

**THE BIORESERVE POTENTIAL OF THE ANCIENT CROSS TIMBERS
ON THE FRANK TRACT, OSAGE COUNTY, OKLAHOMA**

David W. Stahle, Mathew D. Therrell, and Malcolm K. Cleaveland
Tree-Ring Laboratory
Department of Geography
Ozark Hall 108A
University of Arkansas
Fayetteville, AR 72701
501-575-3703

and

Sophonia Roe
Department of Botany
Oklahoma State University
Stillwater, OK 74078-3013
405-744-8440

submitted to:

Mr. Irvin Frank
9 E. 4th St., Suite 702
Tulsa, OK 74103

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An Introduction to the Ancient Forests of the Cross Timbers

The Cross Timbers are a complex mosaic of upland deciduous forest, savanna, and glade communities that highlight the broad ecotone between the eastern forests and the grasslands of the southern Great Plains (Figure 1). The Cross Timbers are dominated by post oak and blackjack oak (*Quercus stellata* and *Q. marilandica*), and may have acquired their name from the earliest pioneers who were obliged to cross the north-south oriented belts of dense upland forest and prairie in their westward travels across northcentral Texas, eastern Oklahoma, and southeastern Kansas. The presettlement Cross Timbers may have covered some 7,909,700 hectares (30,526 square miles; Kuchler 1964), and consisted largely of low-stature oaks that were not suited for timber production. Over the past 20 years we have travelled extensively throughout the Cross Timbers searching for undisturbed ancient forests to sample for the tree-ring analysis of past climate variability. We have also recently tested a predictive model designed to locate undisturbed ancient Cross Timbers in southern Osage County, Oklahoma. This work has demonstrated unequivocally that ancient forests dominated by 200- to 400-year old post oak trees survive in literally hundreds of Cross Timbers forests, particularly in Oklahoma.

Because the entire Cross Timbers formation is essentially noncommercial for timber production, it has never experienced large-scale industrial logging. The Cross Timbers grown on level terrain have been widely cleared for agriculture, but undisturbed tracts of ancient Cross Timbers are still frequently present on steep, rocky terrain where timber removal for farming or grazing was not economically justified. Consequently, we believe that the Cross Timbers may be the least disturbed forest ecosystem that survives in the eastern United States. Considering the full extent of post oak/blackjack oak dominated forests in Oklahoma (Duck and Fletcher, 1945), and the prevalence of ancient timber on rough rocky terrain within this region, we estimate that some 1,700 square miles of ancient post oak forests may survive in Oklahoma alone. In fact, because these undisturbed ancient Cross Timber ecosystems often grade from dense forest to open savanna to countless small glades, we suggest that the largest amount of unplowed, ungrazed, largely undisturbed glade grasslands that still survive in the southcentral United States may actually be found within the ancient forest-glade mosaic of the Cross Timbers.

The surprising abundance of ancient forests in the Cross Timbers of Oklahoma is not widely appreciated by public or private landowners. Admittedly, the ancient Cross Timbers hardly fulfill our notions about what an old-growth forests should look like. Ancient forest stereotypes remain focused on large trees, even though tree-ring research has emphatically demonstrated that tree size does not necessarily equate with great age. The 5000-year old bristlecone pine of California are the oldest living organisms known, but are in fact massive shrubs growing in one of the most hyperarid forest environments on earth. The ancient post oak of the Cross Timbers tend to average only 5 to 15 meters in height (15 to 40'), and 30 to 60 cm in diameter (10 to 20"), and are often dismissed as second growth "brush" by casual observers. But tens of thousands of these living post oak trees were old growth when the United States gained independence, and the amazingly extensive remnants of the ancient Cross Timbers are demonstrably the unaltered representatives of one large and important component of the original native vegetation of Oklahoma and the southcentral United States.

Ancient Forest Definition and Expertise

It may be helpful to begin with a definition of the term "ancient forest," and an explanation of our particular expertise with ancient forests of the eastern United States. The ancient forests that survive on rugged, noncommercial terrain in the Cross Timbers of Oklahoma are authentic examples of what these forests looked like before European settlement. Because these original presettlement forests did not provide valuable timber, farming, or grazing lands, these steep Cross Timbers have not been substantially disturbed by man. Scientific analyses of core samples from thousands of living trees demonstrate that these ancient Cross Timbers are dominated by post oak trees in the 200- to 400-year age class. We can state with absolute authority that the forest canopy that still covers thousands of acres in eastern and central Oklahoma is dominated by post oak trees that were 100- to 300-years old, and were canopy dominants, when Oklahoma was first opened to European settlement only some 100 years ago. These remnant forests were ancient then, and they have only become more ancient during the past century.

In addition to the dominant post oak, several other tree species achieve remarkable old age in the Cross Timbers, including the 300- to 500-year old eastern red cedar (*Juniperus virginiana*) which can often

be found wherever the ancient post oak-blackjack oak forests are broken by rocky blufflines, glades, or barrens.

Beyond the undeniable antiquity of the living trees, the undisturbed portions of the Cross Timbers that still exist also exhibit the classic stand architecture of ancient forests. This includes the heavy, twisted, and weathered canopies of unmistakably ancient post oak, and the mosaic of age classes that populate these forests. Sapling, juvenile, mature, and ancient trees, standing-dead snags, and fallen logs in various stages of decomposition are all evident in undisturbed Cross Timbers, and are typical of ancient forests in general (see Plates 1-11 for photographs and further discussion of the attributes of the ancient Cross Timbers).

Based on these observations, and extensive first-hand experience in the ancient forests of Oklahoma and elsewhere in North America, we believe that the Cross Timbers are the least disturbed forest ecosystem that survives in the eastern United States. In fact, we believe that the post oak-blackjack oak forests of the Cross Timbers have remained largely unchanged on these steep, coarse-textured soils of the forest-prairie margin since the post-glacial period of maximum global temperature some 6,000 years ago. And we do not believe that the Native American inhabitants of this region had a major effect on the ecology of the ancient forests that survive in the Cross Timbers. These remnant tracts survive primarily on the steepest and roughest terrain where human resource values were low. Prehistoric utilization of these areas must have been low because we rarely find the stone and ceramic artifacts of past societies which are so common in the river valleys and in other ecological settings of Oklahoma.

Our statements concerning the relative abundance of ancient forests in the Cross Timbers are based on considerable experience. The University of Arkansas Tree-Ring Laboratory has worked for over 20 years on the ancient forests of the eastern United States. We have been funded by the National Science Foundation since 1980 to locate ancient forests for the development of centuries-long tree-ring chronologies suitable for the reconstruction of past climate variability. During the course of this extensive fieldwork we found the oldest-known living trees in all of eastern North America, the millennium-old baldcypress at Black River, North Carolina (Stahle et al. 1988; Earley 1990). We have personally visited hundreds of old-growth forests in the East, and have detailed knowledge and data on many of the finest remaining examples. Some of the insights gained from this experience are summarized in the article by Stahle entitled "Tree rings and ancient forests history," which will appear in the new book *Eastern Old Growth Forests*, edited by M.B. Davis (scheduled for release by Island Press in February 1996). Based on these many field surveys, the obvious abundance of centuries-old forests in Oklahoma, and on consultation with other old-growth specialists in the eastern United States, we have concluded that the most extensive areas of uncut, largely undisturbed ancient forests are found in the Cross Timbers of Oklahoma.

The Significance of the Ancient Cross Timbers Vegetation on the Frank Tract, Southern Osage County, Oklahoma

During the first three months of 1995 we field tested a predictive model designed to locate ancient Cross Timber forests on steep soils in southern Osage County (Therrell, in preparation; Figure 2). The Niotaze-Darnell soils on 15 to 45% slopes cover some 43.66 square miles in this area, and are associated with a native vegetation cover of post oak and blackjack oak trees (i.e., Cross Timbers). We predicted that these steep soils would still retain noncommercial ancient forest cover. To test this prediction, we personally examined 50 randomly-selected belt transects within the area of Niotaze-Darnell soils. We found that 73% of the area within the belt transects was indeed undisturbed Cross Timbers dominated by ancient trees 200 to 500 years old (documented by the suite of physical attributes associated with ancient forests, and by core sampling and exact age determinations of the dominant trees). Because our 50 belt transects randomly sampled the entire 43.66 square miles of steep Niotaze-Darnell soils predicted to retain ancient Cross Timbers, we further estimate that 73% of these extensive soils are still covered with ancient forests in the study area. This translates into approximately 32 square miles of ancient forest in the southern portion of Osage County on just one of the several soil types associated with Cross Timbers vegetation cover.

Several large contiguous tracts of undisturbed Cross Timbers were found during this fieldwork, including six parcels that are over one square mile in size (Figure 3). We know of no other region in the eastern United States where undisturbed ancient forests are so prevalent, or so little appreciated.

The largest and most interesting tract of undisturbed Cross Timbers found during this research is located on public and private property in the dissected uplands above Keystone Reservoir in Osage County (Figures 4 and 5). This outstanding tract covers approximately 4 square miles, and includes some 2.7 square miles of largely undisturbed forest, savanna, and glade vegetation. The three principal landowners of this tract are the U.S Army Corps of Engineers (COE; which manages the buffer zone of lands surrounding

Keystone Reservoir), the Tulsa Audubon Society (TAS; which owns a 108 acre bald eagle preserve), and Mr. Irvin Frank of Tulsa, Oklahoma, who owns over 1000 acres in the heart of this tract (i.e., portions of Sections 27, 28, 32 and 33, T20N, R10E; Figure 6). An opportunity to maintain the biological integrity of this important tract may exist, if the cooperation of the principal landowners can be arranged.

Mr. Irvin Frank has expressed interest in the true biological and socioeconomic significance of his property, in the event that it were to be managed as some sort of bioserve or park. Therefore, we have prepared this preliminary assessment of significance, which attempts to outline the key biological, educational, recreational, and scientific advantages of the Frank Tract, and the adjacent lands managed by the COE and TAS (which we will refer to collectively as the "Frank Tract" for simplicity). This assessment will also consider the possible disadvantages involved in the management of the Frank tract as a bioserve. Appendix I includes letters of endorsement from some of the botanical and ecological experts who visited the Frank Tract during a fieldtrip on October 27, 1995, to help document the biological integrity of this unique natural area, and its potential suitability for management as a bioserve. Finally, a selection of photographs will illustrate some of the outstanding natural resources at the Frank Tract (Plates 1-11).

Botanical Significance

Duck and Fletcher (1945) estimated that post oak-blackjack oak forests covered some 17,628 square miles in Oklahoma alone, making it the most extensive forest cover type in the state (e.g., Rice and Penfound 1959). Based on three separate calculations (i.e., related to the prevalence of ancient forests in southern Osage County, or to the fraction of steep soils within the Cross Timbers ecosystem), we estimate that 1,700 square miles of the Cross Timbers mapped by Duck and Fletcher (1945) may have escaped human disturbance, primarily on the steepest and rockiest terrain. We plan to test this admittedly crude estimate with a statistically-based large-scale field survey, but if true, the old-growth Cross Timbers of Oklahoma would certainly represent one of the largest concentrations of ancient forest that still survives in the contiguous United States.

In spite of the relative abundance of ancient Cross Timbers in Oklahoma, the true significance of these authentic undisturbed forests has been seriously under-appreciated. To our knowledge, there is not one single park or conservation area in the entire state specifically devoted to the recognition and protection of an ancient Cross Timbers forest. The Frank Tract and adjacent COE and TAS lands represent the most outstanding and diverse example of the Cross Timbers vegetation type we have ever visited. It could serve as an ideal centerpiece of the Cross Timbers, and could help raise public and professional awareness concerning this authentic but little-known component of Oklahoma's natural heritage.

The truly ancient trees are perhaps the most distinguishing feature of the undisturbed vegetation on the Frank Tract. The oldest post oak tree ever documented is located in this ancient forest (400+ years old), and we have determined the age of literally thousands of post oaks throughout its natural range from the Great Plains to the Atlantic Ocean. Also, the oldest eastern red cedar ever documented for Oklahoma are also found on the Frank Tract (individual cedars exceed 500 years in age). In fact, all tree species found on the Frank Tract include many individuals at or above the natural longevity for the respective species. These species include blackjack oak, black oak (*Q. velutina*), black hickory (*Carya texana*), ash (*Fraxinus americana*), and winged elm (*Ulmus alata*), and shrub species in the genus *Vaccinium*.

The longevity of trees on the Frank Tract is certainly impressive, but the variety and integrity of the undisturbed plant communities found on this tract was emphasized by several professional botanists who visited this area during the October 27, 1995, fieldtrip of the Natural Areas Conference (see Appendix 1). The Frank Tract is dissected by several steep ravines that drain into the Arkansas River (now partially impounded by Keystone Reservoir). These ravines fragment the landscape into a wide variety of slopes and exposures, which dramatically modulate the intensity of solar radiation, evapotranspiration, and available soil moisture. The interesting mosaic of undisturbed vegetation cover on the Frank Tract reflects the variety of microenvironments associated with this complex terrain. Many, and perhaps most of the major plant associations typically found in the Cross Timbers of Oklahoma are present on the Frank Tract in a nearly pristine condition. We know of no other single area of largely undisturbed terrain in eastern Oklahoma that presents such a broad cross-section of the vegetation types found in the Cross Timbers.

The unique, undisturbed qualities of the Frank Tract were only discovered in February of 1995, and an exhaustive inventory of the woody and herbaceous vegetation is not available. However, the tract has been visited by a number of skilled botanists, ecologists, and dendrochronologists, and a preliminary listing of plants identified in October of 1995 has been compiled (see the letter from John Schwegman, Appendix 1). Also, a very useful vegetation analysis was conducted only one mile to the west in the

upland drainage known as Bear's Glen (Barclay 1948), before the vegetation was heavily disturbed and subsequently converted into a COE park.

At least nine vegetation associations can be identified at the Frank Tract based only on the dominant plant types. These associations include: post oak-blackjack oak-hickory forests, post oak and red cedar forests on rocky soils, red cedar dominated blufflines, red cedar and black oak rocky ravines, black oak slopes, post oak savannas, blackjack oak barrens, numerous grassy glade openings, and an un-plowed tallgrass prairie community on the ridge top. The tallgrass prairie and some of the post oak savanna, which are both found on more level soils on or near the ridge tops, are the only communities at the Frank Tract with clear evidence for human disturbance. However, this disturbance appears to have been confined to grazing and the development of dirt roads and clearings associated with oil exploration. It was the general consensus of most professional fieldtrip participants that both the tallgrass prairie and the post oak savanna communities might be restored given the careful management of fire.

The vegetation of the Frank Tract is certainly diverse, and it includes a very high quality herbaceous layer, areas of undisturbed moss and lichen ground cover, and largely undisturbed soils. The integrity of the vegetation extends from the soil level to the forest canopy, and is one of the great assets of this tract.

The Cross Timbers are largely noncommercial for timber production, but the Frank Tract includes sizable individuals of red cedar, black oak, and post oak which might have been logged elsewhere. One could reasonably question why the diverse forests found on this tract have survived even selective logging. One possible explanation could be the relative isolation of the area by the very rugged terrain and the Arkansas River. The main channel of the River was located immediately against the base of the steep hillslopes on the western edge of the Frank Tract. The late settlement of Oklahoma could certainly be another factor. Oklahoma was only opened to settlement in 1889, and much of rural Oklahoma was depopulated during the Depression, drought, and Dust Bowl of the 1930's. Consequently, the native vegetation on rugged, remote, and relatively-inaccessible terrain often escaped heavy utilization during the two generations of settlement prior to the Depression.

Geographical and Geological Significance

The Frank Tract is located on the highest and most rugged uplands immediately above the confluence of the Arkansas and Cimarron Rivers (Figure 5, Plate 1). This confluence is one of the most significant physiographic features in eastern Oklahoma, and it has been impounded by the waters of Keystone Reservoir. Many beautiful and sweeping views of the confluence, Keystone Reservoir, and the ancient Cross Timbers are available from the ridgetops, glade openings, and rock formations on the Frank Tract, particularly during winter.

Due to the proximity of the Arkansas River and the heavy dissection of the terrain, there are extensive exposures of bedrock, with many blufflines, large boulders, and rocky ravines. Massive rock exposures are uncommon in the rolling plains of central Oklahoma, and these ravines reveal part of the geological history of the region. The sandstone boulders and blufflines are painted with mineral stains and are decorated with thick, untrammeled layers of mosses and lichens that greatly enhance the scenic beauty of the Frank Tract.

Historical Significance

Lookouts on the Frank Tract present commanding views of the historical crossing of the Arkansas River often used by early exploration parties and pioneers. Many 19th century travelers crossed the Arkansas just upstream from the confluence with the Cimarron, and then traveled westward through the upland prairies north of the Cimarron. The most famous crossing was made by the great American writer Washington Irving in 1832, who appears to have crossed the Arkansas less than one mile north of the Frank Tract. Irving (1835) has eloquently described the Cross Timbers in general, and the terrain surrounding the Frank Tract in particular, in his book *A Tour on the Prairies* published in 1835. Irving's journey is celebrated in Oklahoma history and by the numerous place names associated with his visit, including "Bear's Glen" which is located just west of the Frank Tract across the Arkansas River.

Wildlife Significance

The undisturbed forest and glade vegetation of the Frank Tract provides excellent wildlife habitat, particularly due to its diversity, isolation, and proximity to Keystone Reservoir and the Arkansas and

Cimmarron Rivers. The Tulsa Audubon Society has purchased 108 acres adjacent to the Frank Tract for an American bald eagle preserve. As many as 50 to 60 bald eagles have roosted on winter evenings in the deep ravines adjacent to Keystone Reservoir (Mr. John Kennington, TAS, personal communication). The number of eagles roosting on the Audubon Tract has gone down to perhaps 20 or 30 per night during the past few years, and this may in part reflect dispersal of the eagles into other roosting habitat along the Arkansas. The secluded ravines on the Frank Tract represent some of the most ideal eagle habitat in this portion of Oklahoma.

Osage County, Oklahoma provides habitat for several other bird species being monitored because of declining populations. Because of its diverse habitat, the Frank Tract could play a key role in helping to sustain bird populations whose habitats are in rapid decline elsewhere. This may include the Peregrine falcon, eastern phoebe, ferruginous hawk, barn owl, grasshopper sparrow, loggerhead shrike, northern harrier, short-eared owl, common nighthawk, dickcissel, and Swainson's hawk, which are on the "Blue List" or list of "Birds of Special Concern" maintained by the National Audubon Society.

The Arkansas and Cimmarron Rivers, and Keystone Reservoir, provide important habitat for migratory waterfowl using the Central Flyway of North America. Large concentrations of duck, geese, cranes, pelicans, and other migrants can be viewed seasonally from lookouts on the Frank Tract. This vegetation mosaic also constitutes excellent habitat for most mammals native to northcentral Oklahoma, including deer, coyote, fox, skunk, possum, squirrel, chipmunk, and various rodents.

Educational and Recreational Significance

The Frank Tract is the least disturbed large area of ancient forest and rugged, rocky terrain we are aware of in the greater metropolitan area of Tulsa. The Frank Tract is located only 15 miles west of downtown Tulsa, and a properly developed and managed interpretive center and trail system would constitute an outstanding educational resource for area schools and universities. The University of Tulsa, Oral Roberts University, Oklahoma State University, and some 750,000 people are located within 60 miles of this tract.

We have carefully surveyed the existing woodlands adjacent to Keystone Reservoir and believe that the Frank Tract is one of the largest, and certainly the most significant area of undeveloped ancient forest/glade vegetation that survives near the lake. The Frank Tract offers many excellent opportunities for solitude and nature viewing while hiking within, or boating along the margin of the tract. These ancient woodlands present a beautiful variety of spring flowers; a deep green summer lushness; stunning fall colors; and the stark winter contrasts of painted rocks, rugged silhouettes of stout 300-year old oaks, and the bright green canopies of centuries-old red cedar. A carefully planned trail system could access this diversity and the many commanding views of Keystone Reservoir, the numerous cliffs and rockshelters, the seasonal waterfalls, and the ancient woodlands. A trail system that included signs interpreting the biological, geological, and historical aspects of this unique terrain could certainly become an irreplaceable educational and recreational resource for Oklahoma.

Scientific Significance

The undisturbed ancient woodlands on the Frank Tract represent a priceless scientific resource. The full scientific significance of this ancient woodland cannot be completely articulated today, but will only become more apparent as agricultural and urban development continue, and as undisturbed ecosystems become correspondingly rare in the southcentral United States. Nevertheless, the natural archive of environmental history which is written in the annual growth rings of the ancient trees on the Frank Tract has proven scientific value. This section will briefly review some of the scientific insight gained from the old post oak on the Frank Tract.

The potential for human-induced changes in regional and global climate has focused scientific attention on the natural variability of climate under preindustrial conditions. Tree-ring chronologies from old-growth trees provide one of the best biological or geological proxies of climate variability, and can be used to develop exactly dated, and amazingly accurate estimates of temperature and precipitation for every year over the past 200 to 2,000 years, or more. Hundreds of tree-ring chronologies have been developed from old forests in the United States, including several from the ancient post oak forests of the Cross Timbers. The longest, and one of the most climatically-sensitive post oak chronologies ever developed was derived from the exceptional old trees on, and adjacent to the Frank Tract (Stahle et al., 1985). This chronology is referred to as the Keystone Lake series, and has been used in several published, peer-reviewed

research articles on climate change (e.g., Blasing et al., 1988; Stahle, 1990; Cook et al., 1992; Meko et al., 1993; Stahle and Cleaveland, 1993).

The weathered ancient post oak above Keystone Lake have witnessed a dramatic history of drought, flood, severe spring frost, and periodic wildfire. Most significantly, the Keystone Lake post oak chronology has been used in conjunction with other post oak chronologies in Oklahoma and Texas, and with Douglas-fir chronologies from Mexico to reconstruct an index of the El Niño/Southern Oscillation (ENSO; Stahle and Cleaveland, 1993). ENSO is a gigantic air-sea interaction over the entire equatorial Pacific Ocean. Extreme oscillations of sea surface temperatures and atmospheric pressure over the equatorial Pacific tend to recur every 4-7 years, and can perturb the planetary-scale circulation of the atmosphere in the tropics and extra-tropics. ENSO is the most important cause of interannual climatic variability on earth, and it has a strong and consistent impact on climate over the southern United States and Mexico. The gradual development of ENSO conditions and its associated climate impacts worldwide have been forecast successfully with numerical models up to one year in advance. Because these ENSO-based climate predictions have enormous socio-economic value, there is great scientific interest in the factors which govern the recurrence and intensity of ENSO events. The post oak above Keystone Lake are among the few trees worldwide that have been demonstrated to register a strong ENSO signal in their tree-ring record of past growing conditions. The tree-ring reconstruction of ENSO (Stahle and Cleaveland 1993), developed in part from the small noncommercial post oak trees on the Frank Tract, indicates large fluctuations in the frequency and intensity of prehistoric ENSO events. These changes in event frequency have major implications to our understanding of ENSO, and to the effort to use ENSO conditions in the equatorial Pacific as a climate and crop yield forecasting tool worldwide. Recognition of the true socioeconomic value of these ancient, but otherwise "noncommercial" trees must include some appreciation of their contribution to international scientific issues.

Practical Considerations Concerning the Frank Tract

Several practical factors enhance the potential for management of the Frank Tract as a public bioserve. This ancient woodland is only 15 miles from the Tulsa city center, and is highly accessible by automobile. A major four-lane highway (U.S. 412) is located near the southern margin of the tract (Figure 5, Plate 1). In fact, the Route 151 exit that crosses Keystone Dam adjoins the southern margin of the tract, and could be readily modified to provide direct road access to the Frank Tract. Highway 412 itself crosses Keystone Reservoir by bridge and causeway one mile to the southwest, and provides a sweeping panoramic view of the rugged ancient woodlands rising above the lake and into the Frank Tract.

Although readily accessible by highway, the ecological integrity of the Frank Tract may be protected to a degree by several geographical and land ownership factors which tend to isolate these ancient woodlands. Keystone Reservoir and the narrow lake buffer strip managed by the COE forms the western and northern boundary of the Frank Tract (Figure 6). The Tulsa Audubon Society lands adjoin the property owned by Mr. Frank on the north and east. The regents of the University of Oklahoma also own some 400 acres of land partially adjacent to the TAS eagle preserve. Private property held primarily by two individuals adjoin the Frank Tract to the east and south, and the Prue road is approximately one half mile further east. The north-south flowing Sand Creek is located in the vicinity of the boundary between the Frank Tract and other private property to the east. Sand Creek marks the approximate eastern edge of the undisturbed ancient woodlands on the Frank Tract, and forms a natural physiographic boundary to these upland ecosystems.

The establishment of a public or private bioserve at the Frank Tract would diversify the educational and recreational amenities of the Tulsa area in general and the Keystone Lake area in particular, and might have a favorable impact on the local economy. A well planned and managed bioserve might also favorably impact property values in the immediate vicinity. Strong cooperation with the management objectives of this possible bioserve might also enhance the public perception of the environmental sensitivity of the U.S. Army COE.

Finally, a small number of conservationists have a long range vision concerning the biodiversity goals of the United States, which includes a large-scale biodiversity management plan for the entire Cross Timbers ecosystem (Figure 1). Ideally, a long-term biodiversity management plan could be devised for the relatively undisturbed ancient forests and grasslands of the Cross Timbers in Texas, Oklahoma, and Kansas that would unite federal, state, and consenting private property owners under a coherent region-wide strategy. The development of a bioserve on the Frank Tract would certainly provide the tangible cornerstone that presently does not exist to help articulate this conservation vision for the entire Cross Timbers ecosystem.

Limitations

In spite of the many advantages involved in the management of the Frank Tract as a public or private bioserve, there are several potential impediments that would have to be overcome. The most obvious limitation concerns the private property that is involved. Some 1000 acres of land owned by Mr. Irvin Frank would have to be purchased, donated, or placed under some type of explicit conservation easement. The outright purchase of the Frank Tract and other smaller parcels of private land could theoretically be arranged with the assistance of private conservation organizations or land trusts. Any charitable donation of land for public benefit, or deeded conservation easements, could theoretically incur tax advantages to the donor.

Presuming that the property for a bioserve could be arranged, the even larger responsibility for the development and permanent management of such a bioserve would have to be ensured. The magnitude of this management responsibility would depend partly on the degree to which the bioserve was open to the public. The management of an entirely private bioserve might involve nothing more than caretaker duties. A quasi-public preserve or an entirely public park would both ideally involve the construction of paved roads, an interpretive facility, a well-planned trail system, and possibly a picnic area. The operation of a public or quasi-public bioserve, the restoration of the tallgrass prairie and oak savanna, and the long-term management of the intact ancient forests and glades would almost certainly require a full time professional staff of at least two people. Some rehabilitation work would also be required to remove oil tanks and restore the few small oil exploration areas. For a fully public bioserve, these development, restoration, and management duties might logically be shouldered by state or federal government (e.g., perhaps as an addition to the management mission of the U.S. Army COE at Keystone Reservoir). However, long-term management by a private conservation organization such as the National Audubon Society or the Nature Conservancy might be a simpler proposition, and might still provide for controlled public access and education.

Securing the property and a viable commitment to the permanent management of a bioserve on the Frank Tract will obviously be the two most significant obstacles. If these objectives can be achieved, there are several lesser issues that should also be considered. First, two extensive areas of undisturbed ancient Cross Timbers adjoin the Frank Tract, and would add considerably to the natural function of any bioserve (Figure 5). These tracts include 160 contiguous acres owned by H.S. Childers (S1/2, SE1/4, Sec. 28, and the N1/2, NE1/4, Sec. 33, T20N, R10E), and approximately 110 acres south of the *Hollandia* development owned by R. Duffield (SW1/4, Sec. 22, and SE1/4, Sec. 21, T20N, R10E). The degree to which these owners might be willing to consider sale, donation, or conservation easement on their ancient woodlands is not known.

Finally, a powerline and pipeline both cross portions of the Frank Tract, and the mineral rights of this tract are held separately. The mineral rights would require separate negotiations, but the value of these rights are not believed to be prohibitive.

Conclusions

The Frank Tract provides a premier example of the native vegetation cover that dominated the presettlement landscape of eastern Oklahoma. This tract includes a wide variety of plant associations typical of the Cross Timbers, and many dramatic bluffs and rock formations. Given the proximity of this outstanding natural area to Tulsa and Stillwater, it could serve as a unique ± 1500 acre educational and recreational bioserve. This potential ancient Cross Timbers reserve could play an instrumental role in helping to raise public and professional appreciation for the many ancient forest remnants that survive throughout the Cross Timbers ecosystem in Texas, Oklahoma, and Kansas. We concede that significant limitations to the public or private natural area management of the Frank Tract do exist, but we do not believe that these impediments fundamentally undermine the integrity of this site as a bioserve. In fact, after twenty years of experience with the ancient forests of the Cross Timbers, we cannot identify any other ancient Cross Timbers woodland that is as diverse, as undisturbed, and as accessible to schools, universities, and to the public as the Frank Tract. In spite of these advantages, it is quite clear that a major long-term effort on the part of the public and private conservation community, most notably by the University of Arkansas Tree-Ring Laboratory, The Oklahoma Natural Heritage Inventory, the U.S. Army COE, and the Tulsa Audubon Society, will be necessary to earn the confidence and cooperation of the private landowners. This cooperation will be essential to realize the conservation potential of the wild ancient woodlands and grasslands above the southeastern margin of Keystone Reservoir.

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Figures

(figures not included with this digital file)

Figure 1. The potential natural distribution of the Cross Timbers forest type along the eastern margin of the southern Great Plains. This map was digitized from Kuchler (1964) and only includes Kuchler's type 75 ("Cross Timbers: *Quercus-Andropogon*"), which covers an estimated 7,909,700 hectares (30,526 square miles). Because this entire formation is composed largely of noncommercial forest, it may be the least disturbed forest type still left in the eastern United States. We have already found many ancient post oak dominated forests within the Cross Timbers, and believe that a sizable fraction of the Cross Timbers have never been cut.

Figure 2. The distribution of Niotaze-Darnell soils on 15 to 45% slopes (black polygons) predicted to still retain uncut ancient Cross Timbers forest in southern Osage County, Oklahoma (roads and streams are also indicated). The soil data were digitized from the soil survey maps for Osage County (SCS 1979) and cover 11,308 hectares (43.66 square miles) in this study area at a resolution of 10 acres. Field examination and tree-ring analysis at 50 randomly selected belt transects indicates that 73% of these Niotaze-Darnell soils still retain undisturbed ancient Cross Timbers. We estimate that a total of 8,255 hectares (31.87 square miles) of ancient forest are still present in southern Osage County (Therrell, in preparation).

Figure 3. The black polygons shown here locate large parcels where the vegetation cover is at least 90% undisturbed ancient Cross Timbers (one inch represents approximately one mile). Six tracts of ancient forest exceeding one square mile in size were discovered during fieldwork, but several other large tracts no doubt still exist in this study area. The Frank Tract includes 2.7 square miles of ancient woodlands on the southeast margin of Keystone Lake. The Frank Tract is the most significant area of ancient Cross Timbers we have discovered because of its scenery, diversity, geology, wildlife, and accessibility to metropolitan Tulsa.

Figure 4. Location map for the Frank Tract, Osage County, Oklahoma.

Figure 5. The location of ancient Cross Timbers on and near the Frank Tract in southern Osage County, Oklahoma. The areas outlined retain undisturbed ancient forest on at least 90% of the land surface (Therrell, in preparation). The area of ridge top in section 28 which does not include ancient forest has been disturbed by past grazing and oil exploration. However, we believe that the native tallgrass prairie could be restored to this area.

Figure 6. Ownership map for T20N R10E, Osage County, Oklahoma. Note the Irvin Frank property in sections 27, 28, 29, 32, and 33. The Rosemary McClure tract in section 28 is now owned by Mr. Frank. Also note the Tulsa Audubon Society property in section 22 and 27, and the federally-owned buffer of lands surrounding Keystone Lake. Other key parcels with ancient Cross Timbers adjacent to the Frank Tract include portions of the SW1/4 of section 22; the SW 1/4 of Section 27; the S1/2, SE1/4 of section 28; and the N1/2, NE1/4 of section 33.

Appendix I. Letters of interest in the Frank Tract from science and management specialists who have visited the tract.

(letters not included in this digital file)

Appendix II. A selected portfolio of the ancient forests and undisturbed landscapes on the Frank Tract, Osage County, Oklahoma.

(plates not included with this digital file)

Plate 1. The ancient woodlands on the Frank Tract cover some 2.7 square miles north of Highway 412 and east of Keystone Lake (view to east). All of the wooded uplands illustrated in this photograph north of Highway 412 are essentially undisturbed, and include many post oak trees over 300 years old, black oak over 150 years old, and eastern red cedar over 500 years old (the north-south distance from Highway 412 to the left edge of the photograph is approximately 1.3 miles).

Plate 2 (left). A typical view of the ancient Cross Timbers vegetation type found on the Frank Tract. The post oak trees shown here average only 15" in diameter and 30' tall, but are in the 200- to 300-year age class. Due to the small stature and slow growth rate of the dominant post oak trees, most of the Cross Timbers are not suited for commercial timber production. Consequently, the Cross Timbers, which extend from central Texas across eastern Oklahoma into southeast Kansas, may represent the least disturbed forest ecosystem that survives in the eastern United States. However, land clearing, suburban development, and increased production of wood chip mills in Oklahoma threaten even these marginal slow-growing woodlands.

Plate 3 (right). Tree-ring analysis indicates that this post oak tree on the Frank Tract is at least 250 years old, and it illustrates many of the physical characteristics typical of old-growth oak trees. This small tree has a laterally-twisted stem; a broken, partly-hollow top; a restricted canopy supported by just three heavy limbs; and numerous dead limbs and healed branch scars (it is only some 14" in diameter and 25' tall). Although poorly suited for commercial timber production, annual growth rings from these ancient post oak represent a unique and highly detailed archive of environmental history. These ancient post oak have already been used to reconstruct the history of growing-season droughts and severe spring freeze events since A.D. 1650. These remarkable trees at the Frank Tract have also been used to reconstruct the influence of atmospheric circulation over the equatorial Pacific Ocean on the climate of Oklahoma and subtropical North America.

Plate 4 (left). Ancient post oak grow among the rocks and rugged sandstone blufflines that are so common and picturesque on the Frank Tract. The heavily dissected terrain supports a variety of microclimates and a diversity of plant communities. These secluded woodlands and ravines above Keystone Lake also provide known habitat for the American bald eagle and many other animals.

Plate 5 (right). An ancient eastern red cedar growing on a sandstone bluffline overlooking Keystone Lake and the impounded confluence of the Arkansas and Cimmarron Rivers. This tree is approximately 300 years old. Note the heavy crooked limbs and the several dead branches which are indicative of old-growth conifers. Ancient red cedar are extensive on exposed rocky terrain at the Frank Tract. In fact, the Frank Tract preserves the largest stand of undisturbed old-growth eastern red cedar that we are aware of anywhere in the eastern United States

Plate 6 (left). Old-growth red cedar survive on the Frank Tract in part due to a measure of fire protection provided by the rocky terrain, and by the Arkansas and Cimmarron Rivers, which are located to the southwest and immediately upwind of the Frank Tract in the prevailing winds.

Plate 7 (right). This ancient red cedar exhibits the classic features of antiquity, including a strong laterally-twisted stem and the "strip bark" growth form. This tree is partially hollow, but certainly exceeds 400 years in age.

Plate 8 (left). Ancient black oak trees codominate more mesic microenvironments on the Frank Tract. This black oak is approximately 160-years old, which is near the maximum longevity for this particular species on sandstone-derived soils in the southcentral United States.

Plate 9 (right). An old-growth black oak stem (left) and a dead red cedar stem (right) found in a rocky ravine on the Frank Tract. Red cedar can co-dominate this relatively mesic northerly exposure because the rocky terrain prevents complete closure of the hardwood canopy, and allows sufficient sunlight for these shade intolerant red cedar. There are numerous standing-dead red cedar stems throughout the Frank Tract, which represent additional evidence of the undisturbed nature of this old-growth forest. These dead trees also bear mute testimony to extended droughts of the past, particularly the Dust Bowl of the 1930's and the severe Southern Plains drought of the 1950's.

Plate 10. A thick carpet of mosses and lichens cover the soil and sandstone bedrock in protected microenvironments on the Frank Tract. These beautiful and fragile plant associations are extensive on the Frank Tract, and help document the very low grazing pressure these ancient woodlands have experienced.

Plate 11. One of the many small glades dominated by prairie grasses that punctuate the forest and glade mosaic of the Frank Tract in particular, and the Cross Timbers in general. These grassy openings are so common that we think it is justified to suggest that the largest amount of unplowed, ungrazed, and largely undisturbed glade grassland that still exists in the eastern United States can be found within the ancient Cross Timbers of eastern Oklahoma. The diversity of habitats found within the undisturbed ancient Cross Timbers of the Frank Tract, along with its accessibility to the metropolitan Tulsa area, make this tract an outstanding candidate for management as a natural area designed to increase understanding and appreciation of this authentic and endangered Oklahoma ecosystem.