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The purpose of the ONPS is to encourage the study, protection, propagation, appreciation and use of the native plants of Oklahoma. Membership in ONPS shall be open to any person who supports the aims of the Society. ONPS offers individual, student, family, and life membership.

Cover photo: Sorghastrum nutans, Indian grass, our state grass by Charles Lewallen

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Oklahoma Native Plant Record

Volume 4, Number 1

Table of Contents

Foreword

It was a pleasure to learn that Anne Long's thesis on the distribution and ecology of the American smoketree, *Cotinus obovatus* was to be published in the this issue of the Journal of the Oklahoma Native Plant Society.

I was first introduced to Anne and the American smoke-tree in the spring of 1970 while a student in Dr. Harriet Barclay's ecology class. Anne was one of Dr. Barclay's last graduate students at the University of Tulsa. She was a frequent guest on many of our class fieldtrips, especially to the Redbud Valley Preserve in Eastern Oklahoma. I fondly remember Anne and Dr. Barclay introducing us to *C. obovatus,* describing its characteristics and distribution to the class. Anne's research indicated that this species can often be found distributed atop many of Oklahoma's limestone bluffs, up and down the Arkansas, and other eastern Oklahoma rivers. To this day, I often look for the smoke-tree whenever I am near such a bluff on my many ONPS fieldtrips.

This tree is described by the U.S. Forest Service as a hardy species with beautiful fall foliage and few pests or diseases. They recommend it as a potential attractive native ornamental, but do admit that it is somewhat difficult to get established.

Anne Long's contributions to Oklahoma's' flora was tragically cut short by cancer and one can only guess as to what her future contributions may have been. We currently live in some exciting times, with DNA analysis providing new insights into our knowledge of species relationships. This knowledge still needs to be supported by fieldwork in species distribution and ecology. Hopefully, there will be future graduate students and other researchers that will continue to carry on Anne's legacy and add to our knowledge of Oklahoma's unique geography, flora, and fauna.

James Elder
ONPS President
June 2004

Oklahoma Native Plant Record
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Ecological Factors Affecting the Distribution of Woody Vegetation Near the Arkansas River, Tulsa County

with Special Reference to the Smoke-tree *Cotinus obovatus*

Anne Wanamnaker Long

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Botany The University of Tulsa 1970

ABSTRACT

Ecological factors affecting plant distribution were studied over different rock strata and slope exposures above the Arkansas River, Tulsa County. Here the Wann sandstone caprock is underlain by the Iola limestone formation. The vegetation was analyzed taxonomically by a complete collection throughout one growing season. Belt transects crossing rock strata on all slope exposures permitted computation of parameters summarized by an Importance Percentage for each woody species. Differences in species populations and degree of mesophytism exist on the slope exposures. Sandstone upland dominants are post and blackjack oaks. Smoke-tree, rare in Oklahoma, and chinquapin oak are closely associated in limestone microhabitats, where each occupies a separate niche. The smoke-tree, of disjunct distribution, appears to be a relict of widespread occurrence in past geologic periods. Its survival with limited ecological amplitude is due to the continuance of the microhabitats to which it is so well adapted.

INTRODUCTION

As is evident to even the most casual observer, there is often a marked correlation between the vegetative cover of the land and the rock strata which underlie it. Abrupt changes in vegetation may well indicate distinct changes in subsurface geological formation. This fact has given rise to the rather recent science of Indicator Geobotany. Russian scientists, particularly, are utilizing vegetational analyses as a rapid, inexpensive and reasonably accurate means of evaluating soil, terrain, and hydrogeological conditions. Aerial surveys have made possible the widespread use of these methods over vast expanses of largely inaccessible land (Chikishev 1961).

Piqued by frequent field trips and residences in various sections for the country, the author has become intrigued by this trend to meld the disciplines of botany and geology into an inter-related science with certain universal applications. The purpose of this investigation was to study an area encompassing differing rock strata in order to note possible correlations between the vegetation and the underlying rock formations. A thorough examination of the Geologic Map of Tulsa County, as compiled by Malcolm Oakes in 1952, led to several possible sites. The one selected is in the southwest one fourth of Section 1, T.19 N, R.10 E, 15 miles west of Tulsa (Figure 1). It is about four miles below the confluence of the Cimarron and Arkansas Rivers whose waters are today impounded by Keystone Dam, completed in 1968 by the United States Corps of Engineers.

The location is of interest botanically, since Thomas Nuttall, the early nineteenth century botanist, embarked on the Cimarron River west of this point and proceeded down the Arkansas a short distance before returning to Fort Smith during his travels through Arkansas Territory. In his journal of September 9, 1919, he wrote, “About noon we arrived at the entrance of the Arkansa (sic) and were gratified with the taste of fresh water. Here the stream, now at its lowest depression was almost colorless and scarcely anywhere exceeding the depth of 3 feet. We traveled down it 9 or 10 miles and saw the ascending smoke of the Osages whom if possible we wished to avoid” (Thwaites 1904-07). It may also be noted that Washington Irving and his party camped at a point on the Arkansas River, known as Bear’s Glen, one and a half miles above the mouth of the Cimarron River in 1832 (Barclay 1947).

METHODS

Knowledge of the geology and identification of the rocks exposed in the area were obtained

Long, A.W.
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from Oakes' (1952) detailed study of the character, distribution, and thickness of the formations that outcrop in Tulsa County. Mr. Allan P. Bennison, consulting geologist of Tulsa, confirmed the rock formations in the field.

Climatological data were obtained from the United States Weather Bureau office at Tulsa International Airport. Precipitation and temperature figures are based on records dating back to 1931.

A series of soil samples was taken from the upland where the parent rock consists of sandstone, and from the accumulated soil were obtained by means of a soil auger. They were analyzed by the Tulsa County Agricultural agent for organic matter and pH.

Analysis of woody vegetation was made by belt transects which crossed the rock strata on the different slope and bluff exposures. Weaver and Clements (1938) suggest the use of such transects for analysis of vegetational changes due to differences in environment such as are caused by slope exposure or other irregularities in topography or soil. Six transects five meters wide were made, one each on the south, east, and west slopes and three on the north bluff. Because of the varying widths of the strata exposed, the transects ranged in length from 62 to 108 meters. All trees and shrubs in these transects were recorded and the density, frequency, and basal area were determined for those with a diameter breast high (DBH) of three inches or more. These parameters were used to obtain the relative density, relative frequency and relative basal area of each species in comparison with the other species. The sum of the latter three figures, divided by three, determined the importance percentage of a species (Rice and Penfound 1959). The data were used in comparing the tree species on different slopes and in detecting changes as the transects passed over different rock formations.

Collections and determinations of all vascular plants occurring in the area were made over an entire growing season and are presented in Table I. Weekly trips to the study site were made to collect specimens at the time of blooming. Correlation of the vegetation with the underlying strata and with slope exposure has been corroborated by habitat records of the collections. All specimens are deposited in the University of Tulsa Herbarium

CLIMATE

The climate of Tulsa County is essentially continental with sudden temperature changes and occasional severe storms. Winters are considered to be mild and temperatures are often above 100 degrees F. The average yearly rainfall is 37.25 inches, most of which falls during the long growing season. The prevailing winds are southerly at a yearly average of 10.7 miles per hour. Violent wind storms and tornadoes may occur, particularly during spring and early summer.

For a graphic depiction of Weather Bureau data from 1931 to 1968 see Figure 2. It is evident that the overall development of vegetation is closely related to the climatic features shown. The rainfall is greatest in the spring of the year, thus permitting a fairly luxuriant growth of vegetation. By the end of summer, however, many spring-flowering species have completed their growth cycles. The vegetation then appears notably less dense with an abundance of grasses and late-flowering herbs.

GEOLOGY, TOPOGRAPHY AND SOILS

The rocks exposed in Tulsa County are predominantly shales, interspersed with beds of limestone and sandstone, all of which were deposited during the middle and upper Pennsylvanian Period of the Paleozoic Era. They are a part of the sequence of Pennsylvanian rocks so well exposed in the northern mid-continent region. Having been subsequently uplifted and tilted, they now dip in a direction slightly north of west, at rates ranging form 30-50 feet per mile (Oakes 1952).

The present topography is the result of erosion, mainly by water, which has worn away the soft shales and produced extensive plains with the eroded edges of the more resistant sandstones and limestones forming eastward-facing cuestas or escarpments overlooking the plains. West of Tulsa, where the section contains a greater percentage of hard sandstone, erosion is less advanced. The streams have generally cut narrow valleys which are flanked by steep-sided hills, broken by cliffs and protruding ledges formed by the resistant beds of limestone and sandstone. Drainage of the county is by means of the Arkansas River and its tributaries. In the vicinity of this study, the Arkansas River is deeply incised (Figure 3), the floodplain being less than two miles wide, and the hills on both sides of the river rising precipitously 200-230 feet.

The area encompasses a high bluff on the south bank of the river (Figure 4). Here the limestone, classified as the Iola formation, is conformably overlain and capped by a massive sandstone, the Wann formation. The Wann sandstone is approximately 30 feet thick, and the Iola formation is 60 feet thick (Figure 5). The Iola consists of upper and lower limestone members interbedded with shale. The limestone is very irregular and sandy, and the intervening shale layer is obscured by talus. Due to the greater erosion of the softer shale huge masses of the upper limestone member have broken from the bluff and rest as slump blocks on the slopes (Figure 6). In addition, the Wann sandstone caprock fractures into large blocks on the top of the bluff (Figure 7).

The Iola formation rests on the Chanute sandstone, which is largely covered by debris from the formation above it and is poorly exposed.

The soil analyses (Table II) indicate that the Wann sandstone is strongly acid. The very shallow soil mantle, the decomposition of the leaves of the dominant oaks, and the leaching of carbonates all tend to contribute to lowering the pH. Although the pH of the limestone ledge is approximately neutral, there is a slight increase in pH on the shale below, undoubtedly due to the leaching of the carbonates from the limestone layer.

The analyses also show an increased accumulation of organic matter from the upland to the bottom of the slopes. This can be attributed to erosion from the upland and the more abundant vegetation on the limestone and shale.

For better understanding of the influence of the soil on plant distribution, an investigation of water and mineral relationships should be made. Certain conclusions, however, can be drawn on the basis of the characteristics of the strata. It seems evident that the water moves readily through the sandstone caprock, thus limiting the vegetation on the upland to those species of low moisture requirements. The limestone very likely serves as an aquifer supplying ample moisture to support a dense vegetation, with the underlying shale, because of its small pore size, serving to retard the passage of water.

Since many of the limestone formations in Tulsa County are known to contain phosphatic nodules in significant amounts, it is probable that they are present to some extent in the Iola and may be a contributing factor in determining the vegetation on the slopes.

VEGETATION

Taxonomic Analysis

One hundred and eighty species of vascular plants were collected at the study site which covers an area of approximately 50 acres. This collection represents a total of 134 genera and 54 families (Table I). The variety of the vegetation and the seasonal changes in plant development were apparent on weekly trips to the area. These visits also revealed the segregation of certain species into distinct communities, coinciding with abrupt changes in topography, and they served to illustrate the dynamics of plant growth and reproduction.

Upland

The sandstone upland is characterized by the oak-hickory woodland of the sandstone hills area (Bruner 1931). Here the dominants are post oak (*Quercus stellata*) and black jack oak (*Q. marilandica*). Texas hickory (*Carya texana*) occurs infrequently and is of little importance. Since there are few other woody species on the upland, there is a definite uniformity of the stand as may be seen in Figure 7. Tree species with greater moisture requirements are unable to survive and reproduce.

Rice and Penfound's study of the upland forests of Oklahoma (1959) concurs with these findings. They listed post oak and black jack oak as the dominants for Tulsa County. Barclay (1947) gives post oak as the single dominant on the Wann sandstone above Bear's Glen, Pawnee County, some four miles from this site.

Slopes and Bluff

The vegetation on the slopes is in marked contrast to the upland in that many species occur and they provide a more varied cover. The west slope which forms one side of a wide ravine that drains the area is rather gentle. Chinquapin oak (*Q. muehlenbergii*), and smoke-tree (*Cotinus obovatus)* are the most significant plants. They appear near the top of the slope on the limestone ledge. Among the other trees are post oak, red haw (*Crataegus* sp.), persimmon (*Diospyros virginiana*), sand plum (*Prunus angustifolia*), white ash (*Fraxinus* *americana*), and rough leaf dogwood (*Cornus Drummondii*). An abundant grass cover occurs beneath and between the trees of the west slope.

The ravine on the east is steeper and more protected; the vegetation is, therefore, denser. Chinquapin oak and smoke-tree are prominent along the limestone ledge. On other parts of the slope are post oak, white ash, Texas hickory, shadbush (*Amelanchier arborea*), and Shumard's oak (*Quercus shumardii*). Open areas covered with grasses made up a smaller proportion than on the west exposure.

The heaviest vegetation occurs on the steep north bluff (Figure 8). Here shrubs, trees, and vines form an almost impenetrable thicket early in the growing season. Chinquapin oak and smoke-tree dominate the upper limestone ledge. Along the lower limestone outcrop, chinquapin oak is largely replaced by Shumard's oak growing in association with the smoke-tree. The Oaks are large and impressive as shown in Figure 9. The smoke-tree grows in big clumps with many trunks arising from the base (Figure 10). Other trees on the north face are redbud (*Cercis canadensis*), American elm (*Ulmus americana*), slippery elm (*U. rubra*), Texas hickory, bitternut hickory (*Carya cordiformis*), white ash, and rough leaf dogwood. Grasses occur in an open band between the limestone ledges.

The sandstone caprock on the south is extensive and slopes very gradually with no marked change in the vegetation until the limestone is exposed. Here hackberry (*Celtis laevigata*), blackhaw (*Viburnum prunifolium*), and rough leaf dogwood are present.

In general, the vegetation at this study site corresponds rather closely with that at Bear's Glen, as reported by Barclay (1947). A notable difference is the complete absence of *Cotinus* at Bear's Glen where no limestone was present. (The area is now submerged by Keystone Reservoir.) Red cedar (*Juniperus virginiana*), which was an important species at Bear's Glen, is of little significance here. Only two were encountered in this area.

RELATIONSHIP OF VEGETATION TO UNDERLYING STRATA

Analysis of Woody Vegetation

Since it was impossible to run the south transect from the top of the bluff due to the presence of a small oil field at this point, the transect was made to the east, on the south flank of an adjacent bluff (Figure 4). Because of the slight grade of the slope, this transect should probably be considered as part of the upland. The difference in elevation between the beginning of the transect and the limestone outcrop is not sufficient to cause perceptible changes in vegetation. The dominant trees here are post oak and black jack oak. The importance percentage (I.P.), computed from the transect are 65.9 for the post oak and 41.4 for the black jack oak. Rice and Penfound (1959) consider an importance percentage of 25 or more an indication of dominance.

It was evident, however, from the data obtained from the west, east and north transects that, here, both slope exposure and underlying strata are factors in determining the woody vegetation. The transects are arranged in Figure 11 so as to correlate the upper limestone outcrop on the three exposures. As will be noted from the chart, three transects were made on the north-facing bluff because of the greater variety and density of the vegetation on the north. The chart also shows that the lower limestone member outcrops only on the steep north face and is not reached on the east or the west.

The tree species with a DBH of three inches or more are plotted where they occur within the transects and their diameters are recoded. All species under three inches DBH are considered as reproduction and their counts listed (Figure 11). The presence of multi-trunked *Cotinus* is indicated within the quadrats but since the diameters of the individual trunks were under three inches, their basal areas were not determined. For this reason, although the chart shows that the smoke-tree is confined almost exclusively to the limestone strata, its relative importance and I.P. cannot be computed.

The data in Table III indicate that the three oaks: post, chinquapin, and Shumard's, are dominants on the north-facing bluff but that each occupies a particular habitat on the bluff. Post oak, dominant on the sandstone upland, is largely replaced by chinquapin oak on the upper limestone ledge, and this species is replaced by Shumard's oak on the lower limestone outcrop.

It would seem that this segregation of the oaks is due in part to moisture requirements. The post oak is best adapted to the conditions on the dry upland, chinquapin oak to the more mesophytic habitat on the upper part of the slope, and Shumard's oak requiring the very moist conditions below. The complete absence of Shumard's oak on the west and south exposures gives further evidence of its high moisture requirements; whereas chinquapin oak occurs sparingly on the west slope and is absent on the south.

The occurrence of post oak on the limestone on the east and west-facing slopes and on the east end of the bluff is somewhat misleading, for here erosion has dissected the limestone ledge into large blocks, with small ravines between the blocks. It is in the open, well-drained sites that post oak occurs.

Since white ash occurs almost exclusively below the limestone strata, it seems apparent that it cannot survive the aridity of the upland.

Reproduction counts on the transect chart are significant, for they suggest that each community is continuing to maintain itself. The preponderance of small post oaks on the limestone upland leaves little doubt that it will continue to dominate this location.

As the gaps between the limestone blocks on the east and west slopes enlarge and provide greater open areas for evaporation and runoff, the post oak, already established, will increase. Over a long period of time the decline and eventual elimination of the smoke-tree and chinquapin oak on these slopes seem assured. They will then probably be confined to the north-facing bluff.

Herbaceous Vegetation

It is evident from this investigation that a number of herbaceous plants are restricted to very particular habitats. Two small ferns, *Notholaena dealbata* and *Pellea atropurpurea*, although abundant, were found only in crevices on the limestone ledges or on the limestone slump blocks. Other species confined to the limestone outcrops are: *Yucca arkansana, Gerardia heterophylla, G. tenuifolia, Penstemon cobea, Cleome serrulata, Rosa setigera, R. carolina, Euphorbia hexagona, Ceanothus americanus, Liatris punctata, and L. squarrosa.* Herbaceous species limited to the sandstone were markedly fewer in number. They include *Commelina erecta, Sedum nuttallianum, Tephrosia virginiana, Lechea tenuifolia, Penstemon tubaeflorus, and Antennaria plantaginifolia.* Although no attempt was made to tabulate herbaceous materials on the basis of underlying strata, the collections indicate that the largest number of species was to be found on the talus slopes where the shale is covered with soil and with limestone and sandstone debris from the formations above.

THE IMPORTANCE OF *Cotinus obovatus*

Taxonomy

Cotinus obovatus, or smoke-tree, is a small tree or large shrub up to 35 feet tall, in the family Anacardiaceae. It has alternate, simple, entire, obovate leaves four to six inches long and two to three inches wide, which form dense summer foliage (Figure 12). The plants are usually dioecious with small flowers, many abortive, in loose terminal thyrses. The slender pedicels elongate after flowering and those on the abortive flowers become plumose-villous. The name "smoke-tree" alludes to the "smoky" appearance of the inflorescences. The species tends to grow in clumps and to reproduce asexually by means of root or stump sprouts.

The genus consists of three or more species found in Eurasia and eastern North America. It is represented in the western hemisphere by the single species, *C. obovatus*, of interrupted distribution in southern United States. Although *Cotinus* was originally classified with *Rhus*, recent studies indicate that the two genera are not closely related. According to Engler, *Cotinus* represents a branch of evolution different from but having a common origin with that of *Rhus* (Brizicky, 1962). The European species, *C. Coggygria*, because of its more feathery panicles, is cultivated as a popular ornamental in the United States and Europe.

Distribution

The American smoke-tree is found in disjunct populations on wooded, rocky cliffs and river bluffs, generally on lime stone. It occurs in the mountains of Tennessee, in Daviess County, Kentucky, where it may have been introduced, in southwestern Missouri, in northwestern Arkansas and eastern Oklahoma, and in the canyons of the Edwards Plateau in Texas (Sargent 1965).

Cotinus is reported from several stations in Oklahoma (Figure 13). The earliest record of it was made by Nuttall on a trip up the Grand River in 1819. In his journal of July 18 he wrote, "The morning was find and we embarked at sunrise. About 8 o'clock we passed a bend called Eagle's Nest, a mile above which, and its island (sic), a facade of calcareous rock appears, inlaid with beds of whitish hornstone. While examining these cliffs, I recognized as new a large shrub, and to my great surprise found it to be a simple-leaved *Rhus*, scarcely different from *Rhus. Cotinus* of the south of "Europe and our gardens" (Thwaites 1904-07). In 1928 Palmer reported finding the smoke-tree in a steep, rocky ravine near the base of Rich Mountain in Le Flore County and Little (1942) found it in the Cookson Hills in Cherokee County. Dr. Harriet G. Barclay, of the University of Tulsa collected it in a ravine near Garnett, Rogers County, in 1932. *Cotinus* has also been collected from a location in Tulsa County approximately three miles east of the present study (Clark 1960). Dr. Albert P. Blair of the University of Tulsa, reports finding it in the vicinity of Spring Creek and Little Spring Creek in Cherokee County. In addition, the author has observed it growing in a canyon five miles west of Claremore, Rogers County.

Ecological Requirements

The abundance of the disjunct, *Cotinus,* in this area presents a fascinating picture. The species occurs in large clumps on the upper and lower limestone ledges or on the blocks of limestone that have slumped off the ledge (Figure 6). The largest and most impressive specimens are found on the upper limestone ledge of the north-facing bluff. Here, apparently, its requirements for sunlight and moisture are met most successfully. The roots penetrate the limestone fissures and branch profusely, even when exposed. Many trunks are broken and twisted, but the species has the capacity to produce new shoots, not only from the base, resulting in multiple trunks, but also from the upper branches, making a pollarded effect (Figure 14).

An important relationship between the smoke-tree and the chinquapin oak has become evident in this study. In every location where the author has found the smoke-tree, chinquapin oaks have been present. These two species, unrelated, taxonomically, have become adapted to the same micro-habitat, but they make somewhat different demands upon the environment and fill different niches in the community. The smoke-tree, with the ability of its roots to penetrate the limestone fissures, and its growth habit of proliferating from the base, can gain a foothold on the eroding rock. The chinquapin oak grows so close to the smoke-tree that it overtops the latter although it roots at the base of the limestone ledge. The two species thus seem to complement each other and not to compete. It is noteworthy that a similar relationship exists in Europe where *C. Coggygria* grows in association with another oak (*Q. pubescens*) and the association is described as the Quercito-Cotinetum forest (Penzes 1958).

Hanson and Churchill (1961) have observed this close association within a community. "The individual plant, in order to live, must establish successful relations with its physical environment as well as with other plants and animals. In nature plants usually grow in groups, not as isolated individuals. These groups may consist of a single species but more often the groups comprise individuals of several species constituting a community.... The kinds of plants that grow in a particular habitat must have the ability to grow not only under the prevailing physical environmental conditions but also in association and competition with neighboring plants."

It could be assumed that since the smoke-tree occurs on limestone it is a calciphilous species. It is possible, however, that the physical character of the rock and the ecological niche of the smoke-tree account for its limestone habitat rather than the chemical properties of the rock. The acidity of the Wann sandstone upland may be a factor, in addition to the dryness, in explaining the almost complete absence of the smoke-tree in the habitat. It should be noted that native specimens of *Cotinus* already well developed have bee transplanted and grow well in the Tulsa area on sandstone soils if given sufficient water. Such alteration of the usual habitat is thought to be possible only because of its extensive vegetative growth.

Cotinus grows along the limestone ledge on the east slope where the ravine is narrow and sheltered from the drying southerly winds. On the west slope which is more exposed, the clumps are scattered and on the south they are completely absent. It seems evident that the ecological amplitude of the species is small. When exposed to the greater solar radiation and drying winds it is unable to survive. Hanson and Churchill (1961) define ecological amplitude as the "characteristic potentiality for growth of a species with a limited range of environmental conditions". It often determines whether or not a species will be present in a certain habitat or community.

Paleo-History

The peculiar distribution pattern of *Cotinus obovatus* in North America and its isolation from the European species require consideration of its paleo-botanical record. According to Cain (1944), "Major disjunctions seem almost exclusively to have resulted from historical causes which have produced the disjunction in a once more nearly continuous area, through destruction or divergent migrations caused by climatic or some other changes." Since fossil records give the most reliable evidence of paleo-history, it may be noted that the most important fossil members of the Anacardiaceae belong to the genera *Rhus, Pistacia,* and *Anacardites*, the latter being a form genus for anacardiaceous foliage of uncertain relationship. Many fossil species of *Rhus* have been named but not all of them can be considered authentic. *Rhus* dates from the upper Cretaceous Period, but it seems to have been most prominent in the Oligocene and Miocene (Arnold 1947). According to Barkley (1937) *Cotinus* is well represented in the Miocene, and Little (1942) traces it as far back as the Cretaceous with *Cotinus cretacea* Hollick.

In trying to piece together the past history of the *Cotinus* genus an attempt must be made to trace the evolution of woody angiosperms in North America. Berry (1937) states, "The greatest impediment to a botanical or zoological approach to geologic history is the general lack of realization of the enormous lapse of time involved, and consequently, a complete lack of perspective or orientation." Nevertheless, the challenge is there.

It is the opinion of most authorities that the major part of angiosperm evolution involving the principal modification of flowers took place during the Mesozoic Era. Woody angiosperms appear in abundance in the early part of the cretaceous Period, about 100 million years ago. By the beginning of the Cenozoic Era most of North America, Europe, and Asia were covered by a mixed hardwood forest, the original undifferentiated climax forest. Fossil evidence is sufficient to prove the great extent of this forest, designated by Braun (1950) as the Pan Climax of the Tertiary. It is believed that modern disjuncts of tropical and temperate climates had a continuous range at that time. Later, under the stress of changing climates, new species and ecotypes of woody angiosperms evolved. By the Miocene Period there was undoubtedly a complete separation between the mesophytic forest of North America and Eurasia except for boreal species such as *Picea, Salix, Betula,* and *Acer* (Stebbins 1950).

The latter part of the Tertiary saw the rise of great mountain chains in many parts of the world, including the Alps, Himalayas, Western Cordilleras of North America, and the Andes, which brought about the appearance of semi-arid steppes and deserts in the rain shadows of these mountains, greatly restricting the areas occupied by mesophytic plants of both tropical and temperate climates (Stebbens 1950). In North America the forest contracted. There was a gradual shrinkage from west to east due to increased aridity of the interior caused by the rising of the Rocky Mountains and a later retreat of the forest southward due to the climatic fluctuations brought about by the Pleistocene glaciation. The result was a segregation of communities on a basis of moisture requirements and a retreat eastward of those of highest demands (Braun 1935).

If we assume that *Cotinus obovatus* evolved during the Pan-Climax of the Tertiary it would appear that the species displayed little change while other species were adapting to the diversifications of their environment. Little (1950) states the problem as follows: "Its rarity, discontinuous distribution and lack of related species in the New World, and occurrence as a pioneer species on rocky cliffs all suggest that *Cotinus obovatus* is an old species formerly of general distribution but now approaching extinction."

It is of interest to consider the record of the close associate of smoke-tree, the chinquapin oak. It is believed that modern members of the Fagaceae were derived during the upper Cretacious Period from the extinct genus *Dryophyllum. Quercus* is one of the most frequently encountered genera of the upper Cretaceous and Cenozoic. Practically all of the early oaks were of the unlobed or chestnut type. The prominently lobed leaf was rare until the Miocene (Arnold 1947). Since the chinquapin oak is of the chestnut type, it would seem possible that it may be derived from that ancient line.

While *Cotinus* seems to be past maturity as a genus, its relative, *Rhus*, has survived and increased its range. The latter genus exhibits wide ecological amplitude and it is represented by over 100 species. It is distributed throughout

North America from Canada to southern Mexico and from coast to coast. It is also widely distributed in the southern hemisphere and in Eurasia (Sargent 1961). Stebbins (1950) suggests that changing environments have caused the expansion and variation of some groups, the decline and extinction of others and have left some groups relatively unchanged. The ability of a group to respond to environmental change depends on certain biological characteristics of the group.

Present Status

It seems consistent with the above considerations to call the American smoke-tree a relict, since its present survival appears to be but a remnant of past distribution and importance. In ecological terms, according to Weaver and Clements (1938), a relict is a species or community which has remained after some change has resulted in the elimination or modification of an earlier vegetation, often a climax. “Vegetational analysis of relict communities combines observation, scrutiny of scientific reports and records, experimentation, and interpretation; but its essential feature is the search for areas continuously protected against disturbance.” Because of their rugged topography, *Cotinus* habitats have been relatively undisturbed by man. In this particular study, the land is of little economic importance due to its irregularity and the impurity of the limestone. According to the present owner of the study area, it has not been used except to pasture a few cattle from time to time. It is believed that Indians, particularly the Osages, camped on these bluffs before the coming of the white man, for Indian arrowheads and artifacts have been found.

SUMMARY

A high upland and bluff above the Arkansas River, encompassing different rock strata and slope exposures, was studied to determine the ecological factors affecting plant distribution. Here the Wann sandstone caprock overlies the Iola formation, well exposed on the north bluff, and consisting of upper and lower limestone members interbedded with shale. The soil on the upland contrasts with that of the slopes in pH and quantity of organic matter.

A complete collection of plants was made throughout the area during an entire growing season, and is entered in the University of Tulsa Herbarium.

A small percentage of the herbaceous species is definitely related to the underlying strata. The woody vegetation was analyzed by belt transects which crossed the different strata on all slope exposures. The dominants on the upland are post oak, with an Importance Percentage of 65.9, and blackjack oak, with an I.P. of 41.4. The dominants on the limestone are chinquapin oak, with an I.P. of 34.9, and Shumard’s oak, with an I.P. of 34.9, with the former confined largely to the upper limestone, and the latter to the base of the lower limestone outcrop. The transects on the different slope exposures showed marked changes in species populations and in degree of mesophytism.

A significant tree on the limestone is the American smoke-tree, *Cotinus obovatus*, a comparatively rare species in Oklahoma. Its multipletrunked growth form and its freely branching root system adapt it to the eroding limestone ledges. It grows in close association with chinquapin oak, the two species unrelated taxonomically, but occupying different niches in the same microhabitat. It is notable that the European smoke-tree is also closely associated with an oak. The disjunct distribution of the American smoke-tree indicates that it was probably widespread in former geologic periods. Its survival as a relict with limited ecological amplitude is due to the continuance of the microhabitats to which it is so well adapted.

ACKNOWLEDGEMENTS

Grateful acknowledgements are due to the many, who have been of assistance in the preparation of this thesis – most especially to Dr. Harriet G. Barclay for direction of the study as well as her inspiration and encouragement, to Dr. Paul Buck who has helped in many ways, and to Mr. and Mrs. A.W. Swift who so generously gave permission for the use of their property for this study, to Miss Sandra Forehand, a frequent companion on “collection” trips, and to Mrs. Jean Hamilton for her help in the collection and identification of grasses. To my husband, Walter, whose patience has been unflagging, I express my deepest thanks.

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Editor's notes:

As a charter member of Oklahoma Native Plant Society, Anne Long was an influential figure in its organization. It is with honor that we present her master's thesis as an important historical study to be used by future researchers, teachers, and leaders for native plant conservation and education.

While time has misplaced the original sources for several of her figures, modern technology has provided updated and visually improved ones as noted. [SAS]

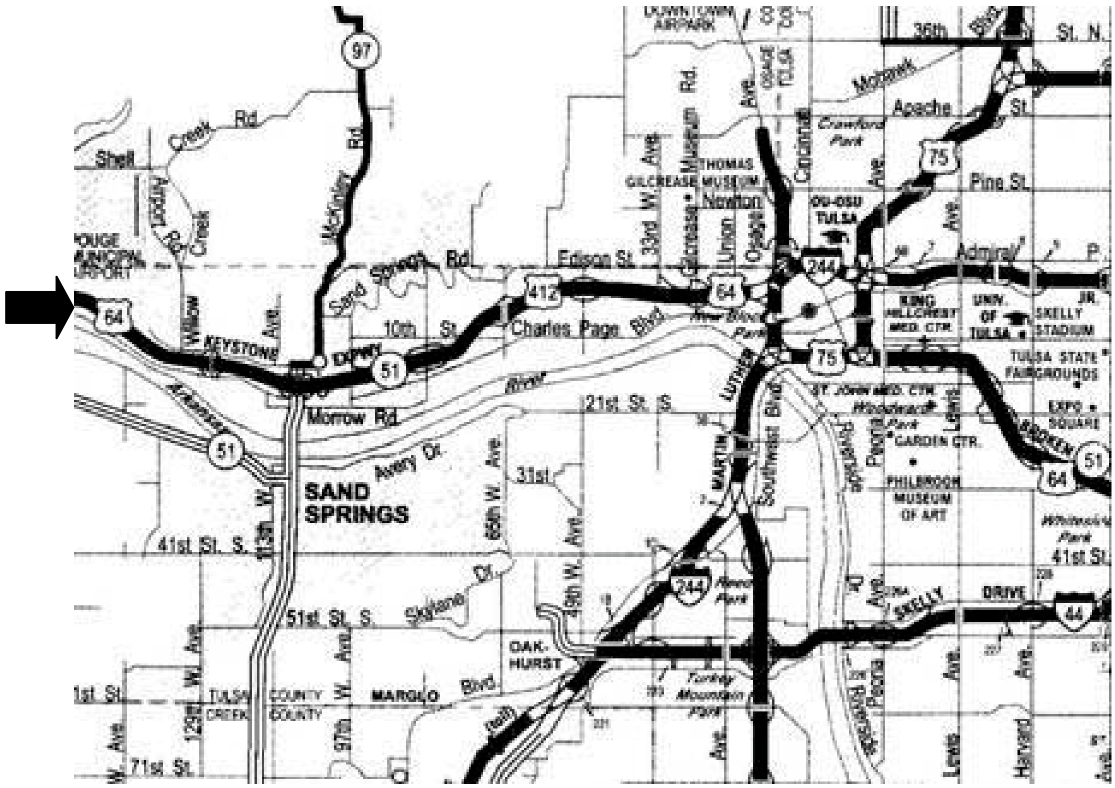


Figure 1 Arrow indicates location of study site with reference to Tulsa County and the Arkansas River. [Map substitution courtesy of the Oklahoma Department of Transportation.]

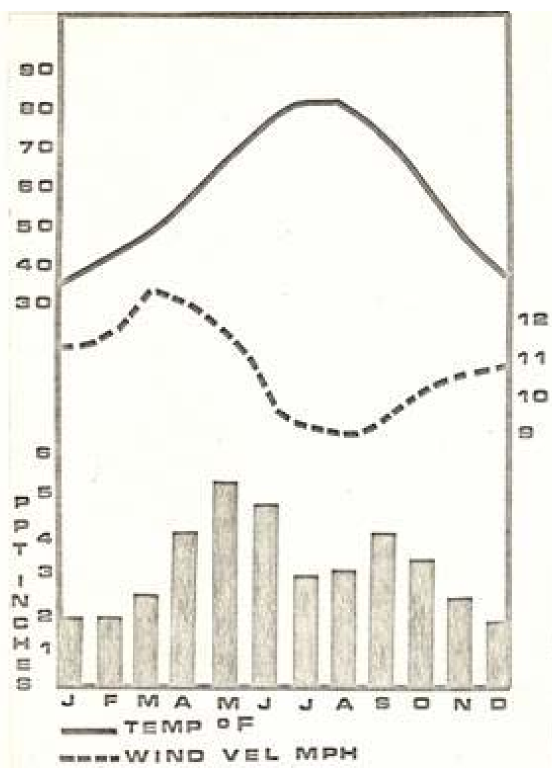


Figure 2 Average monthly temperature, precipitation, and wind data for Tulsa County. From U.S. Weather Bureau (1931-68).

Oklahoma Native Plant Record
Volume 4, Number 1, December 2004

Figure 3 Aerial photograph of S ½ of section 11, T.19 N., R.10 E., Tulsa County. By Aerial Photo Service 2669. Scale: 1"=1000'. [Study site border appended for comparison to contour map.]

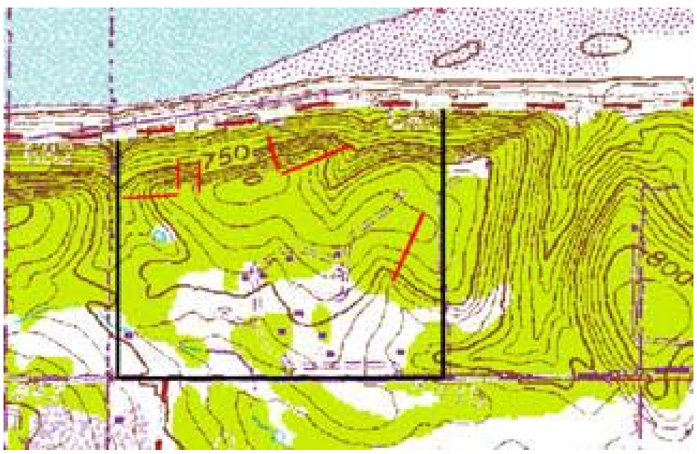


Figure 4 Contour map of study site and environs. Study site border and transects indicated. Contour Interval = 10' Scale 1" = 1000'. [Geo Information Systems, University of Oklahoma (www.geo.ou.edu), substituted with permission.]

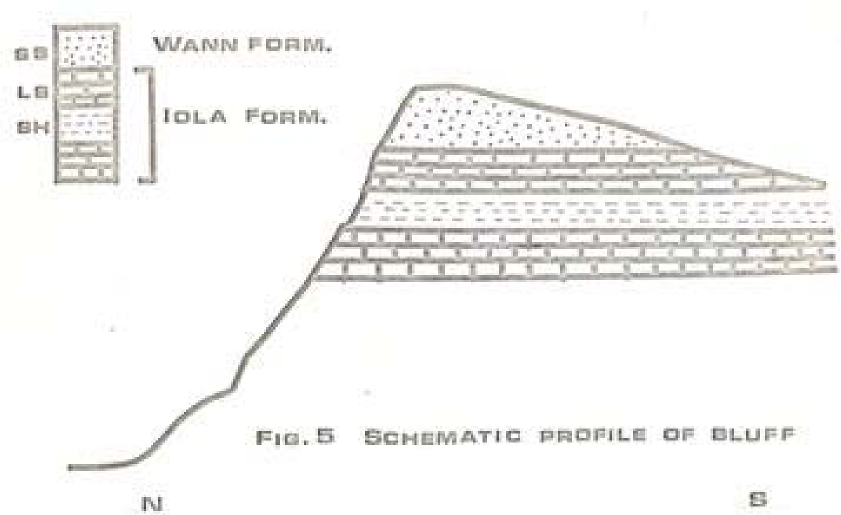


Figure 5 Schematic profile of bluff

Figure 6 Isolated slump block of Iola limestone showing smoke-tree.

Figure 7 Wann sandstone caprock.

Figure 8 Dense tree growth on the north-facing bluff.

Figure 9 Upper ledge of Iola limestone, with smoke-tree and large chinquapin oak.

Figure 10 Multiple-trunked smoke-tree on limestone.

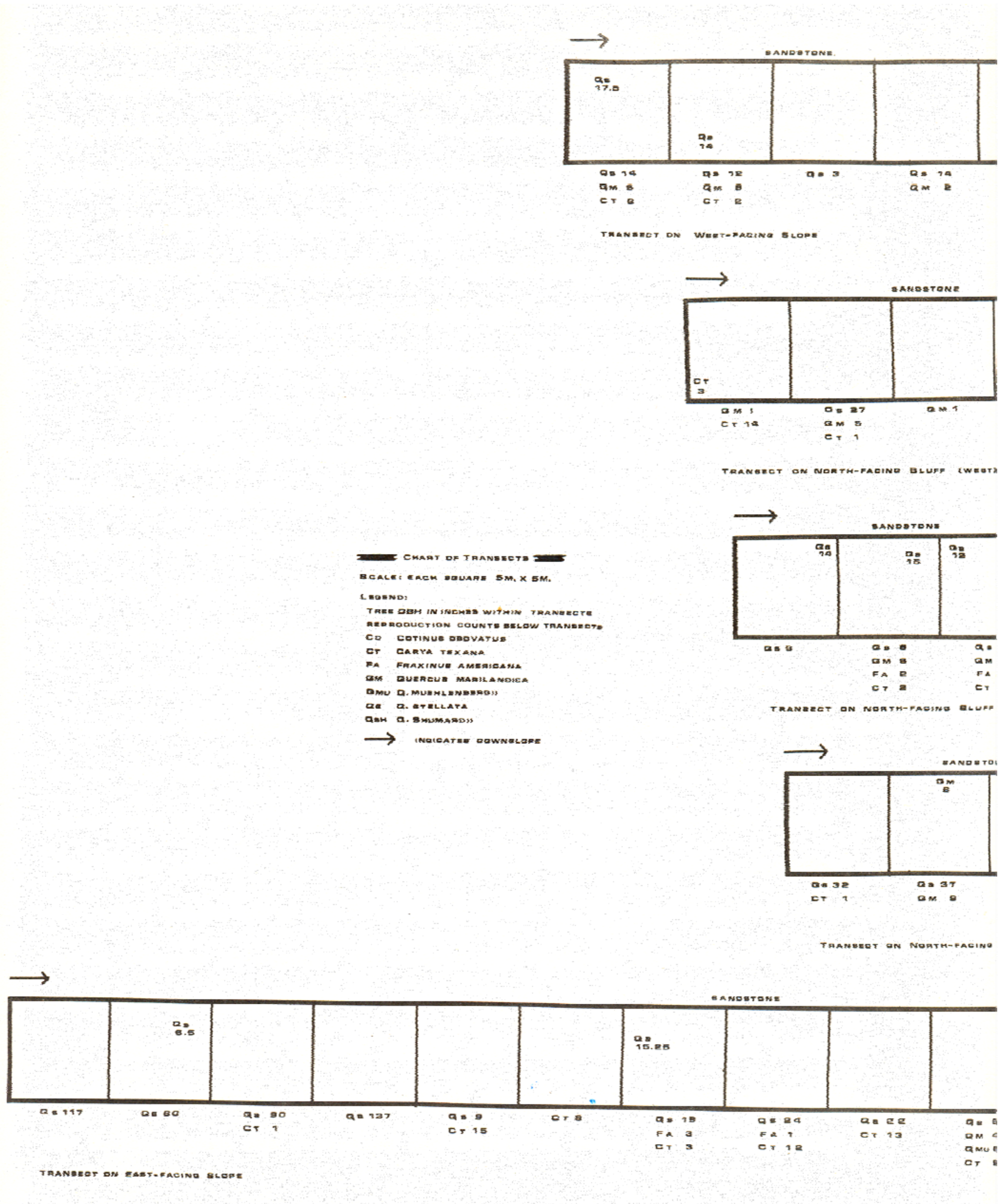
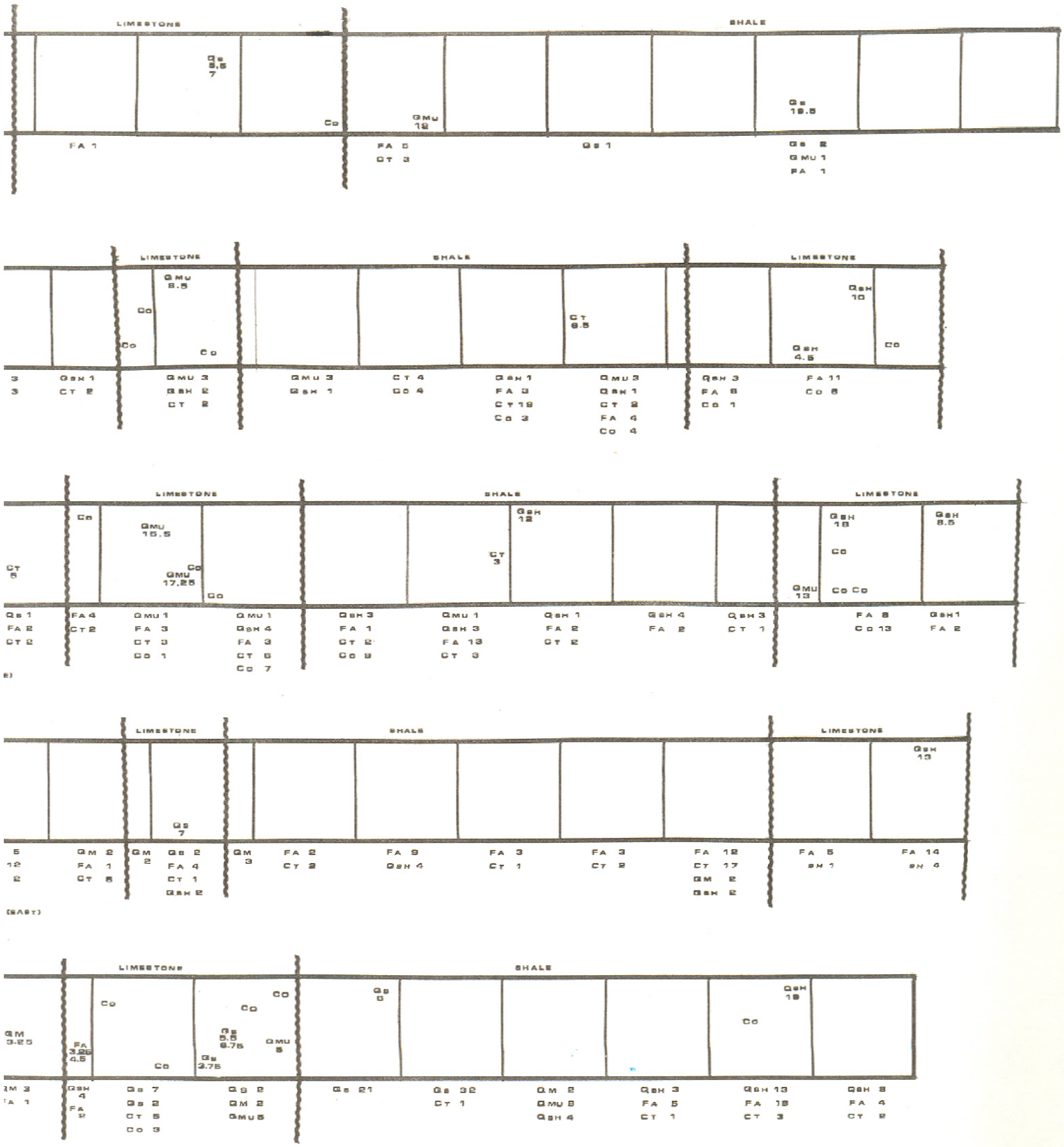


Figure 11 Chart of transects.


LIMESTONE
SHALE
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SHALE

Figure 12 Summer foliage of smoke-tree.

Figure 13 Distribution of Smoke-tree in Oklahoma. [State map substitution courtesy of Geo Information Systems, University of Oklahoma @geo.ou.edu.]

Figure 14 New shoots of *Cotinus* from upper branches.

TABLE 1 COMPLETE COLLECTION OF VASCULAR PLANTS MADE OVER THE GROWING SEASONS OF 1967-8 AT THE STUDY AREA, LISTED BY FAMILIES. NOMENCLATURE ACCORDING TO U.T. WATERFALL (1966). *Editor's note:* Species nomenclature has been updated according to Kartesz (1994) and USDA-NRCS (16 June 2004). Asterisks denote name changes; revisions follow in brackets. [PAF]

Ophioglossaceae
Ophioglossum engelmannii Prantl.

Polypodiaceae
Notholaena dealbata (Pursh) Kunze [*Argyrochosma dealbata* (Pursh.) Windham]
Pellaea atropurpurea (L.) Link, var. *atropurpurea*
Woodsia obtusa (Spreng.) Torr.

*Gramineae [Poaceae]
Andropogon gerardii (Vitman, var. g*erardi*
**Andropogon saccharoides* Sw. [*Bothriochloa laguroides* (Sw.) Rydb.]
**Andropogon scoparis* Michx. [*Schizachrium scoparium* (Michx.) Nash
Aristida purpurescens Poir.
Bouteloua curtipendula (Michx.) Torr.
Digitaria filiformis (L.) Koel., var. *filiformis*
Elymus virginicus L., var*. virginicus* forma *virginicus*
Eragostris capillaris (L.) Nees
Eragrostis hirsuta (Michx.) Nees
Eragrostis intermedia Hitchc.
**Eragrostis oxylepis* (Torr.) Torr., var. oxylepis [*Eragrostis secundiflora* J. Presl. ssp *oxylepis* (Torr.) Koch]
Eragrostis spectabilis (Pursh) Steud., var. *sparsihirsuta* Farwell
Gymnopogon ambiguus (Michx.) B.S.P.
Muhlenbergia sobolifera (Muhl.) Trin.
Panicum capillare L., var. *capillara*
**Panicum lanuginosum* Ell., var. *fasciculatum* (Torr.) Fern. [*Dicanthelium acuminatum* (Sw.) Gould & C.A. Clark, var. fasciculatum (Torr.) Freckmann
**Panicum oligosanthes* Schultes, var. *Scribnerianum* (Nash) Fern. [*Dicanthelium oligosanthes* (J.A. Schultes) Gould, var. s*cribnerianum* (Nash) Gould.]
Panicum virgatum L.
**Setaria geniculata* (Lam.) Beauv. [*Setaria parviflora* (Poir.) Kegguelen
Sorghastrum nutans (L.) Nash
Sporobolus clandestinus (Biehler) Hitchc.

Commelianaceae
Commelina erecta L. var. *erecta,* forma *intercursa* Fern.
Tradescantia ohiensis Raf., forma *pilosa* Waterfall

Liliaceae
Allium perdulce S. V. Fraser
Camassia angusta (Engelm. & Gray) Blankenship
Nothoscordum bivalve (L.) Britton
Smilax bona-nox L.
Smilax glauca Walt., var. *glauca*
Yucca arkansana Trel., var. *arkansana*

Iridaceae
Sisyrinchium campestre Bickn., forma *campestre*
Sisyrinchium campestre Bickn., var. *kansanum* (Bickn.) Steym.

Orchidaceae
Spiranthes cernua (L.) Richards

Juglandaceae
Carya cordiformis (Wang) K. Koch
Carya texana Buckl. (C. Buckleyi Durand)

Fagaceae
Quercus marilandica Muench.
Quercus muehlendbergii Englem., var. m*uehlenbergii*
Quercus Shumardii Buckl., var. s*chneckii* (Britton) Sarg.
Quercus stellata Wang.

Ulmaceae
Celtis laevigata Willd.
Ulmus americana L.
Ulmus rubra Muhl. (U. fulva Muhl.)

Moraceae
Morus rubra L.

Nyctaginaceae
Mirabilis albida (Walt.) *MacM. [Heimerl.]

Portulacaceae
Claytonia virginica L.
**Portulaca mundula* Johnston [*Portulaca pilosa* L.]
Talinum parviflorum Nutt.

Polygonaceae
Polygonum tenue Michx.

Ranunculaceae
**Delphinium virescens* Nutt. [*Delphinium carolinianum* Walt., var. *virescens* (Nutt.) Brooks]

Capparidaceae
Cleome serrulata Pursh.
Cruciferae
Draba cuneifolia Nutt., var. *cuneifolia*
Draba reptans (Lam.) Fern., var. *reptans*
Lepidium virginicum L.
Crassulaceae
Sedum Nuttallianum Raf.
Saxifragaceae
**Ribes odoratum* Dougl.
[*Ribes aureum* Pursh, var. *villosum* DC.]
Rosaceae
Agrimonia rostellata Wallr.
Amelanchier arborea (Michx. f.) Fern.
Crataegus sp.
Prunus americana Marsh.
Prunus angustifolia Marsh.
Rosa carolina L.
Rosa setigera Michx.,
var. *tomentosa* T. & G.
Leguminosae
Acacia angustissima (Mill.) Kunze,
var. *hirta* (Nutt.) Robinson
Amorpha canescens Pursh.,
forma *canescens*
Amorpha fruticosa L.
Amphicarpa bracteata (L.) Fern.,
var. *bracteata*
Astragalus crassicarpus Nutt.,
var. *crassicarpus*
**Baptisia leucophaea* Nutt.
var. leucophaea
[*Baptisia bracteata* (Nutt.)
Kartesz & Ghandi
var. *leucophaea* Muhl.ex. Ell.]
**Cassia fasciculata* Michx.
[*Chamaecrista fasciculata* (Michx.)
Greene]
**Cassia nictitans* L.
[*Chamaecrista nictitans* (L.) Moench]
Cercis canadensis L., var. *canadensis*
Clitoria mariana L.
Dalea purpurea Vent., sen. lat.
Desmanthus illinoiensis (Michx.)
MacM.
Desmodium canescens (L.) DC Wood
Desmodium glutinosum (Muhl.) Wood
Desmodium sessilifolium (Torr.) T. & G.
Galactia volubilis (L.) Britton,
var. *mississippiensis*
Lespedeza violacea (L.) (Pers.)
Lespedeza stuevei Nutt.,
forma *stuevei*
**Psoralea tenuiflora* Pursh.
[*Psoralidium tenuiflora* (Pursh) Rydb.]
Stylosanthes biflora (L.) BSP.,
var. *hispidissima* (Michx.)
Pollard & Ball
Tephrosia virgjniana (L.) Pers.,
var. *virginiana*
Linaceae
Linum sulcatum Riddell
Oxalidaceae
Oxalis corniculata L.
Oxalis violacea L., var *violaceae*
Geraniaceae
Geranium carolinianum L.
Euphorbiaceae
Acalypha virginica L.
Croton glandulosus L.,
var. *septentrionalis* Muell. Arg.
Euphorbia corollata L. var. corollata
Euphorbia hexagona Nutt.
Euphorbia spathulata Lam.
Tragia urticifolia Michx.
Anacardiaceae
Cotnius obovatus Raf.
Rhus aromatica Ait., var. *aromatica*
Rhus copallinum L., var. *latifolia* Engl.
Rhus glabra L.
*Rhus Toxicodendron L.
[*Toxicodendron pubescens* P. Mill.]
Aquifoliaceae
Ilex decidua Walt.
Celastsraceae
Celastrus scandens L.
Rhamnaceae
Ceanothus americanus L.,
var. Pitcheri T. & G.
Vitaceae
Vitis aestivalis Michx.
Malvaceae
Callirhoe alcaeoidesi (Michx.) Gray
**Sphaeralcea angusta* (Gray) Fern.
[*Malvastrum hispidum* (Pursh) Hochr.
Guttiferae*
[Hypericaceae]
Hypericum punctatum Lam.
Cistaceae
Lechea tenuifolia Michx.
Violaceae
Viola pensylvanica Michx.,
var. *leiocarpa* (Fern. & Wieg.) Fern.
Lythraceae
**Cuphea petiolata* (L.) Koehne
[*Cuphea viscosissima* Jacq.]
Onagraceae
Oenothera laciniata Hill, var. *laciniata*
Oenothera linifolia Nutt.
Oenothera speciosa Nutt.
Umbelliferae
Daucus pusillus Michx.

Spermolepis echinata (Nutt.) Heller
Torilis japonica Houtt. DC

Cornaceae
Cornus drummondii Meyer

Ebenaceae
Diospyros virginiana L., var. *virginiana*

Oleaceae
Fraxinus americana L., var. americana

Gentianaceae
Sabatia campestris Nut., forma *campestris*

Apocynaceae
Apocynum cannabium L.,
var. *pubescens* (Mitchell) A. DC.

Asclepiadaceae
Asclepias tuberosa L.
Asclepias verticillata L.
Asclepias viridis Walt.
As*clepias viridiflora* Raf., var. *viridiflora*

Boraginaceae
Heliotropium tenellum (Nutt.) Torr.
Myosotis verna Nutt.
Onosmodium hispidissium Mack.

Verbenaceae
**Lippia incisa* (Small) Tidestrom
[*Phyla nodiflora* (L.) Greene]
**Verbena canadensis* (L.) Britt.
[*Glandularia canadensis (L.) Nutt.*]
Verbena stricta Vent., forma s*tricta*

*Labiatae [Lamiaceae]
Monarda fistulosa L., var. fistulosa
Salvia azurea Moench.,
var. *grandiflora* Benth.
Scutellaria parvula Michx. var. *parvula*
Teucrium canadense L*.,* var. virginicum
(L.) Eat.

Scrophulariaceae
**Gerardia heterophylla* Nutt.
[Agalinus *heterophylla* (Nutt.) Small]
**Gerardia tenuifolia* Vahl.,
var. *parviflora* Nutt.
[*Agalinus tenuifolia* Vahl, Raf.
var. *parviflora* Nutt. Pennell]
Penstemon cobaea Nutt.
Penstemon tubiflorus Nutt.
**Linaria canadensis* (L.) Dumont,
var. *texana* (Scheele) Pennell
[*Nuttalanthus canadensis* (L.) D.A.
Sutton, var. texana (Scheele)Sutton]

Solanaceae
Physalis pubescens L.,
var. *integrifolia* (Dunal) Waterfall
**Solanum Torreyi* Gray, forma *Torreyi*
[*Solanum dimidiatum* Raf.]

Acanthaceae
Ruellia humilis Nutt.

Plantaginaceae
Plantago Purshii R. & S., var. Purshii
Plantago virginica L.

Rubiaceae
**Diodia teres* Walt., var. *setifera* Fern. &
Grisc. [var. *teres*]
Gallium aparine L.
Hedyotis nigricans (Lam.) Fosb.

Caprifoliaceae
Symphoricarpos orbiculatus Moench
Triosteum perfoliatum L.
Virburnum prunifolium L., var. *ferrugineum*
Torr. & Gray

Campanulaceae
**Specularia biflora* (R. & P.)
Fisch. & Mey.
[*Triodanis perfoliata,* var. *biflora*
(R. & P.) Bradley]
**Specularia leptocarpa* (Nutt.) Gray
[*Triodanis leptocarpa* (Nutt.) Nieuwl.]
**Specularia perfoliata* (L.) A. DC.
[Triodanis *perfoliata* (L.) Nieuwl.]

*Compositae [Asteracae]
**Achillea lanulosa* Nutt., forma *lanulosa*
[*Achillea millefolium* L.]
Ambrosia artemisiifolia L.
**Antennaria plantaginifolia* (L.) Richards
[*Antennaria parlinii* Fern]
**Aster azureus* Lindl.
[*Aster oolentangiensis* Riddell]
Aster ericoides L. (A. multiflorus)
Aster patens Ait., var. *patentissimus*
(Lindl.) T. & G.
**Aster sagittifolius* Wedemeyer
[*Aster cordifolius* L., var. *sagittifolius*
(Wed. ex Willd.) A.G. Jones]
Astranthium integrifolium (Michx.)Nutt.
**Cacalia plantaginea* (Raf.) Shinners
[*Arnoglossum plantigineum* Raf.]
Chrysopsis pilosa Nutt.
Cirsium altissimum (L.) Hill.
Erigeron strigosus Muhl. Ex. Willd.
Erigeron philadelphicus L.
Eupatorium altissimum L.
Gnaphalium obtusifolium L.
**Gutierrezia dracunculoides* (DC) Blake
[*Amphiachris drancunculoides* (DC)
Nuttal]
Helianthus hirsutus Raf.,
var. *trachyphyllus* T. & G.
**Kuhnia eupatorioides* L.,
var. *corymbulosa* T. & G.
[*Brickellia eupatorioides* L.,
var. *corymbulosa* (T. & G.) Shinners]

Liatris punctata Hook,
var. *nebraskensis* Gaiser
Liatris squarrosa (L.) Michx.,

var. hirsuta Rydb. Gaiser
**Pyrrhopappus scaposus* DC.
[*Pyrrhopappus grandiflorus* (Nutt.)]
Ratibida columnifera (Nutt.) W. & S.
Rudbeckia hirta L.
Solidago missouriensis Nutt.,
var. *fasciculata* Holz.
Vernonia baldwinii Torr., var. *Baldwinii*

	sandstone				limestone				shale			
	C	S	N	Av.	C	S	N	Av.	C	S	N	Av.
pH	4.9	4.1	5.9	5.3	7.2	7.0	5.9	7.0	7.5	7.7	7.8	7.7
Organic matter	28	35	34	32.3	46	50	34	43.3	70	70	51	63.7

TABLE II. Soil data for pH and organic matter correlated with slopes and strata.

C __ Composite samples from north, east, and west slopes.
S __ Samples from south slope.
N __ Samples from north slope.

Analysis by Tulsa County Agricultural Agent.

	SANDSTONE							LIMESTONE						
	Density	Frequency %	Dominance	Relative Dens. %	Relative Freq. %	Relative Domn. %	I.P. %	Density	Frequency %	Dominance	Relative Dens. %	Relative Freq. %	Relative Domn. %	I.P. %
Quercus Stellata	.32	32	38.33	61.5	61.5	88.7	70.6	.37	18.7	10.7	33	27	9	23
Quercus Marilandica	.107	10.7	3.88	23	23	9	18.3							
Quercus Muehlenbergii								.31	25	39.4	27.7	36.3	40.8	34.9
Quercus Shumardii								.31	25	33.02	27.7	36.3	40.6	34.86
Carya Texana	.07	7.1	.95	15.3	15.3	2.2	10.6							
Fraxinus Americana								.125	6.2	1.5	11	9	1.9	7.3
Cotinus Obovatus								.875	50		43.7	61.5		

TABLE III. Comparison of parameters of tree species on sandstone and limestone. Quantitative values after Phillips (1959)

Oklahoma Native Plant Record
Volume 4, Number 1, December 2004

Cotinus obovatus Raf. (Smoke-tree) in Oklahoma

Bruce W. Hoagland
Oklahoma Biological Survey and Department of Geography
University of Oklahoma, Norman, OK 73019

Cotinus obovatus is a shrub or small tree, up to 6.5 m (20 feet) tall. The twigs are orange to brown, glabrous (without hairs), and aromatic when crushed (Figure 1). The sap is resinous and strong-smelling. The wood is yellow to orange in color with creamy colored sapwood. The leaves are alternate, simple, elliptical to obovate, 5-13 cm (2-5 inches) long, and 4-7.5 cm (1.6-3 inches) wide. They are pointed at the base, but rounded to weakly pointed at the apex and margins are entire. Leaves turn orange to scarlet in the fall (Figure 2). Flowers bloom in early spring, are very small, and have five petals and five sepals that are greenish in color, with five stamens and one pistil. Separate male and female flowers are present on the same plant. The wispy panicles measure 15 cm (6 inches) or more in length and are the root of the common name smoke-tree (Figure 3). However, there are few flowers in the panicle and many of them are sterile. Fruits are small drupes about 5 mm (0.2 in) in diameter. Some flowers are sterile and their stalks are long and covered with purplish or brownish hairs. The tree sprouts readily from the roots (Elias 1987, Hightshoe 1988, Kurz 1997, Little 1996, Sargent 1905).

Cotinus species are members of the Anacardiaceae (cashew) family. Other members of this family occurring in Oklahoma include *Rhus aromatica* (skunkbrush), *Rhus copallinum* (winged sumac), *R. glabra* (shining sumac), and *Toxicodendron radicans* (poison ivy). *Cotinus* is the classic name for wild olive and *obovatus* refers to the leaf shape (Vines 1960). There are only two species in the genus *Cotinus*; *C. coggygria* (European smoke tree) and *C. obovatus* (North American smoke tree). *Cotinus coggygria* is widely planted in the United States as an ornamental tree, but its native range extends from Europe east to the Himalayas (Elias). *Cotinus obovatus* occurs in seven states in the southeastern United States (Little 1943) and six counties in Oklahoma (Figure 4; Johnson and Hoagland 2004). *Cotinus obovatus* grows on calcareous bluffs and ravines where limestone predominates. Associated trees and shrubs often include *Fraxinus quadrangulata* (blue ash), *Philadelphus pubescens* (mock orange), *Staphylea trifolia* (bladdernut), *Quercus muehlenbergii* (chinkapin oak), and *Ulmus rubra* (red elm). Fort Gibson dam in Wagoner County and Chandler Park in Tulsa are excellent locations for viewing *C. obovatus*.

Cotinus obovatus was first discovered in Oklahoma in 1919 by Thomas Nuttall. He encountered this tree on limestone cliffs along the Grand River 30 miles north of its confluence with the Arkansas River. This plant was in fruit and greatly resembled the European species, which was referred to as *Rhus cotinus* in the early 19th century. In this vein, he named the plant *Rhus cotinoides*. The name *Cotinus obovatus* was described by Constantine Rafinesque in 1840. The second discovery of *C. obovatus* in Oklahoma was made by Ernest Palmer on 14 April 1928, 109 years after Nuttall's visit, at a site near Page in LeFlore County (Little 1943).

The wood of *C. obovatus* has no economic value to the timber industry, due to its small size, but it is rot resistant and has been used for fence posts in some regions of the United States. During the Civil War, a yellow dye was extracted from the wood (Elias 1987). Currently *C. coggygria* is sold and planted as an ornamental plant in greater quantity than *C. obovatus*. However, its beautiful panicles of flowers in the spring and brilliant autumn colors make it a worthy addition to any home garden as well.

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Hoagland, B.W.
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Figure 1 Leaves of *Cotinus obovatus,* Fort Gibson Dam, Wagoner County, Oklahoma.

Figure 2 Habitat photo of *Cotinus obovatus*, Fort Gibson Dam, Wagoner County, Oklahoma.

Figure 3 Inflorescence of *Cotinus obovatus*, Fort Gibson Dam, Wagoner County, Oklahoma.

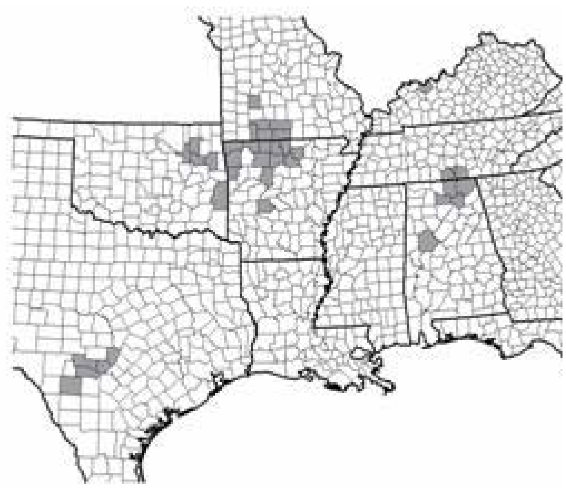

Figure 4 Distribution of *Cotinus obovatus* in North America (Adapted from Little 1977).

Figure 1 Stand of Giant Cane in Cherokee County, Oklahoma.

Figure 2 Fanner or winnowing basket (*obfko'*).

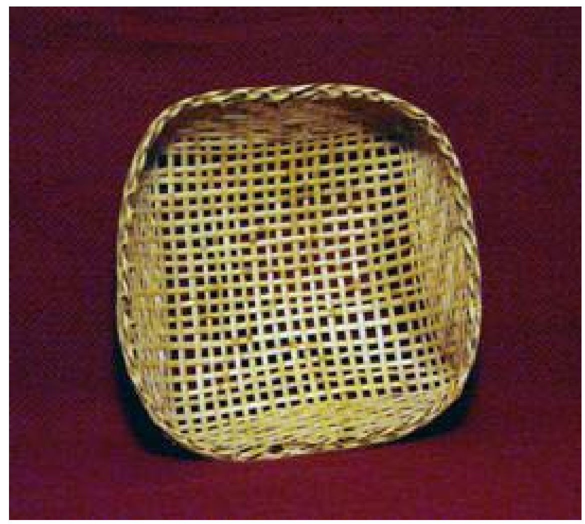

Figure 3 Sifter or sieve (*ishsho'ha).*

Figure 4 Utility basket, a shallow container. or tray (*tapa*).

Cane photo by author.
Basket photos courtesy of Patricia A. Folley

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Giant Cane and Southeastern Indian Baskets

Ms. Julia A. Jordan
233 84th Avenue, N.E. Norman, Oklahoma 73026

Among the wide variety of natural materials suitable for basket making, one of the most attractive is giant cane (Figure 1), an Oklahoma native plant. Taxonomically, giant cane is in the genus *Arundinaria*, and the family Poaceae (grasses). This genus comprises the only native species of bamboo in the continental United States. Hitchcock (1971) recognized one genus: *Arundinaria* Michx. (cane) and two species: *Arundinaria macrosperma* Michx., giant cane, and *Arundinaria tecta* Walt. Muhl., switch cane. However Estes and Thompson (1984), following F. A. McClure, recognized one species, *A. gigantea* (Walter) Muhlenberg (cane) with three inclusive subspecies: *A. gigantea* ssp. *gigantea*, ssp. *tecta* (Walter) McClure, and ssp. *macrosperma* (Michaux.) McClure. Taylor and Taylor (1991) recognized one species, *A. gigantea* (Walt.) Muhl., giant cane. The taxon relevant to Oklahoma, and to southeastern Indian basketry generally, is *A. gigantea* ssp. *gigantea*, which will be referred to herein as giant cane.

Giant cane is a robust grass with culms (stems) reaching five meters or more in height and 5 to 8 cm (2 - 3 in) in diameter. It is the most widespread of the three subspecies, forming extensive colonies or canebrakes on the first and second terraces of major streams and wet lowlands. It is found in the Mississippi River Valley, the Appalachian-Ozarkian Uplands (including the Ouachita Highlands (USGS 2004), and the Gulf Coastal Plain (Estes and Thompson 1984), including much of eastern Oklahoma. It spreads rapidly by creeping horizontal rhizomes. The erect, woody culms are perennial--sometimes branching with flowering branchlets borne in fascicles on the main stem or on primary branches. Giant cane flowers infrequently and the flowering stems die after setting seed. Sterile branches, which are numerous, are branched repeatedly. The caryopses (seed grains) are large, up to 1.5 cm (0.5 in) long, floury, and are edible. They are produced in great abundance on each flowering stem. Swanton (1946) notes that they were used as food by southeastern Indians. Cane stalks grow rapidly, forming dense, tall stands that were formerly widespread and numerous in suitable habitats across the southeast. However, populations are now limited, probably due to the introduction of domestic animals and to the draining and clearing of fertile, lowland sites for agriculture. Both cattle and swine relish the young shoots, while pigs also root in the soil to consume the rhizomes.

Cane culms are jointed with hollow internodes. In contrast to most grasses, the stems are woody and there is extensive deposition of lignin and silica in the outer layer (Estes and Thompson 1984). This and the length of the fibers contribute to the strength of the stem. The culms are round in cross-section; thus they are lightweight and flexible, as well as strong. The hard, shiny surface of the culm results partly from a silica-wax cuticle which forms a thin layer over the silica-impregnated epidermis. The culm is therefore nearly impervious to water. These characteristics make giant cane an excellent material for the manufacture of many items of material culture, and it was utilized for many purposes by both aboriginal and historic Indian peoples of the southeastern United States. Swanton (1946) refers to cane as "one of the most important of all raw materials," for southeastern Indians. It was

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used for spears, arrows, blowguns, fishing crails and traps, beds, corncribs, flageolets, baskets, mats, and many other items. Blake and Cutler (2001) have recorded cane from prehistoric sites in Illinois, Indiana, and Arkansas, indicating some antiquity to the use of this material.

Giant cane was the favorite basketry material of such tribes as the Choctaw, Cherokee, Creek, Chitimacha, Natchez, and Caddo. Most southeastern basketry was made by the technique of weaving, as opposed to coiling (Hudson 1976). That is, weft (horizontal) elements were built up onto a warp (vertical) foundation. Twilling, in which two or more weft splints were passed over two or more warp splints, was the prevailing weave. The twilling technique produced a wide variety of diagonal and herringbone patterns, and when colored splints were combined with natural splints, the resulting baskets and mats were quite decorative, as well as useful.

Cane was usually converted into basketry splints immediately after gathering, though it could be processed later (Gettys 1984). The long lengths of cane were split lengthwise into quarters with a stout sharp knife. The object was to obtain a long and strong, flexible strip of even thickness. The splints were then trimmed along each edge to make them of uniform width, and scraped to a smooth texture on the inner surface. The glossy, natural, outer surface of the cane contributed to the beauty of cane baskets.

Some of the splints were dyed black, red, yellow, purple, or brown using dyes obtained from plants (Sinton 1946, Gettys 1984). A variety of mats and baskets were made. Large twilled cane mats, measuring about 152 cm by 183 cm (5 ft by 6 ft), were used for bedding, for floor covering, to cover the seats in the square ground (summer council arena), to cover the walls and roofs of houses, and to wrap the bodies of the dead for burial. The finest Southeastern baskets were double weave baskets, so called because they are woven with back-toback inside and outside fabrics, such that the surface of the basket was glossy and smooth both inside and out (Hudson 1976).

Like other tribes, the Choctaw produced many types of cane baskets for which they had names, including carrying baskets, hampers, pack baskets, trays, and pointed baskets. Of special importance was a three-piece set of baskets used in the preparation of hominy, a dietary staple. The set consisted of a winnowing basket or "fanner," (*obfko'*) (Figure 2), a sieve or "sifter," (*ishsho'ha*) (Figure 3), and a shallow container or tray (*tapa*) (Figure 4), (Bushnell 1909). Collectively, this trilogy of baskets came to be called "Tom Fuller" baskets, the term deriving from the Choctaw word for hominy, *tanfula* (Edwards 1932).

Hominy was made from whole kernels of dried corn which were first soaked in cool water to which had been added some wood-ash lye (Hudson 1976). The next day the corn was drained and pounded in a mortar to loosen the hulls and crack the grains. The cracked corn was then separated from the hulls with the "fanner," a large flat basket with a shallow pocket at one end. The corn was placed in the basket which was then agitated up and down and back and forth to separate the heavier hominy from the lighter hulls. The "sifter" had a loosely woven plaited bottom through which the smaller grains could be separated from the coarser grains. The latter were returned to the mortar for further cracking. The tightly-woven cane tray had many uses, such as holding cracked and uncracked hominy, corn meal, and bread.

The accompanying photographs are of "Tom Fuller" baskets made of giant cane and purchased by the author in 1977 from a Choctaw basket maker of Wright City, Oklahoma. Fine quality cane baskets are produced today by the Mississippi Choctaw and the Chitimacha of Louisiana. Their sales outlets may be easily located on the internet. Gettys (1984) knew of only three cane weavers in Oklahoma (one of whom had produced this author's baskets), and believed that traditional forms not adaptable to modern uses had been dropped. Although it is highly unlikely that any "Tom Fuller" sets are now made for general sale, it is quite possible that a few Oklahoma Choctaw artisans are capable of filling a special order. Inquiry might begin with the Choctaw Nation Tribal Complex Office in Durant or at museums and specialty shops featuring authentic southeastern Indian arts and crafts.

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Vascular Flora of the Chouteau Wildlife Management Area Wagoner County, Oklahoma

Bruce W. Hoagland
Oklahoma Biological Survey
and Department of Geography
University of Oklahoma
Norman, OK 73019
e-mail: bhoagland@ou.edu

Forrest Johnson (deceased)
Oklahoma Biological Survey
University of Oklahoma
Norman, OK 73019

This article reports the results of a vascular plant inventory of the Chouteau Wildlife Management Area in eastern Oklahoma. One hundred eighty-one species of vascular plants were collected from 144 genera and 63 families. The families with the greatest number of species were the Asteraceae (25), Poaceae (22), and Fabaceae (18). Fifty-seven species were annuals, four biennials, and 120 were perennials. Thirty-nine woody plant species were present. Twenty-one species exotic to North America were collected representing 11.6% of the flora. *Azolla caroliniana* **was the only species tracked by the Oklahoma Natural Heritage Inventory found. This study reports 148 species previously not documented in Wagoner County.**

INTRODUCTION

The objectives of this study were twofold: to fill a gap in floristic data for eastern Oklahoma and provide resource managers at the Chouteau Wildlife Management Area (CHWMA) with a comprehensive species list. Prior to 1996, when collecting began for this study, 198 specific and infraspecific taxa were reported from Wagoner County (Hoagland 2004). The first collections made in Wagoner County were by Robert Bebb, namesake of the University of Oklahoma Herbarium, in 1903 (Hoagland 2004). No additional collections were recorded until 1913, when G. W. Stevens visited the county. The peak collecting year in Wagoner County was 1939 (51 specimens), with work completed by R. Bebb (Hoagland et al. 2004).

STUDY AREA

The CHWMA is located on U.S. Army Corp of Engineers land in Wagoner County (Figure 1) and has been managed by the Oklahoma Department of Wildlife Conservation since 1973. It encompasses 402 hectares, and elevation ranges from 167m to 158m. Latitudinal extent ranges from 35.86o N to 35.85o N and longitudinal extent from 95.34o W to 95.37o W. The CHWMA is located within the subtropical humid (Cf) climate zone (Trewartha 1968). Summers are warm (mean July temperature = 27.7o C) and humid, whereas winters are relatively short and mild (mean January temperature = 2.9o C). Mean annual precipitation is 114.5 cm, with periodic severe droughts (Oklahoma Climatological Survey 2004).

Physiographically, the study area is located in the Osage Plains section of the Central Lowlands province (Hunt 1974) and within the Claremore Cuesta Plains province of Oklahoma (Curtis and Ham 1979). The surface geology is primarily Quaternary silt, sand, and clays deposited along the Verdigris River (Branson and Johnson 1979). The primary soil association at CHWMA is the Sage-Radley, which is composed of deep, level to gently sloping, poorly drained soils (Polone 1976). The potential natural vegetation type at CHWMA is the bottomland Forest type (Duck and Fletcher 1943).

Hoagland, B.W. and Johnson, F.L.
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METHODS

Three collection sites were established at CHWMA for intensive floristic sampling. Sites were selected following a review of US Geological Survey 1:24,000 topographic maps and field reconnaissance. The predominant vegetation associations at these sites were classified according to Hoagland (2000). Collections also were made randomly throughout the site. Collections were made on a monthly basis from March through October 1996. Vouchers for species exotic to North America were made from naturalized populations only, thus excluding cultivated and ornamental plants. Specimens were processed at the Robert Bebb Herbarium of the University of Oklahoma (OKL) following standard herbarium techniques. Specimens were identified using Waterfall (1969) and Diggs et al. (1999). Origin (whether native or introduced to North America) was determined using Taylor and Taylor (1991) and United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS 2004). Nomenclature follows USDA-NRCS (2004). Voucher specimens were deposited at OKL.

RESULTS AND DISCUSSION

A total of 181 vascular plants in 144 genera and 63 families were collected (Table 1). Among the angiosperms, 43 were monocots and 142 were dicots. The most species were collected from the families Poaceae (22), Asteraceae (25), Fabaceae (18). The genera *Polygonum* (6) and *Carex* (5) had the most species. Fifty-seven species were annual, four biennials, and 119 perennial. Thirty-nine woody plant species were present.

Twenty-one exotic species were collected, representing 11.6% of the flora. The numbers of exotic species were greater in the families Poaceae (6) and Fabaceae (7). These numbers are comparable to recent floristic inventories from other areas in Oklahoma. For example, a flora of the Chickasaw National Recreation Area reported 12% exotic species (Hoagland and Johnson 2001), 9% at Oologah Wildlife Management Area (Hoagland and Wallick 2003), 15% at Keystone Wildlife Management Area (Hoagland and Buthod 2003), and 11% for an inventory of Tillman County (Hoagland et al. 2004). However, the percentage was lower, 6.6%, at Red Slough and Grassy Slough in southeastern Oklahoma (Hoagland and Johnson 2004). However, these studies report a higher number of exotic species in the Asteraceae. In addition, CHWMA is the first reported location for *Alternanthera philoxeroides* in Oklahoma, a noxious weed of the southeastern United States (Hoagland and McCarty 1998).

Azolla caroliniana (G5S2) was the only species tracked by the Oklahoma Natural Heritage Inventory found at CHWMA. Species are ranked according to level of imperilment at the state (S) and global (G) levels on a scale of 1•5; 1 representing a species that is imperiled and 5 representing one that is secure (Groves et al. 1995).

As a result of this study, 313 species are now known to occur in Wagoner County. Of the 181 species reported in this study, 33 had been previously collected in the county. There were 165 species reported in the Atlas of the Flora of Oklahoma database that were not reported in this study (Hoagland 2004). This study documented 148 species not previously reported from Wagoner County.

The three collection sites occurred within four vegetation associations. A brief description of each follows:

Aquatic and wetland vegetation

Several aquatic and wetland vegetation types were present at CHWMA. All intergraded with one another, making clear delineations difficult. The predominant emergent wetland vegetation types were *Jussiaea peploides - Polygonum hydropiperoides* herbaceous association, *Nelumbo lutea* herbaceous association, and *Juncus effusus* herbaceous association. *Cephalanthus occidentalis* shrubland association was the predominant woody wetland vegetation type. Associated species included *Hibiscus laevis, Justicia americana, Potamogeton nodosus, Polygonum lapathifolium, P. pensylvanicum, Salix nigra*, and *Typha domingensis*.

Azolla caroliniana, a species tracked by the Oklahoma Natural Heritage Inventory (2004), was found in this habitat type.

Quercus palustris - Carya illinoensis/Ilex decidua forest association

This association was the predominant forest type at CHWMA. However, all stands were immature second growth. Associate species included *Amorpha fruticosa, Ampelopsis cordata, Arundinaria gigantea, Fraxinus pennsylvanica, Gleditsia triacanthos*, *Passiflora lutea* and *Ulmus rubra*. On natural levies along the Verdigris River this association intergraded with the *Acer saccharinum* • *Acer negundo* forest association.

Disturbed areas and old-field vegetation

This designation included areas which have been or are currently in cultivation, roadsides and areas visited by CHWMA visitors, and other areas exhibiting signs of physical disruption. Common plants in disturbed areas and old fields included: *Ambrosia trifida, Geranium carolinianum, Melilotus officinalis, Oenothera biennis*, *Solanum carolinense*, *Sorghum halepense,* and *Trifolium dubium*.

ACKNOWLEDGMENTS

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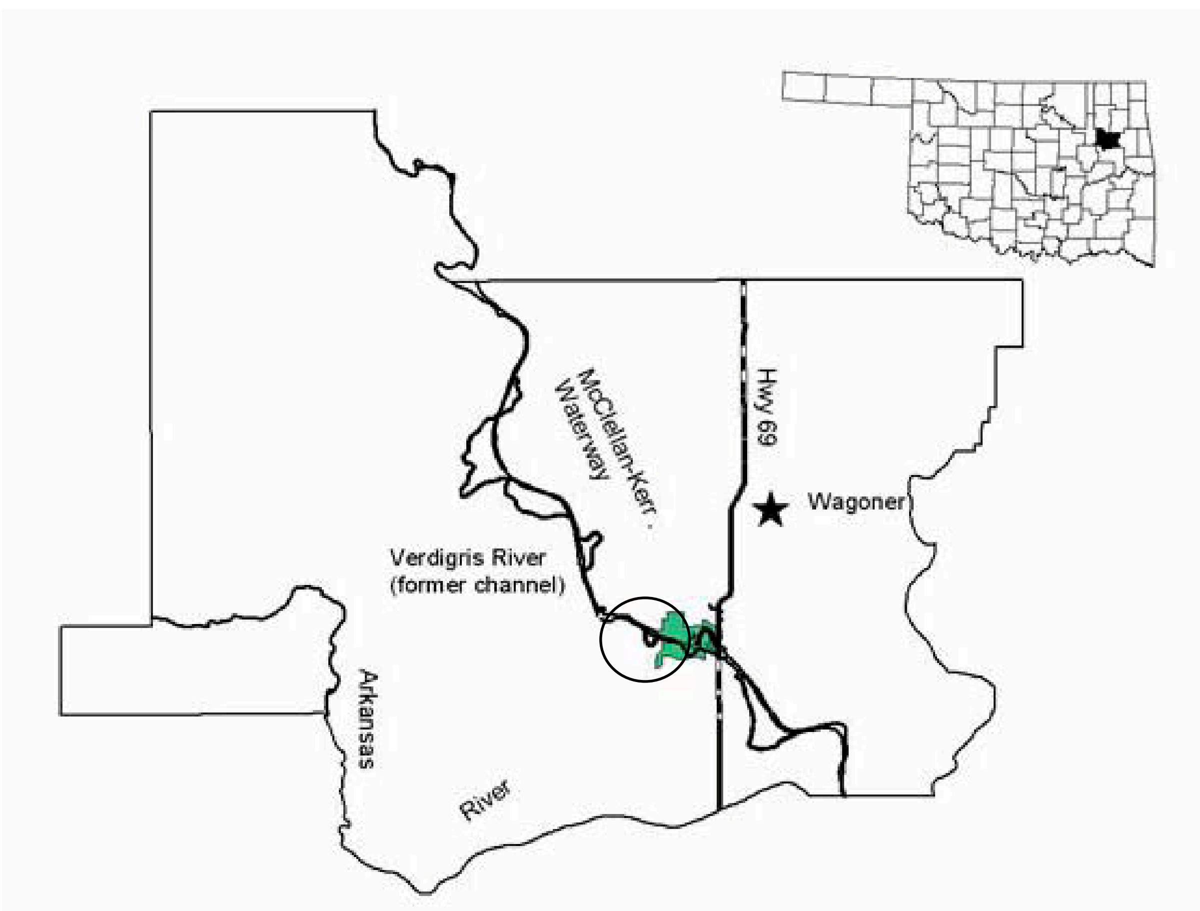

Figure Location of Chouteau Wildlife Management Area, Wagoner County, Oklahoma, site of the floristic collection.

Annotated Species List for the Chouteau Wildlife Management Area

The first entry is life history (A=annual, B=biennial, P=perennial); followed by abundance (1=least 5=dominant or codominant, Palmer et al. 1995); species not native to North America designated with an asterisk (*); habitat (AQ=Aquatic and wetland vegetation, BF = *Quercus palustris* • *Carya illinoensis*/*Ilex decidua* forest association, and DAOF=disturbed area/old-field); and collection number. Voucher specimens were deposited at the Robert Bebb Herbarium at the University of Oklahoma (OKL).

PTERIDOPHYTA

Azollaceae

Azolla caroliniana Willd. (mosquito fern)
A; 2; AQ; CH096

MAGNOLIOPHYTA

MAGNOLIOPSIDA

Acanthaceae

Justicia americana (L.) Vahl (water willow)
P; 2; AQ; CH037

Ruellia strepens L. (wild petunia)
P; 2; BF; CH0173

Aceraceae

Acer negundo L. (boxelder)
P; 3; BF; CH079

A. saccharinum L. (silver maple)
P; 2; BF; CH078

Amaranthaceae

Alternanthera philoxeroides (Mart.) Griseb.* (alligator weed)
P; 3; AQ; CH094

Amaranthus palmeri S. Wats. (Palmer's pigweed)
A; 2; DAOF; CH0144

Apiaceae

Limnosciadium pinnatum (DC.) Mathias & Constance (tansy dog shade)
A; 3; AQ; CH065

Ptilimnium capillaceum (Michx.) Raf. (threadleaf mockbishopweed)
A; 2; DAOF; CH0134

Sanicula canadensis L. (snakeroot)
B; 2; BF; CH0143

Torilis arvensis (Huds.) Link.* (hedge parsley)
A; 2; DAOF; CH063

Apocynaceae

Apocynum cannabinum L. (Indian hemp)
P; 3; DAOF; CH085

Aquifoliaceae

Ilex decidua Walt. (deciduous holly)
P; 3; BF; CH0114

Aristolochiaceae

Aristolochia tomentosa Sims (wooly pipe vine)
P; 2; BF; CH0101

Asclepiadaceae

Asclepias incarnata L. (swamp milkweed)
P; 2; AQ; CH0160

A. viridis Walt. (green milkweed)
P; 2; DAOF; CH072

Asteraceae

Ageratina altissima (L.) King & H.E. Robins. (white snakeroot)
P; 2; DAOF; CH0194

Ambrosia artemisiifolia L. (common ragweed)
A; 3; DAOF; CH0174

A. trifida L. (giant ragweed)
A; 4; DAOF; CH0157

Bidens aristosa (Michx.) Britt. (bearded beggarticks)
A; 2; AQ; CH0206

Boltonia asteroides (L.) L'Her. var. *latisquamata* (Gray) Cronq. (white doll's daisy)
P; 2; AQ; CH0208

Cirsium altissimum (L.) Hill (tall thistle)
B; 2; DAOF; CH0185

Conoclinium coelestinum (L.) DC. (blue mistflower)
P; 2; AQ; CH0199

Conyza canadensis (L.) Cronq. (horseweed)
A; 3; DAOF; CH0162

Coreopsis tinctoria Nutt. (plains coreopsis)
A; 3; DAOF; CH0123

Dracopis amplexicaulis (Vahl.) Cass. (clasping coneflower)
A; 4; AQ, DAOF; CH073

Eclipta prostrata (L.) L. (yerba de tajo)
P; 3; AQ; CH0108

Elephantopus carolinianus Raeusch. (elephant's foot)
P; 2; BF; CH0150

Erigeron strigosus Muhl. ex Willd.
(daisy fleabane)
B; 2; DAOF; CH090
Grindelia papposa Nesom & Suh (goldenweed)
A; 2; DAOF; CH0111
Helianthus annuus L. (common sunflower)
A; 2; DAOF; CH0164
Iva annua L. (marsh elder)
A; 3; DAOF; CH0158
Lactuca serriola L.* (prickly lettuce)
A; 2; DAOF; CH0145
Pyrrhopappus multicaulis (D. Don) DC.
(Geiser's false dandelion)
P; 2; DAOF; CH060
Solidago canadensis L. (Canada goldenrod)
P; 2; DAOF; CH0197
Symphyotrichum ericoides (L.) Nesom
(white heath aster)
P; 2; DAOF; CH0189
S. ontarione (Wieg.) Nesom (bottomland aster)
P; 2; DAOF; CH0200
S. subulatum (Michx.) Nesom (eastern saltmarsh aster)
A; 4; AQ; CH0165
Verbesina virginica L. (frostweed)
P; 2; BF; CH0184
Vernonia baldwinii Torr. (western ironweed)
P; 2; DAOF; CH0163
Xanthium strumarium L. (cocklebur)
A; 2; AQ; CH0209

Balsaminaceae

Impatiens capensis Meerb. (jewelweed)
A; 2; BF; CH0109

Bignoniaceae

Campsis radicans (L.) Seem. ex Bureau
(trumpetvine)
P; 2; BF; CH083

Brassicaceae

Lepidium densiflorum Schrad. (peppergrass)
A; 2; DAOF; CH051
Rorippa palustris (L.) Bess (bog yellow cress)
A; 2; AQ; CH088
Thlaspi arvense L.* (field pennycress)
A; 1; DAOF; CH053

Campanulaceae

Triodanis perfoliata (L.) Nieuw.
(clasping Venus' looking glass)
A; 2; DAOF; CH082

Caprifoliaceae

Sambucus nigra L. ssp. *canadensis* (L.) R. Bolli
(elderberry) P; 2; BF; CH084
Viburnum rufidulum Raf. (rusty blackhaw)
P; 2; BF; CH074

Celastraceae

Euonymus atropurpurea Jacq. (wahoo)
P; 2; BF; CH0187

Chenopodiaceae

Chenopodium standleyanum Aellen
(Standley's goosefoot)
A; 3; DAOF; CH0159

Convolvulaceae

Ipomoea lacunosa L. (white morning glory)
A; 2; DAOF; CH0203
I. pandurata (L.) G.F.W. Mey.
(bigroot morning glory)
P; 3; DAOF; CH0129

Cornaceae

Cornus drummondii C.A. Mey.
(rough leaved dogwood)
P; 3; DAOF; CH069

Crassulaceae

Penthorum sedoides L. (ditch stonecrop)
P; 3; AQ; CH0176

Ebenaceae

Diospyros virginiana L. (persimmon)
P; 2; DAOF; CH025

Euphorbiaceae

Chamaesyce maculata (L.) Small
(spotted spurge)
A; 3; DAOF; CH0151
Euphorbia spathulata Lam. (warty spurge)
A; 2; DAOF; CH049

Fabaceae

Amorpha fruticosa L. (false indigo)
P; 2; AQ; CH052
Cercis canadensis L. (redbud)
P; 3; BF; CH0170
Desmanthus illinoensis (Michx.) MacM. ex B.L. Robins. & Fern. (bundleflower)
P; 2; DAOF; CH0125
Desmodium paniculatum (L.) DC.
(panicled tickclover)
P; 3; BF; CH0106
Gleditsia triacanthos L. (honey locust)
P; 3; BF; CH044
Gymnocladus dioicus (L.) K. Koch.

(Kentucky coffee tree)
P; 2; BF; CH092

Lathyrus pusillus Ell. (low peavine)
A; 2; DAOF; CH002

Lespedeza cuneata (Dum.-Cours.) G. Don* (sericea lespedeza)
P; 2; DAOF; CH0167

Melilotus alba Medikus* (white sweet clover)
A; 2; DAOF; CH071

M. officinalis (L.) Lam.* (yellow sweet clover)
A; 3; DAOF; CH041

Senna marilandica (L.) Link (wild senna)
P; 2; BF; CH0124

Sesbania herbacea (P. Mill.) McVaugh (bequilla)
A; 5; AQ; CH0166

Strophostyles helvola (L.) Ell. (fuzzy trailing bean)
A; 2; DAOF; CH0191

Trifolium arvense L.* (rabbit foot clover)
A; 2; DAOF; CH040

T. dubium Sibthrop* (small hop clover)
A; 2; DAOF; CH026

T. pratense L.* (red clover)
P; 2; DAOF; CH0140

Vicia caroliniana Walt. (pole vetch)
P; 3; DAOF; CH0128

V. villosa Roth* (hairy vetch)
A; 3; DAOF; CH035

Fagaceae

Quercus macrocarpa Michx. (bur oak)
P; 2; BF; CH0135

Q. palustris Muenchh. (pin oak)
P; 3; BF; CH034

Q. velutina Lam. (black oak)
P; 2; BF; CH042

Geraniaceae

Geranium carolinianum L. (Carolina cranesbill)
A; 2; DAOF; CH027

Juglandaceae

Carya illinoensis (Wangenh.) K. Koch (Pecan)
P; 2; BF; CH087

Lamiaceae

Prunella vulgaris L. (Common self heal)
P; 2; BF; CH020

Lauraceae

Sassafras albidum (Nutt.) Nees (sassafras)
P; 2; BF; CH0120

Lythraceae

Ammannia coccinea Rottb. (redstem loosestrife)
A; 2; AQ; CH0141

Lythrum alatum Pursh (winged loosestrife)
P; 2; AQ; CH0121

Malvaceae

Hibiscus laevis All. (halberd leaved rose mallow) P; 2; AQ; CH0153

Sida spinosa L. (prickly sida)
A; 1; DAOF; CH0152

Menispermaceae

Calycocarpum lyonii (Pursh) Gray (cupseed)
P; 2; BF; CH093

Cocculus carolinus (L.) DC. (Carolina snailseed)
P; 2; BF; CH0103

Moraceae

Morus rubra L. (red mulberry)
P; 2; BF; CH0180

Nelumbonaceae

Nelumbo lutea Willd. (Lotus)
P; 2; AQ; CH0179

Oleaceae

Fraxinus pennsylvanica Marsh. (green ash)
P; 3; BF; CH043

Onagraceae

Ludwigia palustris (L.) Ell. (marsh seedbox)
P; 4; AQ; CH055

L. repens Forst. (water primrose)
P; 2; AQ; CH0131

Oenothera biennis L. (common evening primrose)
B; 3; DAOF; CH0161

O. laciniata Hill (cutleaf evening primrose)
A; 2; DAOF; CH061

Oxalidaceae

Oxalis stricta L. (yellow wood sorrel)
P; 2; DAOF; CH081

Passifloraceae

Passiflora lutea L. (yellow passionflower)
P; 2; BF; CH058

Phytolaccaceae

Phytolacca americana L. (pokeweed)
P; 2; DAOF; CH0116

Polygonaceae

Polygonum hydropiper L.* (water pepper)
A; 2; AQ; CH0115

P. hydropiperoides Michx.* (mild water pepper)
P; 4; AQ; CH0113

P. lapathifolium L. (pale smartweed)
A; 3; AQ; CH0190
P. pensylvanicum L. (Pennsylvania smartweed)
A; 2; AQ; CH0204
P. ramosissimum Michx. (knotweed)
A; 2; AQ; CH014
P. scandens L. (false buckwheat)
P; 2; AQ; CH0193
Rumex altissimus Wood (pale dock)
P; 2; DAOF; CH089
R. crispus L.* (curly dock)
P; 3; DAOF; CH091
R. verticillatus L. (Water dock)
P; 2; DAOF; CH07

Ranunculaceae

Clematis pitcheri Torr. & Gray (Pitcher's clematis) P; 2; BF; CH046
Ranunculus sceleratus L. (cursed buttercup)
A; 2; AQ; CH031

Rosaceae

Crataegus viridis L. (green hawthorn)
P; 3; BF; CH06
Geum canadense Jacq. (white avens)
P; 2; BF; CH0112
Rosa multiflora Thunb. ex Murr.* (Japanese rose)
P; 2; DAOF; CH033
R. setigera Michx. (climbing prairie rose)
P; 2; DAOF; CH056
Rubus trivialis Michx. (southern blackberry)
P; 3; BF; CH0105

Rubiaceae

Cephalanthus occidentalis L. (buttonbush)
P; 2; AQ; CH0138
Galium aparine L. (catchweed bedstraw)
A; 2; BF; CH036
Spermacoce glabra Michx. (smooth buttonweed)
P; 2; AQ; CH0155

Salicaceae

Salix nigra Marsh. (black willow)
P; 2; AQ; CH0192

Sapindaceae

Sapindus saponaria L. var. *drummondii* (Hook. & Arn.) L. Benson (soapberry)
P; 2; BF; CH077

Sapotaceae

Sideroxylon lanuginosum Michx. (chittamwood)
P; 2; BF; CH0110

Scrophulariaceae

Lindernia dubia (L.) Pennell (false pimpernel)
A; 2; AQ; CH0136
Penstemon digitalis Nutt. ex Sims (smooth penstemon)
P; 2; DAOF; CH045
Veronica peregrina L. (purslane speedwell)
A; 2; DAOF; CH024

Solanaceae

Physalis angulata L. (cutleaf ground cherry)
A; 2; DAOF; CH015
Solanum carolinense L. (Carolina horsenettle)
P; 2; DAOF; CH062

Ulmaceae

Celtis laevigata Willd. (sugarberry)
P; 4; BF; CH01
Ulmus alata Michx. (winged elm)
P; 3; BF; CH032
U. rubra Muhl. (slippery elm)
P; 4; BF; CH038

Urticaceae

Boehmeria cylindrica (L.) Sw. (false nettle)
P; 2; BF; CH0175

Valerianaceae

Valerianella radiata (L.) Dufr. (common beaked cornsalad)
A; 2; AQ; CH08

Verbenaceae

Phyla lanceolata (Michx.) Greene (northern fogfruit)
P; 2; AQ; CH0139

Viscaceae

Phoradendron leucarpum (Raf.) Reveal & M.C. Johnston (eastern mistletoe)
P; 2; BF; CH086

Vitaceae

Ampelopsis arborea (L.) Koehne (peppervine)
P; 2; BF; CH0100
A. cordata Michx. (racoon grape)
P; 2; BF; CH0147
Parthenocissus quinquefolia (L.) Planch. (Virginia creeper)
P; 3; BF; CH098
Vitis aestivalis Michx. (pigeon grape)
P; 3; BF; CH0102
V. cinerea (Engelm.) Millard (sweet grape)
P; 2; BF; CH0107

LILIOPSIDA

Alismataceae

Echinodorus cordifolius (L.) Griesb. (creeping burhead)
P; 2; AQ; CH0177
Sagittaria latifolia Willd. (duck potato)
P; 2; AQ; CH0186

Araceae

Arisaema dracontium (L.) Schott (green dragon)
P; 2; BF; CH0114

Cyperaceae

Carex crus-corvi Shuttlw. ex Kunze (ravenfoot sedge)
P; 2; AQ; CH070
C. granularis Muhl. ex Willd. var. *haleana* (Olney) Porter (Limestone meadow sedge)
P; 2 BF; CH0032
C. hyalinolepis Steudel (shoreline sedge)
P; 2; AQ; CH0089
C. tribuloides Wahlenberg (blunt broom sedge)
P; 2 BF; CH0103
C. vulpinoidea Michx. (fox sedge)
P; 2 BF; CH0230
Cyperus pseudovegetus Stued. (marsh flatsedge)
P; 2; AQ; CH0114
C. strigosus L. (strawcolored flatsedge)
P; 2; AQ; CH097
Eleocharis compressa Sullivant (flatstem spikesedge)
P; 4; AQ; CH052
E. obtusa (Willd.) J.A. Schultes (blunt spikesedge)
P; 2; AQ; CH0039

Iridaceae

Sisyrinchium angustifolium P. Mill. (blue eyed grass)
P; 2; DAOF; CH0029

Juncaceae

Juncus acuminatus Michx. (tapertip rush)
P; 2; AQ; CH063
J. effusus L. (soft rush)
P; 2; AQ; CH024
J. interior Wieg. (inland rush)
P; 2; AQ; CH041

Liliaceae

Allium canadense L. (wild onion)
P; 2; DAOF; CH030

Poaceae

Agrostis hyemalis (Walt.) B. S. P. (ticklegrass)
P; 2; AQ; CH0017
Alopecurus carolinianus Walt. (Carolina foxtail)
A; 2; AQ; CH0019
Andropogon glomeratus (Walt.) B. S. P. (broomsedge)
P; 3; DAOF; CH0182
Arundinaria gigantea (Walt.) Mulh. (giant cane)
P; 2; BF; CH076
Bromus japonicus Thunb. ex Murr*. (Japanese brome)
P; 3; DAOF; CH047
Digitaria sanguinalis (L.) Scop. (hairy crabgrass)
A; 3; DAOF; CH0169
Echinochloa colona (L.) Link* (barnyard grass)
A; 2; AQ; CH0205
E. crus-galli (L.) Beauv.* (barnyard grass)
A; 3; AQ; CH0104
E. muricata (Beauv.) Fern.* (barnyard grass)
A; 2; AQ; CH0130
Elymus virginicus L. (Virginia wild rye)
P; 2; BF; CH075
Eragrostis spectabilis (Pursh.) Steud. (purple lovegrass)
P; 2; BF; CH0196
Hordeum pusillum Nutt. (little barley)
A; 3; DAOF; CH050
Leersia oryzoides (L.) Sw. (rice cutgrass)
P; 2; AQ; CH0181
Leptochloa panicea (Retz.) Ohwi ssp. *brachiata* (Steudl.) N. Snow (red sprangletop)
A; 2; AQ; CH0201
Lolium perenne L.* (perennial ryegrass)
P; 2; DAOF; CH048
Panicum dichotomiflorum Michx. (fall panicum)
A; 2; BF; CH0198
Paspalum pubiflorum Rupr. ex Fourn. (hairyseed paspalum)
P; 2; DAOF; CH0202
Setaria parviflora (Poir.) Kerguélen. (knotroot bristlegrass)
P; 2; DAOF; CH0207
S. viridis (L.) Beauv.* (green foxtail)
A; 2; DAOF; CH0127
Sorghum halepense (L.) Pers.* (Johnson grass)

Oklahoma Native Plant Record
Volume 4, Number 1, December 2004

P; 3; DAOF; CH021
Sphenopholis obtusata (Michx) Scribn. (wedgegrass)
P; 2; AQ; CH010
Tridens flavus (L.) A.S. Hitchc. (redtop)
P; 3; DAOF; CH0183

Potamogetonaceae

Potamogeton nodosus Poir. (long leaved pondweed)
P; 2; AQ; CH095

Smilacaceae

Smilax bona-nox L. (greenbriar)
P; 2; BF; CH097
S. glauca Walt. (pale greenbriar)
P; 2; BF; CH0119

Typhaceae

Typha domingensis Pers. (southern cattail)
P; 2; AQ; CH0178

Table Summary of floristic collections at the Chouteau Wildlife Management Area, Wagoner County, Oklahoma. Table format follows Palmer et al. (1995).

Taxonomic Group	Species	Native spp.	Introduced spp.
Pteridophyta	1	1	0
Magnoliophyta			
Magnoliopsida	137	122	15
Liliopsida	43	37	6
Total	181	160	21

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Status and Habitat Characteristics of *Cypripedium kentuckiense* (Kentucky lady's slipper) in Southeastern Oklahoma

Amy K. Buthod
Oklahoma Biological Survey
University of Oklahoma
Norman, OK 73019
e-mail: amybuthod@ou.edu

B. W. Hoagland
Oklahoma Biological Survey and
Department of Geography
University of Oklahoma
Norman, OK 73019
e-mail: bhoagland@ou.edu

***Cypripedium kentuckiense* is a long-lived herbaceous perennial that inhabits floodplain and mesic hardwood forests. It occurs in Alabama, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas, and Virginia and has been reported from Choctaw, LeFlore, McCurtain, and Pushmataha counties in Oklahoma. *C. kentuckiense* is considered a rare species throughout its range, but is not currently protected under the United States Endangered Species Act. The objectives of this study were to (1) determine whether known populations of *C. kentuckiense* were persisting in Oklahoma and (2) characterize habitat structure. Twelve sites were surveyed in 2001 and 2002 for populations of *C. kentuckiense*, but only three persistent populations were found. The populations that were relocated numbered fewer than 20 total stems and all showed a dramatic decline in population size relative to previous surveys.**

INTRODUCTION

Cypripedium kentuckiense is a long-lived herbaceous perennial that inhabits floodplain or mesic hardwood forests or woodland springs and seeps (Case et al., 1998; Reed 1982, Hooks 2000, Magrath 2001). Populations of *C. kentuckiense* occur in Alabama, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas, and Virginia (Figure; USDA 2002). In Oklahoma, *C. kentuckiense* has been reported from Choctaw, LeFlore, McCurtain, and Pushmataha counties (Hoagland et al. 2004). Over 156 populations are known to exist throughout its range, the majority of which occur in Arkansas. Oklahoma harbors only 4.5% of *C. kentuckiense* populations (Atwood 1984, 1985; Case et al. 1998). Population size averages less than 20 individuals (Weldy et al. 1996), though some in Arkansas exceed 800 individuals (Hooks 2000).

Cypripedium. kentuckiense is considered a rare species throughout its range, but is not currently protected under the U.S. Endangered Species Act. Prior to 1996, it was listed as a category 2 (C2) species by the U.S. Fish and Wildlife Service. A C2 species is defined as "…a likely candidate for federal listing as endangered or threatened, but it is necessary to obtain further information regarding possible threats" (Department of the Interior 1993).

State and federal agencies evaluate the conservation status of a species using a two tiered, geographical approach developed by The Nature Conservancy (Groves et al. 1995). This system ranks species imperilment at the state (S) and global(G) levels on a scale of 1-5; 1 representing a species that is imperiled and 5, one that is demonstrably secure. NatureServe, a conservation information organization, has assigned *C. kentuckiense* a global rank of G3, indicating a species that is "…either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range, or because of other factors making it vulnerable to extinction throughout its range…" (NatureServe 2004). The Oklahoma Natural Heritage Inventory (ONHI) has assigned *C. kentuckiense* a state rank of S1, indicating a

Buthod, A.K. and Hoagland, B.W.
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species "…critically imperiled…because of extreme rarity (five or fewer occurrences or very few remaining individuals or acres) or because of some factor of its biology making it especially vulnerable to extinction" (ONHI 2001). In comparison, Arkansas and Kentucky rank *C. kentuckiense as* S3 (Arkansas Natural Heritage Commission 2001; Kentucky Nature Preserves Commissions 2001), Tennessee S1S2 (Tenessee Department of Environment and Conservation 2001, and Alabama Louisiana, Mississippi, and Virginia as S1 (Alabama Natural Heritage Program 1996; Louisiana Natural Heritage Program 2002; Mississippi Museum of Natural History 2002; Virginia Natural Heritage Program 2002) by Heritage Programs in those states. An S-rank was not available for Texas (Texas Conservation Data Center 2001.

The objectives of this study were (1) to verify and determine whether known populations of *C. kentuckiense* persist in Oklahoma and (2) to gather quantitative habitat data.

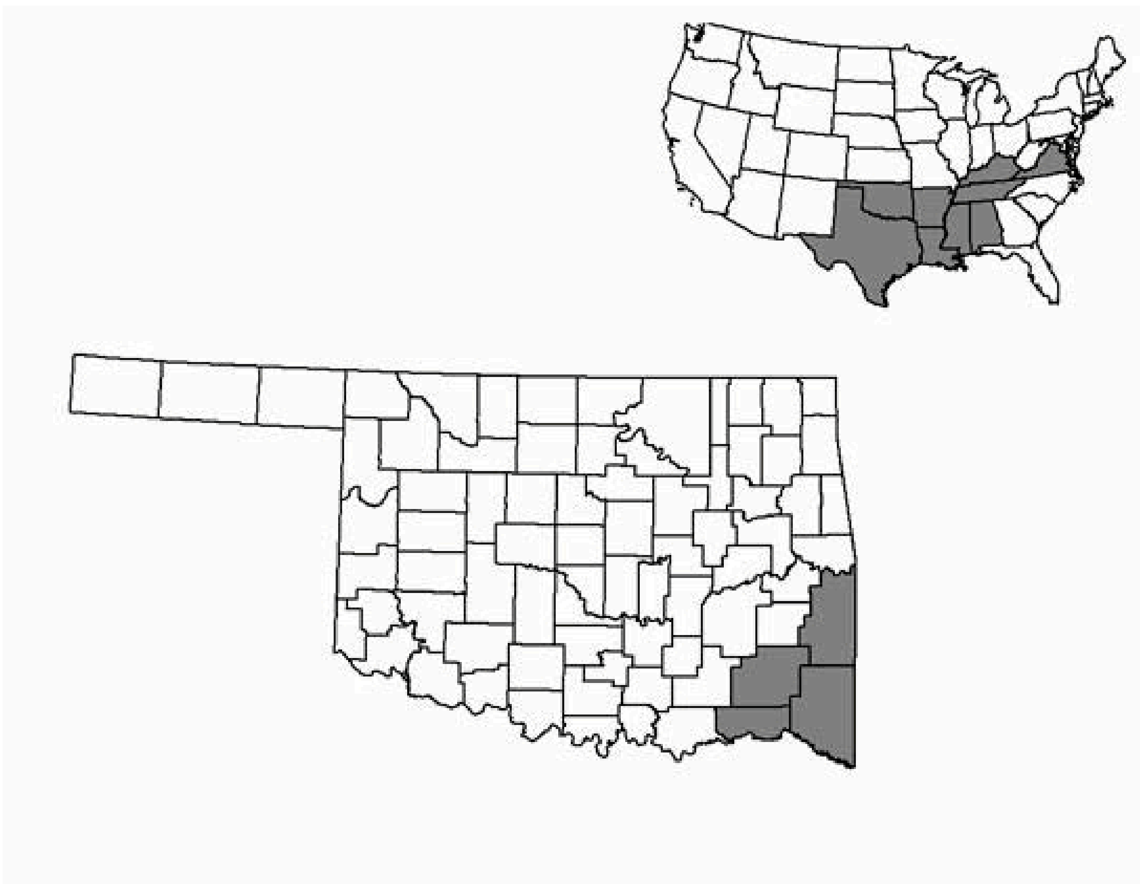

Figure National and state distribution of *Cypripedium kentuckiense* (Kentucky lady's slipper) (USDA 2002).

METHODS

Sites visited in this study were obtained the ONHI, which maintains a spatial database of rare species locations. Each site was visited from late April to early May, the peak blooming period, in the springs of 2001 and 2002. All sites were thoroughly searched in an attempt to relocate previously documented *C. kentuckiense* populations. If a population was not found at a site, the absence was noted and no further data were collected. If a population was found, then several ecological variables were measured. These data were collected to quantitatively characterize the habitat of *C. kentuckiense* and provide information that can be utilized in future attempts to locate new populations.

Population and habitat data were collected from a quadrat encompassing all *C. kentuckiense* stems. The minimal quadrat size used was 1.0 m by 1.0 m. If the population occupied a larger area, additional 1 m^2 quadrats were added until the total population was within a sampling grid. Once the sampling grid was established, percent cover of *C. kentuckiense* was visually estimated in intervals of 5% and the number of stems counted. The numbers of flowering, fruiting (mature and immature), immature stems, and senescent stems were also recorded.

Habitat data consisted of biotic and abiotic factors. First, each species in the sampling grid was recorded. Two types of data were then collected for these associated species. First, percent cover was estimated for each understory species (including woody plants under 2 cm diameter) in increments of 5%. If only a single stem of a species was present, it was given a value of 1%. Second, the diameter-atbreast height (DBH) was measured for all woody plants >2 cm diameter. Basal area for canopy species was calculated following Wegner (1984). Once these data were collected, a spherical densitometer was used to measure canopy closure. Soil depth was measured using an incremental probe. Finally, Universal Transmercator coordinates were recorded using a Garmin 3+ Global Positioning System (GPS) unit in order to resolve ambiguities in written location information. However, these data are not presented here because *C. kentuckiense* is a species of conservation concern.

RESULTS AND DISCUSSION

A total of twelve sites were surveyed in 2001 and 2002 for populations of *C. kentuckiense*; two in Choctaw County, six in LeFlore county, three in McCurtain County, and one in Pushmataha County. The persistence of three populations was verified. Five populations could not be revisited due to insufficient location information. Four populations had been destroyed by timber harvest or conversion to unsuitable habitat for *C. kentuckiense*. No new sites were located.

The first population was verified on 7 May 2001. Thirteen stems of *C. Kentuckiense* were counted, two of which were in flower. This population occurred in a mesic floodplain forest with 78% canopy closure. There were 21 associated plant species present. The most abundant were *Lindera benzoin* (30% cover), *Thalictrum dascycarpum* (15%), *Podophyllum peltatum* (10%), and *Toxicodendron radicans* (10%) (Table 1). The canopy was composed exclusively of *Ilex opaca*, a common bottomland species in southeast Oklahoma (Hoagland et al., 1996). The low diversity of woody plants over 2 cm DBH (Table 2) and relatively open canopy (78%) indicate the second growth character of this forest. Soil depth was equivalent for all sites.

This population was first reported in 1982, at which time 35 stems were recorded, but no observations were made regarding phenological state. The site was visited again in 1984 and 30 plants were recorded. Additional surveys were conducted in 1985 (23 plants located, two flowering), 1988 (13 plants; phenology not recorded), 1990 (less than 20 plants present, phenology not recorded), 1991 (21 plants, four in flower), 1993 (12 plants, two in flower), and 1996 (no plants located).

A second population was verified on 8 May 2001. Nine broadly dispersed stems of *C. kentuckiense* were present. Individuals in this population were widely dispersed. Eleven associated species were present, of which the most common were *Parthenocissus quinquefolia* (20% cover), *Panicum* sp. (10%), and *Podophyllum peltatum* (10%) (See Table 1). The canopy was relatively dense (87.3%) and consisted of eight species. The highest basal areas were recorded for *Quercus shumardii* and *Carpinus caroliniana*, both mesic species (Little 1981).

This population has been visited repeatedly since its discovery in 1988 (two plants, phenological stage not recorded), 1991 (nine plants flowering, two in fruit, and four sterile), 1992 (>10 plants with immature fruit), 1993 (11 plants, nine in flower), and 1996 (11 plants in vegetative condition).

A third population was verified on 8 May 2001. The population consisted of one flowering stem growing on a forested floodplain. Population and associated species data were collected from the 1.0m^2 plot. There were 21 associated plant species at this site (See Table 1). The most abundant were *Panicum* sp. (25% cover), *Parthenocissus quinquefolia* (5%), and *Arisaema dracontium* (5%). Although the canopy density is highest for this plot, there were no canopy trees within the sample plot, therefore no basal area value could be calculated.

Previous surveys of the site were conducted in 1993 (one flowering stem recorded) and 1996 (one vegetative stem recorded).

Because of the limited number of sites sampled, a quantitative analysis of habitat structure is not possible.

CONCLUSIONS

Based upon this research, we conclude *C. kentuckiense* in Oklahoma is in jeopardy. Magrath (2001) had also stated that *C. kentuckiense* populations were in decline in Oklahoma. The populations that were relocated numbered fewer than 20 total stems and all showed a dramatic decline in population size relative to previous surveys. The primary threats to *C. kentuckiense* in Oklahoma are anthropogenic. Most populations of *C. kentuckiense* are located in areas of active timber harvesting, which present both direct and indirect threats. The most likely direct threat is destruction of a population by timber harvesting equipment. Indirect threats include road construction and structural alteration of adjacent forest stands. These reduce forest canopy cover, thus increasing the amount of light reaching the forest floor and allowing the introduction of invasive species. Since *C. kentuckiense* is difficult to propagate, it is frequently collected in the wild for the nursery trade. The construction of logging roads increases access to collectors. In addition, road construction itself can result in the destruction of a population.

Indirect threats to small, isolated populations included reduced genetic variability compared to large, contiguous populations, and the inability of pollinators to locate widely dispersed populations or those on the edge of a species range. In this regard, it is noteworthy that very few mature fruits or seedlings were documented in the populations reported here.

Nevertheless, additional populations of

C. kentuckiense may be found in Oklahoma, with efforts focused on the Oachita National Forest (ONF) in LeFlore and McCurtain Counties. In Arkansas several new populations have been found on the ONF. Some populations consisted of 100 individuals or more (Hooks 2000). Populations located on the ONF are afforded a higher degree of protection and monitoring than those on private land. In addition, seep, spring, and riparian habitats are protected from timber extraction on Forest Service land. Thus, further exploration for populations of *C. kentuckiense* within Oklahoma is recommended. Likewise, sites known to have harbored populations of *C. kentuckiense* should be verified regularly.

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Oklahoma Native Plant Record
Volume 4, Number 1, December 2004

Table 1 Percent cover data for associated herbaceous species and woody species <2 cm DBH at *Cypripedium kentuckense* sites in southeastern Oklahoma.

Site	1	2	3	Site	1	2	3
Acer rubrum	1	0	1	*Podophyllum peltatum*	10	0	10
Allium canadense	0	0	1	*Polystichum acrostichoides*	5	0	5
Arisaema dracontium	0	5	0	*Potentilla* spp.	1	0	0
Campsis radicans	1	0	0	*Prunus* spp.	1	0	0
Carex spp.	1	1	0	*Ribes* sp.	0	1	0
Cercis canadensis	0	0	1	*Quercus alba*	0	0	5
Cypripedium kentuckense	5	5	1	*Salvia lyrata*	0	1	0
Euonymous americanus	1	0	0	*Sassafras albidum*	1	0	0
Galium sp.	1	0	0	*Senecio* sp.	0	5	1
Ilex opaca	1	0	0	*Smilicina racemosa*	0	0	1
Impatiens capensis	0	0	1	*Smilax glauca*	1	0	5
Krigia sp.	0	1	0	*Thalictrum arkansanum*	0	1	0
Lindernia benzoin	30	0	0	*Thalictrum dasycarpum*	15	0	5
Lysimachia quadrifolia	0	0	5	*Toxicodendron radicans*	10	1	10
Mitchella repens	1	0	0	*Ulmus alata*	0	0	1
Monarda virgatum	0	0	1	*Viburnum rufidulum*	1	0	1
Ostrya virginiana	1	0	1	*Viola* sp.	1	0	0
Oxalis violacea	0	1	0	*Viola pedata*	1	0	1
Panicum spp.	0	25	10	Totals	91	52	88
Parthenocissus quinquefolia	1	5	20	Overstory canopy % coverage	78	87.5	93.8
Phacelia sp.	0	0	1	Soil depth (cm)	30	30	30

Table 2 Basal area (cm^2/m^2) for woody species found in *Cypridedium kentuckense*. No woody plants occurred in the plot at site 3

Site	1	2	Site	1	2
Alnus serrulata	0	0.07	*Ilex opaca*	8.56	0
Carpinus caroliniana	0	8.0	*Liquidambar styraciflua*	0	8.0
Cornus florida	0	2.8	*Ostrya virginiana*	0	6.6
Fraxinus pensylvanica	0	0.29	*Quercus shumardii*	0	10.8

Oklahoma Native Plant Record
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Common Lawn and Garden Mushrooms of Central Oklahoma

Clark L. Ovrebo
Department of Biology
University of Central Oklahoma
Edmond, OK 73034

Mushrooms are often abundant in lawns and gardens after periods of wet weather. This article presents photographs of some of the more common mushrooms the author has encountered in Central Oklahoma over the past fifteen years.

INTRODUCTION

A mushroom is the fruiting body of a fungus. The body of the fungus, termed mycelium, is found in soil, compost, wood chips, or logs. Rarely are mushroom species parasitic. The mycelium gets nutrition from breaking down the organic substrates (saprotrophic mode of nutrition). If the yard has oaks, hickories or pines, the fungus forms a mycorrhizal association with the tree roots, an association that is beneficial to both the fungus and the tree. Mycorrhizal fungi are most often found in forested areas, but may also occur in yards or city parks if their symbiotic trees are present. With the exception of *Suillus brevipes,* the fungi treated in this paper are saprotrophic.

The term "common," is not so easily defined. Some mushrooms appear every year after almost every rain, whereas others may appear only sporadically even after wet weather. Some fungi are abundant some years and not the next. Thus, the term "common" as used for fleshy fungi must remain vague. The time of year given for fruiting is also somewhat general and is intended to give an approximation of when the mushrooms fruit.

In addition to photos, a brief description is provided for each species. The intent is not to provide complete macroscopic and microscopic descriptions of the fungi, but rather, the salient morphological features. To be sure of identification, it may be necessary to use microscopic examination and consult field guides or technical literature. Spore print color is presented for some species because determining spore color is often the first step in identifying a mushroom. A spore print is made by cutting off the stipe and placing the pileus with lamellae side down on a piece of white paper. This set-up is covered and left overnight.

Advice is not provided about which lawn mushrooms are edible. Great care must be taken to be absolutely sure of a mushroom's identity. Only after becoming sufficiently familiar with mushroom characters and their identifying features can one be certain of the identification, and only then can the determination about edibility be made.

Many field guides are helpful and provide additional information. A listing of some field guides that are useful for Oklahoma is found at the end of the article.

Agaricales

Fungi in this order comprise one of the more common groups of lawn fungi and include what are called "gilled mushrooms" and "boletes". The parts of a gilled mushroom are the pileus (cap), stipe (stem), and lamellae (gills). A bolete has tubes that end in pores instead of lamellae. The spores are produced on the lamellae or tubes, forcibly discharged, and are dispersed by air currents.

Ovrebo, C.L.
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Chlorophyllum molybdites

Scattered, on lawns or pastures, sometimes in fairy rings or arcs (Figure 1), late spring through mid-fall. *Chlorophyllum molybdites* is one of the most common larger mushrooms occurring on lawns. It is recognized by the rather large fruiting bodies, whitish pileus surface with tan scales near or on the center, green lamellae and by the partial veil which leaves an annulus on the stipe (Figure 2). The lamellae are off-white when young and become green at maturity, and are free (not attached to the stipe). The spore deposit is green. C*hlorophyllum molybdites* is the leading cause of mushroom poisoning in the United States. It causes severe gastrointestinal upset with recovery after several hours. It is especially toxic to young children and people already compromised by health problems.

Figure 1 *Chlorophyllum molybdites,* fairy ring.

Figure 2 *Chlorophyllum molybdites,* fruiting bodies.

Amanita thiersii

Scattered, on lawns, sometimes in fairy rings or arcs (Figure 3), summer and fall. *Amanita thiersii* is another of the larger mushrooms occurring on lawns and may be in fruit at the same time as *C. molybdites*. The pileus and stipe are white and the lamellae light cream-colored. Young fruiting bodies are covered with a flocculent coating that may remain throughout maturation (Figure 4). The covering is easily removed when touched and may be washed away with rain. The spore print is white. This species belongs in the genus that contains some of the most deadly poisonous mushrooms. Though little is known about the toxicity or edibility of *A. thiersii*, it is probably poisonous.

Figure 3 *Amanita thiersii,* fairy ring.

Figure 4 *Amanita thiersii,* fruiting bodies.

Marasmius oreades (fairy ring mushroom)

Scattered, on lawns, occasionally in arcs or fairy rings (Figure 5), summer to late fall. *Marasmius oreades* is a small, thin-statured mushroom with the pileus reaching at most 3-4 cm in diameter. The pileus is smooth, off-white with the center often light tan (Figure 6). The buttons can be light brown overall. The lamellae are rather distantly spaced and off-white. The stipe is also off-white and lacks an annulus. The spore print is white.

Figure 5 *Marasmius oreades,* fairy ring.

Figure 6 *Marasmius oreades,* fruiting bodies.

Coprinus comatus (shaggy mane)

Scattered, on lawns, late summer through late fall. *Coprinus comatus* is easily recognized by the rather tall fruiting bodies that have a vertically elongated pileus. The pileus of the buttons is elliptical. The pileus has a shaggy surface and is off-white although the top can be tan (Figures 7 and 8). The lamellae are off-white when young and black at maturity. The genus is characterized by the fact that the mushrooms deliquesce (auto-digest). Beginning at the margin, the pileus begins to liquefy and the process continues toward the top-center of the pileus (Figure 9). Often only the stipe remains.

Figure 7 *Coprinus comatus,* fruiting bodies showing shaggy surface.

Figure 8 *Coprinus comatus,* mature fruiting bodies.

Figure 9 *Coprinus comatus,* deliquescing fruiting bodies

Coprinopsis variegata

Scattered to clustered, on lawns, but attached to buried wood, or on stumps, summer. *Coprinopsis variegata* appears in clusters on lawns but is actually growing from buried wood such as the remains of a stump. The pileus is off-white to grayish brown to gray, and has scales or patches (Figures 10 and 11). Like *Coprinus comatus,* the fruiting bodies deliquesce. This species was formerly placed in *Coprinus.*

Conocybe lactea

Scattered, on lawns, early summer. *Conocybe lactea* has small fragile fruiting bodies that are evident in the morning but wither away as the heat of the day sets in. The pileus is whitish to light tan and rounded-conic. The lamellae are light cinnamon-brown (Figure 12).

Parasola plicatilis

Scattered, on lawns, early summer. Fruiting bodies of *Parasola plicatilis* are small and thin-statured (Figure 13). The pileus is translucent-gray and plicate (grooved). The lamellae are black. This species is most noticeable in the morning. In sunlight it quickly dries and disappears. This species was also formerly placed in *Coprinus.*

Agaricus campestris (meadow mushroom)

Scattered, on lawns and pastures, summer to early fall. *Agaricus campestris* is characterized by the whitish pileus and stipe, annulate stipe and by the dark brown, free lamellae (Figure 14). The lamellae start out light pink in the button stage and become dark brown as the spores mature. The spore print is dark brown. This species is in the same genus as the cultivated button mushroom that is available fresh or canned in grocery stores.

Figure 10 *Coprinopsis variegata, cluster of fruiting bodies.*

Figure 11 *Coprinopsis variegata,* fruiting bodies.

Figure 12 *Conocybe lactea,* fruiting bodies.

Figure 13 *Parasola plicatilis,* fruiting bodies.

Figure 14 *Agaricus campestris,* fruiting bodies.

Leucoagaricus naucinus

Scattered on lawns, fall. *Leucoagaricus naucinus* is a medium-sized mushroom and is creamy white overall. The pileus is smooth, the lamellae are free and the stipe has an annulus (Figure 15). The spore print is white. This species is not edible and causes mild to severe gastric upset. There is no cup at the base as with *Amanita virosa*, which is similar in coloration but occurs in forests and is deadly poisonous.

Figure 15 *Leucoagaricus naucinus,* fruiting bodies.

Pluteus petasatus

On dead wood or wood chips, in clusters of two or three, summer. The pileus of *Pluteus petasatus* is off-white to light tan with the center becoming brown. The center of the pileus develops cracks in age. The lamellae are pinkish tan and free (Figure 16). The spore print is pinkish tan.

Figure 16 *Pluteus petasatus,* fruiting bodies.

Clitocybe tarda

Scattered, on lawns, generally in clusters, fall. *Clitocybe tarda* is characterized by the smooth, violet-purple pileus (Figure 17). The lamellae and stipe are pigmented similarly but generally lighter. With age considerable fading of the pileus may occur. The spore print is very pale pinkish buff.

Figure 17 *Clitocybe tarda,* fruiting bodies.

Suillus brevipes

Scattered, on soil or lawns underneath *Pinus* spp., late fall. *Suillus brevipes* has tubes and pores rather than lamellae. The pileus is brown and slimy when fresh and in age the color fades to yellowish tan and the surface may dry. The tubes and pores are yellow when young and become more olive-tinged in age (Figure 18). *Suillus brevipes* forms a mycorrhizal association with *Pinus*.

Figure 18 *Suillus brevipes,* fruiting bodies.

Order Phallales (Stinkhorns)

The stinkhorns comprise a most interesting group of fleshy fungi. Rather than using air currents for spore dispersal, the spores are borne on a sticky mass called the gleba, which has a repulsive odor. For the species discussed here, the gleba is formed at the tip of the mushroom and is dark olive to nearly black. The odor attracts flies and other insects which are the agents of spore dispersal. The fungi start out as "buttons" completely encapsulated by an outer membrane (universal veil). When the mushroom bursts out of the button, a cup (volva) is left at the base. A section through the button reveals the immature fruiting body. All species of *Phallus* have a phallus-shaped fruiting body. Various stages of development can be seen in Figures 19-21, 23.

Phallus ravenelii

Scattered on lawns, soil or wood mulch, summer to fall. This species is identical in stature to *Phallus hadriani,* but the gleba is light gray, nearly smooth, and not pitted. Note the flies on the gleba of Figure 21.

Phallus hadriani

Scattered, on lawns, soil or wood mulch, summer to fall. *Phallus hadriani* is distinguished by the pitted gleba (Figure 19). The surface of the volva is pink colored in this species. *Phallus impudicus* is identical in appearance but the outer surface of the volva is white.

Figure 19 *Phallus hadriani,* an intact button whole fruiting body, and a longitudinally sectioned button.

Figure 21 *Phallus ravenelii,* longitudinally sectioned button and fruiting bodies.

Figure 20 *Phallus ravenelii,*Buttons

Oklahoma Native Plant Record
Volume 4, Number 1, December 2004

Phallus rubicundus

Scattered on lawns, summer. Phallus rubicundus also has the phalloid stature but the stipe is orange (Figure 22).

Figure 22 *Phallus rubicundus,* fruiting body.

Lysurus periphragmoides

Solitary or scattered on lawns, summer to late fall. Lysurus periphragmoides is another common stinkhorn. It is generally smaller than the Phallus species, has an orange stipe and the glebal head is different. The glebal head has a sterile orange lattice network with gleba in between the netted pattern (Figure 23). Some field guides refer to this species as Simblum sphaerocephalum.

Figure 23 *Lysurus periphragmoides,* mature fruiting body with intact and longitudinally sectioned buttons.

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Critic's Choice Essay
"SUPPORT YOUR LOCAL HERBARIUM"

Wayne J. Elisens

Are herbaria becoming threatened and endangered? Are natural science collections going extinct? These questions are being posed increasingly by amateur and professional biologists as we witness the closure, dispersion, and scaling back of natural history collections and cutbacks affecting curatorial personnel. Noteworthy examples include the elimination of several collections and removal of the herbarium curator at the University of Nebraska State Museum, the transfer of the herbarium collections from the University of Iowa to the herbarium of Iowa State University, and the narrow escape from closure for the University of Arkansas herbarium in Fayetteville. These and other events at various institutions have prompted several recent editorials in the science literature stating that the nation's natural history collections are "in crisis" (Dalton 2003, Gropp 2003, and Raven 2003). What about Oklahoma's herbaria? Should we be concerned about their health and well-being? What can we do?

The first thing we can do as natural historians and concerned citizens is to dispel misinformation. For example, herbaria and other natural history collections should not be portrayed as the equivalent of a "stamp collection" (as I heard once from a botanical colleague), but rather as *biological research collections*. This latter phrase is the foundation for the acronym of the National Science Foundation program (the BRC program) that funds infrastructural improvement and computerization of natural history collections. A herbarium is more than just the physical collection of plants that have been pressed, dried, and stored in packets or mounted on paper of archival quality. Specimens include labels with critical information about the plant's identity, geographic location, ecological habitat, flowering time, and collecting history. Each specimen embodies the species' morphology (its phenotype) AND its genome (its genotype). In other words, each specimen represents valuable DATA and the entire collection should be viewed as a vast data and DNA bank. Oklahoma's herbaria serve as important resources for its citizens and as critical research tools for an international network of scientists, educators, resource managers, and amateur botanists (see Funk 2003).

Thirteen herbaria with combined holdings exceeding 450,000 specimens constitute the "Oklahoma herbarium community" (Table 1). Twelve of these herbaria are listed in *Index Herbariorum* (Holmgren et al 1990), which is the official international registry of herbaria compiled by the International Association for Plant Taxonomy and the New York Botanical Garden. Each herbarium has noteworthy regional, ecological, and taxonomic specializations. Despite the size and significance of the collections, most of Oklahoma's herbaria are inadequately supported, some have no "hard" budgetary support, most need facility upgrades, and the majority is maintained by the efforts of one or two individuals with limited help from students and a few volunteers. Faculty retirements, budget cuts, and personnel changes make some herbaria "vulnerable." To return to the opening question, some of Oklahoma's herbaria can be categorized as "endangered", because they meet the criterion of possible extinction in the foreseeable future. What is being done to ensure their survivability?

Oklahomans are fortunate to have a highly interactive network of plant taxonomists. More than in most states, plant taxonomists from across Oklahoma have an uncommon sense of collegiality and are collaborating to study the state's flora, to database label information from Oklahoma plant specimens, and to interact with the community of amateur botanists such as those in the ONPS, TNC, etc. Nine botanists representing seven institutions are working to complete a modern flora for the state – the *Flora of Oklahoma* project. Additionally, botanists at OU and OSU working with their colleagues in the Oklahoma herbarium community are recording label data from Oklahoma plant specimens for the *Oklahoma Vascular Plants Database* project. Both of these projects draw on collective knowledge, advance the study of Oklahoma's flora, share scientific expertise and resources, and promote the significance of the state's herbarium collections. Despite these positive developments, there are many areas where the public's help is needed to avoid extinctions.

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Herbaria need advocates in both the professional and public arenas. Just as individual curators must promote research and the importance of their collections to administrators and colleagues, amateur botanists both individually and collectively must elevate public awareness of the importance of herbaria. At the University of Arkansas, two events apparently impressed administrators and "saved" the herbarium from closure – the mass response from the professional botanical community and the widespread support throughout Arkansas from amateur botanists and natural historians. Some important lessons from the Arkansas case are the significance of outreach efforts and the reciprocal nature of herbarium activities. In Oklahoma, I am constantly impressed with the number of curators and professional biologists that maintain active public service involvement as officers and board members of organizations and through participation in lectures, field trips, workshops, and other functions. These activities result directly and indirectly from the presence of functioning herbaria located throughout the state and from the actions of knowledgeable professional staff.

In view of the "crisis" impacting natural history collections and herbaria nationwide, I urge amateur botanists to advocate for and to assist herbaria whenever possible. One mechanism to do this is to use the *PVC model*: **P**articipate in sponsored activities, **V**olunteer your services, and **C**ommunicate your support to others. Oklahoma's herbaria need your help to avoid local or regional extinction. A quick perusal of Table 1 indicates that there is a herbarium located conveniently near you. Support your local herbarium; help preserve our botanical heritage!

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Table. Approximate numbers of specimens housed in the Oklahoma herbarium community

Index Herbariorum acronym	Institution and location	Number of total specimens	Number of Oklahoma specimens
CAMU	Cameron University, Lawton	6000	5000
CSU	University of Central Oklahoma, Edmond	10,000	9000
DUR	Southeastern Oklahoma State University, Durant	20,000	12,000
ECSC	East Central University, Ada	6000	6000
NOSU	Northeastern State University, Tahlequah	6000	5500
NWOSU	Northwestern Oklahoma State University, Alva	5000	4000
OCLA	University of Science & Arts of Oklahoma, Chickasha	20,000	18,000
OKL	University of Oklahoma, Norman	210,000	150,000
OKLA	Oklahoma State University, Stillwater	140,000	112,000
ORU	Oral Roberts University, Tulsa	6000	5500
TULS	University of Tulsa	10,000	8000
WOH	Southwestern Oklahoma State University, Woodward	11,000	10,000
---	Oklahoma Panhandle State University, Goodwell	3000	2500
	TOTALS	**453,000**	**347,500**

ONPS

Editorial
Why Do Species' Names Change?

Patricia A. Folley

The reason why scientific names change is because research is constantly correcting errors and scholarship is constantly untangling the related misconceptions. Until the advent of the Internet new names and name changes were approved by the International Botanical Congresses that met at ten-year intervals. Between intervals, proposed new names were published by recognized publications like *Rhodora* or *Sida*.

In 1994 John T. Kartesz of the *Biota of North American Program* published a two-volume second edition of *A Synonymized Checklist of the Vascular Flora of the United States, Canada, and Greenland,* which became the established reference for names of North American plants on the date of its publication. This work made the Flora of North America project practical by setting a base population against which the specialists could establish the limits of their work.

With this resource there are two transforming innovations that are currently bringing about more rapid name changes in North American flora. First, the advent of the Internet has vastly increased the speed of communication of scientific literature. Results of research are published on the Web within days of their discovery, and search engines make them accessible immediately.

The U.S. Department of Agriculture has long-maintained a database for plant names for use by its agents and agencies. When that database became available on-line, *with the inclusion of the Kartesz checklist*, any person with an Internet connection could find out the current status of a plant name within a few minutes. The USDA Plants database http://plants.usda.gov/plants then became the publisher for all additions and corrections to the Kartesz work, and changes are now posted daily. New names and combinations are also still published in print, including a detailed description of the plants involved. The impact on scholarship can be seen as the difference between the old "10 years or so" and the current "24 hours or so".

The second transformer is the *Flora of North America Project* (FNA) which was begun in 1982 at the Missouri Botanical Gardens. Since the publication of Vol. 1 in 1993 the Flora project has driven both scholarship and research into the details of floristics in America. The list of contributors includes plant systematists and taxonomists still living today. Conceived as a database project from the beginning, it both feeds and is fed by the Internet.

Standards for the FNA work have always compelled workers to research global archives. Information based on past assumptions required verification, and the verification process yielded unexpected results. Many contributors found themselves revising a lifetime of their own research before it could be accepted into the FNA. Verifying the work of contributors who have passed on is being continued by their successors. The majority of these efforts are being made by scholars and scientists who, while publicly funded for their teaching or research work, are not otherwise supported, and thus are volunteering their time and knowledge.

As users of botanical information, we are often challenged to know what "today's name" for a plant may be. But the outcome of the FNA project, coupled with the unparalleled access to the literature provided by the Internet, has made all of us better scholars with more reliable sources of information on the plants themselves. In time, the FNA project will also become a printed reality, and the rate of change will slow. However, it will never cease as long as the real plants out in the real world continue to evolve.

Folley, P.A.
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Editorial Policies and Practices

Oklahoma Native Plant Record is published annually by Oklahoma Native Plant Society. Submission for publication in the journal is open to all. Manuscripts will be accepted on topics related to Oklahoma's regional botany, including historical research reports, current research articles, site record species lists, and descriptions of new or important species sightings in Oklahoma. Oklahoma's environmental gradients of human impact, climate, and elevation make us a prime target for research on habitat edges, species ranges, and edge species, but articles of other themes may be included as well. Important works overlooked by journals of broader geographic regions will also be considered for publication here.

Papers must not have been published previously or accepted for submission elsewhere and should represent research conducted in accordance with accepted procedures and scientific ethics. Submission of the article implies the granting of copyright permission to Oklahoma Native Plant Society.

Manuscripts will be reviewed for content and appropriateness by at least two reviewers. The title page should state the affiliation and complete addresses of all authors and telephone numbers for the corresponding author. Research and technical papers should include a one-paragraph abstract of not more than 250 words. It should concisely state the goals, principal results, and major conclusions of the paper. All references, figures, and tables should be cited in the text. Common names should be referenced to a scientific name. Abbreviations of authorities for scientific names should follow Authors of Plant Names (Brummitt and Powell, 1992). Titles of periodicals should be abbreviated following Botanico-Peridoicum-Huntianum and its supplement - except in historic publications when original format will be used.

Authors with access to IBM-compatible microcomputers are encouraged to send a copy of the manuscript on diskette in rtf (rich text format). If the manuscript is typed, manuscripts should be double-spaced on 8 $^{1/2}$ X 11 inch paper with minimum one-inch margins and should be submitted in duplicate. Diskette or hardcopy manuscripts should be sent to the managing editor at the ONPS address on the back cover by June 1.

Oklahoma Native Plant Society
c/o Tulsa Garden Center
2435 South Peoria
Tulsa, Oklahoma 74114

Oklahoma Native Plant Society
c/o Tulsa Garden Center
2435 South Peoria
Tulsa, Oklahoma 74114

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