ILLINOIS - NORTH CAROLINA COLLABORATIVE ENVIRONMENT FOR BOTANICAL RESOURCES

ABSTRACT

The Illinois - North Carolina Collaborative Environment for Botanical Resources seeks to revolutionize access to botanical resources by incorporating the methods botanists use to identify plant species and by simplifying and visualizing the process of identification. This project is supported by a partnership between the University of Illinois at Urbana Champaign (UIUC) and the University of North Carolina at Chapel Hill (UNC-CH), two leading institutions. The project's major goals include creating four polyclave keys that will visually capture the way botanical experts identify species; teaching and observing nonprofessionals in using and testing these keys for species identification; enlisting community citizens in documenting selected plant habitats in four important environmental monitoring projects (*PrarieWatch* and *ForestWatch* in Illinois and *Wildflower* and *TreeWatch* in North Carolina); creating a use-based collection of botanical resources to support biodiversity surveys; providing citizen and experts with access to a larger array of botanical resources through a UIUC and UNC-CH collaborative collection development and digitization plan; and producing an information store of high-quality botanical images that support species identification. The design of the project provides a framework that will foster scientific learning by citizen scientists who want to assist in documenting plant habits necessary for monitoring changes in the environment. The polyclave keys with data gathered by citizen scientists will be made available to other libraries and museums throughout the World Wide Web after development and testing. We will actively promote the use of the polyclave keys, enhance the flow of scientific information, and share expert investigative processes with other botanists and nonprofessionals who want to expand their knowledge of the natural world and contribute to the documentation of plant habits.

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NARRATIVE –This project seeks to revolutionize access to botanical resources by incorporating the methods botanists use to identify plant species and by simplifying and visualizing the process of identification. To assure transparent sharing of data from different locations and collections, a replicable collaborative environment will be designed, implemented and tested. The work will be developed and supported by a collaboration between two major universities: the University of Illinois at Urbana Champaign (UIUC) and the University of North Carolina at Chapel Hill (UNC-CH).

The objectives of this project are to:

- Create four **polyclave keys [as alternatives to traditional dichotomous keys]** that will visually capture the way botanical experts identify species.
- **Teach and observe** nonprofessionals (e.g., students, amateur botanists, gardeners, naturalists, life long learners, high-school teachers, and other groups of persons with an interest in botanical and environmental sciences) in using and testing these keys for species identification.
- **Enlist community citizens** in documenting selected plant habitats in four important environmental monitoring projects (***PrarieWatch*** and ***ForestWatch*** in Illinois and ***Wildflower*** and ***TreeWatch*** in North Carolina).
- Create a **use-based collection** of botanical resources to support biodiversity surveys.
- Provide citizen and expert **access** to a larger array of botanical resources through a UIUC and UNC-CH collaborative collection development and digitization plan.
- **Produce** an information store of high-quality botanical images that support species identification (e.g., zoom views of leaf scars and plant hair).

UIUC and UNC-CH both have a full range of computer equipment, high-speed Web connectivity, and carefully designed and tested specimen digitization operations. Both institutions have existing partnerships with local public school science teachers and students and local and state botanical groups through past projects. Additionally, these institutions are supported by number-one ranked library and information science programs (*U.S. News and World Report*, 1999) and they have a community of botanists who are committed to polyclave key creation based on expert plant identification processes. Together, the available computing technologies, the digitization experience, the links to education and conservation groups, the partnership between two leading institutions, and the support of botanists willing to share their knowledge provide an ideal infrastructure for developing and testing polyclave keys enhanced by visual images that will encode expert specimen identification processes. The design of the project provides a framework that will foster scientific learning by citizen scientists who want to assist in documenting plant habits necessary for monitoring changes in the environment. The polyclave keys with data gathered by citizen scientists will be made available to other libraries and museums throughout the World Wide Web after development and testing. We will actively promote the use of the polyclave keys, enhance the flow of scientific information, and share expert investigative processes with other botanists and nonprofessionals who want to expand their knowledge of the natural world and contribute to the documentation of plant habits.

This proposal explains the project *goals* using the **10 criteria** outlined in the IMLS Call for Proposals. We first discuss the project's **National Impact** and the **Adaptability** of our findings to other museums and libraries. We then provide a detailed description of the project **Design**, describe the **Management Plan** and **Budget**, and present an overview of **Personnel** involved in the project. We describe our plans to conduct and integrate formative and summative **Evaluation** and to **Disseminate** our findings to appropriate research and educational communities. We explain individual **Contributions** and the appropriateness and cost-effectiveness of items included in the Budget. Finally, we discuss how we will insure **Sustainability** of the results.

1. National Impact

Species identification can be a complicated and timely process for professionals and especially for nonprofessionals. Resources housed in herbaria and botanical libraries are not easily accessible due to insufficient staffing, limited viewing space, and the fragile condition of specimen samples. Nonprofessionals are not aware of the full range of resources used

by botanists for species identification and they find specialized tools difficult to use. The scientific vocabulary is a major barrier. The nonprofessional has limited understanding of the *expert's identification process and approaches the task inefficiently.* Nonprofessionals have difficulty initiating species identification and conducting an efficient search among competing possibilities. Our project will alleviate these difficulties. It will have national impact in three major ways. *First*, we will open more of the huge stores of ***botanical resources*** to the public through web access. *Second*, we will ***develop four visual polyclave keys*** that encode expert species identification processes. *Third,* we will ***contribute to public service and education*** through partnership with citizen-based monitoring programs.

The public has strong interest in natural history research and discovery. These interests include wildflower, grass and tree identification, gardening, observing nature along trails and in parks and conservation of natural areas and greenways. Greater access to the holdings and information contained in natural history museums will serve individuals with these interests and will also serve the museum. Digital technologies and the World Wide Web provide an environment that is hospitable for sharing primary scientific resources and museum information that are inaccessible and *underused* by the public. The UIUC and UNC-CH partnership will *increase access* to botanical resources through a collaborative digital initiative. High-resolution digital processes will be used to produce quality images of specimens housed in the UIUC and UNC-CH herbaria and at other institutional affiliations. This will result in the compilation of a more comprehensive Web-accessible collection that can be used by both experts and nonprofessionals for species identification.

Species identification for the non-expert often begins by asking and expert or searching for a picture that resembles the plant sample. Unfortunately experts are rarely available and the hunt method is time-consuming and rarely successful. A taxonomic key can lead an individual to the correct identification. The most common taxonomic keys are *dichotomous,* that is two-forked. They consist of a series of paired, mutually exclusive statements that describe some feature of the plant (e.g., *"Leaves pinnately compound with linear leaflets*" or "*Leaves simple, linear, acicular, subulate, or scale-like*"). A decision must be made between each set of statements before proceeding. The process can be time consuming and fraught with difficulty for the nonprofessional often because of the uncommon terms used. A *polyclave key*, by contrast, offers a more sophisticated approach in that it allows the user to select plant attributes in any order from a character set (e.g. a table, chart, or a series of images). Identifying plants with a polyclave key is a process of elimination. In a polyclave key the user can start anywhere, for example with characters that are easy to observe. There is no predetermined order and polyclave keys are easily computerized. Polyclave keys are easier for the nonprofessional to use because they suggest but do not require particular plant characteristics to focus on during the species identification. A very few such keys exist. We not only propose the development of four new keys, but plan to add two enhancements—visual representation of the more confusing plan features and a *prompt* system whereby the plant characteristic(s) that the expert would select will be provided as a suggested path through the identification process.

Because we anticipate that the use of these enhanced visual polyclave keys will be easily navigable by nonprofessionals, we anticipate greater accuracy in novice identification and thus greater assistance in documenting plant habitats in Illinois and North Carolina. After testing, these keys (and the process of creating them) will be made Web accessible and contribute to nation-wide educational and plant habitat documentation initiatives.

Instruction in biology is a critical part of public school curricula. Appreciating biological diversity and learning about the classification and identification of organisms (with associated vocabulary and observational skills) are important components of public school biology classes. Once an image-based polyclave is completed, the tool can be used in classrooms nationwide to teach the process of plant identification. Many of the *EcoWatch* [an environmental monitoring network set up by the Illinois Critical Trends Assessment Program] volunteers are high school teachers who train their students in these procedures. We will build on our experience with the K-12 education community to foster educational use of our materials. We will also build on experience garnered through the Plant Information Center (UNC-CH), an IMLS supported project that partners with science teachers and students McDougle Middle School, Carrboro, North Carolina.

2. Adaptability

While the World Wide Web has prompted natural history museums and librarians to share their resources through digital projects, the majority of these initiatives are still formative. Achievement of the objectives of our project will contribute new knowledge and processes that can be adapted to assist current and future museum digital initiatives. New contributions include:

Digital standards for specimen features. We will test and identify the appropriate range of standards for digitizing *key features* of plants to be used by the public through a Web. Not only will these standards be useful for plants, but for any set of museum objects (i.e., fungi, minerals, insects) or archives that, for one reason or another (including fragility and value), cannot be directly accessed by the public. The use of digitization standards will build on prior work conducted by IMLS-supported projects: Plant Information Project (UNC-CH) and several Missouri Botanical Garden projects.

Web-based Visual Polyclave keys. We will develop four image-based polyclave keys that will reflect the processes that botanists use when identifying plants. We will work with botanists to document their experiences in the scientific discovery process via simple marking techniques described below under design. We will test the system's functionality with users during development and will also involve users in the design process so that the system will be practical from a non-professional viewpoint. We are confident our project will provide better methods for users to identify museum specimens.

Involvement of citizen scientists in plant habitat documentation. We will engage the citizens from the community, including teachers and students, in the process of scientific discovery. These Citizen Scientists will contribute to the network of botanical specimens by identifying species in the four critical ecosystems in the two geographic regions proposed by our project. An **EcoWatch** system is already in place across Illinois and through the North Carolina Botanical Garden's volunteer organizations. Our techniques are adaptable to other community grassroots projects such as the National Butterfly Watch and the annual Audubon Christmas Bird Count.

3. Design

The project is designed around three tasks: collection development, development of image-based identification polyclave keys, and development of browsable annotated images. We describe each of these below, and then integrate all tasks in a description of the workflow. Our system will be designed to give access to professional taxonomists, systematists and the general public alike. We will test the usability of the system with several specified user communities (See the Evaluation section below).

Collection Development

Our collection development strategy will center on a particular four critical ecosystems in two geographic regions. The data in the collection will include a comprehensive representation of species from these critical ecosystems: Midwestern prairies, Piedmont glades and prairies, Midwestern forests, and North Carolinian forests. Lists of the bioindicator species are included in the appendices.

The species that we include in our collections were determined through the following criteria. *Dominant species* are those that have the highest biomass in the community; however, they may range over many communities; *characteristic species* are those that are diagnostic for that habitat, even if not dominant; *rare species* are important for monitoring since they are the most vulnerable to loss and have the greatest value to conservation areas; and *bioindicator species* are those that have the most significance for evaluating change (these changes can be both negative, as in the invasion by foreign weeds or the damage to ozone sensitive species; or they can be positive indicators of good habitat quality).

The North Carolina Botanical Garden (NCBG) and UNC Herbarium maintain extensive databases for North Carolina and for the Nature Preserves and lands of the Garden. The selected taxa were taken from these databases and include species that occur on NCBG permanent study plots in forest and in a Piedmont prairie at Penny's Bend Nature Preserve. In North Carolina these species occur on botanical garden lands (NCBG has permanent study plots on all of its lands, including 600

acres in Chapel Hill and four outlying nature preserves--one has a Piedmont prairie, one is on the coastal plain and two are in the mountains). The data about these species will include label data and images of herbarium specimens, as well as live plant photography, both in isolation and in natural environment setting.

The Illinois species were selected based on the criteria listed above. Well established and tested monitoring systems, PrairieWatch and ForestWatch, created as part of the Illinois Critical Trends Assessment Program (CTAP), EcoWatch Network, are the basis for the species lists in **Appendix A**. The Illinois Department of Natural Resources administers the CTAP program out of Springfield, Illinois. EcoWatch is one branch of CTAP.

We will digitize plant species in priority sequence, using what we term here a "centrifugal approach". The centrifugal approach ultimately derives from our purpose (species used in inventory and monitoring of ecosystem quality) and our audience (non-professionals working as field naturalists). We illustrate the centrifugal approach with the tallgrass prairie ecosystem in Illinois. This ecosystem has approximately 500 species of plants associated with it. While it is certainly possible to digitize all species in a taxonomic framework, a more useful approach, at least for the lay audience, is to start with the critical species of most importance in inventory and monitoring (see **Appendix A, Species Lists**). We will digitize species in the following sequence:

- First, all PrairieWatch species will be scanned and will serve as the starting point;
- Then, other species that are not necessarily closely related taxonomically, but that could be confused with the target species will be scanned next;
- Then, those species that are closely related taxonomically to the PrairieWatch species will be scanned;
- Finally, species that were related to the previous to subset three will be scanned to the point where all the tall grass species are present in the database.

Ideally, the process will include all 500 prairie species, but the centrifugal approach allows flexibility in the digitization process with regard to time and budgetary constraints. At any point in the centrifugal testing past the second level, a useful product will be available to PrairieWatch citizen scientists and to all prairie enthusiasts. While the ultimate goal remains all prairie plant species, the initial targets can mediate many identification problems currently associated with Illinois PrairieWatch by providing online identification aids.

Development of multi-entry, image-based, morphological plant key : Image Polyclave

Our second task is to create a means for image-based species identification and to support biodiversity survey work by scientists and lay naturalists. The system will be designed in context. This means that rather than digitizing a collection and hoping that a general user community will find it useful, we will focus design around actual uses of the information, while keeping more general uses in mind. We will test the system functionality during development and keep the users involved in the design process.

We will develop image-based online keys that will enable users to select plant specimen characteristics in any order (to create a "polyclave" key described above). For the most part, users will be freed from the need to know the specialized vocabulary of botany by referring to the images generated for the project. These keys will allow users to search and then browse for plant identification activities. An example of a character that a user might include would be "leaf margin" as a characteristic he/she might know. The system would present a series of images showing different possibilities for leaf margins, such as a "smooth leaf margin," a "toothed margin" and a "wavy margin" as well as other margin types appropriate for the collection. The user could pick one or more of these images as being most like the species that they are trying to identify. Based on this information the system reduces the number of possible species it could be. The system would then list another set of icons and text representing the other characteristics of the plant that might be useful in identifying it, for example, leaf size, leaf thickness, leaf shape or bark texture. The user could select the next characteristic in any order. For each characteristic the user selects, a table of images of possible shapes will be presented for the user toselect one of more. Eventually, the user will have selected enough characteristics to reduce the possibilities

to a relatively small set. At any point the user can stop and browse this set, examining images of all the specimens in the collection.

Some other polyclave systems, such as IntKey, NaviKey and LucID, allow some degree of image-based identification of characteristics. This project is unique in that we will integrate key construction with the specimen digitization process to insure that all specimens are accessible. Our method will insure that the broadest possible display of species variation is included within the collection. At present, no good publicly available on-line multi-entry keys to forest and prairie plants exist

Most guides and keys contain some type of visual representation of specimens. These visual representations include drawings, black-and-white photos, and color photos of preserved and live specimens. The text structure associated with these specimen treatments varies widely and acts subordinately or superordinately in relation to visual representations. In the two prairie plant guide examples below, the web page **(Appendix B, Figure 1)** provides a direct color representation, which is much more dominant and diagnostic than the black-and-white drawing from the book **(Appendix B, Figure 2)** or the text in either example. It is hard to imagine a person feeling more confident making an identification based on a black-and-white drawing as opposed to a color photo of a live specimen. However, the photo has its drawbacks, too. This particular prairie phlox is in bloom. The photo does not accurately represent the plant in winter. Other accompanying photos can show dissections and can zoom in on the plant parts that interest professionals or that reveals the leaf texture for laypeople. The particular choice of features to illustrate will be based on user input in the design stage.

The amount and kind of text to include in a guide or key should be based on the audience. Professionals are interested in comprehensiveness, specificity, and scientific terminology; whereas, laypeople may want ease of use and characters that relate to their personal ideas and experiences with the specimens. For example, a botanist may identify a flower arrangement as a panicle or umbel; a layperson may describe the same flower arrangement as a tree (panicle) or a rake (umbel). The particular characters to include and the choice of language does not have to be a choice, as we will be able to l include language for both botanists and non-botanists.

Image Annotation and Browsing

Our third task is to build a set of browsable and annotated images. Once a user has identified a small set of candidate images the next step in identification will be the examination of annotated digital images of these species. We will include images of live plants, as well as images of multiple herbarium specimens for each species in order to show different stages of development as well as variation within the species. Although we retain and will, in some cases display, unannotated ("clean") images, we will also annotate images for each species with arrows and text pointing out the critical features of the species or group. This feature is unique and critical. Without it citizen scientists and even professionals who are not expert in a particular family will not be aware of what is a critical feature for identification purposes. For example, if the botanist decides that bud scales are critical for identifying a species, the annotated image version for the species would have a bud circled with an explanatory note such as "Bud scales detached distally." The user may not know exactly what this means or what it should look like on a specimen. Using our image zooming software, he/she will be able to get a closer look at this feature. Our quality control process with verification from the botanists will insure that the critical feature is visible. If it is not visible on the primary high-resolution image we will include additional macro photography of the feature along with the primary image. The creation of the annotations and the macro photography for some specimens will add significantly to the processing time for images but it is a valuable addition as it will greatly enhance the usefulness of the images and the museum collections at large.

Workflow

A workflow diagram is included in **Appendix C**. In process 1.0, a botanist selects specimens from the collection. They may include herbarium sheets but also photographs and other visual material about the plants in their natural environments. The botanists will select specimens that best demonstrate critical characteristics. For example, one specimen may include good examples of flowers, whereas another specimen of the same species may provide a better example of a leaf bud or fruit. In process 2.0, the botanists will use a hand-held digital camera to create and print an image of each specimen. In process 3.0 the botanist circles critical features on the image and generates instructions to the

photographer about what is important to image for each specimen. The botanist also enters key characteristic information into a polyclave key tool (discussed elsewhere). In effect the botanists are making their expert knowledge about the plant family available to the general public. At the beginning of the project we will use DELTA (Description Language for Taxonomy, from the Natural Resources and Biodiversity Program of the CSIRO (Commonwealth Scientific and Industrial Research Organization, Australia) . We will develop our own tools later in the project to support features that are not normally included in DELTA based programs. Some of these will be based on user studies as part of this project. We also know from prior work (Heidorn, 1999) that nonprofessional users prefer retrieval by analogy to similar species. This feature is not supported by current DELTA-based polyclaves. This key will be converted into web-format to allow people anywhere in the world to access the images by specifying key characteristics.

In process 4.0, a non-botanist photographer will take several high-resolution images of the specimen. At the University of Illinois this photography will take place in the Imaging Lab in the Grainger Library. At North Carolina this takes place in the Herbarium. The photography will include one image that portrays the entire specimen. UIUC staff will consult with UNC members of the Missouri Botanical Garden Staff to cross validate imaging procedures. The photographer will also produce an annotation layer at this point. In this layer the photographer will use circles and arrows to direct the eventual viewers toward the critical features of the plant..

In process 5.0 the botanist will review the images to insure that critical features are indeed captured in the images. If all images are satisfactory, the botanist will return the specimens to the respective herbarium. Some features will be too small to capture with the standard digital photography equipment. These specimens will be marked for micro photography and the specimens will be moved to process 6: "Macro and Micro Photography." Finally, finished photographic images will be stored in the image database. Each specimen's label data will be added to the database, a barcode will be added for unique identification of the specimen sheet and the specimen returned to the herbarium.

4. Management

A national advisory board will be created consisting of experts who have been involved in similar work. The board will be convened approximately twice a year throughout the duration of the project. In addition, two local advisory groups – one at Illinois and one in North Carolina – will be created consisting of people representing the various constituencies the project is intended to serve. The local advisory groups will be convened approximately three times a year to provide input on procedures and assistance in identifying possible volunteers for testing various aspects of the project as it developments.

The management of the project will be shared by the senior principals identified in the project at both sites and by the principal investigators. The two institutions have appropriate offices for helping to support the business and financial end of the project and much experience in administering projects like this one. Leading institutions involved in the management of the project are described below:

The Herbarium of the University of Illinois (ILL) was established in 1868 coincident with the establishment of the University. Total holdings at ILL exceed 500,000.. Among United States institutions, the Illinois herbarium ranks approximately 17th nationally and about tenth among university herbaria (1984). ILL collections are especially rich in species from the upper Mississippi valley. Close to one-fourth of the specimens are Illinois material, comprising a nearly complete collection of the extant species, and also including some that possibly are now extinct in Illinois.

The North Carolina Botanical Garden has established itself as a national leader in conservation and native plant gardening. Established in 1971, the Garden has grown to 600 acres, 27 staff members, some 200 active volunteers, and a budget of over one million dollars. Cultivated grounds include the Coker Arboretum (5 acres on the main UNC campus) and the Garden proper (7 acres located 1.5 miles from the center of campus). The Garden holds approximately 2,500 species of plants and produces educational programs for the public, including school groups, throughout the year. The Garden was a founding member of the Center for Plant Conservation, a national organization that protects US endangered plant species.

The UNC Herbarium was founded in 1908. It now holds 660,000 specimens of plants, the largest herbarium in the Southeast. It is a key resource for any work on the identification and distribution of plants in our region. Among the important books produced from this collection are the landmark *Manual of the Vascular Flora of the Carolinas*, the ongoing *Flora of the Southeast* (two volumes published), and *Vascular Plant Systematics*. The Herbarium routinely serves as a center for plant identification (new weeds, rare plants, poisonous plants) and for studies of changing plant distributions.

The UNC School of Library and Information (SILS) is tied with the University of Illinois for the top program in library/information science (*U.S. News & World Report*, 1999). SILS offers a full education program: two Master's degrees, one in Library Science and one in Information Science; a Ph.D. program, an undergraduate minor and will soon have an undergraduate major in Information Systems; and continuing education programs. The school's extensive computing technology and support plus library facilities and collections provide an extensive resource for instruction and resource. Library specializations include school, public, and academic librarianship, and archives and cultural resources; and information science specializations include database administration and Internet applications offered by the 20-member full time faculty.

The UIUC Graduate School of Library and Information Science is also consistently ranked one of the best in the field. The University's long-time commitment to libraries and to computing (the Illiac computer was developed at UIUC) serves it well in this era of digital libraries. At the same time, the School remains committed to providing access to information for all and is the home of Prairienet, the community network for East Central Illinois. The School's faculty is outstanding in systems design and information retrieval, as well as in the areas of youth services, information policy, and the sociology of information use.

Both schools are accredited by the American Library Association.

5. Budget

A budget has been prepared that supports the goals and deliverables. Deliverables include two parallel digitized collections (prairie and forest), web-enabled database search and retrieval of specimens included in this project, four image-based polyclave keys, and the necessary documentation showing the development of the supporting systems and the standards used for the project. The budget justification provides additional detail.

6. Personnel

Our principal project leaders are:

P. Bryan Heidorn (PhD, School of Information Sciences, University of Pittsburgh) is an Assistant Professor in the Graduate School of Library and Information Science at – University of Illinois. His research interests include: cognitive and collaborative information retrieval, bioinformatics, collaborative publishing, graphical user interfaces and human information processing. He is a PI in the NSF Grant: Biological Information Browsing Environments and Co-PI of the National Biology Digital Library.

Jane Greenberg (PhD, School of Information Sciences, University of Pittsburgh) is an Assistant Professor in the School of Information and Library Sciences at UNC-Chapel Hill. She teaches and conducts research in the area of metadata, lexical-semantic relationships, and abstracting and indexing. Dr. Greenberg is a project leader for The Plant Information Center, an IMLS Library-Museum Collaboration grant.

Senior UIUC Staff

Michael R. Jeffords (Assoc. Prof., Natural Resources and Environmental Sciences, University of Illinois, Public Relations & Education Liaison, Illinois Natural History Survey). He helped designed the EcoWatch procedures for citizen

scientists. He has numerous scholarly and educational publications. He is a PI in the NSF Grant: Biological Information Browsing Environments.

Ken Robertson, Curator INHS Herbarium, Center for Biodiversity Illinois Natural History Survey, Adj. Prof Department of Plant Biology and Department of Natural Resources and Environmental Sciences.

David Seigler, Curator UIUC Herbarium, Professor, Plant Biology, UIUC, Professional Scientist, Illinois State Natural History Survey.

Beth Sandore, Head, Digital Imaging and Media Technology Initiative, Professor of Library Administration, University of Illinois.

Mary F. Lokhaiser is a doctoral student in the Department of Natural Resources and Environmental Sciences. Her dissertation topic in the effectiveness of identification keys.

Senior UNC Staff:

Peter White (PhD, Dartmouth, postdoc at the Missouri Botanical Garden) has been Director of the North Carolina Botanical Garden since 1986. He has published over 100 scholarly articles. His book, Wildflowers of the Smokies, won a national award for natural history interpretation in the National Parks. Dr. White is currently a PI for an IMLS Library-Museum Collaboration grant, The Plant Information Center.

Evelyn Daniel (PhD in information science, University of Maryland) is a professor at the School of Information and Library Science at the University of North Carolina, Chapel Hill, and was dean of the School between 1985 and 1990. She teaches and writes in the area of library and information science education and management. She has worked collaboratively with the public schools on a number of prior project. Dr. Daniel is also a PI for the IMLS Library-Museum Collaboration grant.

Michelle Fox (MEn in Environmental Science, Miami University of Ohio), is the Plant Information Center Coordinator for the Plant Information Center at the University of North Carolina, Chapel Hill.

7. Project Evaluation

Plant keys will be tested within the citizen scientist communities through activities in the field. These field naturalists will be asked to assist in documenting the health of various habitats. Through these efforts they will contribute to the development of a distributed digital library/museum that documents endangered plant species. Evaluation methods include observation of the citizen scientist activities in using the plant keys, online capture of their search techniques, transaction logs (use statistics) showing their interactions with the retrieval systems and polyclave keys set up for them, surveys asking for opinions and degree of satisfaction with the support system set up for them. Both formative and summative data will be collected.

In controlled studies, we will give volunteers plant specimens to identify. The subjects will be trained volunteers from associated biodiversity surveys. The two main groups of volunteers include adults and high school student volunteers. The plant specimens will include some that have only foliage, some with only bark, some with flowers and others with other plant parts. We will record variables including: time to correct identification, number of mis-identifications, the set of specimens observed and compared. Through usability studies we will identify patterns of use and misuse. We will use this information to improve the system.

The best way to evaluate a guide or key is to create one appealing to a target audience and then have that audience test it. Photos and text can be tailored to the need of our intended audience. Subjects will use both traditional paper-based keys and computer-based interactive keys. The order of key type presentation will be counterbalanced. Our goal is to test at least 120 subjects of both genders and of different ages at the level of expertise that is being targeted.

In the research project we will have four keys: one for Midwestern grass prairies, one for South Eastern Piedmont prairies, one for Midwest forests and one for South East forests. In Illinois the test subjects will be PrairieWatch and ForestWatch volunteers working with the appropriate keys. In North Carolina subjects will be recruited from NCBG volunteers and students, some of whom have had experience in prior plant identification projects with us. The best initial indicators of how well the key works are the accuracy of the identifications are and the speed with which correct identification is made.

To determine accuracy and speed, researchers will observe subjects using a computer key and elicit subject reactions to the key after it is used. Subject reactions, as answers to open-ended questions, will provide information for improvements, such as including additional or alternate character traits or changing the webpage layout.

8. Dissemination

We will disseminate results to several audiences and in several formats: botanical gardens (annual meeting and publications of the American Association of Botanical Gardens), environmental educators (annual meeting and publications of the North Carolina Environmental Educators), regional herbaria and science museums (*Bulletin of the Association of Southeastern Biologists*, Association of Systematics Collections), garden clubs and civic groups (Peter White and Ken Robertson are frequent speakers for these groups), high school teachers (Bryan Heidorn and Michael Jeffords hold training sessions for these groups), the University and community (*Endeavours* magazine, Botanical Garden *Newsletter, EcoWatcher* from the Illinois Department of Natural Resources), and librarians and information scientists (North Carolina Public Library Association, North Carolina Chapter American Association of School Librarians, *School Library Journal*, *American Libraries* (Evelyn Daniel and Jane Greenberg are frequent speakers for these groups), *Information Quest*, American Library Association, American Society for Information Science and Technology). In addition, we will present results of the project to various digital library conferences. We will create a project web page to report progress throughout the project. Project leaders will connect with the University libraries to submit collection-level metadata records to OCLC bibliographic database and the ARL Digital Initiatives Database (ARL/DID) to further disseminate and share resources.

9. Sustainability

We predict that improved access with increase use of the collections will reduce internal costs. Savings may be realized not only at the institutions involved in this proposal but also in later projects, that adopt the techniques developed in this project. Increased use will help justify additional fund raising from the user community, both foundation and research support. Both the Illinois group and the North Carolina group will be working with well-established user populations. These populations will form an initial long-term user base that can assist staff in one of the most frequently performed activities at the herbaria – identifying unknown specimens by comparing them to specimens in the collection.

Both herbaria collections (like other natural history collections) are valuable for urban planning and development, conservation efforts and basic research. Heavy herbarium users include departments of transportation, Army Corp of Engineers, the State and Federal EPA and private developers. These users will be able to do an increased percentage of identification online without help form professional staff.

There is also potential for internal savings. New items introduced to a collection must be accurately identified. Our image environment will allow professionals to narrow the choices more quickly. Even in cases which an original specimen from the collection is needed for final identification, the total time for identification will be reduced by reducing the number of items that must be examined, borrowed or loaned out. We will track sample identification times for professionals and non-professionals using the new technique vs. paper based keys and other paper media to verify difference in time and accuracy.

In addition, the collections in both sites are used in teaching at the college level. In Illinois they are also used for EcoWatch training where hundreds of volunteers and thousands of high school students around the State must learn to identify these species in the field.

The School of Information and Library Science and Graduate School of Library and Information Science each maintain several web pages that will house and sustain the web information developed in the proposed project.

We anticipate the growth in the user population will produce enthusiasm within the respective universities and states for additional state support to expand on the project described here.

10. Contributions

The University of Illinois is cost-sharing nearly 40% of the costs of the proposed budget. UIUC, Office Vice Chancellor of Research Office has contributed over $15,000 cash to the project. The personal commitment of faculty includes 5% of the salary of Drs. Ken Robertson, David Siegler, and Michael Jeffords. The Biology department is contributing a half-time hourly to the project.

The University of North Carolina is cost-sharing over 35% of the costs of the proposed budget. Contributions from the University and from personal commitment of faculty include 10% of the salary of two senior faculty from two different departments. Supplies and equipment will be cost-shared by the North Carolina Botanical Garden and the UNC Herbarium. The University of North Carolina is supporting one graduate assistant for the project. Additional resources from the NC Botanical Garden include the time and expertise of staff and resource material for educational use, resources from the UNC Herbarium including print files, the collection and the expertise of staff. Resources from SILS will contribute resources through its computer labs, software and hardware dedicated to the project and expert faculty members ready to provide advice and counsel, contribution consultation advice on an ongoing basis on the database and retrieval system design plus additional assistance from laboratory and library staff, and advice on the web interface and structure and educational material.

References

Heidorn, P. B. (1999). Image Retrieval as Linguistic and Nonlinguistic Visual Model Matching. *Library Trends,* 48(2): 303-325.

U.S. New and World Report. (1999.) Library Science [rankings]. Available [on-line] at: http://www.usnews.com/usnews/edu/beyond/gradrank/gbinfos.htm.

Appendix A

Species Lists

Illinois PrairieWatch Plants

1. Echinacea pallida
2. Amorpha canescens
3. Asclepias viridiflora
4. Sporobolus heterolepis
5. Dalea candida
6. Dalea purpurea
7. Gentiana puberulenta
8. Gentiana andrewsii
9. Gentiana clausa
10. Baptisia leucophaea
11. Parthenium integrifolium
12. Andropogon gerardii
13. Schizachyrium scoparium
14. Sorghastrum nutans
15. Panicum virgatum
16. Silphium terebinthinaceum
17. Silphium laciniatum
18. Liatris
19. Ceanothus americanus
20. Eryngium yuccifolium
21. Dipsacus sylvestris
22. Pastinaca sativa
23. Melilotus officinalis
24. Melilotus alba
25. Festuca pratensis
26. Poa pratensis
27. Poa compressa
28. Cirsium arvense
29. Hemerocallis fulva

Indicator Plants of the Diabase Glades and Prairies of the North Carolina Piedmont

1. Ageratina altissima
2. Allium cernuum
3. Asclepias verticillata
4. Baptisia australis
5. Berberis canadensis
6. Blephilia ciliata
7. Cardamine douglassii
8. Cercis canadensis
9. Chionanthus virginicus
10. Clematis ochroleuca
11. Delphinium exaltatum
12. Echinacea laevigata
13. Isanthus brachiatus
14. Isoetes piedmontana
15. Juniperus virginiana
16. Lathyrus venosus
17. Liatris squarrulosa
18. Lithospermum canescens
19. Manfreda virginica
20. Marshallia obovata
21. Matelea decipiens
22. Opuntia humifusa
23. Parthenium integrifolium
24. Quercus marilandica
25. Quercus stellata
26. Rhus aromatica
27. Ruellia caroliniensis
28. Ruellia humilis
29. Ruellia purshiana
30. Silphium terebinthinaceum
31. Solidago ptarmicoides
32. Talinum teretifolium
33. Tragia urticifolia
34. Trichostema dichotomum
35. Trichostema setaceum
36. Triosteum perfoliatum
37. Ulmus alata
38. Verbena simplex

Indicator Trees of North Carolina

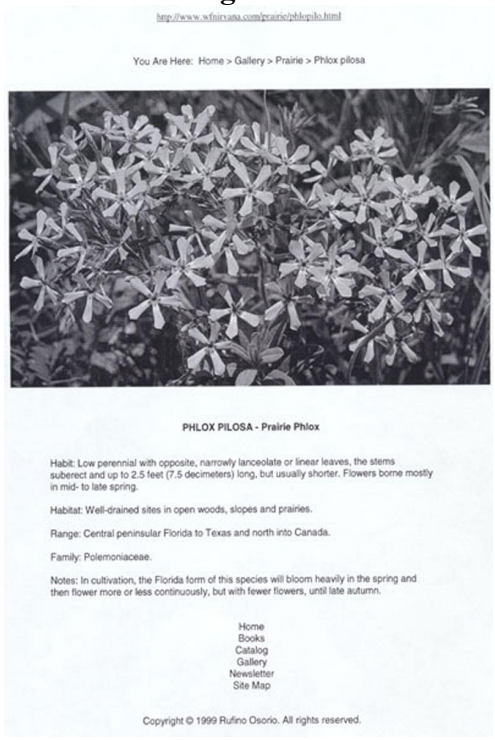
1. Acer barbatum
2. Acer leucoderme
3. Acer negundo
4. Acer nigrum
5. Acer pensylvanicum
6. Acer platanoides
7. Acer rubrum
8. Acer saccharinum
9. Acer pseudoplatanus
10. Acer saccharum
11. Acer spicatum
12. Aesculus flava
13. Aesculus hippocastanum
14. Aesculus pavia
15. Aesculus sylvatica
16. Ailanthus altissima
17. Albizia julibrissin
18. Amelanchier laevis
19. Aralia spinosa
20. Asimina parviflora
21. Asimina triloba
22. Betula alleghaniensis
23. Betula lenta
24. Betula nigra
25. Betula papyrifera
26. Betula populifolia
27. Broussonetia papyrifera
28. Buddleja alternifolia
29. Carpinus caroliniana
30. Carya alba
31. Carya aquatica
32. Carya carolinae-septentrionalis
33. Carya cordiformis
34. Carya glabra
35. Carya illinoinensis
36. Carya laciniosa
37. Carya myristiciformis
38. Carya ovalis
39. Carya ovata
40. Carya pallida
41. Castanea dentata
42. Castanea mollissima
43. Castanea pumila
44. Celtis laevigata
45. Celtis occidentalis
46. Celtis tenuifolia
47. Cercis canadensis
48. Chamaecyparis thyoides
49. Chionanthus virginicus
50. Cornus alternifolia
51. Cornus florida
52. Cyrilla racemiflora
53. Fagus grandifolia
54. Fraxinus americana
55. Fraxinus caroliniana
56. Fraxinus pennsylvanica
57. Fraxinus profunda
58. Gordonia lasianthus
59. Halesia tetraptera
60. Hamamelis virginiana
61. Ilex ambigua
62. Ilex amelanchier
63. Ilex cassine
64. Ilex collina
65. Ilex coriacea
66. Ilex cornuta
67. Ilex crenata
68. Ilex decidua
69. Ilex laevigata
70. Ilex longipes
71. Ilex montana
72. Ilex myrtifolia
73. Ilex opaca
74. Ilex verticillata
75. Ilex vomitoria
76. Juglans cinerea
77. Juglans nigra
78. Juniperus virginiana
79. Ligustrum japonicum
80. Ligustrum lucidum
81. Ligustrum ovalifolium
82. Ligustrum sinense
83. Liquidambar styraciflua
84. Liriodendron tulipifera
85. Magnolia acuminata
86. Magnolia fraseri
87. Magnolia grandiflora
88. Magnolia macrophylla
89. Magnolia tripetala
90. Magnolia virginiana
91. Melia azedarach
92. Morus alba
93. Morus rubra
94. Nyssa aquatica
95. Nyssa biflora
96. Nyssa sylvatica

97. Osmanthus americanus
98. Ostrya virginiana
99. Oxydendrum arboreum
100. Paulownia tomentosa
101. Persea borbonia
102. Persea palustris
103. Picea rubens
104. Pinus clausa
105. Pinus echinata
106. Pinus elliottii
107. Pinus palustris
108. Pinus pinaster
109. Pinus pungens
110. Pinus resinosa
111. Pinus rigida
112. Pinus serotina
113. Pinus strobus
114. Pinus taeda
115. Planera aquatica
116. Platanus occidentalis
117. Prunus serotina
118. Quercus alba
119. Quercus austrina
120. Quercus bicolor
121. Quercus coccinea
122. Quercus falcata
123. Quercus geminata
124. Quercus hemisphaerica
125. Quercus ilicifolia
126. Quercus imbricaria
127. Quercus incana
128. Quercus laevis
129. Quercus laurifolia
130. Quercus lyrata
131. Quercus margarettiae
132. Quercus marilandica
133. Quercus michauxii
134. Quercus muehlenbergii
135. Quercus myrtifolia
136. Quercus nigra
137. Quercus pagoda
138. Quercus palustris
139. Quercus phellos
140. Quercus prinoides
141. Quercus montana
142. Quercus rubra
143. Quercus shumardii
144. Quercus stellata
145. Quercus velutina
146. Quercus virginiana
147. Rhamnus cathartica
148. Rhamnus davurica
149. Rhus copallinum
150. Rhus glabra
151. Rhus typhina
152. Robinia pseudoacacia
153. Sabal minor
154. Sabal palmetto
155. Sassafras albidum
156. Sorbus americana
157. Stewartia malacodendron
158. Stewartia ovata
159. Styrax americanus
160. Styrax grandifolius
161. Symplocos tinctoria
162. Taxodium ascendens
163. Taxodium distichum
164. Tilia americana
165. Tsuga canadensis
166. Tsuga caroliniana
167. Ulmus alata
168. Ulmus americana
169. Ulmus floridana
170. Ulmus procera
171. Ulmus pumila
172. Ulmus rubra
173. Vitex agnus-castus
174. Zanthoxylum americanum
175. Zanthoxylum clava-herculis

Appendix B

Visual Representation

Figure 1



http://www.wfnirvana.com/prairie/phlopilo.html

You Are Here: Home > Gallery > Prairie > Phlox pilosa

PHLOX PILOSA - Prairie Phlox

Habit: Low perennial with opposite, narrowly lanceolate or linear leaves, the stems suberect and up to 2.5 feet (7.5 decimeters) long, but usually shorter. Flowers borne mostly in mid- to late spring.

Habitat: Well-drained sites in open woods, slopes and prairies.

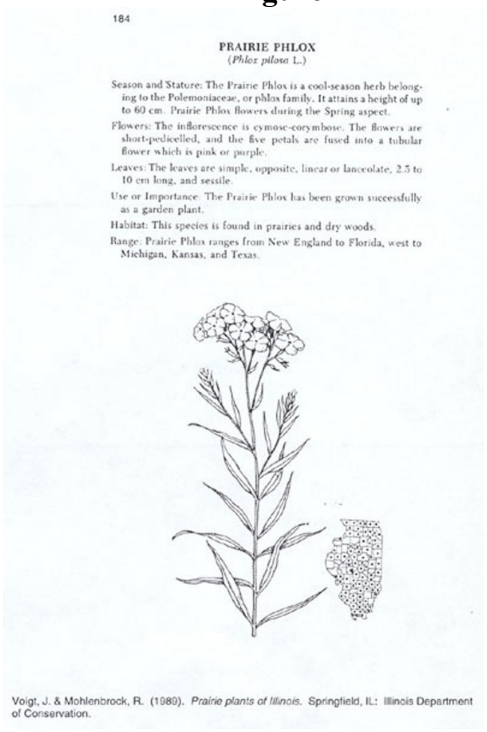
Range: Central peninsular Florida to Texas and north into Canada.

Family: Polemoniaceae.

Notes: In cultivation, the Florida form of this species will bloom heavily in the spring and then flower more or less continuously, but with fewer flowers, until late autumn.

Home
Books
Catalog
Gallery
Newsletter
Site Map

Figure 2



184

PRAIRIE PHLOX
(*Phlox pilosa* L.)

Season and Stature: The Prairie Phlox is a cool-season herb belonging to the Polemoniaceae, or phlox family. It attains a height of up to 60 cm. Prairie Phlox flowers during the Spring aspect.

Flowers: The inflorescence is cymose-corymbose. The flowers are short-pedicelled, and the five petals are fused into a tubular flower which is pink or purple.

Leaves: The leaves are simple, opposite, linear or lanceolate, 2.5 to 10 cm long, and sessile.

Use or Importance: The Prairie Phlox has been grown successfully as a garden plant.

Habitat: This species is found in prairies and dry woods.

Range: Prairie Phlox ranges from New England to Florida, west to Michigan, Kansas, and Texas.

Voigt, J. & Mohlenbrock, R. (1989). *Prairie plants of Illinois.* Springfield, IL: Illinois Department of Conservation.