus japonicus* Thunb. (Japanese Brome). Early successional powerline corridor along Emma Drive and unmowed station yard edges. Occasional; annual. *Thompson 00-159*

o*B. pubescens* Muhl. (Woodland Brome). Dry-mesic oak-hickory forest, valley hillsides by boat dock cove. Occasional; perennial. *Thompson 99-219*

Chasmanthium latifolium (Michx.) Yates (Wild Oats). Pacer Point valley bottom and boat dock cove floodplain. Frequent; perennial. *Thompson 99-378*

**Cynodon dactylon* (L.) Pers. (Bermuda Grass). Mowed and unmowed station yard. Abundant; perennial. *Thompson 98-352*

**Dactylis glomerata* L. (Orchard-grass). Unmowed roadsides along Emma Drive and unmowed station yard borders. Occasional; perennial. *Thompson 02-200; Woods 613*

Danthonia spicata (L.) F. Beauv. (Poverty Oatgrass). Dry oak-hickory forest, cherty openings around Kentucky Lake, ubiquitous. Abundant; perennial. *Thompson 01-111; Woods 611*

**Digitaria ischaemum* (Schreber) Muhl. (Smooth Crabgrass). Kentucky Lake gravel shoreline. Infrequent; annual. *Thompson 98-668*

**D. sanguinalis* (L.) Scop. (Hairy Crabgrass). Disturbed gravel area by glasshouse mesocosm and mowed station yard. Frequent; annual. *Thompson 99-448*

**Echinochloa crusgalli* (L.) P. Beauv. (Barnyard-grass). Kentucky Lake gravel shoreline. Frequent; annual. *Thompson 99-446*

**Eleusine indica* (L.) Gaertn. (Yard-grass). Mowed station yard off Emma Drive circle at edge of asphalt. Occasional; annual. *Thompson 98-300*

o*Elymus virginicus* L. var. *glabriflorus* (Vasey) Bush (Smooth Wildrye). Early successional old-field south of Emma Drive. Occasional; perennial. *Thompson 99-275*; *Woods 740*

E. virginicus L. var. *virginicus* (Virginia Wildrye). Dry-mesic oak-hickory forest, Pacer Point cove valley. Occasional; perennial. *Thompson 01-205*

**Eragrostis ciliaensis* (All.) Janchen (Stinkgrass). Disturbed gravel area by glasshouse mesocosm. Rare; annual. *Thompson 98-605*

E. hypnoides (Lam.) BSP. (Creeping Lovegrass). Kentucky Lake gravel shoreline at Pacer Point cove. Occasional, annual. *Thompson 98-666*

o*E. pectinacea* (Michx.) Nels. (Small Lovegrass). Emma Drive circle in front of at asphalt edge and glasshouse mesocosm. Occasional; annual. *Thompson 01-250*

E. spectabilis (Pursh) Steudel (Spangletop). Early successional burned old-field restoration prairie. Occasional; perennial. *Thompson 98-593*

Erianthus alopecuroides (L.) Ell. (Silver Plume Grass). Dry-mesic oak-hickory forest, cherty open hillsides at Kentucky Lake. Occasional; perennial. *Thompson 01-632*

**Festuca pratensis* Hudson (Meadow-fescue). Unmowed roadsides along Emma Drive and unmowed station yard borders. Abundant; perennial. *Thompson 99-172; Woods 600*

**Holcus lanatus* L. (Velvet Grass). Early successional old-field next to ponded borrow pit. Rare; perennial. *Thompson 02-229*

Hordeum pusillum L. (Little Barley). Gravel roadside leading to boat dock by washhouse. Occasional; annual. *Thompson 99-113*

Leersia oryzoides (L.) Swartz. (Rice Cutgrass). Emergent wetland, Pacer Point and station wetland complex. Frequent; perennial. *Thompson 98-655*

L. virginica Willd. (Whitegrass). Dry-mesic oak-hickory forest, Pacer Point valley bottom. Occasional; perennial. *Thompson 98-598*

†**Lolium perenne* L. var. *aristatum* Willd. (Italian Ryegrass). Planted around ponded borrow pit and glasshouse mesocosm. Rare; perennial. *Thompson 01-107*

Melica mutica Walter (Two-flowered Melic-grass). Dry-mesic oak-hickory forest, hillside opening north of boat dock. Rare; perennial. *Thompson 99-157*

**Microstegium vimineum* (Trin.) A. Camas (Nepalese Eulalia). Dry-mesic oak-hickory forest, cove floodplains, ubiquitous. Frequent; prennial. *Thompson 01-631*

Muhlenbergia schreberi J.F. Gmelin (Nimble-will). Unmowed and mowed yard border by main laboratory building. Frequent; perennial. *Thompson 98-693*

M. sobolifera (Muhl.) Trin. (Rock Satin Grass). Pacer Point cove valley bottom. Infrequent; perennial. *Thompson 98-492*

Panicum anceps Michx. (Beaked Panicum). Wet meadow, Pacer Point and swale across Boy Scout Trail. Frequent; perennial. *Thompson 99-382*

P. boscii Poir. (Bosc's Panicum). Dry-mesic oak-hickory forest, upland open areas. Frequent; perennial. *Thompson 02-215*; *Woods 614*

P. clandestinum L. (Deer-tongue Panicum). Dry-mesic oak-hickory forest, boat dock and Pacer Point valley floodplains. Occasional; perennial. *Thompson 98-430*

P. commutatum Schultes (Variable Panicum). Early successional old-field edge near ponded borrow pit. Frequent; perennial. *Thompson 99-145*

P. depauperatum Muhl. (Starved Panicum). Dry oak-hickory forest, north peninsula cherty openings. Occasional; perennial. *Thompson 01-133*

P. dichotomiflorum Michx. (Spreading Witchgrass). Kentucky Lake gravel shoreline. occasional; annual. *Thompson 98-679*

P. dichotomum L. (Forked Panicum). Dry-mesic oak-hickory forest, valley and hillside near Pacer Point cove. Frequent; perennial. *Thompson 98-17*

P. lanuginosum Ell. var. *fasciculatum* (Torr.) Fern. (Woolly Panicum). Early successional old-fields and powerline corridor. Abundant; perennial. *Thompson 01-138*

P. lanuginosum Ell. var. *lindheimerii* (Nash) Fern. (Woolly Panicum). Early successional old-fields by ponded borrow pit. Infrequent; perennial. *Thompson 01-201*

P. laxiflorum Lam. (Lax Panicum). Dry-mesic oak-hickory forest, wooded openings and borders along mowed station yard. Abundant; perennial. *Thompson 98-23; Woods 612*

P. polyanthes Schultes (Many-flowered Panicum). Dry-mesic oak-hickory forest, opening near Kentucky Lake shoreline. Occasional; perennial. *Thompson 01-115; Woods 738*

P. rigidulum Nees (Monro Grass). Emergent wetland and wetland meadow, Pacer Point. Frequent; perennial. *Thompson 99-384*

P. villossimum Nash (Villous Panicum). Early successional powerline cut along Emma Drive. Infrequent; perennial. *Thompson 99-203*

**Paspalum dilatatum* Poir. (Dallis-grass). Unmowed station yard near washhouse. Rare; perennial. *Thompson 00-327*

P. floridanum Michx. (Giant Beadgrass). Wetland meadow, Pacer Point at Kentucky Lake. Infrequent; perennial. *Thompson 98-715*

P. laeve Michx. (Smooth Beadgrass). Mowed and unmowed station yard and Emma Drive roadsides. Frequent; perennial. *Thompson 01-186*

**Phleum pratense* L. (Timothy). Unmowed roadsides along Emma Drive and unmowed station yard borders. Rare; perennial *Thompson 02-220*

**Poa annua* L. (Annual Speargrass). Mowed station yard near Emma Drive circle and greenhouse mesocosm. Frequent; annual. *Thompson 99-15*

**P. pratensis L.* (Kentucky Bluegrass). Unmowed roadsides along Emma Drive and unmowed station yard borders. Abundant; perennial. *Thompson 99-54*

P. sylvestris A. Gray (Woodland Bluegrass). Dry-mesic oak-hickory forest, Pacer Point valley bottom. Occasional; perennial. *Thompson 00-328*

Schizachyrium scoparium (Michx.) Nash (Little Bluestem). Early successional burned old-field restoration prairie and early successional old-fields by Emma Drive. Frequent; perennial. *Thompson 01-641*

**Setaria faberii* R. Herrm. (Nodding Foxtail). Disturbed gravel area by glasshouse mesocosm. Infrequent; annual. *Thompson 01-188*

S. geniculata (Lam.) P. Beauv. (Perennial Foxtail). Early successional old fields adjacent to Emma Drive. Frequent; perennial. *Thompson 98-597; Beck 77B*

**S. glauca* (L.) P. Beauv. (Yellow Foxtail). Disturbed gravel area by glasshouse mesocosm. Infrequent; annual. *Thompson 99-260*

Sphenopholis nitida (Biehler) Scribn. (Hairy Wedgegrass). Dry-mesic oak-hickory forest, north peninsula east-trending cliffside by Kentucky Lake. Occasional; perennial. *Thompson 99-102*

Sorghastrum nutans (L.) Nash (Indian Grass). Early successional old field by Emma Drive. and burned old-field restoration prairie. Occasional; perennial. *Thompson 98-642*

**Sorghum halepense* (L.) Pers. (Johnson-grass). Early successional old field next to ponded borrow pit. Infrequent; perennial. *Thompson 01-194*

Tridens flavus (L.) A. Hitchc. (Purple-top). Unmowed roadside and early successional old-field of Emma Drive. Occasional; perennial. *Thompson 01-639*

Tripsacum dactyloides (L.) L. (Eastern Gammagrass). Early successional burned old-field restoration prairie. Occasional; perennial. *Thompson 98-97; Hunter and Austin 1803*

†**Triticum aestivum* L. (Common Wheat). Planted in disturbed old-field by ponded borrow pit and disturbed gravel area by glasshouse mesocosm. Rare; annual. *Thompson 01-135*

Vulpia octoflora (Walter) Rydb. (Six-weeks Fescue). Dry oak-hickory forest, south and north peninsula ridgecrests. Abundant; annual. *Thompson 01-110*

POLEMONIACEAE (Phlox Family)

Phlox divaricata L. (Forest Phlox). Dry-mesic oak-hickory forest, valley along creek at Pacer Point. Occasional; perennial. *Thompson 99-23*

†*P. paniculata* L. (Summer Phlox). Planted at entrance to main laboratory building. Rare; perennial. *Thompson 99-321*

POLYGALACEAE (Milkwort Family)

Polygala ambigua Nutt. (Loose Milkwort). Early successional burned old-field restoration prairie. Infrequent; annual. *Thompson 98-404*

P. sanguinea L. (Field Milkwort). Early successional old-field north of Emma Drive. Rare; annual. *Thompson 98-124*

POLYGONACEAE (Buckwheat Family)

Brunnichia cirrhosa Gaertn. (Lady's-eardrops). Riparian forest, north peninsula and boat dock cove floodplains. Occasional; woody vine. *Thompson 99-377*

Polygonum amphibium L. var. *emersum* Michx. (Scarlet Smartweed). Emergent wetland, Pacer Point at Kentucky Lake shoreline. Infrequent; perennial. *Thompson 98-652*

**P. aviculare* L. (Knotweed). Mowed station yard at asphalt edge of Emma Drive circle. Infrequent; perennial. *Thompson 99-462*

o**P. caespitosum* Blume var. *longisetum* (DeBruyn) Stewart (Asiatic Water Pepper). Kentucky Lake gravel shoreline. Frequent; annual. *Thompson 01-638*

P. hydropiperoides Michx. (Mild Water Pepper). Emergent wetland, Pacer Point Kentucky Lake. Occasional; perennial. *Thompson 99-438*

P. pensylvanicum L. (Pennsylvania Smartweed). Kentucky Lake gravel shoreline at boat dock bridge. Rare; annual. *Thompson 98-664*

**P. persicaria* L. (Lady's-thumb). Disturbed gravel area around glasshouse mesocosm. Infrequent; annual. *Thompson 01-187*

P. sagittatum L. (Arrow-leaved Tearthumb). Wetland meadow, Pacer Point and Kentucky Lake. Infrequent; annual. *Thompson 99-447*

P. virginianum L. (Woodland Jumpseed). Dry-mesic oak-hickory forest, trail to burned old-field restoration prairie at boat dock cove. Infrequent; perennial. *Thompson 98-568*

**Rumex acetosella* L. (Sheep Sorrel). Mowed station yard inside Emma Drive circle. Occasional; perennial. *Thompson 98-77*; *Hunter and Austin 1821*

**R. crispus* L. (Curly Dock).). Thicket edge south of station wetland complex. Infrequent; perennial. *Thompson 98-83*

**R. obtusifolius* L. (Bitter Dock). Roadside edge off Watersport Road at junction with Pacer Point. Infrequent; perennial. *Thompson 98-446*

PONTEDERIACEAE (Water-hyacinth Family)

†*Pontederia cordata* L. (Pickerel Weed). Planted in station wetland complex. Rare; perennial. *Thompson 98-86*

PORTULACACEAE (Purslane Family)

Claytonia virginica L. (Spring Beauty). Mowed station yard by workshop and inside Emma Drive circle. Occasional; perennial. *Thompson 99-38*; *Kozusnicek s.n.*

POTAMOGETONACEAE (Pondweed Family)

Potamogeton pusillus L. (Slender Pondweed). Ponded depression pit adjacent to Boy Scout Trail. Frequent; perennial. *Thompson 99-422*

PRIMULACEAE (Primrose Family)

Lysimachia ciliata L. (Fringed Loosestrife). Roadside ditch at Pacer Point near Watersport Road. Rare; perennial. *Thompson 99-254*

L. lanceolata Walter (Lance-leaf Loosestrife). Low wet woods in ditch. Rare; perennial. *Hunter and Austin 1806*

RANUNCULACEAE (Crowfoot Family)

Anemone virginiana L. (Thimble-weed). Dry-mesic oak-hickory forest, south of Emma Drive. Infrequent; perennial. *Thompson 98-102*; *Beyer s.n.*; *Hunter and Austin 1813*

Anemonella thalictroides (L.) Spach. (Rue Anemone). Dry-mesic oak-hickory forest, along trail to burned old-field restoration prairie at boat dock cove. Occasional; perennial. *Thompson 99-21*; *Abbott 12480*; *Woods 377*

Clematis virginiana L. (Virgin's Bower). Roadside thicket near creek off Watersport Road near Pacer Point. Infrequent; woody vine. *Thompson 98-447*

Myosurus minimus L. (Mousetail). Kentucky Lake gravel shoreline north of boat dock cove. Rare; annual. *Thompson 99-49*

Ranunculus abortivus L. (Small-flowered Buttercup). Mowed station yard on hillside by station wetland complex. Infrequent; biennial. *Thompson 99-08*

o*R. micranthus* L. (Small-flowered Buttercup). Trailside near Aubudon House. Occasional; perennial. *Thompson 99-59*

o**R. parviflorus* L. (Stickseed Crowfoot). Mowed station yard of washhouse and workshop areas. Rare; annual. *Thompson 99-61*

R. recurvatus Poir. (Hooked Crowfoot). Roadside thicket near creek off Watersport Road near Pacer Point. Infrequent; perennial. *Thompson 99-150*

RHAMNACEAE (Buckthorn Family)

Ceanothus americanus L. (New Jersey Tea). Early successional burned old-field restoration prairie. Infrequent; shrub. Thompson 98-149; *Hunter and Austin 1793*

ROSACEAE (Rose Family)

Agrimonia rostellata Wallr. (Beaked Agrimony). Dry-mesic oak-hickory forest, open area adjacent to boat dock cove. Infrequent; perennial. *Thompson 98-549*

Amelanchier arborea (Michx. f.) Fern. (Common Serviceberry). Dry oak-hickory forest, south peninsula cherty hillside. Frequent; subcanopy tree. *Thompson 99-25*; *Woods 378*

Crataegus pruinosa (Wendl.) K. Koch (Frosted Hawthorn). Dry oak-hickory forest, edge of embankment above Kentucky Lake. Rare; small tree. *Thompson 99-278*

Fragaria virginiana Duchesne (Virginia Wild Strawberry). Roadside ditch along Watersport Road. Infrequent; perennial. *Thompson 99-140*

Geum canadense Jacq. (White Avens). Dry-mesic oak-hickory forest, trail to burned old-field restoration prairie. Occasional; perennial. *Thompson 98-209*; *Woods 814*

Porteranthus stipulatus (Muhl.) Britton (Indian Physic). Dry oak-hickory forest, north and south peninsula ridgetops and hillsides. Frequent; perennial. *Thompson 01-100*; *Woods 622*

Potentilla simplex Michx. (Common Cinquefoil). Early successional old-field powerline corridor. Frequent; perennial. *Thompson 99-79*; *Woods 408*

Prunus americana Marshall (American Plum). Edge of gravel trail beside Aubudon Cabin. Rare; small tree. *Thompson 02-218*; *Beard 07*

P. angustifolia Marshall (Chickasaw Plum). Thicket northeast of workshop and west of Aubudon House. Rare; small tree. *Thompson 00-164*; *Woods 978*

P. serotina Ehrh. (Wild Black Cherry). Dry-mesic oak-hickory forest, south of main laboratory building. Frequent; canopy tree. *Thompson 99-99; Abbott 12478*; *Woods 440*

Rosa carolina L. (Pasture Rose). Mid-successional old-fields openings. Occasional; shrub. *Thompson 98-560*; *Woods 615*

**R. multiflora* Thunb. (Multiflora Rose). Early successional burned old-field restoration prairie. Infrequent; shrub. *Thompson 01-176*

R. setigera Michx. (Prairie Rose). Early successional old-field powerline corridor north of Emma Drive. Infrequent; shrub. *Thompson 01-192*

Rubus argutus L. (Common Blackberry). Early successional old-fields, powerline corridor, and forest edges. Frequent; biennial. *Thompson 02-221*

R. flagellaris Willd. (Northern Dewberry). Early successional old-fields north and south of Emma Drive. Frequent; biennial. *Thompson 99-229*; *Woods 441*

RUBIACEAE (Madder Family)

Cephalanthus occidentalis L. (Buttonbush). Shrub swamp, north peninsula and Pacer Point coves of Kentucky Lake. Occasional; shrub. *Thompson 01-206*; *Woods 802*

Diodia teres Walter (Rough Buttonweed). Abandoned gravel road west of Emma Drive by powerline corridor. Frequent; annual. *Thompson 01-246*; *Hunter and Austin 1822; Woods 185*

D. virginiana L. (Virginia Buttonweed). Wetland meadow, Pacer Point by Kentucky Lake. Occasional; annual. *Thompson 99-346*

Galium aparine L. (Cleavers). Early successional old-field poweline corridor north Emma Drive. Occasional; annual. *Thompson 99-119*

G. circaezans Michx. (Wild Licorice). Dry oak-hickory forest, open areas and slopes. Occasional; perennial. *Thompson 02-217*; *Hunter and Austin 1811* o**G. pedemontanum* All. (Piedmont Bedstraw). Mowed station yard enclosed by Emma Drive circle. Rare; annual. *Thompson 98-78*

G. pilosum Aiton (Hairy Bedstraw). Early successional powerline corridor and forest edge. Occasional; perennial. *Thompson 99-316*

G. tinctorium L. (Swamp Bedstraw). Wetland meadow, Pacer Point and station wetland complex. Rare; perennial. *Thompson 98-133*; *Woods 800*

G. triflorum Michx. (Fragrant Bedstraw). Dry-mesic oak-hickory forest, valley northwest of boat dock floodplain. Occasional; perennial. *Thompson 98-425*

Hedyotis caerulea (L.) Hook. (Spring Bluets). Mowed station yard enclosed by Emma Drive circle. Occasional; perennial. *Thompson 99-50*; *Woods 376*

H. canadensis (Willd.) Fosb. (Canada Bluets). Dry oak-hickory forest, south peninsula openings east of Watersport Road. Occasional; perennial. *Thompson 99-135*

H. crassifolia Raf. (Small Bluets). Mowed station yard by Emma Drive circle. Occasional; annual. *Thompson 99-57*; *Abbott 12477*

SALICACEAE (Willow Family)

Populus deltoides Marshall (Eastern Cottonwood). Riparian forest, Pacer Point cove floodplain. Rare; canopy tree. *Thompson 98-327*; Beck 56A

Salix humilis Marshall (Prairie Willow). Early successional old-field near of Boy Scout Trail. Infrequent; shrub *Thompson 99-415*

S. nigra Marshall (Black Willow). Riparian forest, Kentucky Lake gravel shoreline. Occasional; canopy tree. *Thompson 99-239*

SANTALACEAE (Sandlewood Family)

Comandra umbellata (L.) Nutt. (False Toadflax). Dry oak-hickory forest, south peninsula cherty hillside. Infrequent; perennial. *Thompson 99-139*

SAPINDACEAE (Soapberry Family)

**Cardiospermum halicababum* L. (Balloon-vine). Rocky shoreline of cove. Rare; perennial. *Fuller 3006*

SAURURACEAE (Lizard's-tail Family)

Saururus cernuus L. (Lizard's-tail). Shrub swamp, Pacer Point cove floodplain. Infrequent; perennial. *Thompson 99-344*

SAXIFRAGACEAE (Saxifrage Family)

Heuchera americana L. (American Alum-root). Dry-mesic oak-hickory forest, north peninsula east cliffside of above Kentucky Lake. Rare; perennial. *Thompson 98-13*; *Woods 431*

SCROPHULARIACEAE (Figwort Family)

Agalinis tenuifolia (Vahl) Raf. (Slender Agalinis). Early successional old-field around ponded borrow pit. Infrequent; annual. *Thompson 01-616*; *Wagaman 22*; *Woods 323*

Aureolaria flava (L.) Farw. (Smooth False Foxglove). Dry upland oak-hickory forest, east of station wetland complex. Infrequent; perennial. *Thompson 98-615*; *Woods 974*

A. pedicularia (L.) Raf. (Clammy False Foxglove). Dry oak-hickory forest, south peninsula ridgecrest. Infrequent; annual. *Thompson 01-624*; *Koreck 36*

o*Leucospora multifida* (Michx.) Nutt. (Cleft-leaved Conobea). Mowed station yard by asphalt edge of Emma Drive circle. Infrequent; annual. *Thompson 99-361*

Lindernia dubia (L.) Pennell var. *anagallidea* (Michx.) Cooperrider (False Pimpernel). Kentucky Lake gravel shoreline. Frequent; annual. *Thompson 99-437*; *Fuller 3008*

Mecardonia acuminata (Walter) Small (Mecardonia). Kentucky Lake shoreline embankment near Pacer Point. Rare; perennial. *Thompson 98-653*

Mimulus alatus Aiton (Winged Monkey-flower). Wetland meadow, Pacer Point by Kentucky Lake. Infrequent; perennial *Thompson 98-515*

M. ringens L. (Alleghany Monkey-flower). East end of station wetland complex. Rare; perennial. *Thompson 98-494*

Penstemon digitalis Nutt. (Foxglove Beard-tongue). Dry-mesic oak-hickory forest, open area east of picnic area at Kentucky Lake. Infrequent; perennial. *Thompson 99-134*

P. laevigatus Aiton (Smooth Beard-tongue). Abandoned gravel roadside west of Emma Drive by powerline corridor; perennial. *Thompson 01-116; Woods 527*

**Verbascum blattaria* L. (Moth-mullein). Roadside edge of Watersport Road. Rare; biennial. *Thompson 00-168*

**V. thapsus* L. (Great Mullein). North peninsula eastside grassy thicket adjacent to Kentucky Lake. Rare; biennial. *Thompson 98-146*

**Veronica arvensis* L. (Corn-speedwell). Mowed station yard along Emma Drive. Frequent; annual. *Thompson 98-55, 99-88*

**V. peregrina* L. (Purslane-speedwell). Mowed station yard and Kentucky Lake gravel shoreline. Occasional; annual. *Thompson 99-48*

Veronicastrum virginicum (L.) Farw. (Culver's Root). Dry-mesic oak-hickory forest, east hillside of Kentucky Lake. Rare; perennial. *Thompson 99-418*; *Woods 811*

SIMAROUBACEAE (Simarouba Family)

**Ailanthus altissima* (Miller) Swingle (Tree-of-Heaven). North peninsula east cliffside of Kentucky Lake. Rare; canopy tree. *Thompson 01-231*

SMILACACEAE (Greenbrier Family)

Smilax bona-nox L. (Catbrier). Dry-mesic oak-hickory forest, Kentucky Lake shoreline thickets. Occasional; woody vine. *Thompson 98-117*; *Woods 813*

S. glauca Walter (Glaucous Greenbrier). Early successional powerline corridor along Emma Drive. Frequent; woody vine. *Thompson 98-239; Woods 811*

o*S. hispida* Muhl. (Bristly Greenbrier). Dry-mesic oak-hickory forest, north peninsula cove valley. Rare; woody vine. *Thompson 99-223*

S. pulverulenta Michx. (Carrion Flower). Dry-mesic oak-hickory forest, Pacer Point valley. Rare; perennial vine. *Thompson 99-370; Woods 407*

S. rotundifolia L. (Common Greenbrier). Dry-mesic oak-hickory forest, open areas by Kentucky Lake. Frequent; woody vine. *Thompson 99-273; Woods 812*

SOLANACEAE (Nightshade Family)

Physalis pubescens L. (Downy Ground-cherry). Kentucky Lake gravel shoreline near boat dock. Infrequent; annual. *Thompson 99-426*

Solanum carolinense L. (Horse-nettle). Early successional old-field powerline corridor along Emma Drive road shoulder. Rare; perennial. *Thompson 98-339*; *Beck 36B*

S. nigrum L. var. *virginicum* L. (American Black Nightshade). Unmowed station yard along staff cabins trail. Rare; annual. *Thompson 99-396*; *Woods 142*

STAPHYLEACEAE (Bladdernut Family)

Staphylea trifolia L. (American Bladdernut). Dry-mesic oak-hickory forest, on east-trending hillside near north peninsula cove. Rare; shrub. *Thompson 98-266*

STYRACACEAE (Storex Family)

Styrax americanus Lam. (American Snowbell). Shrub swamp, north peninsula and boat dock coves. Infrequent; shrub. *Thompson 99-343*

TYPHACEAE (Cat-tail Family)

Typha latifolia L. (Common Cat-tail). Ponded borrow pit, wet roadside ditch along Emma Drive, and station wetland complex. Frequent; perennial. *Thompson 01-252*

ULMACEAE (Elm Family)

Celtis occidentalis L. (Common Hackberry). North peninsula east cliffline and Kentucky Lake rocky shoreline. Infrequent; canopy tree. *Thompson 02-211*

Ulmus alata Michx. (Winged Elm). Dry oak-hickory forest and mid-successional old-fields. Frequent; canopy tree. *Thompson 98-151*; *Beard 06*; *Beck 74B*; *Kozusnicek 01; Woods 890*

U. americana L. (American Elm). North peninsula east cliffline and Kentucky Lake gravel shoreline. Occasional; canopy tree. *Thompson 98-220*; *Beck 67A*

U. rubra Muhl. (Slippery Elm). Dry-mesic oak-hickory forest, north peninsula and powerline corridor along Emma Drive. Frequent; canopy tree. *Thompson 98-164*; *Woods 891*

URTICACEAE (Nettle Family)

Boehmeria cylindrica (L.) Swartz. (False Nettle). Pacer Point and north peninsula floodplains. Frequent; perennial. *Thompson 98-292*; *Hunter and Austin 1799*; *Woods 80*

Pilea pumila (L.) A. Gray (Clear-weed). Boat dock cove floodplain by Kentucky Lake. Occasional; annual. *Thompson 98-441*

VALERIANACEAE (Valerian Family)

Valerianella radiata (L.) Dufr. (Corn Salad). Roadside ditch by powerline corridor along Emma Drive. Occasional; annual. *Thompson 99-74*; *Woods 519*

VERBENACEAE (Vervain Family)

Phyla lanceolata (Michx.) Greene (Frog-fruit). Wetland meadow, Pacer Point and station wetland complex. Occasional; perennial. *Thompson 01-240*

Phyrma leptostachya L. (Lopseed). Dry-mesic oak-hickory forest, Pacer Point valley by creek. Infrequent; perennial. *Thompson 98-279*

Verbena simplex Lehm. (Narrow-leaved Vervain). Unmowed road shoulder at station near entrance gate of Emma Drive. Rare; perennial. *Thompson 98-50; Woods 742*

V. urticifolia L. (White Vervain). Wetland meadow, Pacer Point. Infrequent; perennial. *Thompson 98-436; Woods 809*

VIOLACEAE (Violet Family)

Viola palmata L. (Lobed Wood Violet). Dry-mesic oak-hickory forest, west of Wolfson House driveway. Occasional; perennial. *Thompson 99-65*

V. pedata L. (Bird's-foot Violet). Dry oak-hickory forest, south peninsula cherty opening off Watersport Road. Occasional; perennial. *Thompson 99-78; Woods 439*

V. rafinesquii Greene (Field Pansy). Mowed station yard and powerline corrodor near workshop. Frequent; annual. *Thompson 99-36*

V. sororia Willd. (Meadow Violet). Mowed station yard around station wetland complex. Frequent; perennial. *Thompson 99-09*

VITACEAE (Grape Family)

o*Ampelopsis cordata* Michx. (Raccoon Grape). Dry-mesic oak-hickory forest, woodland edge west of Wolfson House driveway. Infrequent; woody vine. *Thompson 99-364*

Parthenocissus quinquefolia (L.) Planchon (Virginia Creeper). Dry and dry-mesic oak-hickory forests, ubiquitous. Abundant; woody vine. *Thompson 01-208*

Vitis aestivalis Michx. (Summer Grape). Dry and mesic oak-hickory forests. Frequent; woody vine. *Thompson 98-118*; *Woods 898*

V. palmata Vahl (Swamp Grape). Riparian forest, Pacer Point and boat dock cove floodplains. Rare; woody vine. *Thompson 01-217*

V. rotundifolia Michx. (Muscadine Grape). Riparian forest and boat dock, north peninsula, and Pacer Point cove floodplains. Abundant; woody vine. *Thompson 01-114; Woods 899*

APPENDIX 2

PLANT COLLECTORS AT HANCOCK BIOLOGICAL STATION.

Collectors	Collections	Collecting Dates	Percent(%)
Thompson, Ralph L.	552	1998-2002	69.4
Woods, Michael	120	1981-1982	15.0
Beck, Joe	38	1969	4.8
Hunter, Gordon E.	30	1966	3.8
Abbott, J. Richard	16	1999	2.0
Fuller, Marian J.	11	1986	1.4
Beard, William	5	1969	0.6
Kozusnicek, Frederick	5	1969	0.6
Adams, Burnetta	4	1966	0.5
Obourn, J. S.	3	1969	0.4
Beyer, Blake	2	1988	0.3
Wagaman, Deborah A.	2	1980	0.3
Sparks, Dale W.	1	1991	0.1
Koreck, Kimberly	1	1989	0.1
Alverson, Leland	1	1988	0.1
Hemberger, Tracy	1	1987	0.1
Hildebrandt, Christine	1	1987	0.1
Green, Loren J.	1	1969	0.1
McLemore, William N.	1	1969	0.1
Winstead, Ann	1	1969	0.1
SUMMARY: Collectors-20	795	1966-2002	100.0

ETHYLENE AS A POSSIBLE CUE FOR SEED GERMINATION OF *SCHOENOPLECTUS HALLII* (CYPERACEAE), A RARE SUMMER ANNUAL OF OCCASIONALLY FLOODED SITES

CAROL C. BASKIN[1,2,3], JERRY M. BASKIN[1,3], EDWARD W. CHESTER[3] AND MARIAN SMITH[4]

[1]Department of Biology, University of Kentucky, Lexington, Kentucky 40506
[2]Department of Agronomy, University of Kentucky, Lexington, Kentucky 40546
[3]Center for Field Biology, Austin Peay State University, Clarksville, Tennessee 37044
[4]Department of Biological Sciences, Southern Illinois University, Edwardsville, Illinois 62026

ABSTRACT. **The purpose of our research was to determine why seeds of *Schoenoplectus hallii* germinate only in some wet years. Seeds mature in autumn, at which time they are dormant. Seeds come out of dormancy under natural temperature conditions in Kentucky during winter, if buried in nonflooded, moist soil, but they remain dormant if buried in flooded soil. Nondormant seeds require flooding, light, and exposure to ethylene to germinate. One piece of apple in water (1/12 of an apple in 125 ml of water in a glass jar for a depth of 5 cm) or a 1 µM solution of ethephon, an ethylene (C_2H_4) releasing compound, elicited very similar (high) germination percentages and vigor of seedlings. Apple, which was shown to produce ethylene in the air space of the jar, was used in a series of experiments to better understand germination. Seeds germinated to 72% if apple was removed from the water after 1 day of incubation, and they germinated to 97% if seeds were washed and placed in fresh water after 3 days of exposure to apple. No seeds germinated in the control with no apple. Seeds incubated in apple leachate for 5 days and then transferred to filter paper moistened with distilled water germinated to 90%. Minimum depth of flooding in apple leachate (no soil in jars) for optimum germination was ≥3 cm. Buried seeds of *S. hallii* exhibited an annual conditional dormancy/nondormancy cycle. Regardless of the month in which seeds were exhumed, they germinated to 59-100% in light in water with apple at daily alternating temperature regimes of 25/15, 30/15, and 35/20°C, but germination at 20/10°C (and to some extent at 15/6°C) tended to peak in autumn to spring. Thus, seeds can germinate throughout the summer if flooded (ethylene production) and exposed to light. An ethylene cue for germination serves as a "flood-detecting" mechanism and may serve as an indirect signal that water is available for completion of the life cycle and competing species are absent.**

APPLICATION OF THE TERM "CEDAR GLADES" TO VEGETATION TYPES IN PHYSIOGRAPHIC REGIONS OUTSIDE THE CENTRAL BASIN OF TENNESSEE

JERRY M. BASKIN[1,3] AND CAROL C. BASKIN[1,2,3]

[1]Department of Biology, University of Kentucky, Lexington, Kentucky 40506
[2]Department of Agronomy, University of Kentucky, Lexington, Kentucky 40546
[3]Center for Field Biology, Austin Peay State University, Clarksville, Tennessee 37044

ABSTRACT. **At the 1995 meeting of this group, JMB presented a talk entitled "Use of the term 'cedar glades' for a type of vegetation in the Central Basin of Tennessee: An historical perspective and some misinterpretations" [see abstract (p. 311) in Proc. 6th LBL Symp. 1995]. He showed that (1) historically "cedar glades" has been used by geologists, botanists, soil scientists, and zoologists to describe the rocky openings/redcedar/redcedar-hardwood (and sometimes even hardwood) forest complex, which was (is) especially abundant on the Lebanon limestone in the Inner Basin, and (2) "cedar glades," "limestone glades," and "limestone cedar glades" increasingly are being used in reference to the rocky (treeless, or nearly so) openings only, which have C_4 native annual grass/C_3 annual-perennial forb/cryptogam-dominated vegetation. The purpose of the 2003 talk is to review use of the term "cedar glades" as a descriptive term for certain types of vegetation *outside* the Central Basin. In brief, the term has been applied to a variety of plant communities in several states and physiographic regions in the eastern United States, including: open limestone glades ("glades"), xeric limestone prairies (limestone prairie barrens) with Little bluestem (*Schizachyrium scoparium*), redcedar-perennial prairie grass savanna, redcedar forest with open limestone flats, redcedar forest, redcedar/Ashe's juniper forest with dry-site hardwoods, redcedar-hardwood forests with rocky openings, and even to an open forest of redcedar-shortleaf pine-sweetgum with *Andropogon* spp. and *Schizachyrium scoparium* dominant in the openings. In the Great Lakes region (US and Canada), on the Paleozoic limestone islands of Gotland and Öland in southeast Sweden, and in the Baltic state of Estonia, rock outcrop vegetation very similar to that of open cedar glades of southeastern United States is included under "alvars."**

QUANTITATIVE VEGETATION ANALYSIS OF XERIC LIMESTONE PRAIRIES IN THE OUTER BLUEGRASS AND MISSISSIPPIAN PLATEAUS PHYSIOGRAPHIC REGIONS OF KENTUCKY: A PROGRESS REPORT

P.J. LAWLESS, JERRY M. BASKIN, AND CAROL C. BASKIN

Department of Biology, University of Kentucky, Lexington, Kentucky 40506

ABSTRACT. Xeric limestone prairies (sensu J.M. Baskin, C.C. Baskin, and E.W. Chester 1994. *Castanea* 59: 226-254; J.M. Baskin and C.C. Baskin 2000. *Ann. Missouri Bot. Gard.* 87: 286-294) are characterized by shallow rocky soils, dominance of C_4 perennial grasses (*Schizachyrium scoparium*, *Sorghastrum nutans*, *Andropogon gerardii*, and/or *Bouteloua curtipendula*), a forb flora rich in species of Asteraceae, and susceptibility to woody plant invasion. I (PJL) used a nested subquadrat sampling design adapted from Peet et al. (R.K. Peet, T.R. Wentworth, and P.S. White 1998. *Castanea* 63: 262-274) to quantitatively sample seven xeric limestone prairies in Kentucky. Sample sites were located in the Shawnee (n =1), Highland Rim (n = 4), and Outer Bluegrass (n = 2) sections of the Interior Low Plateaus physiographic province. I determined frequency at multiple scales (0.01, 0.1, 1.0, 10, and 100 m^2), estimated cover (10 cover classes) in 100-m^2 quadrats, and used relative cover and relative frequency values in 100-m^2 quadrats to calculate importance values for each species within a site. I recorded 191 species in the 4200 m^2 (42 100-m^2quadrats) sampled. The three families with highest species richness were Asteraceae (34 species), Poaceae (15 species), and Fabaceae (13 species). This plant community is also rich in *Carex spp.*, but all of them have not yet been identified. *Schizachyrium scoparium* had the highest importance value in all seven sample sites. However, *Sporobolus vaginiflorus*, a C4 summer annual grass, was in the highest cover class (class 6, 10-25% or class 7, 25-50%) in 14 of 42 100-m^2 quadrats. *Echinacea simulata* had the highest importance value of all forbs in five of the seven sites. Trees and shrubs comprised 12.6% of the flora. *Juniperus virginiana* and *Cercis canadensis* ranked first or second in percent relative frequency of trees in four of the seven sites. Only four of the 191 species were exotics.

ECOLOGICAL LIFE CYCLE OF THE WINTER ANNUAL *CHAEROPHYLLUM PROCUMBENS* VAR. *SHORTII* (APIACEAE)

CAROL C. BASKIN[1,2], TRACY S. HAWKINS[1*], AND JERRY M. BASKIN[1]

[1]Department of Biology, University of Kentucky, Lexington, Kentucky 40506
[2]Department of Agronomy, University of Kentucky, Lexington Kentucky 40546

ABSTRACT. Seed dormancy and germination, flowering, and biomass allocation patterns of the deciduous forest species *Chaerophyllum procumbens* var. *shortii* were investigated relative to its winter annual life cycle. Seeds of this species have morphophysiological dormancy (MPD) at maturity and dispersal in late May. In the laboratory, high temperatures (30/15, 35/20 °C) promoted, and low temperatures (5, 15/6 °C) inhibited, loss of physiological dormancy (PD); thus, in nature the physiological component of MPD is broken during summer. Embryos grew, i. e., the morphological component of MPD was broken, after the loss of PD, and light was required for embryo growth (from 0.5 to 4.6 mm in length before seeds can germinate) in a high percentage of the seeds. Since seeds required warm but not cold stratification for loss of PD and subsequent embryo growth and germination, they have nondeep simple MPD. Under natural seasonal temperature conditions, seeds sown in late spring germinated only in autumn; however, germination of some seeds was delayed until the second to fifth autumn after sowing. Thus, the species has the potential to form a small persistent seed bank. Plants exposed or not to low autumn-winter temperatures flowered; thus, vernalization is not required for flowering. In field populations, plant growth and development occurred while the trees were leafless, *i. e.*, during autumn, winter, and early spring, and plants reached highest total plant biomass [0.28 ± 0.12 g (mean ± SD)] at flowering. Total plant biomass decreased from flowering to mericarp maturity due to loss of root and leaf mass, which was concurrent with canopy closure. The proportion of total biomass allocated to roots (≤24.0%) at five growth stages was less than that allocated to other plant structures in two successive annual cohorts. Changes in biomass allocation during reproductive growth stages occurred only in above-ground structures, and reproductive allocation (22.7 ± 1.2% and 36.0 ± 2.9%) differed significantly between years. Although mass of reproductive structures was strongly correlated (2000 cohort, r^2 = 0.8692; 2001 cohort, r^2 = 0.9621) with plant vegetative mass, differences in slopes of the regressions (P = .0044) between years indicated that between cohort differences in percent allocation were not completely accounted for by overall plant size.

DETERMINING SOLAR INTENSITY WITH SURROGATE AND DIRECT MEASUREMENTS AT ARNOLD AIR FORCE BASE, TENNESSEE: A CASE STUDY IN ADAPTIVE MONITORING

KEVIN FITCH

Arnold Air Force Base, Tullahoma, Tennessee 37389

ABSTRACT. Determination of solar intensity is critical to the monitoring of target plant communities and Barrens restoration sites at Arnold Air Force Base (AAFB), TN. Barrens restoration goals include reducing the percent cover of canopy species and increasing the percent cover of ground-cover species. Reducing canopy cover is thought to be important for increasing solar radiation reaching the ground and stimulating growth of forbs and graminoids. Canopy cover, a surrogate for solar intensity, was measured within restoration sites and tracked in relation to changes in ground cover following management. The GRS-densitometer and spherical-densiometer were used to measure canopy intercepts overhead and determine percent canopy cover, but were limited in their applicability over large sites and various habitat types. These sampling devices can require substantial time to characterize canopy cover within a single restoration site due to the spatial heterogeneity and large sample sizes required for precise estimates. These devices are not effective in savanna, shrubland, or other structurally complex habitat types. Direct measures of solar intensity can be superior to these surrogates due to their wider applicability and greater efficiency. Methods evaluating direct solar intensity include digital and analog measurements. Evans (2002) indicated that digital hemispherical vertical photographs can be collected in a wide variety of habitat types and with computerized post-processing can measure direct and diffuse solar intensity. Digital hemispherical photography is costly and susceptible to varying weather conditions that make direct comparisons problematic. Analog measures of direct solar intensity can be obtained with a Solar Pathfinder™ (SP) a device originally developed to aid in the placement of solar panels. The device can be used to determine maximum potential solar intensity for any month of the year. Swenson (1999) used the SP to characterize solar intensity and its effects on establishment of prairie and savanna species along light gradients in southern Wisconsin. Swenson and Beilfuss (2001) evaluated the SP and hemispherical vertical photography and noted that the SP is a viable alternative to hemispherical vertical photography due to the accuracy of the acquired data and the minimal investment of resources. Baseline SP data were collected at AAFB to determine the applicability of the device in various habitat types. Results were used to evaluate the various solar measurement devices for vegetation monitoring at AAFB. The sampling devices were evaluated using the following criteria: type of solar measurement (i.e., direct and surrogate measures), technical complexity, statistical power and sample size requirements, protocol requirements, durability, weather limitations, time requirements, and cost. Results indicate that the SP is a superior method for estimating direct solar intensity due to sampling efficiency when compared to surrogate methods and lower cost and technical complexity when compared to digital hemispherical vertical photography.

A FLORISTIC INVENTORY OF RATTLESNAKE FALLS, A POTENTIAL STATE NATURAL AREA ON THE HIGHLAND RIM ESCARPMENT IN TENNESSEE

L. DWAYNE ESTES AND JEFFREY L. WALCK

Department of Biology, Middle Tennessee State University, Murfreesboro, Tennessee 37132

ABSTRACT. Rattlesnake Falls is located in the escarpment portion of the Western Highland Rim in Maury County, Tennessee. The vascular flora of this 62.5-ha area was sampled from February 2000 to August 2001. Six hundred and six species and infraspecific taxa representing 341 genera and 107 families were found. Families with the largest number of species were Asteraceae, Poaceae, and Fabaceae. Rare plant taxa at Rattlesnake Falls included the federally threatened species *Helianthus eggertii* and probably *Apios priceana*. Species listed at the state level as threatened were *Lilium michiganense* and *Juglans cinerea*, and as special concern were *Aster oolentangiensis*, *Castanea dentata*, *Phlox pilosa* ssp. *ozarkana*, and *Parnassia grandifolia*.

TROPICAL FOREST RESTORATION IN PANAMA: EVALUATING SEED DORMANCY OF POTENTIAL FRAMEWORK SPECIES FOR NURSERY PLANNING

ADRIANA SAUTU

Department of Biology, University of Kentucky, Lexington, Kentucky 40506, and
Smithsonian Tropical Research Institute, Panama

ABSTRACT. The "framework species" method involves planting 20-30 local tree species that promote more rapid natural succession. Nursery production for a wide range of mostly unknown tree species is a challenge for nursery managers in countries with a seasonal tropical forest. Eighty-one potential framework species native to the Panama Canal Watershed were evaluated based on germination studies in conditions similar to those in a commercial nursery. Collection of the seeds was complicated by lack of enough phenological information. Forty species had a germination percentage of 50% or greater without pretreatment. Median length and mean length of the germination period (MLG) were calculated as a measure of rate of germination, and they were highly correlated. Similarly, close correlation was found between the standard deviation of germination and total length of germination period as a measure of synchrony. Using definitions similar to those of D. Blakesley et al. 2002 (For. Ecol. Manage. 164:31-38), the germination was considered rapid if MLG was 21 days or less, intermediate if it was more than 21 and less than 84, and slow if it was 84 days or more. The majority of the species had rapid or intermediate germination (47% and 41%, respectively), and 10 species (12%) had slow germination. There are two peaks of fruit production: at the end of the dry season and before the end of the rainy season. If no pretreatment is applied, and considering the MLG, there will be an "overlap" of time for species seed collection and seedling production during most parts of the year.

SITE PREFERENCES OF *CASTANEA DENTATA* ON THE HIGHLAND RIM OF KENTUCKY AND TENNESSEE

T. CLINT NEEL

Tennessee Technological University, Cookeville, Tennessee 38505

ABSTRACT. Through field inspection of chestnut sites across middle Tennessee and south central Kentucky, trends were observed linking these sites by similar geomorphologic characteristics. To test this hypothesis, GPS locations and site characteristics were recorded during the past year at 44 chestnut sites, mostly on the Highland Rim with a few in the Outer Basin. Data on 230 chestnut trees were gathered and soil samples were obtained at some sites. These locations were overlain on GIS coverages containing topographic, physiographic, geologic, and State Soil Geographic Database (STATSGO) themes and were correlated with soil series using county soil surveys. Trends, such as an affinity of *Castanea dentata* for the Fort Payne Geologic Formation, and particular topography and soil series were observed from these overlays. Additional generalizations were made concerning the geographic distribution of fruiting chestnut trees and chestnut blight (*Cryphonectria parasitica)* occurrence. Effects of other pathogens such as *Phytophthora cinnamomi* and *P. cambivora* (ink-root disease fungi) and their possible relation to specific chestnut site preferences were studied.

EFFECTS FROM MANAGEMENT OF THE NONNATIVE SHRUB *LIGUSTRUM SINENSE* ON NATIVE VEGETATION

KYLE D. HURT[1,2], RACHAEL B. SULKERS[1], JEFFREY L. WALCK[1], AND SITI N. HIDAYATI[1]

[1]Department of Biology, Middle Tennessee State University, Murfreesboro, Tennessee 37132
[2]Stones River National Battlefield, 3501 Old Nashville Highway, Murfreesboro, Tennessee 37129

ABSTRACT. Nonnative woody plants, especially *Ligustrum sinense* (Chinese privet), are targets of an eradication program at the Stones River National Battlefield in Rutherford County, Tennessee. This effort has been largely focused in the *Juniperus virginiana – Forestiera ligustrina* woodland that surrounds the cedar (limestone) glades. Management practices involve hand-cutting of plants by National Park Service personnel and by park volunteers, and application of herbicides to stumps by NPS staff. Park volunteers are trained in the identification of plants before any removal occurs. The purposes of the present study were to ascertain the (1) effects of management practices done by NPS staff versus volunteers, and (2) resemblance of treated sites to a noninvaded site and potential for vegetation recovery. Vegetation was surveyed along a transect placed into each of the following sites at the Battlefield: woody exotics removed by NPS staff, woody exotics removed by volunteers, and nontreated but invaded by *L. sinense*. Another transect was established at the nearby Flat Rock State Natural Area where *L. sinense* has not heavily invaded. Ten 1-m^2 plots were established at 5 m intervals along each 50-m transect. For each species, the number of individuals (or clumps) was counted and coverage was classified into (Daubenmire) classes. Woody species were assigned to three strata layers: seedling/sapling, shrub/small tree, and tree canopy. In addition, coverages of leaf litter, bare soil, rock, and bryophytes were determined. Density and cover of woody exotics significantly (P £ 0.05) decreased on treated sites, especially so in the one done by volunteers. Although species richness, density, and cover of native trees and shrubs in the NPS-treated site were significantly higher than the volunteer site, neither one differed significantly from the invaded site. On the other hand, richness, density, and cover of native herbaceous plants significantly decreased on both treated sites apparently due to trampling. The NPS site resembled the noninvaded site in terms of richness, density, and/or cover of native trees, shrubs, vines, forbs, and graminoids but not ferns. Ferns were present only in the treated site. Moreover, coverage of leaf litter was significantly lower in the treated site than in the noninvaded one. Regeneration of native trees and shrubs in the NPS site was similar to that in the noninvaded site, but woody exotics had a dramatically higher amount of regeneration. Although management practices have been effective in removing *L. sinense* from the woodland community, continued efforts will be needed for full recovery of the vegetation.

EFFECTS OF THE NONNATIVE SHRUB *LIGUSTRUM SINENSE* ON NATIVE HERBACEOUS AND WOODY VEGETATION

RACHAEL B. SULKERS[1], KYLE D. HURT[1,2], JEFFREY L. WALCK[1], AND SITI N. HIDAYATI[1]

[1]Department of Biology, Middle Tennessee State University, Murfreesboro, Tennessee 37132
[2]Stones River National Battlefield, 3501 Old Nashville Highway, Murfreesboro, Tennessee 37129

ABSTRACT. Several species of nonnative woody plants, particularly *Ligustrum sinense* (Chinese privet), have invaded the *Juniperus virginiana – Forestiera ligustrina* woodland that surrounds the cedar (limestone) glades in middle Tennessee. The purpose of the present study was to explore the effects of *L. sinense* on the structure and composition of native herbaceous and woody vegetation in the woodland community. The vegetation was surveyed along two 50-m transects placed at each of two sites in Rutherford County, Tennessee: Flat Rock State Natural Area, containing a very low abundance of *L. sinense*, and Stones River National Battlefield, which is infested with the species. Ten 1-m^2 plots were established at 5 m intervals along each transect. For each species, the number of individuals (or clumps) was counted and coverage was classified into (Daubenmire) classes. Woody species were assigned to three strata layers (seedling/sapling, shrub/small tree, tree canopy). Coverages of leaf litter, bare soil, rock, and bryophytes also were determined. Species richness, density, and cover of native trees and shrubs were significantly (*P* £ 0.05) higher, and those of ferns lower, in the noninvaded site than in the invaded site. Richness and cover of native forbs were lower in the noninvaded than in the invaded site, but cover of native graminoids was higher. On the other hand, density and/or cover of native trees, shrubs, vines, forbs, and graminoids significantly decreased with an increase in density and cover of woody exotics. Considering all ground cover, only leaf litter significantly differed between sites, being greater in the noninvaded site. Regeneration of important native trees and shrubs was significantly reduced in the invaded site compared to the noninvaded one. However, regeneration of the exotic woody plants was dramatically higher than the native ones. Our results show that with exotic species invasion in the middle Tennessee woodland community decreases in (1) richness, density, and cover of native herbaceous and woody vegetation can be expected, and (2) nutrient cycling might occur due to a decrease in leaf litter decomposition.

SEED GERMINATION ECOLOGY OF THE RARE TENNESSEE PLANT, YELLOW SUNNYBELL (*SCHOENOLIRION CROCEUM*)

JEFFREY L. WALCK AND SITI N. HIDAYATI

Department of Biology, Middle Tennessee State University, Murfreesboro, Tennesee 37132

ABSTRACT. Seeds of *Schoenolirion croceum* (Michx.) Wood are dispersed in late spring/early summer in middle Tennessee. Germination occurs in autumn if fresh seeds are buried in soil following dispersal, whereas it takes place in late winter/early spring if they are sown on the soil surface. To determine the cause(s) for this difference in germination phenology, we examined the temperature and light requirements for dormancy break and germination. Fresh seeds did not germinate during 2 weeks of incubation at alternating thermoperiods of 15/6, 20/10, 25/15, 30/15, and 35/20°C in light or darkness. No seeds germinated during 2 weeks of incubation at 15/6-35/20°C in light following 12 weeks of warm stratification at 25/15°C in light, whereas 80-95% germinated in darkness following warm stratification in darkness. On the other hand, seeds germinated to 1-69% in light and 17-93% in darkness during 2 weeks of incubation at 15/6-35/20°C following 12 weeks of cold stratification at 5°C in light and darkness, respectively. If seeds were exposed to light during simulated summer (30/15-35/20°C), autumn (15/6-20/10°C), and winter/early spring (5°C) temperatures, they germinated to high percentages in winter/early spring. Seeds exposed to light during summer and darkness during autumn and those exposed to darkness during both summer and autumn germinated to high percentages in autumn. However, seeds exposed to darkness during summer and light during both autumn and winter/early spring germinated to high percentages in winter/early spring. Thus, light conditions during autumn are critical for determining whether seeds will germinate in autumn or winter/early spring. In contrast to many other species in which germination phenology is mostly controlled by temperature, the timing of germination for *S. croceum* depends on the light conditions in relation to temperatures experienced during dormancy release.

EPICOTYL DORMANCY IN THE MESIC WOODLAND HERB *HEXASTYLIS HETEROPHYLLA* (ARISTOLOCHIACEAE)

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

[1]Department of Biology, University of Kentucky, Lexington, Kentucky 40506
[2]Department of Agronomy, University of Kentucky, Lexington, Kentucky 40546

ABSTRACT. The purpose of this study was to determine the kind of dormancy in seeds of the mesic woodland herb *Hexastylis heterophylla* (Ashe) Small (Aristolochiaceae). The only other known report for seed germination in *Hexastylis* spp. was from V.C. Gonzalez's 1972 dissertation, in which he stated that seeds of *H. arifolia* require two cold periods (i.e., two winters) to come out of dormancy. Seeds of *H. heterophylla* were incubated in two sequences of temperature regimes: (a) warm -> cool -> cold -> cool -> warm, and (b) cold -> cool -> warm -> cool -> cold -> cool -> warm. These two sequences were used to determine whether seeds need warm only, cold only, or warm + cold to break dormancy. In the first sequence, roots emerged during the first cool period ("autumn") and shoots during the second cool period ("spring"). In the second sequence, roots emerged during the second cool period ("autumn") and shoots during the third cool period ("spring"). Thus, in seeds of *H. heterophylla* a period of warm temperatures is required for subsequent emergence of roots at cool ("autumn") temperatures, and a period of cold ("winter") temperatures is required for subsequent emergence of epicotyls (shoots) at cool ("spring") temperatures (in seeds with roots emerged). These dormancy-breaking and germination requirements demonstrate clearly that seeds of this species have deep simple epicotyl morphophysiological dormancy (epicotyl dormancy). They do not have deep simple double morphophysiological dormancy (double dormancy) as reported for *H. arifolia* by Gonzalez. Epicotyl and double dormancy are two of the eight types of morpholphysiological dormancy (MPD), all of which are characterized by an underdeveloped embryo and a physiological inhibiting mechanism of germination. Seeds of *H. heterophylla* clearly have epicotyl dormancy as do the seeds of *Asarum canadense* (Aristolochiaceae) another herb of mesic woodlands of eastern North America (Jerry and Carol Baskin, 1986, Am. Midl. Nat. 116: 132-139.) It seems unlikely that *H. arifolia* has double dormancy, since in addition to being a close relative of *H. heterophylla*, the life cycle and habitat of the two species are very similar.

FLORISTIC STUDIES WITHIN THE DUCK RIVER UNIT OF THE TENNESSEE NATIONAL WILDLIFE REFUGE, HUMPHREYS COUNTY, TENNESSEE

STEPHANIE M. GUNN AND EDWARD W. CHESTER

Department of Biology, Austin Peay State University, Clarksville, Tennessee 37044

ABSTRACT. The Duck River Unit of the Tennessee National Wildlife Refuge includes 10,817 ha in Humphreys County, Tennessee. It is managed by the United States Fish and Wildlife Service, primarily to provide food, water, and cover for resident, migratory, and over-wintering waterfowl. Most of the unit is bottomlands of the impounded Tennessee and lower Duck Rivers (Kentucky Reservoir) that were agricultural prior to 1945. Management practices include wildlife plantings, agricultural production, and pools where dams and watergates allow water-level manipulations. Wetland habitat and community types include swamps, sloughs, marshes, wet meadows, dewatered zones, permanent deep water, variable shorelines, and bottomland forests. Although limited in area, uplands with secondary forests, successional fields, bluffs and outcrops, home sites, and cemeteries add to habitat diversity. Forty-nine collecting trips in 2001--2003 documented the vascular flora that is known to include 95 families, 408 genera, and 718 species. Over one-half of the species encountered were county records and one [*Echinochloa walteri*] was a state record. Introduced taxa (121) constitute almost 17 percent of the flora; 145 taxa (20.2 percent) are woody. Large families are the Asteraceae (86 taxa), Poaceae (81), Cyperaceae and Fabaceae (42 each), Lamiaceae (24), Scrophulariaceae (20), Rosaceae (18), and Fagaceae (17). Large genera are *Carex* (21 species), *Quercus* (16), *Cyperus* and *Solidago* (9 each), and *Desmodium, Eupatorium,* and *Polygonum* (8 each). Six taxa are on the Tennessee elements of concern list: *Echinochloa walteri* (Pursh) Heller (special concern), *Heteranthera limosa* (Sw.) Willd. (endangered), *Liparis loeselii* (L.) Rich. (endangered), *Sagittaria brevirostra* Mack. & Bush (threatened), *Scirpus fluviatilis* (Torr.) Gray (special concern), and *Spiranthes odorata* (Nutt.) Lindl. (endangered).

THE VASCULAR FLORA OF FORT DONELSON NATIONAL BATTLEFIELD AND CEMETERY, STEWART COUNTY, TENNESSEE

EDWARD W. CHESTER

Department of Biology, Austin Peay State University, Clarksville, TN 37044

ABSTRACT. Fort Donelson National Battlefield and Cemetery is a 250-ha (600-acre) historic site in Stewart County, northwestern Middle Tennessee, that preserves the site of a major Civil War battle. The impounded Cumberland River (Lake Barkley) forms the northern boundary. The northwestern boundary is Hickman Creek; other boundaries are without natural demarcations. Indian Creek bisects the Park, generally running south to north. The river, and lower sections of both creeks, are subjecting to fluctuating water levels of about five feet between winter (low levels) and summer pools (water levels are controlled by the U.S. Army Corps of Engineers at Barkley Dam, approximately 58 river miles downstream and to the northwest). The topography is mostly dissected uplands with ridges, slopes of various aspects, and ravines. Habitat types range from older hardwood forests, successional fields, limestone outcrops, cultural sites, and mudflats as waters decline in autumn. This paper reports the results of floristic studies from 1982-1985 and from 2000-2002, with occasional visits between. As now known, the vascular flora consists of 718 taxa representing 110 families and 395 genera. Nearly 23 percent (163 species) of the flora is not indigenous. The largest families are the Asteraceae (94 taxa), Poaceae (90), and Fabaceae (49). The largest genera are *Carex* (23 taxa), *Quercus* (13), and *Eupatorium* and *Polygonum* (12 each). Six taxa are state-listed; one of these is federal-listed.

CONTRIBUTED PAPERS

SESSION II: AQUATIC BIOLOGY AND ZOOLOGY

Saturday, March 22, 2003

Moderator and Editor:

A. Floyd Scott
Austin Peay State University

USING THE STATISTICAL PROPERTIES OF AN INDEX OF BIOTIC INTEGRITY TO EXAMINE TEMPORAL CHANGES IN STREAM HEALTH IN CREEKS OF SOUTH-CENTRAL KENTUCKY

ZACCHAEUS COMPSON, ROBERT D. HOYT, AND WILLIAM J. OLIVER

Department of Biology, Center for Biodiversity Studies
Western Kentucky University, Bowling Green, KY 42101

ABSTRACT. In an effort to detect temporal changes in ecological studies, scientists are often faced with one of two dilemmas involving data collection practices: 1) having few sites with multiple replicates or 2) having multiple sites with few replicates. In monitoring studies over large geographic regions, this sacrifice of replication translates to an inability to achieve statistical power. In some cases, valuable long-term data sets lack enough replication to conduct traditional statistics, such as ANOVA or t-tests, which limits the ability to perform important site-specific comparisons. This study involves a long-term data set with multiple sample sites but few replicates. The data include 17 sampling sites representing 10 creeks in south-central Kentucky. An initial sampling survey took place from 1969 to 1975 and a second survey was conducted from 1999 to 2001. The problem of low replication was resolved by using the inherent statistical properties of an Index of Biotic Integrity (IBI). IBI values have been demonstrated to represent significant changes in stream condition in the local region when differences greater than +/- 4 points occur. Using this criterion, significant differences were found in 11 of the 17 sampling sites, with 7 of the 11 altered sites demonstrating a decrease in biotic integrity. Of the degraded sites, all but two are proposed to have been affected by increased anthropogenic activity, such as residential or agricultural development. All but one of the sites that displayed increased biotic integrity were influenced by the introduction of low-water bridges, which expand fish habitat by scouring down-stream of the culvert. Based on the results of this study, we conclude IBI metrics to be powerful monitoring tools capable of detecting biological changes in conditions over time.

INTRODUCTION

For decades scientists have been trying to establish ways to detect changes in stream condition over time (Ross et al. 1987, Hansen and Ramm 1994, Taylor et al. 1996). Throughout the 1980s and 1990s, much of the seminal temporal work in stream ecology sought to address the issue of temporal assessments by using one of two multivariate techniques: 1) multiple regression to determine temporal effects on variables over time (Matthews 1990) or 2) multivariate techniques such as principle components analysis (PCA) or detrended correspondence analysis (DCA) to uncover large-scale trends in the data (Matthews 1985, Hoyt et al. 2001).

The regression technique has proven useful in fairly short-term studies in which sufficient replication has taken place over discrete time intervals to allow for regression techniques to be implemented. Quinn (1980), for example, implemented a study in which dermersal fish were sampled every fortnight from November 1975 to April 1977. Using multiple regression techniques, he demonstrated that fish assemblages are temperature-stabilized and determined correlations between rainfall and salinity values, allowing for postulations on the commonality between tropical and temperate estuaries in the maintenance of community cycles.

Unfortunately, intensive temporal studies such as that of Quinn (1980) seldom include data much over one or two years. More commonly, studies have utilized multivariate techniques such as PCA or DCA to make broad-scale assessments of changing macroinvertebrate or fish communities. Lienesch et al. (2000) was able to detect slight seasonal changes in a small stream isolated by a reservoir by analyzing two river surveys (1954-1955 and 1995) using DCA. However, as is often the case in long-term, multiple-survey studies, DCA revealed little change in fish assemblages from 1955 through 1995.

In rare cases, fairly short-term studies have been able to illuminate temporal trends using multivariate statistics. Taylor et al. (1996) demonstrated significant spatial (tributary vs. main-stem) and temporal differences in 10 sites of the upper Red River Basin in Oklahoma. Though it is not unusual to uncover these spatial relationships using multivariate techniques, temporal differences are harder to detect and often require, as in this case, where flooding was suspected as a major factor, large-scale disturbances

One of the consequences of temporal studies is the inherent trade-off between site-selection and sample replication resulting from time and/or money constraints, often resulting in one of two extremes: 1) studies including low numbers of sample sites with multiple replicates or 2) studies including multiple sampling sites with few replicates. The first extreme depicts a data set robust enough to support simple descriptive statistics but lacks in its ability to employ descriptions of anything more than a single stream or section of stream; the second extreme attains the utility to look at a wide geographic region, but often suffers from a loss of statistical power due to few replicates.

In some instances of the latter case there may not be enough replicates to generate simple comparative statistics (e.g. ANOVA or t-tests). In these instances researchers have often resorted to multivariate statistics, which have several inherent limitations. PCA, for example, is solely a descriptive technique and is seldom accompanied with statistical power. This limitation has been met in one of two ways: 1) using multivariate techniques (e.g. DCA) that can utilize jackknifing and bootstrapping to generate significance values; or 2) performing statistics on component loadings (Matthews 1998).

Despite these solutions, multivariate analysis remains a largely objective way for researchers to summarize and explore data (Gauch 1994). Multivariate techniques are strongest when the data contain high numbers of variables and can handle with ease mixtures of different types of variables (Williams and Gillard 1971, Gauch 1994). Consequently, multivariate techniques tend to lump data together, and, in site-specific ecological studies, generally give no more than a large-scale overview of a specific ecological system. Moreover, in dealing with one or very few variables of approximately known distribution, multivariate analogues of standard statistical methods tend to be weaker and are computationally intractable if the system is over-defined or non-orthagonal (Williams and Gillard 1971). Ultimately, multivariate methods are useful primarily for data exploration and hypothesis generation and provide little power for hypothesis testing afforded by traditional statistics. This, becomes a major problem for researchers interested in testing specific situations (e.g. before and after, site-by-site comparisons) for data sets confined by minimal replicates.

Efforts have been made to establish methodology allowing for statistical hypothesis testing of multi-site data sets with few replicates. Van Sickle (1997) describes a method using mean similarity dendrograms to evaluate classifications that is intended to compliment multidimensional scaling plots and permutation tests of class structure. This technique can also be used for single-factor classification of fish communities of large geographic regions.

A more promising solution utilizes the implementation of Karr's IBI values (1981). Karr's IBI integrates metric scores into a multimetric index, allowing researchers to take advantages of properties of the mean (Karr and Chu 1999). Integration of metric scores can be achieved by either summing or averaging metric scores, with both methods achieving the same results (Karr and Chu 1999). Since the values of multimetric indices approximate a normal distribution (Fore et al. 1994), they can be tested with familiar statistics such as ANOVA and regression (Karr and Chu 1999). Additionally, these metrics include inherent statistical properties of their own. Fore et al. (1994) determined that for the Ohio EPA's version of the IBI (very similar to the original IBI), 95% of the variablility in IBIs generated by the bootstrap procedure fell within +/- 4 points of the observed IBI. Consequently, Fore et al. (1994) suggested that a difference of +/- 4 points in IBI values represents a statistically significant change in biological condition. Moreover, Karr and Chu (1999) demonstrated that the IBI can detect six non-overlapping categories of biological condition. Ultimately, Fore et al. (1994) claimed that IBI is an effective monitoring tool for evaluating the effects of human influences on rivers and streams in Ohio, and suggested that the above statistical properties of the IBI apply to similar streams in the local area.

In addition to Karr's IBI (1981), diversity indices have been used with success to determine community stability in both terrestrial (Caswell 1976) and freshwater (Gorman and Karr 1978, Zaret 1982) systems. Three common indices are species richness, Shannon's H and Simpson's E. Species richness is simply a measure of the number of species in a community (Krebs 1999) and can indicate a general sense of temporal community perturbation based on increases or decreases in species numbers. The primary limitation of this metric is that it is usually impossible to quantify all of the species in a natural community (Krebs 1999).

One of the most popular measures of species diversity is Shannon's H, which is based on information theory (Krebs 1999). Shannon's H measures the amount of order contained in a system, with larger values indicating greater uncertainty, and is a *Type I* index that is most sensitive to changes in the rare species of a community. The primary limitation of Shannon's H is that it must be used on random samples from a large community in which the total number of species is known.

Evenness quantifies the unequal representation of species in a community against a hypothetical community where all species are equally common, expressed as the nearness of the observed data to the hypothetical community of maximum diversity (Brower and Zac 1984). Evenness measures such as Simpson's E are *Type II* indices that are most sensitive to changes in the more abundant species (Krebs 1999), and therefore is ideal for measuring perturbations of the dominant species in a community. Limitations of evenness measures include the tendency toward over-estimation (except in very large samples) and their dependence on species richness, which necessitates sample comparisons of similar species richness values.

The purpose of this study was to examine a long-term data set composed of 10 streams and 17 sampling sites using species diversity measures (species richness, Shannon's H and Simpson's E) and the diagnostic statistical properties of Karr's IBI in an effort to uncover temporal changes that may have occurred over the past 30 years. Two *a priori* hypotheses are proposed: 1) all but three sites should demonstrate significant negative changes in stream health over the past 30 years; and 2) three sites should demonstrate significant positive changes due to the addition of low-water bridges at these sites, which scour out the substrate down-stream from the culvert, thereby creating deep pools and increasing habitat diversity.

MATERIALS AND METHODS

Three creeks within the Green River drainage basin and seven within the Barren River drainage basin were sampled from 1970 and 1975 for the initial survey (Survey I) and from 1999 to 2001 for the follow-up survey (Survey II) (Table 1). For each site, up to 100 yards of stream were sampled, including at least one complete riffle and the upper and lower ends of the adjacent pool to ensure all habitats were sampled. Sampling techniques consisted of electro-shocking, seining, and kick-net sampling. Electroshocking was conducted with an AC *Tiny Tiger* back-pack electro-shocker for Survey I and an industrial-grade AC/DC generator for Survey II. Seine samples were obtained using a 30-ft (or smaller), 3/16-inch ace mesh seine and were standardized using one-hour increments of effort, with electro-shocking samples defined by one complete hour of shocking time. Kick-net samples were taken at all riffles to ensure the sampling of darter species.

All fish were placed in 10% formalin when collected. Fixed samples were washed, sorted, and identified in the laboratory. Samples were then preserved in 70% ETOH for permanent storage in the ichthyology collection at Western Kentucky University.

All data were analyzed using a qualitative statistical test of IBI differences described by Fore et al. (1994). This test recognized statistically significant differences in stream health (95% confidence intervals) if a change of greater than +/- 4 units in IBI occurred. IBIs were constructed according to the technique of the Kentucky Department of Environmental Protection (KDEP), Division of Water, criterion (Kentucky Division of Water 1997). This version of the IBI, ranging from 12-60, was developed for the Kentucky region and is comparable to both the Ohio EPA version of the IBI and the original IBI. In cases where replicate samples were taken, an overall IBI was calculated by averaging the individual IBI scores for each sample.

RESULTS

The use of Karr and Chu's (1999) IBI difference method allowed each site to be tested qualitatively to determine whether a given site had changed enough during the interim between sampling events to represent a statistically significant change in condition over time. Sites with greater than +/- 4 units of difference in IBI values could be classified as significantly different, which characterized the following sites: WD1, WD2, WD5, WD6, MD1, IC2, BC, TFD, LMC, RB, and LC (Table 2, Figure 1). Of these sites, only four improved in health: WFD2, WFD5, WFD6, and BC. All other sites either exhibited no change or a statistically insignificant change.

As a whole, IBI and simple species richness values increased or decreased in synchrony with the exception of IC1, where species richness actually increased over time despite a non-significant decrease in IBI value. This basic trend of synchronously increasing or decreasing index values held true for heterogeneity (Shannon's H) and evenness (Simpson's E) measures, but with slightly more variation (Table 2, Figure 2). Four sites demonstrated an alternate trend, with one index increasing while the other decreased over time: WD5, WD6, LMC and RB.

Table 1. Symbology codes for each site, including creek name (WFD = West Fork of Drake's Creek; MFD = Middle Fork of Drake's Creek; TFD = Trammel Fork of Drake's Creek), location, and average number of fish species captured per site for each survey. Enumerated sites represent creeks with more than one sampling site. Averages were taken to summarize sites that included one or more replicate samples.

			Avg. No. of Fish	
Site Code	Creek Name	Location	Survey 1	Survey 2
WD1	WDF	Simpson Co. at Peden's Mill	292.0	92.0
WD2	WDF	Simpson Co. at Hayden Snyder Road	239.5	203.0
WD3	WDF	Simpson Co. Government Property in Franklin	268.0	125.0
WD4	WDF	Simpson Co. at Highway 1434	233.5	151.0
WD5	WDF	Simpson C. at Woody Adkins Road	145.0	144.0
WD6	WDF	Simpson Co. at Sadler Ford Road	211.0	127.0
MD1	MFD	Warren Co. south of Highway 265	687.0	165.5
MD2	MFD	Warren Co. at ford at Drake	504.0	129.0
IC1	Indian Creek	Warren Co. at Highway 185	213.0	93.0
IC2	Indian Creek	Warren Co. at Anna-Richardsville Road	113.0	130.0
BC	Belcher Creek	Warren Co. at Cohron Road	100.0	278.0
SLC	Salt Lick Creek	Warren Co. Highway 231	117.0	133.0
TFD	TFD	Warren Co. at Romanza Johnson Park	118.0	127.5
LMC	Little Muddy Creek	Warren Co. at Dimple-Sugar Grove	1031.0	103.0
RB	Ray's Branch	Warren Co. at Carmel Road	145.0	43.0
IVC	Ivy Creek	Warren Co. at Highway 185	347.0	91.0
LC	Lick Creek	Simpson Co. at Sharer-Hadley Road	341.0	98.0

However, in two of these cases (WD6 and RB) one of the two index values was very close to zero, indicating no change over time. Viewing all four indices together demonstrated that 1) on average, the indices verify one another, indicating either an unanimous increase or decrease in stream integrity over time, and 2) all but five sites (WD2, WD5, WD6, BC and SLC) indicated decreasing stream integrity over time, with three of the five sites of increasing integrity representing a single stream (Table 2, Figure 1, Figure 2).

DISCUSSION

Aside from six sites that demonstrated no significant difference temporally in stream health, the results supported both *a priori* hypotheses. Sites that decreased significantly in health between the two surveys included WD1, MD1, IC2, TFD, LMC, RB, and LC. Possible interpretations for these declines all involve some form of anthropogenic activity. MD1, for

Table 2. Differences in Index of Biotic Integrity (IBI), species richness (SR), Shannon's H (SH) and Simpson's E (SE) values between Survey I and Survey II for each site. Bolded values indicate indices that changed in a different direction than the IBI. To interpret site codes, refer to Table 1.

Site	Change in IBI	Change in SR	Change in SH	Change in SE
WD1	-6.0	-4.0	**0.816**	**0.42**
WD2	4.0	1.5	0.893	0.122
WD3	0.0	-3.0	-0.265	-0.023
WD4	-1.0	-2.5	-0.9	-0.3045
WD5	10.0	11.0	0.863	**-0.104**
WD6	7.0	3.5	0.426	**-0.02**
MD1	-5.0	-11.5	-0.787	-0.0125
MD2	-3.0	-8.0	**0.1935**	**0.2025**
IC1	-2.0	**1.0**	**0.246**	**0.022**
IC2	-7.5	-9.5	-1.2565	-0.0825
BC	10.0	2.0	**-1.198**	**-0.296**
SLC	2.0	3.0	2.063	0.407
TFD	-5.0	0.0	-0.109	-0.0395
LMC	-14.0	-11.0	-0.606	**0.301**
RB	-22.0	-8.0	-0.036	**0.575**
IVC	0.0	0.0	0.199	-0.006
LC	-4.0	-4.0	-1.295	-0.197

example, remained fairly unaltered in regard to agricultural activity in its near vicinity; however, only six miles upstream a large potential point source for fecal coliform and other possible contaminants moved into the system with the construction of a bio retaining facility near Pleasant Ridge in Allen County. This facility generated and maintained hundreds of genetically altered, disease-resistant pigs. Run-off from this large-scale operation could possibly be a factor in the decrease in stream integrity experienced at this site.

LMC was another site that displayed a significant amount of agricultural development over the past thirty years. The site was visibly altered by over-grazing of cattle, resulting in a lower riparian zone that was muddy and barren of grass or shrubs. In the streambed there was a much more pronounced volume of sediments observed when taking the samples for Survey II. RB also may have suffered because of increased agricultural use, for though the riparian zone was much less affected, much of the surrounding area had been converted to farmland and a highly increased level of sediments was noted between the two sampling times.

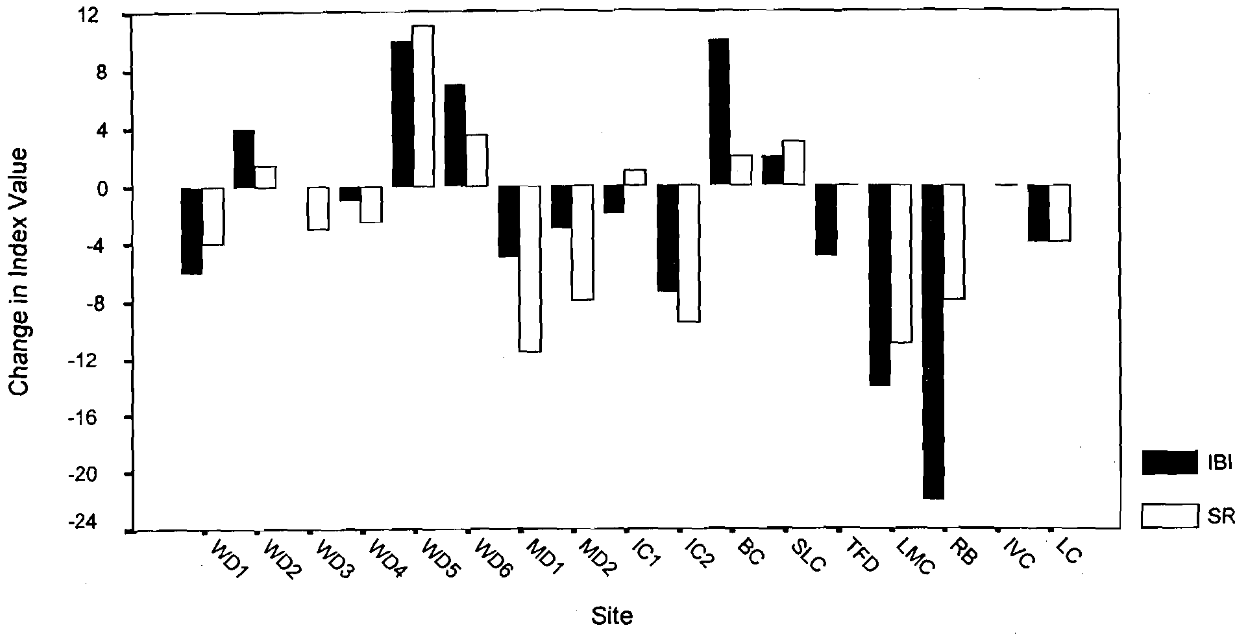

Figure 1. Differences in Index of Biotic Integrity (IBI) and species richness (SR) values between Survey I and Survey II for each site. Bars greater than 0 represent positive changes in stream integrity over time and bars less than zero represent negative changes in stream integrity over time. To interpret site codes, refer to Table 1.

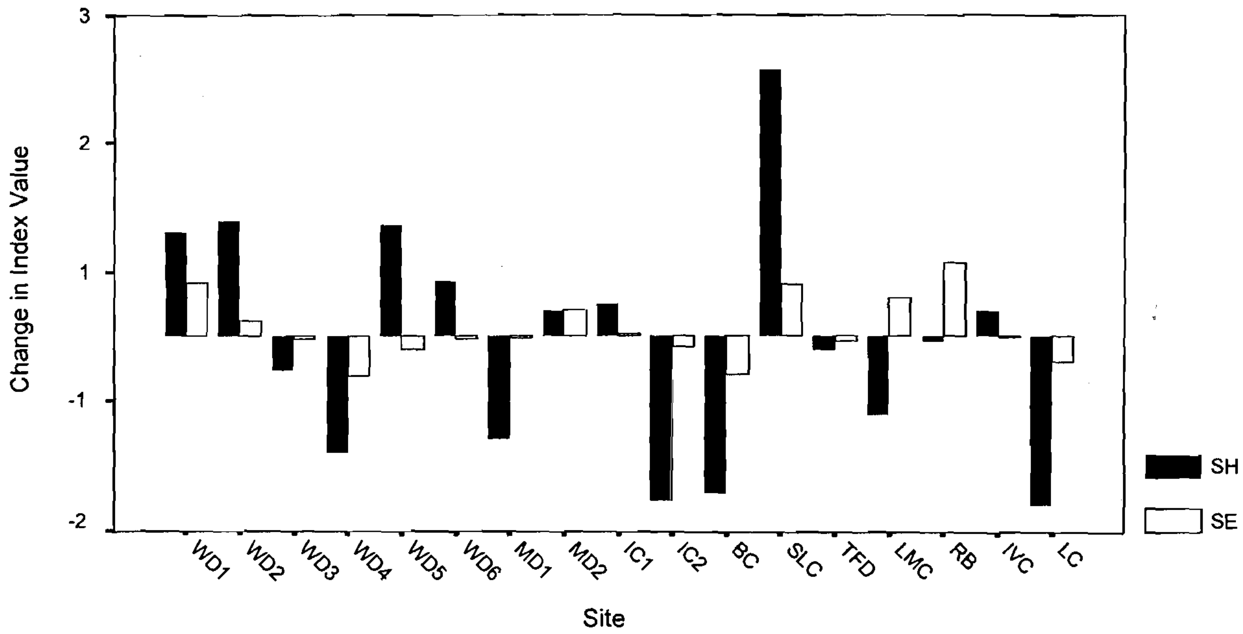

Figure 2. Differences in Shannon's H (SH) and Simpson's E (SE) values between Survey I and Survey II for each site. Bars greater than 0 represent positive changes in stream integrity over time and bars less than zero represent negative changes in stream integrity over time. To interpret site codes, refer to Table 1.

IC2, decreasing by nearly 8 IBI points, represented a site severely affected by anthropogenic development: during Survey I the area in and around the sampling site was undeveloped and in the interim before Survey II the area became highly developed with residential housing. Finally, LC (-4) represented a border-line significant result, which can be explained by a drought that dried up much of the stream habitat at the sampling site.

Despite the correlation between negatively affected sites and anthropogenic disturbances, several of the sites decreasing in biotic integrity either could not be explained or represented potential sampling bias/error. For instance, WD1 endured no observable land-use changes and likely represented a non-point source effect due to general increases in agricultural land-use practices upstream. The decline in biotic integrity at TFD could have been influenced by human error. In the interim between survey periods, a low water bridge replaced a gravel ford in order to make for safer vehicle crossing. The culvert crossing was later replaced by a large bridge several hundred yards upstream from the original ford and sampling site. Upon returning to the site it was assumed that the new bridge was at the location of the old ford, causing a slight change in the sampling location. Consequently, instead of the increased stream health predicted by the addition of the low water bridge, the new site actually displayed a decrease in stream integrity despite its close proximity to the original down-stream site.

Three of the four sites that actually showed an increase in stream health over time (WD5, WD6, and BC) can all be explained by the addition of low-water bridges that were added within the habitat reaches of the original sites. These bridges were made of solid concrete with large pipe conduits running parallel to the stream. Consequently, water builds on the upstream side and scours out the downstream side via fast-moving water transmitted through the conduits. This has a positive effect on expected fish diversity because the downstream scouring forms pools that represent further habitat diversification. Consequently, with increased fish diversity, one typically expects an increased IBI value unless this increase in species indicates more invading species, giving a false-positive result towards the IBI.

The very large increases in IBI values for WD5 (+10) and WD6 (+7) may have additionally been impacted by a large chemical spill that occurred in September of 1969. At that time, Prackett, Incorporated, a company dealing in automotive chemicals, owned a plant in Simpson County that manufactured aerosol-based de-icer products. A human mistake led to the release of thousands of gallons of ethylene glycol into a catchment pool that leaked over into West Fork of Drake's Creek less than ¼ mile from WD4, causing the extirpation of all fish communities for several miles downstream. By the time sampling for Survey I commenced in late autumn of 1969, the fish communities were judged to have been largely recovered. However, as there was no previous data with which to compare, it is impossible to tell just how recovered the stream may have been at the time. Indeed, it is feasible that WD4, just downstream from the pollution point-source, would have been the quickest to recover simply because of the proximity to unaffected upstream populations that were able to replenish the system not long after the contaminants moved out of the area. Consequently, WD4 may have been less affected initially, resulting in the non-significant result, whereas WD5 and WD6 could have been still greatly repressed at the time of initial sampling, recovering slowly over the next thirty years.

The only site that could not be explained by this low-water bridge phenomenon was WD2, which increased in health (+4 IBI points) despite no noted habitat alteration. It remains unclear why this change may have occurred.

The use of Karr's IBI as a statistical indicator of change appears to work exceptionally well in describing the local system of this study. However, a few assumptions have been made about this method. First, slight differences between the Ohio EPA IBI and the KDEP IBI were assumed to present no assessment discrepancies. Secondly, the justification for using IBI values as statistical indicators was based on an electrofishing data-set generated from Ohio streams and therefore any geographical or regional differences between the two regions was assumed to play no role in biasing the data. Any compromises in accuracy potentially caused by false assumptions, however, should not alter the consistency of detectable changes in the current data set since methodology remained consistent between Survey I and Survey II.

An additional problem may have resulted from small sample sizes. Fore et al. (1994) recommended using 400 individuals per sample, with the amount of gain in precision beyond 400 being less important than the loss below 400. Consequently, they recommend that the sampling protocol should specify a large enough area to ensure that most sites yield at least 400 individuals (Fore et al. 1994). In the present study, only three sites yielded more than 400 individuals, with many sites represented by fewer than 200 individuals (Table 1). One of the consequences of having many samples below 400 individuals is increased variability and less information (Fore et al. 1994).

Despite these obvious limitations, Fore et al. (1994) recognize that the lower limit of 400 individuals may be impossible in one of two cases: 1) for extremely degraded sites, and 2) for zoogeographic regions or streams naturally supporting few fish. Fortunately, we believe the robustness of the +/- 4 IBI point threshold may compensate for this added variation. This is seen in the lower estimates of +/- 2 to +/- 3 IBI points generated by bootstrapping alone for sites with over 400 fish (Fore et al 1994). Consequently, estimates including time and fewer individuals may employ some degree of statistical freedom. Moreover, only two sites designated as statistically distinct over time had IBI differences less than +/- 5 points: WD2 (+4), in which the change could not be explained by direct habitat alterations, and LC (-4), which suffered a drought during the second sampling period.

The implications of this study are important for several reasons. For one, they provide a way for multiple-site, long-term data sets to be analyzed despite the constraints of sample size. Additionally, the results indicate that, despite noted biases due to sampling size and variations in ecology between Kentucky and Ohio, it is possible to effectively detect changes in stream health using the inherent statistics of Karr's (1981) IBI.

Ultimately, however, more research needs to be conducted. Specifically, similar studies to that of Fore et al. (1994) need to be conducted to determine the specific cut-off range for areas outside of the Ohio River basin to determine if +/- 4 is an appropriate statistical threshold for significance, or if it varies more locally. Finally, studies need to be conducted detailing the effects of depressed sample sizes (eg. those below 400 individuals) in order to determine if the statistical threshold should be increased above +/- 4 or if the value is robust enough to accommodate the inherent variation from these low sample sizes.

LITERATURE CITED

Brower, J. E. and J. H. Zac. 1984. *Field and Laboratory Methods for General Ecology.* W. C. Brown Publishers, Dubuque.

Caswell, H. 1976. Community structure: a neutral model analysis. Ecological Monographs 46:327-354.

Fore, L. S., J. R. Karr, and L. L. Conquest. 1994. Statistical properties of an index of biological integrity used to evaluate water resources. Canadian Journal of Fishes and Aquatic Science 51:1077-1087.-

Gauch, Jr., H. G. 1994. *Multivariate Analysis in Community Ecology.* Cambridge University Press, Cambridge.

Hansen, M. J., and C. W. Ramm. 1994. Persistence and stability of fish community structure in a southwest New York stream. American Midland Naturalist 132:52-67.

Hoyt, R. D., McElroy, and D. Stiles. 2001. Spatio-temporal assessment of stream fish communities adjacent to an agricultural best-management practices operation. *In* A. F. Scott et al. (eds.), *Proceedings of the Ninth Symposium on the Natural History of Lower Tennessee and Cumberland River Valleys*, pp. 101-114. The Center for Field Biology, Austin Peay State University, Clarksville, TN.

Karr, J. R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21- 27.

Karr, J. R. and E. W. Chu. 1999. Restoring Life in Running Waters. Island Press, Covelo: 80-83.

Krebs, C. J. 1999. *Ecological Methodology.* Addison-Welsey Educational Publishers, Menlo Park.

Lienesch, P. W., W. I. Lutterschmidt, and J. F. Schaffer. 2000. Seasonal and long-term changes in the fish assemblage of a small stream isolated by a reservoir. The Southwestern Naturalist 45:274-288.

Matthews, W. J. 1985. Distribution of midwestern fishes on multivariate environmental gradients, with emphasis on *Notropis lutrensis.* American Midland Naturalist 113:225-237.

Matthews, W. J. 1990. Spatial and temporal variation in fishes of riffle habitats: A comparison of analytical approaches for the Roanoke River. American Midland Naturalist 124:31-45.

Matthews, W. J. 1998. *Patterns in Freshwater Fish Ecology.* Kluwer Academic Publishers, Hingham. Kentucky Division of Water. 1997. Reference reach fish community report. Kentucky Department of Environmental Protection, Division of Water, Frankfort.

Kentucky Division of Water. 1997. Reference reach fish community report. Kentucky Department of Environmental Protection, Division of Water, Frankfort.

Quinn, N. J. 1980. Analysis of temporal changes in fish assemblages in Serpentine Creek, Queensland. Environmental Biology of Fishes 5:117-133.

Ross, S. T., J. A. Baker, and K. F. Clark. 1987. Microhabitat partitioning of southeastern stream fishes. *In* W. J. Matthews and D. C. Heins (eds.). *Community and Evolutionary Ecology of North American Stream Fishes*, pp. 42-51. University of Oklahoma Press, Norman.

Taylor, C. M., M. R. Winston, and W. J. Matthews. 1996. Temporal variation in tributary and mainstem fish assemblages in a Great Plains stream system. Copia 1996:280-289.

Williams, W. T. and Gillard, P. 1971. Pattern analysis of a grazing experiment. Australian Journal of Agricultural Research 22:245-260.

Van Sickle, J. 1997. Using mean similarity dendrograms to evaluate classifications. Journal of Agricultural, Biological and Environmental Statistics 2:370-388.

Zaret, T. M. 1982. The stability/diversity controversy: a test of hypotheses. Ecology 63:721-731.

IMPLICATIONS OF SENSE ORGAN DEVELOPMENT AND PREY DENSITY ON FIRST FEEDING IN LARVAL FATHEAD MINNOWS (CYPRINIDAE: *PIMEPHALES PROMELAS*)

JARRETT H. SUTTON[1] AND ROBERT D. HOYT[2]

[1]University of Kentucky Medical Center, Lexington KY 40506
[2]Department of Biology and Center for Biodiversity Studies, Western Kentucky University, Bowling Green, KY 42101

ABSTRACT. Larval and juvenile fish require a high density of prey organisms to initiate first feeding successfully. This study describes the influence of varying densities of prey organisms on the early feeding behavior of larval *Pimephales promelas* and the influence of different sense organs on first feeding. Fish were tested on freshly hatched brine shrimp daily during the first 11 to 14 days of life. After 14 hours without food, groups of five fish each, in replicate, were fed 35, 70, or 105 brine shrimp. Test conditions included feeding live and dead prey in the light and dark. In the light, first feeding occurred on day 3 at all densities on both live and dead prey. In the dark, first feeding occurred on live prey on day 3 but on day 4 on dead prey. The attainment of 100% feeding occurred in both light and dark on day 7 on live prey. One hundred percent feeding on dead prey did not occur until day 11 in the light and day 12 in the dark. In the light, prey densities produced no feeding differences; in the dark the lowest density produced the lowest feeding. Significantly more fish fed on all prey types combined in the light than the dark and on live prey more than dead prey. Based upon the results of this study, prey density is a limiting factor in early feeding if the prey do not emit mechanoreceptive stimuli. Dead prey emit only smell and perhaps a weak visual stimulus making it less recognizable, while easily detected stimuli such as swimming vibrations produced by live prey provides for more successful feeding activity in both light and dark conditions. Smell as a feeding sense only became effective from day 11 to 14 suggesting that it is poorly developed early in life and/or is a learned sense.

INTRODUCTION

Sense organ development among fishes is progressive and closely associated with early behavior formation (Batty and Hoyt 1995). The majority of fish species rely upon information from all their senses for food detection, recognition, and selection (Hara 1986), although the ontogenetic timing of the recruitment of the respective organs is unclear. Iwai (1980) reported the timing of sense organ development in teleost larvae to differ from species to species. However, the sequence of sense organ use in early feeding is generally agreed upon. Iwai (1980) and Blaxter (1986) reported that all teleosts have well developed eyes, as well as other sense organs, at hatch and to search for food mainly by sight. Noakes and Godin (1988) suggested a clear correlation between ontogenetic timing of structural and functional changes in the teleost eye and changes in behavior which coincide with ontogenetic shifts in their ecology.

Blaxter (1986) and Noakes and Godin (1988), among others, reported free neuromasts/mechanoreceptors to also be present and functional at hatching. Iwai (1980) reported the lateral line system (mechanoreceptors) in teleost larvae to be secondary in feeding and Noakes and Godin (1988) suggested an uncertain role of the lateral line in locating prey.

Blaxter (1986) also added that feeding in pure dark had been substantiated for some teleosts and reported larvae to collect in food patches in large rearing tanks, both in light and dark. Blaxter and Fuiman (1989), however, reported it doubtful that free neuromasts play a major role in feeding but most likely function in detecting predators and conspecifics. Montgomery (1989) reported that while lateral line information is usually processed in combination with and used synergistically with vision in plankton feeding fish it alone provides sufficient information for detecting live plankton by the common bream, *Abramis brama*, and piper, *Hyporhampus ihi*, up to a distance of 5 mm. Batty and Hoyt (1995) and Salgado and Hoyt (1996) observed mechanical stimuli to be a major component of the prey search image in early feeding in freshwater as well as marine species.

Chemoreception, including olfaction and gustation, is involved in early feeding, although less implicated and documented than the preceding senses. Based on histological evidences of olfactory organ development, it is possible that early *Tilapia* and *Pagrus* larvae are capable of perceiving olfactory stimuli, but their use in feeding is not documented (Iwai 1980). He concluded by suggesting that fish larvae probably do rely on olfaction in feeding. Salgado and Hoyt (1996) found chemoreception to be an effective sense in early feeding by the fathead minnow although delayed in its ontogenetic development.

The distinction of the senses in larval feeding is not clear (Hara 1986, Montgomery 1989). However, given the importance of plankton feeding among teleost larvae, the ubiquitous presence of the early lateral line, and the advantages and opportunities for feeding in conditions suboptimal for vision, it is necessary to learn as much about the ontogenetic involvement of each major sense in early feeding as possible.

Much confusion surrounds the importance of food concentration in larval fish feeding, growth and survival. Noakes and Godin (1988) reported first feeding by fish larvae to be the consequence of prey abundance, size, visibility, and evasiveness, with abundance appearing to be the major factor influencing prey selection. Hart and Werner (1987) and Letcher and Bengston (1993) also found prey availability/concentration to significantly affect larval growth and survival. Frank and Leggett (1986) reported first feeding larvae to depend on the combined influence of the size distribution of the plankton, its nutritional value, and its concentration. They summarized their findings by suggesting that the size structure of the plankton community can dramatically influence growth and survival of larvae and that this influence can override the importance of total plankton abundance.

Early laboratory rearing experiments of larvae required prey density requirements far in excess of those in the sea for acceptable survival and growth (Houde 1975, Heath 1992). Feeding densities including 100, 500, 1000, 1500, 3000 prey/liter and even greater have been utilized (O'Connell and Raymond 1970, Laurence 1974, Houde 1975, Hart and Werner 1987, among many others). Hart and Werner (1987) reported a Critical Prey Density (prey density supporting 10% larval survival) of 160/l for pumpkinseed sunfish and 150/l for white sucker, and 250/l for growth. On the basis of the results of early larval rearing experiments, Blaxter (1986) concluded that a food density of at least 1 prey/ml was necessary for successful growth and survival of laboratory raised larvae. However, improved rearing techniques, namely large rearing enclosures, subsequently reduced the critical food requirements in successful rearing operations well below 1 prey/ml, approximating the average prey density in the sea.

Irrespective of mean prey concentrations in the external environment or the optimal ration for effective laboratory rearing is the importance of prey organisms of the proper size and concentration at the time of earliest feeding. Blaxter (1986) and Heath (1992) reported prey density requirements to be much more stringent for very small, first feeding larvae. Once feeding is established and larvae grow, the requirements for high prey densities decrease accordingly (Houde 1975, Heath 1992).

The objective of this study was to investigate the relationship between prey density, condition of prey, and the use of the various senses in first feeding larval fathead minnows. A series of test conditions was devised to limit the participation of each sense and various combinations of senses in feeding (Batty and Hoyt 1995). Prey densities were chosen on the basis of prey availability sufficient to elicit a feeding response. Feeding was selected as the behavior tested because of the interaction of all major senses (Salgado and Hoyt 1996).

METHODS AND MATERIALS

Rearing

Fathead minnows used in this project were hatched from brood stock obtained from the U.S. EPA, New Town, OH, and were maintained at the fish rearing facility at Western Kentucky University's Department of Biology. The eggs were harvested within 2 h of fertilization and incubated at 25 ± 1.5 C at a light-dark 16:8 photo-period (0400-2000 light phase) in a one-liter beaker containing 800 ml of dechlorinated water and 100 ml of 28% saltwater. The eggs hatched 5 d after fertilization.

The larvae were reared using the same laboratory conditions as for egg incubation, except without the salt component in the rearing tank water. Once hatched, larvae were divided equally into six, aerated, 2-liter glass bowls. The larvae were fed freshly hatched brine shrimp twice daily at 0800 and 1600 during the light period. Each feeding averaged approximately 870 brine shrimp per fish. The rearing bowls were cleaned and fresh water added every third day.

Test Groups

Two cohorts of fish were used during the study. The first cohort of eggs hatched on 6 Oct 1996 and the second on 6 Nov 1996. The October group was tested in the light for 11 consecutive days from 8 Oct through 19 Oct 1996. The November group was tested in dark conditions during the daylight activity phase with the lights turned off and the room completely darkened. This was intended to show the sensory abilities of the fish under dark conditions rather than dark-phase behavior. The second cohort of larvae was tested for 14 days from 8 Nov through 21 Nov 1996. Each feeding regimen was continued until 100% success feeding was achieved at all conditions.

Test Procedures

Test fish were randomly selected before being fed at 1600 the day prior to the trial and transferred to 100-ml petri dishes containing approximately 95 ml of dechlorinated water. The test fish were selected from the rearing bowls in a sequence such that no one fish could be tested at the same condition more often than every third day. Five fish were placed in each test dish and a replicate set of fish prepared for each feeding density. The fish were without food for 14 h prior to each trial to ensure the digestive tract would be void of food matter at the time of each trial. Test groups of larvae, in replicate, were fed three different densities, 35/95 ml, 70/95 ml, and 105/95 ml of live or dead brine shrimp. Brine shrimp were selected and counted using 10-cc hypodermic syringes and a dissecting microscope. Brine shrimp for dead-prey feeding trials were killed in an ultrasonic bath (20-25 sec). Only dead, but intact, brine shrimp were selected. Larvae were allowed to feed for 10 min after food was added to the test dishes.

For dark testing, the lights in the test room were turned off 30 min prior to and during the test. This was done to allow the larvae to acclimate to the dark. After the larvae were in the presence of food for 10 min, they were separated from the test water by means of a sieve cup. They were then transferred to 100-ml holding dishes with rearing water for approximately five min until they could be examined for evidence of feeding. The larvae were removed from the holding dishes by means of a wide-mouth pipette and placed on a 2-inch concave dish. The water was removed from the dish until the fish lay on their sides. They were then examined under a dissecting microscope. Feeding was evidenced by the presence of food deposits in the digestive tract and was recorded as Feeding Incidence, or the number of larvae having at least one food item in its digestive tract. There are few instances where either Feeding Incidence or Feeding Ratio, the mean number of prey per fish stomach, have been related to prey density in the environment (Heath 1992), so the most accurate measure was adopted in this study. Fish total lengths were taken at hatching, on day 4, and everyday thereafter. Larvae were measured using a millimeter rule placed under the concave dish on the microscope stage. Once a day's test was concluded, the fish were returned to their respective rearing container.

Data Analysis

Statistical analyses were done using Systat (Version 5.0 for windows; SYSTAT, Inc., 1992). Effects of feeding conditions, light-dark, live-dead, and feeding densities (35, 70, 105) on feeding activity over the course of the experiment were examined separately with ANCOVA, using day (1-11) as the covariate. When slopes were found to be homogeneous among conditions, tests for significant differences among means were carried out using ANCOVA. Pairwise differences in means among conditions were tested for significance using Tukey's HSD multiple comparison test.

RESULTS

Growth

The two cohorts of larvae (Table 1) used in the light and dark trials were similar in size throughout the experiment having a minimum difference in total length of 0.06 mm on days 7, 8, and 10 and a maximum difference of 0.67 mm on day 5.

Feeding

First feeding occurred on day 3 in the Light Group on both live and dead prey (Figures 1 and 2, respectively). One hundred percent feeding first occurred in the light on day 7 on live prey and on day 11 on dead prey. During dark testing, first feeding occurred on day 3 on live prey and on day 4 on dead prey (Figures 3 and 4, respectively). The first occurrence of 100% feeding in the dark was observed on day 7 on live prey and day 12 on dead prey.

Table 1. Average of and difference in total length (in millimeters) of fathead minnow larvae tested under light and dark conditions over a period of 11 days.

Day	Light Group	Dark Group	Difference Between Groups
1	5.36	5.53	0.17
4	6.50	6.58	0.08
5	7.01	6.34	0.67
6	7.46	7.13	0.33
7	7.52	7.58	0.06
8	7.64	7.58	0.06
9	7.91	7.41	0.50
10	8.30	8.36	0.06
11	9.13	9.05	0.08
Overall Means	7.42	7.28	0.34

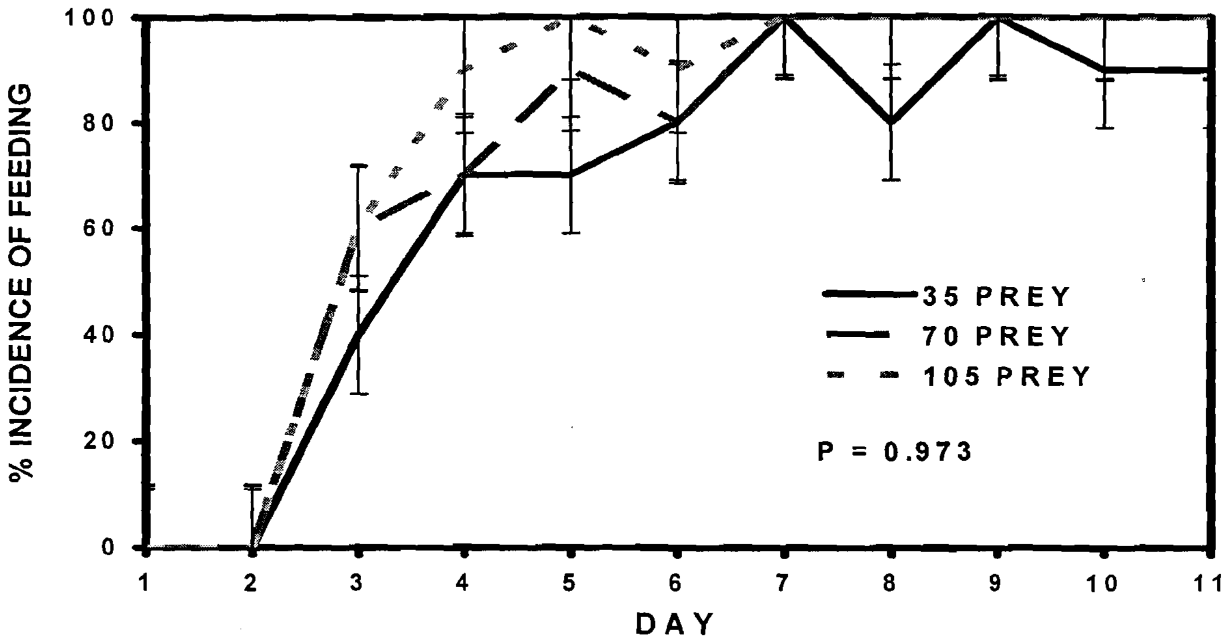

Figure 1. Proportion of fathead minnow larvae (n = 10) feeding on different densities of live brine shrimp in the light on successive days of the experiment. Vertical bars represent one standard error of the mean.

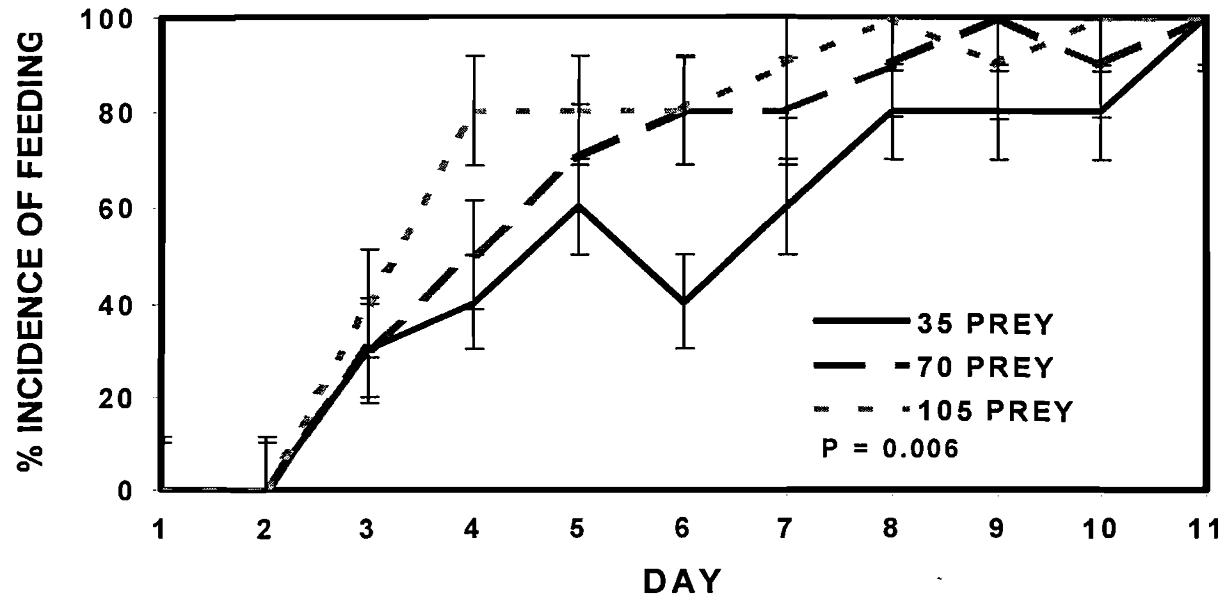

Figure 2. Proportion of fathead minnow larvae (n = 10) feeding on different densities of dead brine shrimp in the light on successive days of the experiment. Vertical bars represent one standard error of the mean.

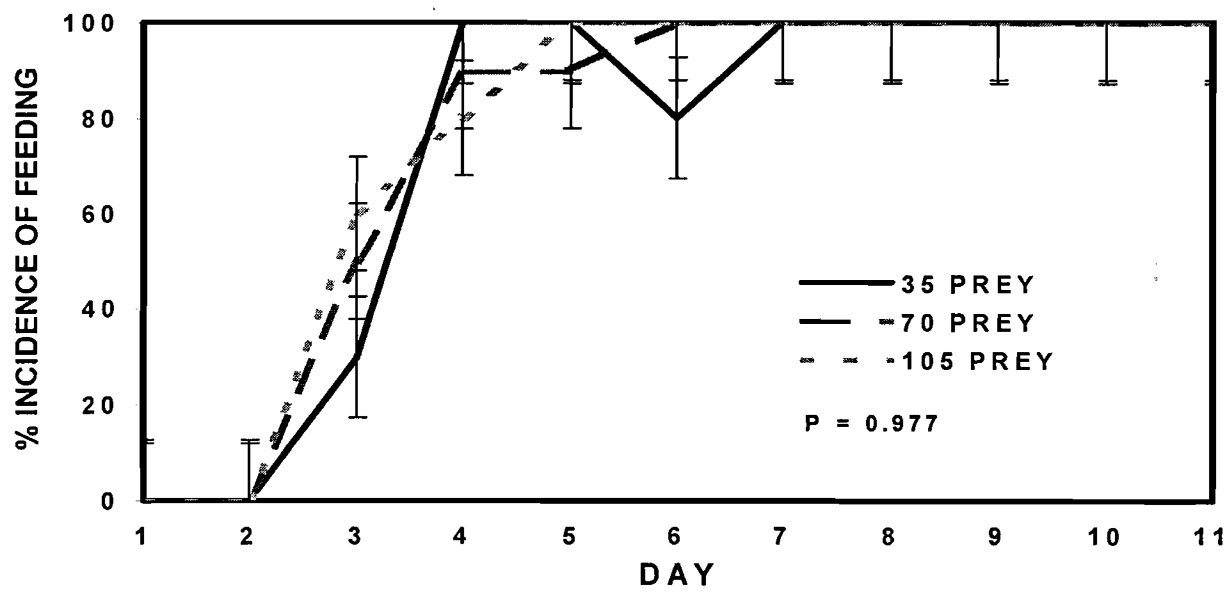

Figure 3. Proportion of fathead minnow larvae (n = 10) feeding on different densities of live brine shrimp in the dark on successive days of the experiment. Vertical bars represent one standard error of the mean.

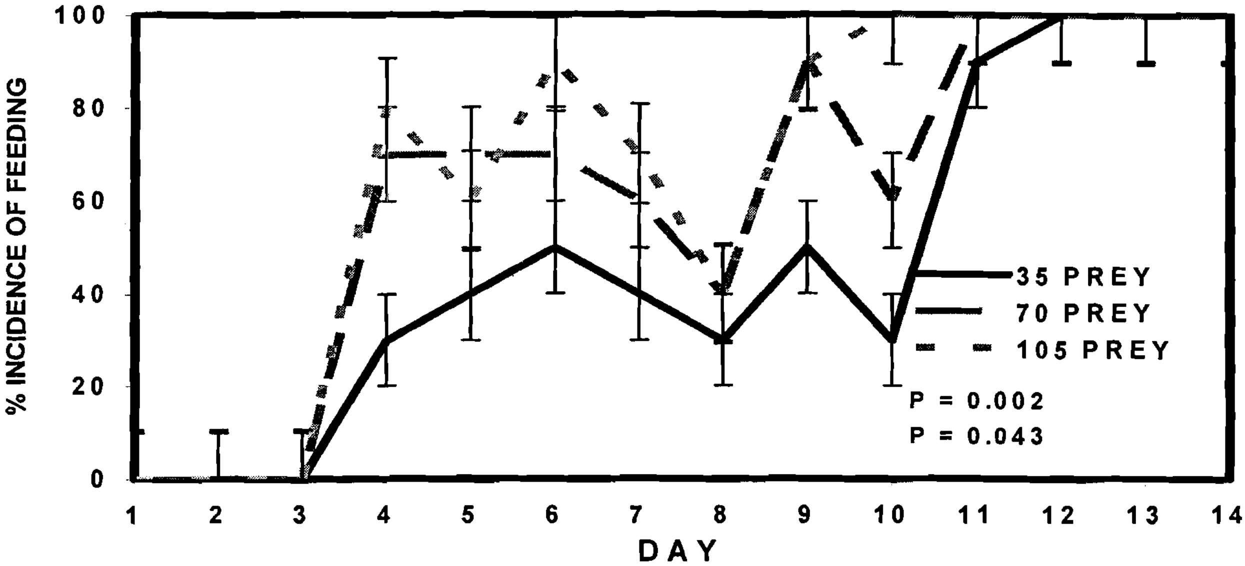

Figure 4. Proportion of fathead minnow larvae ($n = 10$) feeding on different densities of dead brine shrimp in the dark on successive days of the experiment. Vertical bars represent one standard error of the mean.

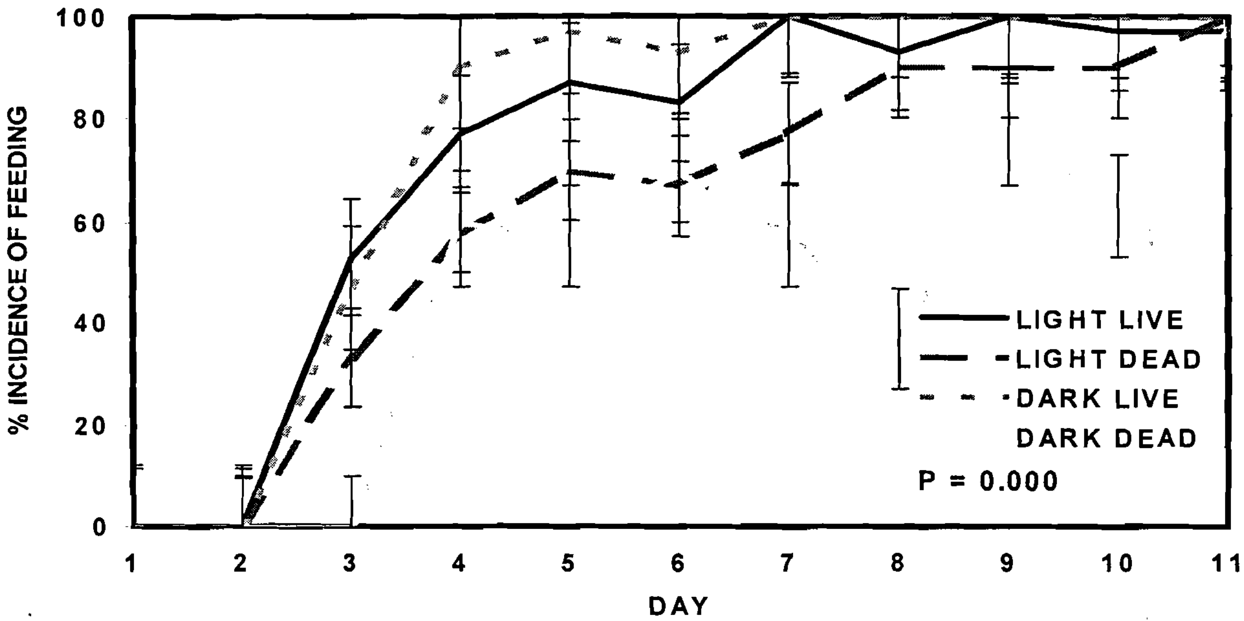

Figure 5. Proportion of fathead minnow larvae ($n = 30$) feeding on live and dead brine shrimp in the light and dark on successive days of the experiment. Vertical bars represent one standard error of the mean.

Light-Dark/Live-Dead Effects

As evidenced by significantly different feeding slopes (df = 300, P = 0.000), fish fed progressively more through time in the light than the dark. When all feeding conditions were combined, fish fed significantly more on live food than dead food (df = 300, P = 0.000). Fish fed significantly more on live food than dead food in both the light (df = 132, P = 0.005) and the dark (df = 168, P = 0.000) (Figure 5). When each feeding combination of light/dark and live/dead were compared, feeding slope differences suggested that fish fed progressively less on dead food in the dark (df = 300, P = 0.000) than under any other test conditions (Figure 5).

Prey Density Effects

No influence of food density was observed when fish were fed live food in the light (df = 66, P = 0.973; Figure 1). On dead food in the light, significantly more fish (df = 66, P = 0.006) (Figure 2) fed at the 105 density than at the 35 density (Tukey's df = 63; 105 density > 35 density, P = 0.005) while there were no differences in feeding between 105 and 70 and 70 and 35 densities. Similar results occurred in the dark; fish fed live food in the dark produced no different feeding responses among rations (df = 84, P = 0.977) (Figure 3). However, fish fed dead food in the dark showed two different feeding responses (df = 84, P = 0.02), the 35 prey density produced a significantly lower feeding response than the other two densities (Tukey's df = 81; 105 density > than 35, P = 0.001, and 70 density > 35, P = 0.43) (Figure 4).

When all prey conditions, light/dark and live/dead, were combined significantly different responses (df = 300, P = 0.002) occurred between the different densities of prey. More fish fed at the 105 density and fewest at the 35 density (Tukey's df = 297); 105 density > than 35 density P=0.001, and the 70 density was > than the 35 density, P = 0.046. No differences occurred between the 105 and 70 densities. In the light, the highest combined live/dead prey density produced a greater feeding response than the 35 density (Tukey's df = 129, P = 0.004); but no other differences were observed. In the dark, no differences in feeding were observed among the different prey densities (df = 168, P = 0.943).

DISCUSSION

Results of this study suggest that conditions of prey presentation, live vs. dead and light vs. dark, do identify the use and coordination of various sensory modalities in early larval fathead minnow feeding and that the quality and density of prey influence early feeding success. The two cohorts of fish tested were similar in size at all ages; therefore behavior and developmental stages associated with varying body size or maturation can be discounted as having influenced the observed results.

Fish fed live prey in both light and dark showed 100% feeding at all prey densities by day 7 indicating that daylight feeding fishes such as the fathead minnow utilize a combination of photoreception, and mechanoreception, and possibly chemoreception in early feeding in daylight and mechanoreception and possibly chemoreception in complete darkness, similar to that reported by Montgomery 1989, Salgado and Hoyt 1996, and Ore et al. 1997. The observation of 100% feeding on dead prey on days 11 and 12 (no vibratory stimuli) in light and dark, respectively, and significantly less feeding success on dead food prior to those days identifies the delayed onset of chemoreception, but its involvement in feeding. Similar results have been reported by Silberhorn, et al. (1993).

Fathead minnows are considered to be primarily visual feeders. The observation that fathead minnow larvae fed better in the light than the dark supports the important role visual stimuli play in prey capture, similar to that of other cyprinids (Wanzenbock and Schiemer 1989). However, when vibratory stimuli were removed in the light, the fish fed less. This finding is similar to that reported by Ore et al. (1997) that mechanical stimuli are important to the early feeding success of larval fathead minnows.

These results also suggest that olfaction is the least used sense in early feeding in this species. Yet, in both light and dark tests using dead food, feeding success reached the same high degree as the other test conditions by days 11-14 implying that olfaction organ development was protracted or that it was a learned sense requiring several days to become effective. Hara (1986) reported that olfactory stimuli are used to locate prey in various species.

Prey concentration is an important requirement in the initiation of early feeding and is much more stringent for the earliest, smallest larvae (Blaxter 1986). While average prey concentrations in the oceans have been described as much lower than that required for successful laboratory rearing experiments, higher density aggregations of microplankton which go undetected by conventional sampling techniques do exist which can be found by larvae (Arthur 1977). As larvae achieve first feeding, possibly the most critical stage in early larval life, their subsequent activity and prey searching abilities define their chances of survival and growth (Houde 1975, Blaxter 1986, Heath 1992). Consequently, higher than normal prey densities expected to sustain fathead minnows in the wild were employed in this study to facilitate the initiation of first feeding and enhance early growth and survival.

Feeding was not influenced by prey density when fish had visual, mechanical, and chemical stimuli (live food in the light). Letcher and Bengtson (1993) reported similar results in larval silversides feeding under the same conditions. Ivlev (1965) reported that in cases of non-moving prey, fish larvae cannot or have difficulty in satisfying their food requirements. Only the active movements of both predator and prey bring the number of contacts high enough to produce sufficient rations. When dead food was fed in the light, feeding success was significantly less at the lowest prey density amplifying the predator/prey movement criterion. This further suggests that when fish have only olfactory and visual stimuli, their ability to capture and ingest food organisms is compromised when food density is at a minimum.

Montgomery (1989) found that fish will feed effectively on live prey in the dark using lateral line information, yet the opposite was true when fed dead prey. Similar results were observed in this study. Under dark conditions, fish fed effectively on live prey, food ration having no influence on feeding success. Likewise, when visual stimuli were removed, leaving only mechanical and olfactory stimuli, fish fed statistically the same regardless of the number of prey organisms available. Contrastingly, when fish were given dead prey in the dark, they fed significantly less as prey density decreased suggesting that when fish are limited only to olfactory stimuli, feeding success is reduced as prey density decreases.

When results from all light conditions and prey types (light/dark and live/dead) were combined, it was observed that feeding success was lowest at the 35 food density. This supports

Heath's (1992) findings that early larval fish feeding is hindered when food abundance is low or prey concentrations are patchy. Total feeding in the light was influenced by prey density; less feeding occurring at the 35 ration. In the dark, however, no feeding differences were observed among the different prey rations. Therefore, when fish have live and dead prey stimuli, they feed the same despite the number of food organisms present. No feeding differences were observed among the varying prey densities when total feeding (light/dark) on live food was examined. This observation implies that whenever mechanoreceptive stimuli (live food) are present, food density does not impact feeding success in larval fathead minnows. However, prey density did impact total feeding in the light/dark trials when fish were fed dead prey at the lowest ration, suggesting that in the absence of mechanical stimuli it becomes more difficult for the larvae when prey concentration is low. This conclusion is in agreement with Montgomery's (1989) suggestion that larval fish do not feed effectively without vibratory stimuli.

LITERATURE CITED

Arthur, D. K. 1977. Distribution, size, and abundance of microcopopods in the California Current system and their possible influence on survival of marine teleost larvae. Fishery Bulletin 75:601-611.

Batty, R. S. and R. D. Hoyt. 1995. The role of sense organs in the feeding behaviour of juvenile sole and plaice. Journal of Fish Biology 47:931-939.

Blaxter, J. H. S. 1986. Development of sense organs and behaviour of teleost larvae with special reference to feeding and predator avoidance. Transactions of American Fisheries Society 115:98-114.

Blaxter , J. H. S. and L. A. Fuiman. 1989. Function of the free neuromasts of marine teleosts. Pp. 481-499. *In*: Coombs, S, P. Gorner, and H. Munz (eds.). The Mechanosensory Lateral Line, Springer-Verlag, New York.

Frank, K. T. and W. C. Leggett. 1986. Effect of prey abundance and size on the growth and survival of larval fish: an experimental study employing large volume enclosures. Marine Ecology Progress Series 34:11-22.

Hara, T. J. 1986. Role of olfaction on fish behaviour. Pp. 52-176. *In*: Pitcher, T. J. (ed.). The behaviour of teleost fishes. Croom-Helm, London.

Hart, T. F., Jr., and R. G. Werner. 1987. Effects of prey density on growth and survival of white sucker, *Catostomus commersoni*, and pumpkinseed, *Lepomis gibbosus*, larvae. Environmental Biology of Fishes 18:41- 50.

Heath, M. R. 1992. Field investigations of the early life stages of marine fish. Pp 1-131. *In*: Blaxter, J. H. S. and A. J. Southward (eds.). Advances in Marine Biology. Academic Press, London.

Houde, E. D. 1975. Effects of stocking density and food density on survival, growth, and yield of laboratory-reared larvae of sea bream, *Archosargus rhomboidalis* (L.) (Sparidae). Journal of Fish Biology 7:115-127.

Ivlev, V. S. 1965. On the quantitative relationship between survival rate of larvae and their food supply., Bulletin of Mathematics and Biophysics 27:215-222.

Iwai, T. 1980. Sensory anatomy and feeding of fish larvae. Pp. 124-145. *In*: Bardach, J. E., J. J. Magnuson, R. C. May, and J. M. Reinhart (eds.). Fish Behavior and Its Use in the Capture and Culture of Fishes, ICLARM Conference Proceedings 5. International Center for Living Aquatic Resources Management, Manila, Philippines.

Laurence, G. C. 1974. Growth and survival of haddock (*Melanogrammus aeglefinus*) larvae in relation to planktonic prey concentration. Journal of Fisheries Research Board of Canada 31:1415-1419.

Letcher, B. H. and D. A. Bengtson. 1993. Effects of food density on growth and patterns of prey depletion by larval silverside fish, *Menidia beryllina* (Cope); a laboratory investigation with image analysis. Journal of Experimental Marine Biology and Ecology 167:197-213.

Montgomery, J. C. 1989. Lateral line detection of planktonic prey. Pp 561-574. *In*: Coombs, S., P. Gorner, and H. Munz (eds.). The Mechanosensory Lateral Line, Springer-Verlag, New York.

Noakes, D. L. G. and J.G. J. Godin. 1988. Ontogeny of behavior and concurrent developmental changes in sensory systems in teleost fishes. Pp. 345-395. *In*: Hoar, W. S. and D. J. Randall (eds.). Fish Physiology, Volume XI: The Physiology of Developing Fish. Part B. Viviparity and Posthatching Juveniles, Academic Press, New York.

O'Connell, C. P. and L. P. Raymond. 1970. The effect of food density on survival and growth of early post yolk-sac larvae of the northern anchovy (*Engraulis mordax* Girard) in the laboratory. Journal of Experimental Biology and Ecology 5:187-197.

Ore, S. G., D. M. McElroy, and R. D. Hoyt. 1997. Exposure to acute low pH impairs chemoreception and feeding performance in larval fathead minnows (*Pimephales promelas*). Marine and Freshwater Behavior and Physiology 30:1-17.

Salgado, S. D. and R. D. Hoyt. 1996. Early behavior formation in fathead minnow larvae, *Pimephales promelas*: implications for sensory function. Marine and Freshwater Behavior and Physiology 28:91-106.

Silberhorn, E. M., W. A. Robison, T. M. Short, J. A. Black, and W. J. Birge. 1993. Comparison of *Artemia* feeding regimens on larval growth in a short-term fathead minnow toxicity test. Bulletin of Environmental Toxicology 50:179-186.

SYSTAT, Inc. 1992. SYSTAT for Windows: Statistics, Version 5 Edition. SYSTAT, Inc., Evanston.

Wanzenbock, J. and F. Schiemer. 1989. Prey detection in cyprinids during early development. Aquatic Science 46:995-1001.

WATER QUALITY ASSESSMENTS USING AQUATIC MACROINVERTEBRATES: HOW OFTEN DO STUDENT MONITORS GET IT RIGHT?

S.W. Hamilton[1], D.L. Hamilton[2], and H.E. Gillis[3]

[1]The Center for Field Biology, Austin Peay State University, Clarksville, TN
[2]Logan-Todd Regional Water Commission, Guthrie, KY
[3]University of Minnesota, Minneapolis, MN

ABSTRACT. From 1997-2000, high school students from Clarksville Academy, Clarksville, Tennessee, participated in stream monitoring using a modified Isaac Walton League "Save Our Streams" methodology. Several times per school year, students visited Miller and Buzzard creeks in Robertson County, Tennessee, to perform a comparison of water quality. Miller Creek, an agriculturally impacted stream, and Buzzard Creek, an ecoregion reference stream, were compared. Students received identification training each year and were accompanied in the field by experienced teachers as well as university students and faculty. Students measured basic water quality parameters using instrumentation, chemical test kits and aquatic macroinvertebrate assessment. Four groups of three to four students performed biological monitoring by collecting macroinvertebrates from riffles in each stream. Each group identified and enumerated the organisms at the taxonomic level prescribed by the "Save Our Streams" data sheet. Students used the numbers to calculate a water quality rating on site. For the last five sets of samples (October 1999 to September 2000) students preserved the specimens after completion of their field ratings. The preserved specimens were re-identified to the lowest practical taxon, typically genus, by the authors using stereo and compound microscopes. Lab-identified taxa were then placed into the same taxonomic categories used by the students to determine the accuracy of their field identifications and resultant water quality ratings. The average student-generated ratings for each date were comparable to lab-generated results six out of ten times. In the four cases of disagreement, the students had given the stream a lower rating. The average student ratings for a given date were "fair" or "good" for Miller Creek, while lab rating averaged "good" or "excellent." Except for one time, average student rating classified the Buzzard Creek as "excellent" while the average lab rating was "excellent" for all dates. Of greater concern is the rating generated from individual riffle samples. On one date for Miller Creek, individual student-group ratings varied from "poor" to "excellent," while Lab ratings ranged from "fair" to "excellent." For the other four sampling dates, the variation in individual ratings for Miller Creek was not as great. For a given sampling date, individual student ratings were more consistent in Buzzard Creek ("good" or "excellent"). Overall the students were more likely to underrate the stream's water quality. Forty percent of the time students rated Miller Creek lower than the lab rating. Nearly 90% of the student ratings were correct at Buzzard Creek. The "quick and dirty" method of stream analysis (i.e., "Save Our Streams" and field "Rapid Bioassessment Methods") have been criticized for their inability to identify streams accurately that are moderately impacted because of its "broad brush" categorization of macroinvertebrates. With this type of methodology citizens are more likely to identify severely impacted streams and high quality streams accurately while having a greater difficulty identifying streams that are moderately impaired.

The Center for Field Biology and Tennessee Project WET supported this project.

AMPLIFIED RIBOSOMAL DNA RESTRICTIONS ANALYSIS OF ARCHEBACTERIA OF THE LITTORAL ZONE OF LEDBETTER EMBAYMENT, KENTUCKY LAKE

HANNAH M. BEARD AND TIMOTHY C. JOHNSTON

Department of Biological Sciences and the Center for Reservoir Research
Murray State University, Murray KY 42071

ABSTRACT. DNA was extracted from sediment samples using the Ultraclean Soil DNA kit (Bio101) with the FastPrep instrument (Bio101) and used as template to amplify rDNA fragments. Samples for DNA extraction were taken from five sites along a transect from the littoral zone of the Ledbetter Embayment in June and July, 2002 (zone flooded) and in February 2002 (zone exposed). The primers used in the PCR reactions were shown to be specific for Archebacterial sequences. The fragments were then inserted into the pGEM cloning vector and transformed into *E. coli.* Plasmid DNA was reisolated from 10 transformants from the five samples taken on each date and used as template in PCR reactions to amplify the inserts. The amplified inserts were then digested with AluI and the fragments resolved on 4 to 20% non-denaturing polyacrylamide gels to yield a restriction pattern for each clone.

The restriction patterns were visually analyzed to reveal the identical clones. Each different pattern indicated a separate Archeal species. In February 38 different patterns were found, and in June, 38 different patterns were found. Altogether, 76 different patterns were found, with only four patterns found in both February and June. These data suggest succession of archebacterial species in the littoral zone sediments as the temperature and water level changes between winter pool and summer pool. The clones will be sequenced and compared to a database to determine the species and group of Archaea that each clone came from.

AMPLIFIED RIBOSOMAL DNA RESTRICTION ANALYSIS OF EUBACTERIA OF THE LITTORAL ZONE OF LEDBETTER EMBAYMENT, KENTUCKY LAKE

DAVID V. CANO AND TIMOTHY C. JOHNSTON

Department of Biological Sciences, Murray State University, Murray KY 42071

ABSTRACT. The littoral zone of Kentucky Lake reservoir, unlike a natural lake in the Midwestern U.S., is flooded at summer pool and dry at winter pool. Essentially nothing is known about the microbial communities of reservoir littoral zones and their contribution to the chemistry of the lake. We used molecular techniques to compare the microbial communities of the littoral zone of this reservoir when the sediment is flooded and exposed. Samples for DNA extraction were taken from five sites along a transect from the littoral zone of the Ledbetter Embayment in summer pool (flooded) and winter pools (exposed). DNA was extracted from sediment samples using the Ultraclean Soil DNA kit (Bio101) with the FastPrep instrument (Bio101) and used as template to amplify rDNA fragments. Primers 68F and 1392R where used to amplify segments of 16srDNA of Eubacteria. The fragments were then inserted into the pGEM T-Easy cloning vector and transformed into E. coli. Plasmid DNA was reisolated from 10 transformants from the five samples taken on each date and used as template in PCR reactions to amplify the inserts. The amplified inserts were then digested with AluI and the fragments resolved on 4 to 20% non-denaturing polyacrylamide gels to yield a restriction pattern for each clone. The restriction patterns were analyzed to reveal identical clones. Each different pattern indicated a separate Eubacterial species. In winter samples 32 different Eubacterial patterns were found and 24 Eubacterial patterns for summer pool. While several species were found in more than one sample, no Eubacterial pattern was found to occur in both winter and summer pools. These data suggest succession of prokaryotic species in the littoral zone sediments as the temperature and water level changes between winter pool and summer pool. The clones will be sequenced and compared to the database of rRNA sequences to determine the group from which each clone came.

COMPARISON OF VISIBLE AND THERMAL-INFRARED CHLOROPHYLL-*A* PREDICTION MODELS FOR KENTUCKY LAKE USING LANDSAT ETM+ DATA

JUSTIN HUNTEMAN

Department of Geosciences, Murray State University, Murray KY 42071

ABSTRACT. **The utilization of Landsat TM imagery for predictive chlorophyll-*a* modeling has proved to be a valuable tool in the monitoring of reservoir water quality. Varying techniques focusing on certain band combinations have been used with varying degrees of success in the prediction of chlorophyll-*a* content in reservoirs. Traditionally the visible and infrared bands of Landsat TM have been used in conjunction with linear regression to yield predictive chlorophyll-*a* models. Thermal infrared data have shown potential in past research for prediction, but because of poor radiometric resolution, the preferred method for prediction mainly focused on visible and infrared data. Landsat ETM+ has a high-gain radiometric resolution thermal-infrared band. This new band may show greater potential for prediction than older thermal-infrared data. It may also prove to be superior to traditional image data modeling methods. This study will focus on visible versus thermal-infrared statistical regression models for prediction of chlorophyll-*a* content in Kentucky Lake.**

USING CHLOROPHYLL FLUORESCENCE TO DETERMINE WETLAND PLANT RESPONSE TO FLOODING STRESS

JOELL HILL AND WILLIAM SPENCER

Department of Biological Sciences and Hancock Biological Station
Murray State University, Murray, KY 42054

ABSTRACT. Chlorophyll Fluorescence is the emission of energy as light from excited electrons in plants. Under "normal" conditions the energy would be used to produce ATP, and NADPH. When the light-dependent reactions of photosynthesis are decoupled from the light-independent reactions fluorescence occurs. Fluorescence estimates the amount of absorbed quanta that are not used in photosynthesis. In other words, the more light that is emitted the more stressed the plant. Two hypotheses were formed. Aerial leaves from *Justicia americana* plants exhibit acclimation to the aerial environment, and submersed leaves do not exhibit acclimation to the aerial environment. Using pulse-modulated chlorophyll fluorescence it was found that aerial leaves exhibit less stress in the submersed environment than submersed leaves in the aerial environment. When the environment was changed the amount of stress increased in both submersed and aerial leaves suggesting that each leaf type performs best in the environment in which it developed.

ALLELOPATHIC INTERACTIONS AMONG FLORA OF THE LEDBETTER EMBAYMENT MUDFLAT OF KENTUCKY LAKE

MELISSA ENGLEMAN AND WILLIAM SPENCER

Department of Biological Sciences and Hancock Biological Station
Murray State University, Murray, KY 42071

ABSTRACT. Observations of monotypic communities of *Eleocharis acicularia* within the Ledbetter embayment mudflat of Kentucky Lake suggested the presence of allelopathic interactions. Allelopathy is the direct or indirect effect of one plant on another mediated by organic chemicals that escape into the environment. Allelochemicals produced in the leaves escape as leachates, while those produced in the roots escape as exudates. Laboratory experiments using lettuce seed assays and photosynthetic rate comparisons suggested that allelopathic interactions occur. Experiments using plants that co-occur with *E. acicularis* indicate the presence allelopathy in the mudflat environment. Species including, *Potamogeton diversifolius, Rotala ramosior, Sagittaria montevidensis, Justicia americana, Xanthum strumarium,* and *Carex spp.* exhibited differential response to leachates from *E. acicularia.* Preliminary results suggest that allelopathy plays a role in determining plant community composition within the Ledbetter embayment mudflat.

VARIATION IN SEASONAL ACTIVITY OF NARROW-MOUTHED TOADS (*GASTROPHRYNE CAROLINENSIS*) AT TWO SMALL PONDS IN THE TENNESSEE PORTION OF LAND BETWEEN THE LAKES

A. FLOYD SCOTT

Department of Biological Sciences and Center for Field Biology
Austin Peay State University, Clarksville, TN 37044

ABSTRACT. The eastern narrow-mouthed toad, *Gastrophryne carolinensis*, is a widespread inhabitant of terrestrial habitats throughout southeastern United States. It breeds in temporary bodies of water and small fishless ponds. Outside the breeding season, it lives concealed under surface cover or in subterranean burrows where it feeds mainly on ants and termites. Despite its broad range and easy detection when breeding, relatively little is known of long-term fluctuations in its annual cycles, especially in the north-central portion of its range. The objective of this study was to analyze data on the seasonal activity of the species obtained over an eleven-year period (January 1988 through December 1998) at two closely situated ponds in the Tennessee portion of Land Between The Lakes. Toads were caught as they moved to and away from the ponds (one at the edge of a field and the other about 30 meters distant in the edge of a deciduous forest) in pitfall traps set along drift fences, which were checked every other day, except during subfreezing weather when they were checked weekly. A total of 1107 captures (88% at the field pond) were recorded. Total captures varied widely from year to year as did dates of first and last appearance. Earliest date of annual appearance averaged 16 May (range 20 April-31 May), while the last date seen averaged 22 September (range 23 Aug-7 November). The yearly average for time between the dates of first and last appearance was 128.5 days (range 88-187 days). Adults predominated from the date of first appearance through July and were most abundant in June. Juveniles, which were encountered in large numbers only two of the 11 years, predominated from August, when their numbers peaked, until activity ceased. Correlation analyses comparing levels of activity and selected abiotic variables are underway and will be discussed.

BREEDING PHENOLOGY IN THE POLYMORPHIC MOLE SALAMANDER, *AMBYSTOMA TALPOIDEUM*, IN WESTERN KENTUCKY

CATHERINE B. AUBEE AND HOWARD H. WHITEMAN

Department of Biological Sciences, Murray State University, Murray, KY 42071

ABSTRACT. *Ambystoma talpoideum*, commonly known as the mole salamander, reaches the northern extremities of its range in western Kentucky. As a facultatively paedomorphic species, *A. talpoideum* presents an opportunity to study the comparative life histories and potential interactions of metamorphic and paedomorphic individuals within the same population. The focus of this research was to locate potential breeding sites of *A. talpoideum* in western Kentucky and to observe breeding patterns within these populations. Paedomorphic individuals have been confirmed at two sites in rural Calloway County and at one of twelve potential sites in Land Between the Lakes (LBL). Breeding activity (indicated by cloacal swelling and the presence of spermataphores) at the LBL site concluded by mid-February 2002. No metamorphic salamanders were found at this site until December 2002. Metamorphic individuals were discovered at the Calloway County sites in December 2001 and 2002, and have shown signs of breeding activity during the same time frame as paedomorphic individuals. Breeding at the Calloway County sites continued through February 2002 and waned in early March 2002 during the first year of study. The timing of breeding is atypical because previous studies have shown that paedomorphic individuals generally begin and cease breeding earlier than metamorphic individuals. Exceptions have been noted when paedomorphic salamanders have only recently reached maturity. Current analysis of paedomorphic versus metamorphic snout-vent length (SVL) measurements supports this hypothesis. Sampling will continue through the 2002-03 season.

TESTING THE MAINTENANCE OF LIFE HISTORY DIMORPHISM IN TIGER SALAMANDERS, *AMBYSTOMA TIGRINUM NEBOLOSUM*, USING AGE STRUCTURE ANALYSIS

CHRIS EDEN, LEON DUOBINIS-GRAY AND HOWARD H. WHITEMAN

Department of Biological Sciences, Murray State University, Murray, KY 42071

ABSTRACT. Facultative paedomorphosis in salamanders is a complex phenomenon resulting in two distinct morphs. Environmental conditions affect the growth of salamander larvae, resulting in either terrestrial, metamorphic adults or aquatic, paedomorphic adults. Although the occurrence of this salamander dimorphism has been well documented, the mechanisms, which maintain coexistence of the two morphs, are not well understood. The focus of this study was to test three hypotheses for the maintenance of facultative paedomorphosis in the tiger salamander, *Ambystoma tigrinum nebolosum*. These ecological hypotheses predict the effects of dimorphism on various fitness components, such as body size, survivorship, age of maturity, and longevity. Skeletochronology was used to assess the age of 270 individuals that were initially sampled during 1990-1991. Age was determined by counting the number of lines of arrested growth (LAG) in cross-sections taken from phalanges. By combining age with previously collected data such as morph, snout-vent length (SVL), and mass, the fitness of each morph was assessed. The implications of these results in light of the hypotheses will be discussed.

UTILIZATION OF REMOTE SENSING TO MODEL CURRENT AND FUTURE THREATS TO AMPHIBIAN POPULATIONS IN WESTERN KENTUCKY

JESSICA BOYNTON AND HOWARD H. WHITEMAN

Department of Biological Sciences, Murray State University, Murray, KY 42071

ABSTRACT. Humans are constantly changing the environment, often by altering and fragmenting land cover. Recently, scientists have become interested in using remote sensing as a tool to quantify habitat change and fragmentation, and examine their potential effects on plant and animal populations. The long-term goal of this project is to correlate habitat change and fragmentation with the health of amphibians. Amphibians are a potential group of "indicator species", which are sensitive to environmental stress. Scientists use indicator species as an early warning system for environmental problems. As a first step, this study focused on quantifying habitat change and fragmentation. Using LandSat 7 ETM+ images and GIS software, I created two land cover maps for 1994/95 and 2000/01. Using these maps, I examined change over time and fragmentation. The initial analyses indicated that the majority of the habitat changed from one type to another during the five-year interval. The change has been predominantly of four types: cropland becoming grassland (and vice-versa), cropland becoming deciduous forest, and grassland becoming deciduous forest. Fragmentation analyses showed that there are an increased number of "patches" (higher fragmentation) in agricultural areas compared to less disturbed areas. In addition, the patches in agricultural areas are smaller with more edge than those in less disturbed areas. After quantifying habitat change and fragmentation, I will compare the results to those on amphibian health to better understand how remote sensing might be used to better manage and conserve amphibian populations.

A STUDY OF THE EFFECT OF TAIL AUTOTOMY ON SOCIAL DOMINANCE AMONG MALE FIVE-LINED SKINKS, *EUMECES FASCIATUS* IN CONTESTS OVER MATING ACCESS TO REPRODUCTIVE FEMALES

AMY N. EVJEN, JOSEPH R. SCHILLER, AND AMELIA C. LEWIS

Department of Biology, Austin Peay State University, Clarksville, Tennessee 37044

ABSTRACT. Social dominance of many lizard species, including *Eumeces laticeps*, has been shown dependent on body size. This study investigated change in social dominance among *E. fasciatus* due to a change in body size caused by tail autotomy. The skinks were obtained from an area of grazed forest that had been selectively logged 5 years earlier South of Clarksville, Tennessee. Contests over breeding access to females were conducted between pairs of adult male *E. fasciatus* in order to establish social dominance rankings. Tongue flicks, orientations, bites, grapples and tail wags were observed and quantified in the contests. The male that forced its opponent to retreat was considered dominant. Contests were repeated after the tail of the dominant male was autotomized. These contests resulted in no change in the previously established social dominance among male pairings.

PATTERNS OF MOVEMENT IN THE COPPERHEAD (*AGKISTRODON CONTORTRIX*) IN THE LAND BETWEEN THE LAKES NATIONAL RECREATION AREA

VALORIE TITUS AND EDMUND J. ZIMMERER

Department of Biological Sciences, Murray State University, Murray, KY 42071

ABSTRACT. The copperhead (*Agkistrodon contortrix*) is possibly the most abundant large snake species found in the Land Between the Lakes National Recreation Area (LBL). Between 60-70% of snakes captured at night road cruising are copperheads. To investigate population densities and patterns of movement in this species, snakes were sampled by night-driving roads associated with the Wranglers Camp area, the Nature Station Area, and the Trace connecting the two. GPS coordinates were recorded at every point of observation for both alive (AOR) and dead (DOR) snakes. DOR individuals represent nearly 50% of those observed. Live snakes were marked and released at their site of capture. Out of 101 marked, and 198 observed (DOR + AOR) only one was a recapture. Current data suggests that sites of road crossing are not random in this area with some sites showing apparently greater activity than others. It is not yet determined whether this is due to local differences in population density or to preference variability in road crossing sites.

ANALYSIS OF RED MILKSNAKE (*LAMPROPELTIS TRIANGULUM SYSPILA*) AND SCARLET KINGSNAKE (*L. T. ELAPSOIDES*) HABITAT IN THE LAND BETWEEN THE LAKES NATIONAL RECREATION AREA

MARK HATFIELD AND EDMUND J. ZIMMERER

Department of Biological Sciences, Murray State University, Murray, KY 42071

ABSTRACT. An in-depth habitat analysis was performed to determine use and differences between *Lampropeltis triangulum elapsoides* and *L. t. syspila* found in Land Between The Lakes National Recreational Area (LBL). The relationship of *elapsoides* and *syspila* is variable across their range with evidence that they occur as sympatric populations in some areas and as intergrading populations in other regions. Historically LBL has been documented to be an intergrade zone, but recent findings suggests *elapsoides* and *syspila* are acting as distinct populations with little or no gene flow.

At each *elapsoides* (n =17) and *syspila* (n = 23) collection point 16 habitat characteristics were collected. Elevation (ELV) and distance to closest water (DW) was calculated from each collection point. Habitat type (HBT), top soil depth (cm) (SCD), leaf litter depth (cm) (LLD), coarse woody debris area (cm^2) (CWDA), distance to closest coarse woody debris (m) (DCWD), dead standing timber dbh (cm) (DSTDBH), distance to closest dead standing timber (m) (DDST), dead standing timber condition (DSTC), dead standing timber genus (GDST), and canopy tree species (CTS) were collected in a 10 ha perimeter from each point. Soil type (SOIL), slope (%) (SLP), and slope aspect (SLPA) were collected in a 225 m radius from each point. Chi-square of independence indicated that HBT, DSTC, SOIL, SLP, and SLPA were significantly different between *elapsoides* and *syspila* sites (p-value <0.0001). Discriminate analysis using mean values of ELV, DW, SCD, LLD, CWDA, DCWD, DSTDBH, and DDST was able to successfully classify 36 of the 40 (90 %) sample sites to each correct subspecies. *L. t. elapsoides* in LBL utilizes habitat different than what is commonly associated with this species in more southern and eastern populations.

HABITAT USE AND HOME RANGE ANALYSIS OF THE NORTHERN PINE SNAKE (PITUOPHIS MELANOLEUCUS MELANOLEUCUS) ON ARNOLD AIR FORCE BASE, TENNESSEE

Gary Gerald[1], Mark A. Bailey[2], Karan A. Bailey[2], and Jeff Holmes[3]

[1]Middle Tennessee State University, Murfreesboro, TN 37132
[2]Conservation Southeast, Shorter, AL 36075
[3]The Nature Conservancy, Nashville, TN 37212

ABSTRACT. Northern pine snakes (*Pituophis melanoleucus melanoleucus*) were "fitted" with radiotransmitters and tracked from April to December 2001 and March to November 2002 at Arnold Air Force Base (AFB) in Coffee and Franklin counties in Tennessee. Snakes were located a total of 1463 times at 566 locations to determine habitat use and home ranges. Northern pine snakes were most active from May through July for both 2001 and 2002. They spent the majority of their time underground or in abandoned building foundations. Of the observations made in which the position could be determined, 75.1% of observations were recorded underground (49.4%) or within a building foundation (25.7%). Snakes selected open areas with little or no canopy cover dominated by herbaceous and shrubby substrates. Habitats with closed canopies such as pine and hardwood forests with little herbaceous groundcover were avoided. Snakes significantly preferred areas with greater than 50% herbaceous substrates and avoided substrates composed of leaf/straw litter. Snakes significantly utilized areas with no canopy and avoided hardwood canopies. Snakes preferred areas with less than 25% canopy cover and avoided areas with greater than 50% canopy cover. Northern pine snakes averaged 281 m per move with the average distance per move decreasing in fall. Mean minimum convex polygon (MCP) home range for all eight snakes tracked was 87.3 hectares. Mean MCP home range for males was 101.2 hectares. Mean MCP home range for females was 67.8 hectares. Home ranges overlapped considerably with core areas of activity being shared by multiple snakes.

Northern pine snakes prefer areas with a low level of human disturbance. Nearly 25% of the locations recorded were in building foundations and many other locations were recorded in recent clear-cuts or maintained open areas. Northern pine snake preferences for old structures and early successional vegetation have several management implications. Maintaining open areas and remnant building foundations may be an important aspect to the survival of this local population.

SPECIES DIVERSITY AT TERRAPIN CREEK STATE NATURE PRESERVE: AN ASSESSMENT OF TERRESTRIAL SMALL MAMMAL FAUNA

KELLY E. SOMERLOT AND TERRY L. DERTING

Department of Biological Sciences, Murray State University, Murray, KY 42071

ABSTRACT. The Terrapin Creek State Nature Preserve (TCSNP) in Graves County, KY, was established in 1992 by the Kentucky State Nature Preserves Commission in order to protect the unique assemblages of plants and animals found in the Terrapin Creek Wetland Complex. Trapping of small terrestrial mammals was conducted throughout eight tract areas of TCSNP using Sherman Live traps and pitfall arrays. A total of 10,890 trap nights were conducted over a one- year period, at six-week intervals, in order to inventory the species composition and small mammal communities of the area. A total of 1,382 animals were recorded, representing 14 small mammal species. The species list determined from the trapping effort was found to be comparable with a predicted species occurrence list generated from the Kentucky Gap Analysis Project database. Diversity, dominance, and evenness indices revealed that a high level of diversity and unique communities of small mammals are contained within the preserve. The white-footed mouse (*Peromyscus leucopus*) and marsh rice rat (*Oryzomys palustris*) were the dominant species on seven out of the eight tract areas. Tract analysis using polar ordination techniques revealed that most of the eight tracts at TCSNP support unique communities of small mammals. The inventory provides new information for the state's documentation of the area, including the confirmation of nine additional species. We predict that the high biodiversity at TCSNP will persist if management practices that maintain the vegetation and habitat heterogeneity are implemented.