The Ancient Bayou & Oxbow Forest Project

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Mission: The conservation of ancient bald cypress and bottomland hardwood forests

Introduction

Bald cypress (*Taxodium distichum*) forests have been heavily logged across the southeastern United States but a few ancient bald cypress stands still survive. Spectacular examples can be found on Bayou DeView, Arkansas, and Black River, North Carolina, which are two of the most remarkable natural areas left in the eastern United States. Many Black River bald cypress trees are over 1,000-years old and a few may even exceed 2,000-years in age on this acidic, nutrient-poor stream. Bald cypress on the nutrient-rich Bayou DeView do not live as long, but individuals over 800-years old have been documented and some probably exceed 1,000 years in age (Figure 1). These are the oldest known-trees in eastern North America and they are among the oldest living trees on earth. They rival the beauty and grandeur of the California redwoods, to which they are related botanically. The exceptional longevity of bald cypress trees at Bayou DeView and Black River was first documented with tree-ring dating by Dr. David Stahle of the University of Arkansas Tree-Ring Laboratory (Stahle et al 1988, 2006, 2012). The Nature Conservancy has since preserved over 18,000 acres of habitat on and adjacent to the floodplain of the Black River. Bayou DeView includes some 5,000 acres of ancient bald cypress and tupelo forests that are publically owned in the Cache River NWR and Dagmar WMA. The Nature Conservancy has also contributed to bald cypress and bottomland hardwood habitat protection and restoration on thousands of additional acres in the "Big Woods" of eastern Arkansas.

Ancient bald cypress and bottomland hardwoods survive today only because they were too low lying and frequently flooded for agriculture (e.g., Figure 2). Bald cypress is known as the "wood eternal" due to its resistance to decay and was heavily exploited for timber, but some native cypress stands were too senescent and dominated by "overmature," "non-commercial," partly hollow trees to produce high quality lumber (Figure 3). Some hardwood species native to these low-lying wetlands such as overcup oak (*Quercus lyrata*) were also not preferred for lumber production. As a result, many unmapped and unrecognized wetlands with ancient bottomland hardwood and bald cypress forest stands remain scattered in a complex mosaic across the human altered landscape of Arkansas and the southeastern United States. This includes bald cypress up to 1,000-years old, water tupelo (*Nyssa aquatica*) up to 600-years old, and overcup oak in the 300-year age class. These ancient forest remnants constitute some of the most valuable wildlife habitat left in the lower Mississippi Valley. This was proven in Arkansas by the rediscovery of the ivory-billed woodpecker (*Campephilus principalis*) in 2004 along the lower reaches of Bayou DeView (Fitzpatrick et al 2005), a nearly 40-mile long corridor of wetland habitat that contains extensive stands of old-growth bald cypress and bottomland hardwoods.

Thousands of additional acres of ancient bald cypress and bottomland hardwoods are known to still be present on picturesque southern bayous and oxbows because the

stream margin trees were not ideal for timber production due to low branching, lack of clear stem, partial heart rot and other lumber defects associated with their great age and stream side habitat (Figures 3,4). Due to this amazing coincidence, some of the most beautiful natural lakes and waterways in eastern and southern Arkansas are still graced by their original old growth forests, in spite of widespread land clearing for agriculture. It also means that these ancient bayou and oxbow forest remnants can be readily incorporated into effective habitat restoration efforts designed to sustain wildlife and rehabilitate water quality in this heavily agricultural sector of Arkansas (Figure 5).

A Crisis of Ancient Forest Destruction

The bald cypress-bottomland hardwood forest ecosystem is one of the most heavily altered forest cover types in the United States. Massive habitat loss in this ecosystem contributed to the extinction of the Carolina Parakeet, likely the Ivory billed woodpecker, and the near extinction of many other plant and animal species. Only three virgin bald cypress forests with commercially valuable timber are known to remain: the National Audubon Society sanctuaries at Four Holes Swamp, South Carolina, and Corkscrew Swamp, Florida, and the private Grassy Lake in southwestern Arkansas. These three tracts only total approximately 6,000 acres out of at least 24 million acres of virgin bald cypress forest estimated to have originally existed in the South (Stahle et al 2006). Fortunately, a few stands of ancient "overmature" bald cypress and bottomland hardwoods survived the era of massive timber cutting and agricultural land clearing. Two important large areas are the ancient bald cypress woodlands along Black River, North Carolina, and the old-growth bald cypress-tupelo forests of Bayou DeView, Arkansas.

Considering the scale of logging and land clearing in eastern Arkansas (Holder 1970), it is amazing that thousands of acres of ancient bald cypress trees, some of which are likely 1,000-years old, still exist on remote waterways in eastern and southern Arkansas. Even now in the early 21st Century, we have the opportunity to preserve lakes and bayous with primeval forests and some of the highest quality wildlife habitat left in the Lower Mississippi Valley. However, we must act quickly to protect these ancient forests because many are immediately threatened by logging, land development, and a host of incompatible uses, even in some cases when found on state and federal wildlife refuges.

The Requested Funds and Objectives of the OXBOW Project

The Ancient Bald Cypress Consortium seeks funding to initiate a comprehensive conservation program designed to locate, accurately map, and protect ancient bald cypress and tupelo forests along bayous and oxbow lakes in eastern and southern Arkansas. The goals of this Ancient Bayou and Oxbow Forest Project (OXBOW) are to:

- establish the OXBOW Project in Arkansas;
- locate and map all remaining old-growth bayou and oxbow lake forests in Arkansas;
- document the age of the ancient trees in these stands using dendrochronology;
- develop a public education program with oral, written, and video communications;
- promote conservation and best management practices of the remnant ancient bayou and oxbow forests discovered during this project.

The requested funds will be used to conduct the first phase of the project. These funds will support (1) a graduate student stipend; (2) travel for field surveys in Arkansas; (3) and summer funding for undergraduate student participation, including field and

laboratory work and their supervised creation of web and video productions. No administrative expenses or indirect costs will be charged to the Project. Dr. David Stahle will direct the project, supervise students involved with the research, contribute to the public education and communication mission, and assist the fieldwork. Dr. Stahle will contribute his time and effort at no cost to the project. Colleagues in the Department of Geosciences and Center for Advanced Spatial Technologies (CAST) will provide our students with expert assistance in remote sensing and Geographic Information Systems. Once the OXBOW Project has successfully identified ancient oxbow and bayou forests during the first phase of this project, the Consortium will seek additional funding for the identification and protection of ancient forested wetlands that are threatened elsewhere in the southeastern United States.

Accomplishments to date of the Ancient Bald Cypress Consortium

The initial efforts of the University of Arkansas Tree-Ring Laboratory to identify ancient cypress along the Black River in North Carolina led to the 2015 formation of "The Ancient Bald Cypress Consortium for Research, Education and Conservation." The mission of the Consortium is scientific research, public education, and the permanent protection of ancient bald cypress and bottomland hardwood forests across the southeastern United States. The Consortium is a "Bottomlands Conservation Initiative" of the University of Arkansas Foundation, a 501c3 organization. In 1985 conservation professionals in North Carolina thought that the bald cypress along the Black River were interesting botanically, but were likely not more than 200 years old. When the Tree-Ring Laboratory published in the journal *Science* that these were actually very ancient trees from 1,000 to 1,600 years old (Stahle et al 1988) it completely changed conservation priorities in southeastern North Carolina, and The Nature Conservancy began land acquisition to protect these ancient trees. In recent years, as the threat to the cypress has increased, the Consortium was formed to make a more concerted effort to identify the extent of ancient forests along the Black River and other waterways in Arkansas and the Southeast. As a result, the work of the Consortium has led to the discovery that the area of ancient cypress and bottomland hardwood forests along the Black River is much more extensive than previously thought, with hundreds of trees that are 1,000 years or older, an ancient forest like few other on Earth. In just the last year the Consortium has helped The Nature Conservancy identify and purchase two large tracts totaling approximately 2,000 acres. In addition, a bill is now being considered by the North Carolina state legislature that will create a state park on the Black River. The Consortium met with the director of North Carolina State Parks and with The Nature Conservancy in February of 2017 and helped convince these agencies and organizations to promote the legislation to establish the Black River State Park. The Ancient Bayou and Oxbow Forest Project will work to advance the public and private protection of ancient bald cypress and bottomland hardwood forests in Arkansas.

The Goals of the Ancient Bayou and Oxbow Forest Project

The mission of the Ancient Bald Cypress Consortium is to identify and conserve ancient bald cypress forest ecosystems along scenic bayous and oxbow lakes in Arkansas and the southeastern United States. The initial OXBOW project will:

Create the OXBOW Project within the Ancient Bald Cypress Consortium: The Consortium has united universities, agencies, private organizations and individuals for interdisciplinary research, multi-institutional education, and the public and private

protection of ancient bald cypress and bottomland hardwood forests in the Southeast. An advisory board has been created for the Consortium and a Memorandum of Understanding has outlined the administrative agreements between agency, institutional, and private members of the Consortium. These voluntary cooperative agreements are intended to advance public appreciation and scientific understanding of these unique old-growth ecosystems. The Nature Conservancy, Arkansas Game and Fish Commission, Arkansas Natural Heritage Commission, Cache River NWR, White River NWR, and other organizations already have serious conservation interests in the bald cypress and bottomland hardwood forests of the Lower Mississippi Valley. Colleagues at the Arkansas Natural Heritage Commission, Clemson University, Harvard Forest, The Nature Conservancy, the University of Alabama, University of Minnesota, and elsewhere have pledged support for the Consortium. The Consortium will expand partnerships with these groups, which have been developed over 35 years of research in the Lower Mississippi Valley and the Southeast by the University of Arkansas Tree-Ring Laboratory.

Mapping and Tree-Ring Dating: The accurate mapping of ancient bald cypress stands on oxbow lakes and bayous in Arkansas is a vital first step in the conservation and restoration of these over-exploited floodplain ecosystems. We must know exactly where these remnant old-growth forests are located in order to set priorities for land protection. We will analyze and interpret aerial photographs and remotely sensed imagery to locate where ancient forests still survive in the highly altered agricultural landscapes of eastern Arkansas. This work will involve a multi-stage predictive modeling framework involving digital elevation data to isolate low-lying bayous and oxbow lakes, remote sensing analyses to identify the largest and oldest trees in existing cypress-tupelo wetland forests, and selected site specific drone surveys and on the ground vegetation surveys to locate all unprotected old growth forests at least 20-acres in size that still remain in eastern Arkansas. Our laboratory-based predictions of old growth cover will be field tested with landowner permission using the techniques of dendrochronology (tree-ring dating). Tree ring core samples will be extracted non-destructively and the *minimum age* of the sample trees will be determined exactly with the tree-ring dating method. Vegetation cover at the study sites will be classified into four categories: high-quality uncut ancient forest, selectively logged old-growth forest, second growth without any old trees, and cleared land. Our conservation and education efforts will concentrate on the highest quality old-growth forests.

Education: The educational goals of this project will involve oral presentations, written publications, web site development, and video productions. They will be focused on our own students, on the conservation community in Arkansas, and on citizens in the Lower Mississippi Valley region and nationwide. We will promote understanding, acceptance, and support of our protection efforts in one-on-one conversations with landowners and neighbors, through public presentations, and through video productions. We will collaborate with the University of Arkansas Department of Journalism to produce multiple length videos describing the significance of the ancient bayou and oxbow lake forests, the challenges they face, and the opportunities for protection promoted by our project.

Conservation: The Ancient Bald Cypress Consortium will actively pursue the permanent protection of the additional old-growth oxbow and bayou forests identified and precisely mapped during the proposed OXBOW project. Project leaders will articulate conservation options with interested landowners of parcels with high-quality ancient

forest and assist efforts to expand the size and integrity of these valuable woodlands with ecosystem restoration and other best management practices. We will also collaborate with private organizations, and state and federal agencies to identify high value properties for possible acquisition through the Agricultural Conservation Easement Program (ACEP), or through private fund raising efforts.

Data and Methods for the Remote Sensing of Ancient Forests

The accurate and precise mapping of all remaining old-growth bald cypress and bottomland hardwood forests in eastern and southern Arkansas is the first goal of the OXBOW Project. Once the remaining ancient forests have been carefully identified we will then select the highest priority subset for targeted conservation efforts. The accurate mapping of ancient forest remnants on state and federal wildlife management areas will also be used to advocate for the exclusion of these old-growth forests from the harvestable timber base on these public wildlife lands.

A stratified predictive modeling scheme involving digital elevation data to isolate low-lying bayous and oxbows, along with remote sensing to isolate the largest and oldest trees in existing wetland forests will be employed by the OXBOW Project. Light detection and ranging (LIDAR) imagery is available for most of eastern Arkansas from the U.S. Army Corps of Engineers (soon to be available for the entire state) and will be used to map the subtle elevation changes on the alluvial floodplains of Arkansas with a precision and resolution not previously available. These digital terrain data will be used to extract all bayous, oxbow lakes, and adjacent low-lying terrain from the landscape of eastern and southern Arkansas, greatly simplifying the search for ancient forest remnants. Remote sensing will then be used to exclude cleared or non-forested bayous and oxbows from the search, and to then identify those highest quality areas with the oldest trees. Publically available sensor data should have sufficient information content to achieve the goals of this project (e.g., NASA/USGS Landsat 8 Operational Land Imager (OLI) sensor with a nominal spatial resolution of 30 x 30 meters, NASA's bi-monthly Moderate Resolution Imaging Spectrometer (MODIS) sensor with a nominal 250 x 250 meter resolution). However, the entire state of Arkansas has recently been imaged with high-resolution four-band aerial imagery with a spatial resolution of 12 inches and this product will be available for our research in the fall of 2017.

Aerial photograph interpretation and object based image analysis using Trimble eCognition will be employed to identify areas that retain ancient forest. Drone surveys to obtain ultra high-resolution imagery (nominally 3-inch) will be flown over a subset of the best remaining areas to provide the detailed remotely sensed information on these last remaining ancient forests in Arkansas. On the ground field surveys will then be conducted and a random sample of tree age and structure will be gathered at this highest quality subset of old growth forests. The proposed predictive modeling system will be developed as a customized geographic information system (GIS) using Esri's ArcGIS platform and will leverage Google Earth Engine or a comparable high throughput GIS resource.

Expertise

The University of Arkansas Tree-Ring Laboratory is uniquely qualified to conduct the proposed project (www.uark.edu/dendro). The Tree-Ring Laboratory specializes in old-growth forest research and conservation. We have used tree-ring chronologies developed from ancient forests to reconstruct the history of drought and wetness across

North America for over 1,000 years (Cook et al 2004, Stahle et al 2016). We have also helped to conserve ancient forests throughout the United States and Mexico. We have already established the Ancient Cross Timbers Consortium for Research, Education, and Conservation that has successfully united federal, state, and private conservation organizations with university scientists for the conservation management of old-growth oak woodlands adjacent to the southern Great Plains (www.uark.edu/xtimber). The Ancient Cross Timbers Consortium contributed to the acquisition of the Keystone Ancient Forest Preserve near Tulsa, Oklahoma, the new Cross Timbers Wildlife Management Area near Mineral Wells, Texas, and several other private conservation easements. The Tree-Ring Laboratory collaborates with the University of Arkansas Center for Advanced Spatial Technologies (CAST), particularly with Dr. Xuan Shi and Dr. Jason Tullis. Our CAST colleagues have expertise in the remote sensing of forested environments and with geospatial analysis using high performance computing (Shi et al 2014; Tullis et al 2016).

David W. Stahle is a Distinguished Professor in the Department of Geosciences at the University of Arkansas. He is the founder and director of the Tree-Ring Laboratory and has been extensively funded by the National Science Foundation for tree ring and climate research in the United States and abroad. Dr. Stahle is a co-founder and the current director of the Ancient Cross Timbers Consortium that promotes research, education, and conservation in the old-growth woodlands that survive across the ecotone between the eastern deciduous forest and the grasslands of the southern Great Plains. Dr. Stahle has also founded the Ancient Bald Cypress Consortium for Research Education, and Conservation (https://cypress.uark.edu), which is designed to identify and conserve old-growth bald cypress and bottomland hardwoods and to train the next generation of conservation scientists and professionals. Dr. Stahle was recently elected as a Fellow of the *American Association for the Advancement of Science*. He received the award for his "study of past climates and for his conservation efforts for ancient forests." With colleagues he recently published the "Mexican Drought Atlas" (http://drought.memphis.edu/MXDA/). Dr. Stahle is currently working on a National Science Foundation grant to develop tree-ring chronologies for climate reconstruction in the Amazon River basin with colleagues from Brazil, Bolivia, and Argentina.

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