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

Cover photo: *Aesclepias speciosa* by Leslie Cole, ONPS photo contest winner

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Oklahoma Native Plant Record

Volume 13

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Foreword

This year we have a special Critic's Choice Essay, "A Cavalcade of Field Botanists in Oklahoma" by Ron Tyrl and Paula Shryock. It is a tribute to all those botanists who have contributed to the database of native plant species in Oklahoma. Many are native Oklahomans. Many have been members of the Oklahoma Native Plant Society. All have been dedicated to documenting the state's botanical diversity. They have been compiling biographical and professional information to write this article for us for several years. We are excited to share it with you in Volume 13.

One of those botanists Ron Tyrl writes about is Connie Taylor, author of our historical article in this volume. A Professor Emeritus at Southeastern Oklahoma State University, she submitted her Master's thesis to the University of Oklahoma in 1961, based on research done in the Water Canyon Complex. It is a taxonomic comparison of the canyons, based on their ecology; their geology, microclimate, and habitat. She has revised her thesis and updated her species list so that we can make the data globally available. Her figures and detailed descriptions of the canyons help the reader picture the landscape and hypothesize about the causes and effects of the environmental conditions with which the species interact. Data from this study could provide an important building block for long term ecological studies and future research in climate change effects.

While many researchers have reported on the effects of fire, a common environmental factor in Oklahoma, Stan Rice and Sonya Ross have been looking at several different effects of fire, including the effects of chemicals in smoke on plant establishment after a fire. It is a preliminary report that looks at germination rates of *Phacelia strictifloria* seeds that have been watered with smoke-produced chemicals dissolved in water.

Also in this issue, Amy Buthod, of the Oklahoma Biological Survey and Oklahoma Natural Heritage Inventory, provides us with another valuable flora; that of the Oxley Nature Center in Mohawk Park in Northwestern Tulsa County. This study has provided voucher specimens for Oxley personnel to use in education and outreach, as well as a species list for their use and for your enjoyment when you visit there.

Open access journals published by non-profit or not-for-profit organizations can provide a quick way to share data and bring valuable feedback to the author. They are a valid way of ensuring conflict of interest is not the issue that it can be when publication is profit driven. However, it depends heavily upon authors to review each other's articles and upon volunteer editorial staff to proof-read and format them. Please volunteer to write, review, or serve on the editorial board of the *Oklahoma Native Plant Record*. We need your help to get more of Oklahoma's native plant research out to the world.

Remember to tell everyone that all volumes of the *Record* are now available online through Oklahoma State University's Edmon Low Library as an e-journal publication. Our abstracts are indexed by the Centre for Agricultural Biosciences International (CABI). The journal is listed in the *Directory of Open Access Journals* (DOAJ). It can be accessed globally at http://ojs.library.okstate.edu/osu/

Sheila Strawn
Managing Editor

ECOLOGY AND TAXONOMY OF WATER CANYON, CANADIAN COUNTY, OKLAHOMA

Master's Thesis, University of Oklahoma 1961
[Revised 2013]

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Keywords: disjunct species, erosion, microclimate, plant distribution, sediment, Caddo Canyons, Acer saccharum

[ABSTRACT]

Numerous canyons have been cut into the Rush Springs Sandstone of Permian age in West Central Oklahoma and subsequently refilled. Some of these canyons have been partly exposed by erosion of the sediment fill. Fossils collected indicate the canyon fill is sub-Pleistocene to geologically recent. The microclimate of these canyons is more mesic compared to the dryer prairie uplands. Sugar maple (*Acer saccharum*) persists there, far west of its other locations in very eastern Oklahoma. Beginning in 1932 several of these sediment-filled canyons began a process of rapid erosion, exposing the rock walls of the canyons. This study is a comparison of Water Canyon and two of its branches: Water Branch Canyon, a stable canyon wooded with mature vegetation including sugar maple and Activity Branch Canyon, a newly excavated canyon branch that began eroding after excessive rainfall in 1932. This study was completed in 1960. Six transects are used to show the distribution of the 233 plant species found in the Water Canyon complex. Herbaceous species generally were unique to each canyon type.

[2013 INTRODUCTION]

This 1959-60 study of the Water Canyon complex, a part of the Caddo Canyons, compares the vegetation of an actively eroding canyon branch to the vegetation of a more stable canyon branch. At the time of the study, there was little overlap of herbaceous species in the two branches. With over 50 years of succession, it would be most interesting to compare the current vegetation of the recently eroded Activity Branch of Water Canyon with that currently present in the more stable and mature Water Branch Canyon to see how many species of the more stable canyons have become established.

Scientific names have been updated according to USDA PLANTS Database, 2013. Common names have been added according to Taylor and Taylor (1994).

1961 INTRODUCTION

This morning we continued up the south side of the creek . . . at the point where the road strikes the crest of the ridge we found ourselves only one mile from the river, and continued . . . until we reached the head of Spring Creek, where we encamped, making our day's march sixteen miles. The valley of Spring Creek . . . is a mile in width, abundantly watered, arable soil,

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> *and timbered with black walnut, elm, hackberry and cottonwood. It is in the immediate vicinity of the Upper Cross Timbers, where postoak timber is abundant. It is also directly opposite the head of the Little Washita River, where there is said to be hickory and sugar-maple timber, within a distance of ten miles from this place.* (Foreman 1939)

On May 22, 1849, Captain R. B. Marcy made camp near the head of what is now Boggy Creek in Caddo County, Oklahoma. The next day, he and his company travelled the ridge dividing the South Canadian River and Sugar Creek (called by him, Little Washita) drainage basins. This prairie road passes through one of the most interesting and unique areas in Oklahoma. Within a half mile of both sides of the divide lie numerous steep walled canyons where water flows year round and eastern sugar maples (*Acer saccharum*) occur (Little 1939; Taylor 1960). The relic maples here are growing 160 to170 miles (258 to 273 km) west of their western most locations in eastern Oklahoma.

The Caddo Canyon area, as it is frequently called, lies principally in northeastern Caddo County and southwestern Canadian County. Steep box canyons have vertical rock walls at their upper end. Numerous canyons occur from Binger, Oklahoma to 8 miles (12.8 km) north of Hinton in Blaine County, and from 4 miles (6.4 km) west of Hinton, east along the South Canadian River into Canadian County to a point northeast of Cogar. To the west of the general area, the streams flow in shallow V-shaped valleys approximately 50 feet (15m) wide. North of Hinton, on the north side of the South Canadian River, a few shallower box canyons are found, but most streams there are in rounded valleys where erosion has not removed the sediment from the canyon walls.

The so-called Caddo Canyons are located in the South Canadian and Washita river basins which are separated by a relatively narrow ridge or divide. Marcy's route followed the ridge, which is now traversed by Oklahoma State Highway 37 between Cogar and Hinton, and by a section line road west of Hinton. The steep canyons have cut back into the ridge for distances of a mile or more. Downstream they gradually spread out into low rounded valleys. The South Canadian River is three to five miles (5-8 km) north of the ridge; whereas, the Washita River lies about 24 miles (38 km) south of the divide. The canyons of the Washita drainage flow first into Sugar Creek which flows to the southeast into the Washita River. The canyons on the north side drain directly into the South Canadian River.

THE STUDY AREA

Little (1939) studied the vegetation of four canyons: South, Devils, Kickapoo, and Water. Both Devils Canyon (site of the United Methodist Church Canyon Camp) and Kickapoo Canyon are located on many maps. South Canyon is now called Red Rock Canyon and is the location of a state park. The exact location of Water Canyon was not mentioned by Dr. Little. However, Smith (1930), in her study of the geography of Canadian County, includes a map of the county's water drainage and the location of this canyon.

The Water Canyon complex was chosen for detailed study because many disjunct species occur there and its branches are representative of the two major canyon types. It is located in the very southwestern corner of Canadian County. Hinton, Oklahoma is five miles (8 km) west; the small community of Niles is on the eastern edge. The main stream of the complex flows

directly 4.5 miles (7.2 km) from its head to the South Canadian River (Figure 1).

This study dealt with the vegetation in the canyon proper and its two large east-west branches. The northern boundary was placed at the Moss Grove School site's section line bridge which is about 1.5 miles (2.4 km) south of the South Canadian River. The vegetation here is similar to the floodplain, which has been greatly influenced by human activity. Oklahoma State Highway 37 defines the boundary of the canyon complex drainage on the south and west, while the north-south section line road which passes through Niles roughly defines the drainage boundary of the east side of the study area. The area studied is located in T11S, R10E in Sections 3, 4, 5, 8, 9, 16, and 17.

Creeks in the canyons on the south side of the South Canadian River flow northward, entering the river at more or less right angles. Therefore, that part of the Water Canyon complex, which was designated as the Main stream, flows from the very north central part of Section 16 north to the Moss Grove School bridge and on to the South Canadian River. There are four major branches in the complex.

There are two major types of canyons in the Caddo Canyons. Previously excavated, stabilized canyons with deep sheer walls, little erosion, and mature trees are the first type. Water Canyon Branch is an example of this type. Other examples are the Red Rock Canyon State Park and Devils Canyon. The other type of canyon is characterized by recent rapid erosion, having been excavated to depths of as much as 100 feet (30 m) starting in 1932. With slump, unstable slopes, and young trees, Activity Canyon Branch represents this type.

This research was done from September 1959 to September 1960. Specimens are deposited in the Bebb Herbarium at the University of Oklahoma, Norman, Oklahoma.

[Portions of Water Branch, as well as the main canyon, now have dams, including the northeast corner of Sec. 4. Google Maps (Niles Cemetery, Canadian, Oklahoma) shows the upland vegetation strongly contrasts with the mesic vegetation in the canyons which are dark green.]

GEOLOGY

Canyon Formation

The canyons are cut in the Whitehorse Formation of late Permian age (270-250 million years ago). The upper member, Rush Springs sandstone, is a poorly cemented and very friable rock with much cross-bedding. It varies from 160 to 300 feet (48 to 91 m) in thickness. The lower Marlow member in its upper part is composed of red brick shale with bands of white sand, sandy gypsum, and thin beds of dolomite. It is approximately 120 feet (36 m) thick. The box heads and upper canyons are cut in the Rush Springs sandstone; the lower parts farther downstream 1.5 to 3 miles (2.4 to 4.8 km) are cut in the Marlow member. The general widening into rounded valleys is due in part to the Marlow member being more easily eroded.

The origin of the canyons is not completely known. They are believed to have formed after the creation of the South Canadian River, which controls the water gradient of drainage in the area. In road cuts along State Highway 37, rounded quartzite pebbles form a layer at about the 1600 foot (480 m) contour level. This pebbly deposit is believed to have been laid down by the ancestral Canadian River during the early part of the Pleistocene. Since that time, the river has moved 4 miles (6.4 km) north of this locality and has cut down about 300 feet (480 km). The highest elevation in the study area is slightly over 1700 feet (510 m) and the lowest point is approximately 1380 feet (415 m) at the stream near Moss Grove School bridge 3 miles (4.8 km) away. Rough calculations from the topographic map

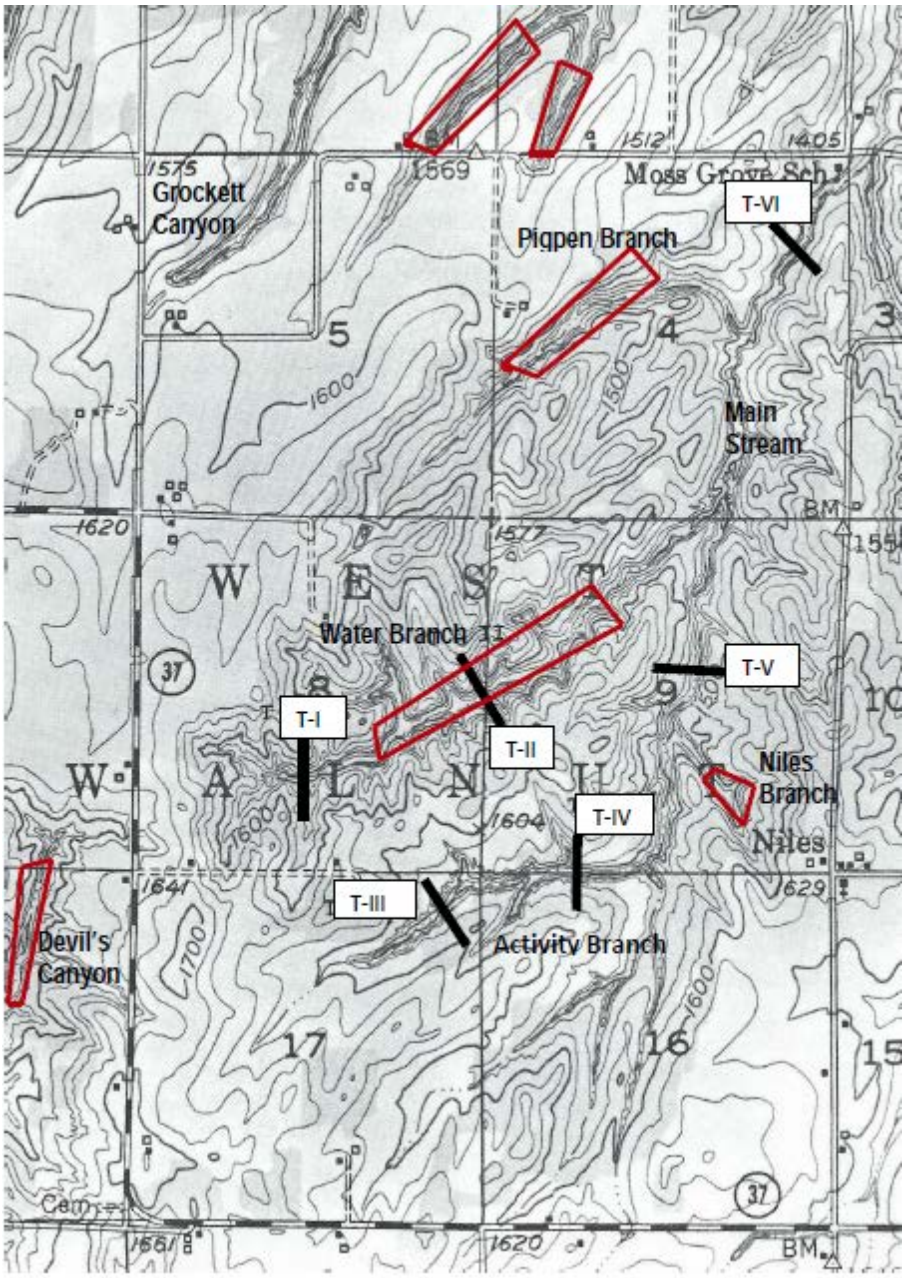

Figure 1 Canyon Transect Locations. Binger Quadrangle map, 1951. U.S. Geological Survey. Black lines indicate *Transects I* through *VI*. Red outlines indicate sugar maple habitats.

indicate the gradient of the stream bed from the head of Water Branch to Moss Grove is about 80 feet per mile (24 m per 1.6 km). It is thought that four cycles of cutting occurred in relation to the ice ages (one million to 12, 000 years ago).

Norris (1951) suggests that rounded valleys were cut during the Nebraskan glaciations, with the box heads appearing during the Kansan. During the Illinoian stage of glaciations, the old canyons were widened and cut deeper. [Suneson and Johnson (1996) suggest the colder wetter glaciation periods produced permanent streams with waterfalls cutting back the box heads, and interglacial periods were a time of filling with sediment.]

Norris reports finding a sediment filled canyon. Once one is familiar with the area, other non-eroded canyons can be identified. The forested slopes indicate that erosion in most exposed canyons is currently slow. Several exceptions occur, among which are Activity Branch and Grokett Canyon. Here, rapid re-excavation has occurred since 1932. Before this time, small ravines marked the drainage channel. Mr. Frank Hagen states he drove lumber wagons across Grokett Canyon on a road which followed the entire north side of Section 5 (see Figure 1) as late as 1925. There is no record of a bridge. This location is about one-third mile downstream from the present box head, and the sheer walls of the canyon are over 70 feet (21 m) in height.

Activity Branch began its extensive erosion May 31, 1932, when a reported 15 inches (38.1 cm) of rain fell in the area within 12 hours. This was followed by a week of extremely rainy weather. Here too, almost one-half mile of ravine was eroded and re-excavated back to bedrock canyon. The drainage area had been cleared, recently plowed, and planted to cotton just prior to the rainy period. This increased runoff of the drainage area and the increase in the amount of sediment carried by the stream has affected the topography of the main stream. At Moss Grove, a bridge 25 feet (7.5 m) in height is now necessary to cross the stream. Local inhabitants report that upstream a 6 foot (1.8 m) fence was buried under sediment in less than 5 years.

Sedimentation and Fossils

Norris (1951) reports that the sedimentary fill in the canyons is composed of rather uniform particles. Close examination of the sandstone bedrock shows it too is composed of similar particles. It can thus be concluded that the sandstone bedrock was formed from wind deposited material, and that the fill in the canyons resulted from water deposition of the weathered parent rock. Various means were employed to date the sediments in certain areas. Fragile snail specimens were collected from various locations in several canyons. Dr. Branley Branson (Kansas State College) was kind enough to identify all specimens collected. Two snail species dated as sub-recent to sub-Pleistocene were identified as *Mesodon* sp. and *Viviparus* sp. These forms are characteristic of the more mesic forests in the eastern United States. Other species dated this age were *Helisoma triavolvis*, *Lymnaea bulimoides*, *Gyralus parvus*, and *Succinea avara*. Dated as recent forms were *Zonotoides arboreus*, *Polygyra stenotrema*, *Monodon aliciae*, *Physa anatina*, *P. halei*, and *Helicodiscus parallelus*. [These investigations were later published by Branson, Taylor, and Taylor (1962, 1982).]

Soil samples taken near the box head of Niles Branch were analyzed for pollen. Each sample was collected 6 inches (15.24 cm) into the slope at 5 feet (1.5 m) intervals vertically. The first sample was taken about one foot above the stream bed; the last sample was taken about 2 feet (0.6m) below the rim. Care was taken to avoid contaminating samples with surrounding soil that might have been washed down from the top. All samples were found to contain fossil pine pollen, *Pinus* sp. The nearest stands of pine growing naturally in

Oklahoma are the shortleaf pine, *Pinus echinata* Mill., found near Coalgate, about 150 miles (240 km) southeast of the study site. Grass and oak pollen were also abundant. Dr. L. R. Wilson, Oklahoma Geological Survey, University of Oklahoma, made the analysis.

Near the junction of Niles Branch and the main stream several fossil seeds were dug out of a 50 foot (15 m) sediment wall. Specimens were removed about 20 feet (6 m) above the base. The seeds are probably those of *Celtis occidentalis*. In the same layer with the seeds were several fingernail clam shells in the Order Sphaeriidae. Species could not be determined.

A buffalo (*Bison bison)* molar was also found in this general area, and along the main stream a buffalo skull was dug out of a sediment wall. The specimen was located about 27 feet (8.1 m) from the base of a 40 foot (12 m) wall. Soil around the specimen was very firm, while the skull itself was extremely fragile. The probable age is late Wisconsin.

CLIMATE

Since the soils in the area are all derived from sandstone, the controlling factors for vegetation were topography and climate. The hot dry winds of summer are important in limiting the western extent of species. Maximum precipitation occurs during the spring and summer months. In this section, a large portion of the spring rains come during violent storms from the southwest. Much of the torrential rain water is lost in runoff despite the porous, sandy soil. Such rains are significant in erosion of the canyon sediments, particularly where vegetative cover is sparse.

Weather data since 1912 are available for Geary, Blaine County, Oklahoma which is about 14 miles (23.3 km) north. The table below gives the monthly average rainfall in inches and average temperature for the Geary Station. Averages are U.S. Weather Bureau data taken from 1931 to 1952.

The averages are given for a period of erratic rainfall that includes the drought period of the early thirties. The temperature during the summer frequently surpasses 100 degrees F (37.7 degrees C), though winter temperatures rarely go below zero degrees.

Rice (1960) studied the microclimate of a sugar maple stand in Devils Canyon located about one-half mile (0.8 km) west of the study area. This canyon drains into the Washita River. Data were collected from April to November of 1958. He compared the microclimate inside the canyon with that above the rim. Data were obtained during a relatively wet year, the precipitation being about twice the average during the summer months. Rice found that the average daily air temperature was consistently higher at stations located outside and just above the canyon as was the average daily air movement, which was from 3.5 to 15 times higher outside. After the first week in May, the average daily relative humidity was consistently higher at stations located within the canyon. The precipitation/evaporation ratio in the canyon was about 1:1; whereas, it was about 1:3 outside the canyon. Average soil temperature was also higher outside. These differences emphasize the more mesic environment in the bottom of the canyons as compared with the upland areas. Differences were greatest during hot, dry periods.

Sugar maple (*Acer saccharum)* has thus been able to retain numerous populations in the canyons as hot and dry conditions have eliminated this species from all but very eastern Oklahoma.

Table Average Monthly Rainfall (in.) and Average Temperature (°F)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	total
in.	1.23	1.17	1.63	2.87	4.14	3.89	2.14	2.66	3.03	1.91	1.50	1.34	27.51
°F	38.3	42.0	49.8	60.0	68.5	78.5	83.4	83.2	74.6	64.4	49.4	40.8	61.1

GENERAL VEGETATION OF THE AREA

According to the Duck and Fletcher Game Type Map of Oklahoma (1943), the two major vegetation types occurring in the area are the Tall Grass Prairie and Oak Woodlands. Due to the extensive cultivation of the upland area, its general appearance is that of Mixed Grasses. Among the more abundant species found here are western ragweed (*Ambrosia psilostachya*), little blue stem (*Schizachrium scoparium* var. *scoparium*), fall witch grass (*Digitaria cognata*), triple awn grass (*Aristida oligantha*), hairy grama (*Bouteloua hirsuta*), and Indian grass (*Sorghastrum nutans*).

On the more thinly soiled, steeper slopes not cleared for cultivation is found red cedar (*Juniperus virginiana),* blackjack oak (*Quercus marilandica*), and some post oak (*Q. stellata*). There, open savannahs become scrubby forests in places. The major grasses which grow in the savannah area are those listed above, particularly the triple awn grass and hairy grama. Prickly pear cactus (*Opuntia* sp.) is a prominent savannah species. The sheer walls of the canyon, especially on the north facing side, are frequently covered with mosses and lichens, depending on how long they have been exposed. The talus slopes of the stable canyons support a forest vegetation: sugar maple (*Acer saccharum*), hackberry (*Celtis* spp.), black walnut (*Juglans nigra*), chinkapin oak (*Quercus muehlenbergii*), bur oak (*Q. macrocarpa*), Shumard's oak (*Q. shumardii*), and American elm (*Ulmus americana*). An understory of redbud (*Cercis canadensis*), rough-leaved dogwood (*Cornus drummondii*), coralberry (*Symphoricarpos orbiculatus*), poison ivy (*Toxicodendron radicans* spp. *radicans*), and greenbriar (*Smilax* spp.) is to be found. The floor of the canyons have these same species, with slippery elm (*Ulmus rubra*) and blackhaw (*Viburnum rufidulum*) characteristically occurring. The stream is generally without vascular forms of aquatic vegetation.

Species occurring on the newly formed talus slopes were noted to come from two major sources. The first was the expansion of the clumps of vegetation which were not covered by soil when the slope or wall collapsed; these clumps usually occurred on the top of the slope. The second source of species was seed dispersal from plants growing in the area. The more stable and older slopes are covered by tall grass prairie species, the major species being little blue stem and Indian grass, with smooth sumac (*Rhus glabra*) and coralberry represented by scattered individuals. The bottoms of the actively eroding canyons, particularly in the upper end, are occupied by cottonwood (*Populus deltoids*) and black willow (*Salix nigra*), with some sandbar willow (*S. interior*). Downstream where less severe erosion has occurred, red cedar and chinkapin oak are predominant on the talus slopes and the floor, with Shumard's oak being common. The stream edges support stands of cattail (*Typha* sp.) and horsetail (*Equisetum* sp.).

The canyon complex, midway from its box canyon head to the floodplain, is characterized by much lower rims. The walls are soil and are rarely over 50 feet in height, being generally about 30 feet high, with severe erosion occurring. Deposition of

material in the stream is continuous. The trees on this flat floodplain are box elder (*Acer negundo* var. *texanum*), cottonwood, black willow, and American elm. Water speedwell (*Veronica anagallis-aquatica*) and members of the Cyperaceae are present along the stream edge and in other permanently moist areas.

DISJUNCT SPECIES

The accepted explanation for the presence of disjunct species in western Oklahoma is the relict vegetation theory. This theory proposes that at one time middle and western Oklahoma had a wetter climate, enabling the eastern maple forest to grow naturally throughout the state. As the climate became dryer and dryer, the western boundary of the distribution range of some species moved eastward.

In the Caddo Canyon area, the more mesic conditions of the canyons enabled the disjunct species to survive generation after generation. The presence of a number of disjunct herbaceous species seems to rule out chance seed dissemination to the area. The presence of pine pollen and fossil snails all tend to support the theory. Some of the canyons in the area would have to have been excavated at the time the more mesic vegetation receded or the habitat would not have been available for the survival of the disjunct species.

Sugar maple is the most obvious of the disjunct species. It has a rather large distribution—from Blaine County just north of Bridgeport to south of Binger in Caddo County, and from just west of Hinton to its eastward extension in Canadian County north of Cogar in the Cedar Lake Sportsman Club area. In only one location in the study area did maple become dominant, although it was a common tree in some areas. Figure 1 shows that the maples are found in three branches of Water Canyon, becoming dominant in Water Branch about halfway downstream from the head of the box canyon. In the head of the Niles Branch box canyon, sugar maple trees are distributed from the stream edge to the canyon rim. Trees at the latter location are small. No trees were of the large diameter reported by Little (1939). Several core samples were taken from sugar maple trees at a height of four feet. Many had rotten centers. Tentative identification of the disease is brown checked wood rot caused by *Polyporus sulphureus*. The year this study was done, no seeds were produced by the maple trees. An attempt was made to dig up several young trees, and it was found that they were attached by underground rootstock to the larger parent tree nearby.

A specimen of sugar maple from Blaine County was not collected, as the tree was discovered during the winter. It is located just northeast of the center of Sec. 17, T13N, R11W. This tree is growing on the upper half of the talus slope in a rather rounded canyon. The presence of maples on the rim or near it might suggest that they are fairly drought resistant.

There is one strong piece of evidence that suggests that the Caddo Canyon sugar maple might possibly be a different biotype than the eastern maples. On Oct. 3, 1954, Dr. G.J. Goodman, University of Oklahoma, made a trip to the Noble Nursery at Noble, Cleveland County, Oklahoma, where he collected specimens from two rows of sugar maple trees. One of the rows had been grown from stock obtained from an eastern nursery, while the other row had been grown from seeds collected in the canyons. The sun-scorched and dried leaves of the eastern maple were quite striking in comparison with the Caddo sugar maple. Dr. Goodman states that the difference between the rows of trees was much more striking than is indicated by the specimens. The collections, Goodman 6012 and 6013, are deposited in the Bebb Herbarium, University of Oklahoma, Norman, Oklahoma. Survival of the sugar maples in the canyons may be due partially

to the fact that they are a more drought resistant biotype than those that grow in eastern Oklahoma.

The disjunct species of coralroot (*Corallorhiza wisteriana*) was collected for the second time. This saprophytic orchid is a member of the more mesic eastern Oklahoma forests.

One of the most interesting disjunct species collected was figwort (*Scrophularia lanceolata*). It is reported to be present also in the Wichita Mountains. Identification of a duplicate specimen (Stevens No. 923) was made by Pennell and was cited in his work (Pennell 1935) on the Scrophulariaceae of the eastern temperate section of North America.

Other disjunct species which occur in the Caddo Canyon area are deertongue panicum (*Dichanthelium clandestinum*), woodnettle (*Laportea canadensis*), bonewort (*Cryptotaenia canadensis*), aniseroot (*Osmorhiza longistylis* var. *villicaulis*), fragrant bedstraw (*Galium triflorum*), daisy fleabane (*Erigeron annuus*), enchanter's nightshade (*Circaea lutetiana* ssp. c*anadensis*), and purple-leaved willow weed (*Epilobium coloratum*). The only collections of *E. coloratum* from the state are from the canyon area. Hackberry (*Celtis occidentalis*) is also disjunct; however, specimens have been collected from Custer County, farther west. Many species reach their western limit in the canyon area, and these are usually found growing in the stable type canyons.

One specimen of dwarf prairie willow (*Salix humilis*) [later corrected to *Salix exigua*] was collected. Verification of the identification of this specimen, as well as that of a specimen tentatively identified as slender muhly (*Muhlenbergia tenuiflora*) [later corrected to *Muhlenbergia sobolifera*], will add two more species to the list of disjuncts.

Although eastern redcedar (*Juniperus virginiana*) is not disjunct, its distribution in the area has had an interesting history. The local inhabitants of the area remember few redcedar occurring when they first settled the land in 1902. At the present time [1960], it is one of the most abundant and widely distributed species, occurring in almost all habitats. There are a number of very old trees, but most trees are small, young individuals. [Continued expansion of populations is such that in 2013, redcedar is considered a nuisance tree by the State of Oklahoma.]

HABITATS

The habitats described below all have distinctive vegetation types or species which are characteristic. One may delineate the habitats vertically from rim of canyon to stream edge in the bottom and horizontally from the box head to the Canadian River floodplain. They may also be separated into two distinct types. Niles, Water, and Pigpen Branches represent the first type of canyon where very little erosion is taking place at the present time [1960]. They may be described as stable. Activity Branch is an example of the second type which is characterized by rapid erosion that has resulted in the recent excavation of the sediment in the upper end of a previously filled bedrock canyon.

The vegetation growing in the habitats along the main stream is similar to the second or recently excavated type. Habitat locations are discussed below with the use of six transects taken across the canyon branches at various positions from the box head to the floodplain. Transect locations are indicated on the study area topographic map (see Figure 1). Distribution of species within the habitats of the transects are found in the Appendix.

Water Branch illustrates the typical habitats of the stable type canyons. *Transect I* (Figure 2) is taken at the box head where two habitats may be distinguished: the canyon floor (a) and the plunge pool-seep area (b). *Transect II* (Figure 3) is taken about one-half mile from the box head and is typical of most of the branch. Sheer

bedrock walls typical of *Transect I* are also present as a result of the stream meandering from wall to wall eroding sediment away from the bedrock walls. Major habitats that were collected here are: the north and south facing slopes of sediment remnants (a), the floor of the canyon (b), and the stream edge (c).

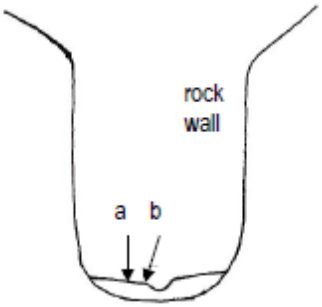

Figure 2 *Transect I* (T-I)
Water Branch's stable box head
a floor
b plunge pool-seep area

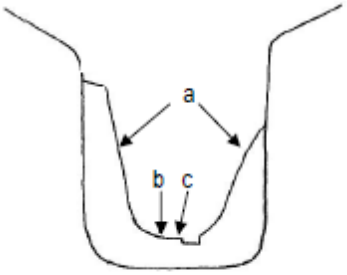

Figure 3 *Transect II* (T-II)
One-half mile downstream from Water Branch's stable box head
a talus slopes
b floor
c stream edge

Activity Branch represents the rapidly eroding type of canyon. The upper half of the canyon is more eroded than the lower end. *Transect III* (Figure 4), taken about one-fourth mile down from the box head, shows the following habitats: extensive north (a) and south (b) facing talus slopes, which are continuously changing; floor of the canyon (c,) where deposition of sediment is common; and the stream edge (d,) which is frequently inundated. The sheer bedrock walls were recently exposed by erosion. The curve of the canyon from a slight southwest-northeast direction to a west-east direction has caused the stream to flow on the north side of the floor. Thus, a large portion of the remnant fill has eroded away on this side, exposing more of the wall. The slopes themselves are continually slumping, the sediment sliding into the stream bed. This causes a frequent change in the stream course. These habitats, exclusive of the slopes, occupy the box head area.

Transect IV (Figure 5), taken about three-quarters of a mile from the box head of Activity Branch, has habitats in the lower part where less erosion has occurred. Habitats include the north and south facing talus slopes (a), the floor of the canyon (b), and the stream edge (c). The rim is not as high above the canyon floor, and the width is slightly greater.

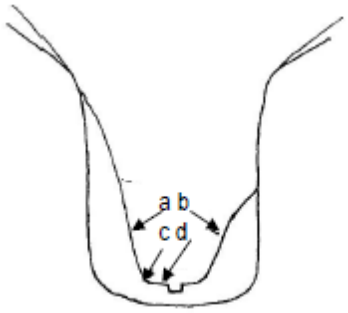

Figure 4 *Transect III* (T-III)
Upper half of Activity Branch's rapidly eroding canyon one-fourth mile downstream from its box head
a south facing talus slope
b north facing talus slope
c canyon floor
d stream edge

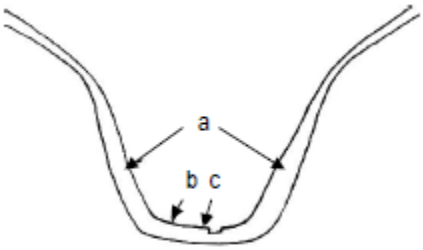

Figure 5 *Transect IV* (T-IV)
Lower half of Activity Branch canyon three-quarters mile from its box head
a talus slopes
b floor
c stream edge

Transect V (Figure 6) is taken along the main stream of the drainage between Niles Branch and Water Branch junction. The bedrock form in this area is probably of an older cutting cycle than that of Activity Branch, and the upper level habitat was probably at one time the bottom of the canyon. During the next cutting cycle, the channeling of water would have caused a new inner canyon to develop in the old canyon. As erosion developed this new inner canyon, the walls of the older canyon were rounded and the floor widened. Then the entire canyon complex was probably filled with sediment. The form of the topography at present is the result of geologically recent erosion. Habitats in this transect are: upper slopes (a), in which the sheer rock walls may reach a height of 50 feet (15 m); the slump slopes (b), resulting from the sediment not yet removed by erosion; the floor (c); and stream edge (d).

Transect VI (Figure 7), taken at the north end of the study area near the Moss Grove School site, shows later development of the previous profile. Here the canyon proper is wider than its approximately 35 foot (10.5 m) depth. The upper level has developed into an extensive flat area which is cultivated and grazed. For this reason it was not studied. From the rim there are stable slopes (a) into the canyon, and at one time the local inhabitants crossed without the need of a bridge. The meandering of the stream from one side of its bed to another has cut into these slopes and produced, in many places, sheer sediment walls which are continuously collapsing into slump slopes (b) above the floor (c) and stream edge (d). Not studied was one small area that was commonly covered with a few inches of standing water. It was the only marsh type habitat noted.

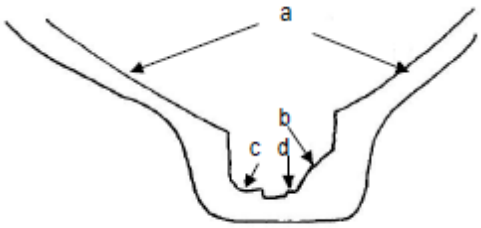

Figure 6 *Transect V* (T-V)
Main upper canyon between its Niles and Water Branch junctions
a upper slope
b slump slopes
c floor
d stream edge

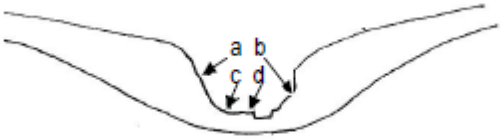

Figure 7 *Transect VI* (T-VI)
Main lower canyon downstream from its Water Branch junction
a stable slopes
b slump slope
c floor
d stream edge

VEGETATION OF HABITATS

***Transect I* – Across the box head of Water Branch** (See Figure 2)

The north and west facing sheer bedrock walls are almost continuously shaded and are covered with lichens and liverworts. Dry as this habitat may be, after rains, when the air is very humid, the walls take on a definite green hue. In some places, the wall has a narrow ledge where the most important species are grasses.

Virginia creeper (*Parthenocissus virginiana)* and poison ivy (*Toxicodendron radicans*) climb the walls to considerable heights. The ferns found in crevices and at the base of the wall are lady fern (*Asplenium* sp.), Eaton's lipfern (*Cheilanthes castanea*), purple cliff break (*Pellaea atropurpurea*), and blunt lobed cliff fern (*Woodsia obtuse*). Little (1939) states that *Reboulia hemisphaerica* is the common liverwort in the shaded moist areas. The south facing sheer bedrock walls receive considerable sun and vegetation is sparse. Near the base of the cliff where the walls are shaded by trees, the species are the same as those listed above.

The plunge pool-seep area has two major divisions. On the walls of the seep area, which are moist at all times, *Conocephalum conicum* is common. Ferns, such as common bladder fern (*Cystopteris fragilis)*, may be found. These areas are almost continually shaded, and where there is enough soil for herbaceous plants, the following species are found which are characteristic of the seep habitat (see Appendix). These are hairyseed paspalum (*Paspalum pubiflorum* var. *glabrum*), fragrant bedstraw (*Galium triflorum)*, small flower brookweed (*Samolus parviflorus)*, and water speedwell (*Veronica anagallis-aquatica)*, the latter not being restricted to the seep area. The plunge pool at the base of the cliffs where stream runoff comes over the rim does not have aquatic or wetland vegetation zonation, probably due to the fluctuation of the water level.

The floor at the base of the canyon extends to the base of the walls. Many of the species found on the slopes and in the more shaded parts of the canyon are present here. However, the trees are young without dense forest canopy, allowing denser growth of understory plants. Here, greenbriar (*Smilax* sp.) and poison ivy make passage very difficult. Chinkapin oak (*Quercus muhlenbergii*), American elm (*Ulmus americana),* and redcedar (*Juniperus virginiana*) are the common trees. The forenamed vines and grape (*Vitis* spp.), which climb the wall, are extensive. Species which grow here are not only those of the shaded slopes, but many upland grasses such as bluestem (*Schizachrium* sp.) and grama grass (*Bouteloua* spp.) are found less extensively.

***Transect II* – One-half mile down from Water Branch box head** (See Figure 3)

The walls in *Transect II* are similar to the walls at the box head. The talus slope generally slants up at an angle of over 60 degrees, but the dense vegetative cover is a great deterrent to erosion. In places where a path has been made up the slope, deep ruts are now present.

The vegetation of the slopes are variable, determined by degree of slope, age, and soil stabilization. The major woody plants are American elm, chinkapin oak, bur oak (*Quercus macrocarpa*), Shumard's oak (*Q. shumardii*), redcedar, netleaf hackberry (*Celtis reticulata*), sugar maple (*Acer saccharum*), and black walnut (*Juglans nigra*). Major understory species are redbud (*Cercis canadensis*), rough leaf dogwood (*Cornus drummondii*), elbowbush (*Forestiera pubescens*), and coralberry (*Symphoricarpos orbiculatus*). Virginia wild rye (*Elmus virginicus*) seemed to be the most common grass in the less densely shaded areas. Herbaceous species were limited in number, the most common being the sedge (*Carex artitecta*) and Missouri violet (*Viola missouriensis*). The ground had a very dense covering of mosses, the major species being *Mnium cuspidatum*. No attempt

was made to identify the bryophytes. Little (1935) gives a fairly comprehensive list of the species of this group and the Pteridophytes which occur in the Caddo Canyon area.

There are several differences in the north and south facing slopes. The species are the same, but the south facing side has a slightly thinner tree canopy, particularly near the rim, and the density of shrubs and herbs is slightly greater. The major difference was the number and abundance of upland species which could be found on the upper slopes of the canyons right below the rim. As is expected, both number and abundance were greater for the south facing side. I have included many of the upland species which grow in this area and have indicated them with a "u" (see Appendix). It was interesting to note that many of the upland species found here were not found in other places throughout the canyon complex. Many of these species were collected in the few areas along the slopes where there is slight erosion or in clearings.

The floors of the stable type canyons supported almost all species present in the slope habitats. They contained many species not found on the slopes, including hackberry (*Celtis occidentalis*), white mulberry (*Morus alba*), red mulberry (*M. rubra*), green ash (*Fraxinus pennsylvanica*), and slippery elm (*Ulmus rubra*). Shrubs such as blackhaw (*Viburnum rufidulum*) and wahoo (*Euonymus atropurpurea*) were mostly limited to this habitat, while both greenbriar and Virginia creeper were usually on the more level grounds. Grasses found only in this locality were stout woodreed (C*inna arundinacea*) and slender muhly (*Muhlenbergia tenuiflora*). When the upland species found on the slopes are not taken into consideration, the number of herbaceous species was greater for this habitat. Some of the more common herbs included green dragon (*Arisaema dracontium*), day-flower (*Commelina erecta*), and white avens (*Geum canadense*).

The stream itself was generally one to three feet below the general canyon floor. Among the characteristic species of the stream edge were coralroot orchid (*Corallorhiza wisteriana*), veiny pepperweed (*Lepidium oblongum*), bloodleaf (*Iresine rhizomatosa*), richweed (*Pilia pumila*), false nettle (*Boehmeria cylindrica*), elephant's foot (*Elephantopus carolinianus*), and inland sea oats (*Chasmanthium latifolium*) which reached its greatest development here.

Transect III **– Upper end of Activity Branch** (See Figure 4)

The box head of Activity Branch does not contain any distinct vegetation types. The recent exposure of the canyon bedrock walls is the reason for the limited development of the liverwort population. The talus slopes here have only been recently formed, and many are not stabilized. Some are presently being held by a rather dense grassland cover, as trees are absent or rare on the slopes. The north facing slope supports more mesic vegetation than the south facing slope. Major grasses are little bluestem (*Schizachrium scoparium*), Indian grass (*Sorghastrum nutans*), knotroot bristlegrass (*Setaria parviflora*), little barley (*Hordeum pusillum*), and others. The major grasses of the south facing talus slopes are bluestems in lesser quantity with purpletop (*Tridens flavus*) dominant in some localities. Species composition depends on the age of the slope.

The floor of the area near the box head is dominated by cottonwoods (*Populus deltoids*) about 25 years of age and by both sandbar and black willows (*Salix exigua* and *S. nigra*). It was noted that the sandbar willow was more abundant on the lower part of the talus slope than in the level bottom. In this canyon as well as in the others, the vegetation of the floor tends to extend up the bottom of the talus slope until the incline becomes steeper than 45 degrees. The extensive erosion of sediment from the drainage area above the canyon

and from the slopes has resulted in the deposition of sediment in the stream, burying the bases of the cottonwoods and willows. Here, during the spring, large portions of the canyon bottom are inundated. Farther downstream, Indian cigar tree (*Catalpa speciosa*) is abundant with a few elm trees. Many cedar trees only 4 feet (1.3 m) in height or less are dead, probably from inundation. Both poison ivy and greenbriar are present, but not to great extent. Barnyard grass (*Echinochloa crus-galli*) and water speedwell are present, but cattail (*Typha latifolia*) and horsetail (*Equisetum hyemale*) are the more abundant species of the stream edge.

***Transect IV*– Lower part of Activity Branch** (See Figure 5)

In this area of less erosion, the talus slopes are forested. The major woody species include red cedar and chinkapin oak, with Shumard's oak occurring frequently. Blackjack oak (*Quercus marilandica*) is also present. Coralberry is the common shrub, and bluestem and grama grasses are present in sunny spots. These slopes support a forest which is transitional between the upland forests and the more mesic forests of the box head area of the stable type canyons. The floor is not densely wooded, and greenbriar and bluestem cover most parts. The increased amount of water flowing through the stream, as well as the effect of deposition, cause the stream edge to closely resemble that of the upper end of the branch. Species which are most common along the stream edge are cattail and horsetail.

***Transect V*– Across the main stream and canyon** (See Figure 6)

The main stream has forest occurring on the upper level. Species here are generally the same as those of the slopes of Water Branch, but sugar maple is absent, and Shumard's oak is the predominant species along with chinkapin oak and American elm. The canopy is such that most of the shrubs are on the slope. Common are rough leaf dogwood, elbowbush, some blackhaw (*Viburnum rufidulum*), and coralberry. The moss ground cover is not as thick as that of the slopes of Water Branch. Herbaceous species are the same, but are few in number in comparison to the other habitats.

Along the main stream, the upper level begins to slope upward to the upland, and the more mesic oak forest gradually grades into the redcedar – blackjack oak shrub savannah characteristic of the less protected areas. In some places, the upper level slopes downward to the stream, but this is infrequent, as the sediment-carrying stream has caused extensive cutting, which in turn has produced sheer walls. The stream meanders from side to side and cuts under the walls, causing frequent collapsing with production of slump slopes. The common species of these recently produced slopes depend in part on the composition of species growing on the top before it collapsed. Other species include sandbur (*Cenchrus spinifex*), hairy grama (*Bouteloua hirsuta*), Canada wild rye (*Elmus canadensis*), sixweeks fescue grass (*Vulpia octoflora*), and little barley (*Hordeum pusillum*). Also, little bluestem is frequently found here. Woody species, such as smooth sumac (*Rhus glabra*) and coralberry, are present on the older slopes. Herbs include *Croton* spp., Wild buckwheat (*Eriogonum annuum*), white sweetclover (*Melilotus alba*), and yellow sweetclover (*M. officinalis*). It is felt that the list of species occurring in this habitat is not complete.

Woody species on the floor include hackberry, *Celtis* spp., green ash, Kentucky coffeebean (*Gymnocladus dioica*), chinkapin oak, Shumard's oak, and Indian cigar tree. These trees are widely scattered, and the floor habitat itself is quite narrow due to the wide stream edge where black willow is abundant. Occurring along the stream edge

with black willow is water speedwell, cattail, and horsetail.

***Transect VI* – near the Moss Grove School site** (See Figure 7)

Here, stable slopes around 35 feet (10.7 m) in height are common. Woody species are box elder (*Acer negundo*), redbud, redcedar, American elm with rough leaf dogwood, smooth sumac, and coralberry. Trees are widely spaced, and in the sunny areas one finds rescue grass (*Bromus catharticus*), Japanese brome (*B. arvensis*), Canada brome (*B. pubescens*), sixweeks fescue, and little barley (*Hordeum pusillum*), with various species of corydalis, croton, wild buckwheat, and sweet clover.

On the slump slopes, species present are characteristic of newly formed surfaces. These include water hemp (*Amaranthus tamariscinus*), toothcup (*Ammannia coccinea*), goosefoot (*Chenopodium hybridum*), carpetweed (*Mollugo verticillata*), and sandbur. The canyon floor is wider than the walls are high, and the meandering of the stream from side to side forms isolated spots of habitat. The trees occurring here are the same as those on the slopes, but box elder is more abundant. Cottonwood and black willow are common. Herbaceous species characteristic of this area are the grasses mentioned above for the stable slope plus Scribner's panic grass (*Dichanthelium oligosanthes* var. *scribnerianum*), meadow dropseed (*Sporobolus asper*), Venus looking glass (*Specularia holzingeri*), spurge (*Euphorbia heterophylla*), three-seed mercury (*Acalypha ostryaefolia*), salt marsh aster (*Aster exilis*), western ragweed (*Ambrosia psilostachya*), toothed spurge (*Euphorbia dentata*), and sweetclovers.

The stream edge is also wide at this location. Here also, frequent inundation and deposition of sediment occur. Horsetail and cattail are infrequent, with water speedwell being the more abundant species. In one isolated spot in the Moss Grove area there was a depression which was usually covered with water. Here several species occurred which were found nowhere else. They were fescue sedge (*Carex brevior*), slimpod rush (*Juncus diffusissimus*), one-flowered flatsedge (*Cyperus uniflorus*), dark green bulrush (*Scirpus pallidus*), swordgrass (*Scirpus americanus*), water speedwell, and barnyard grass which grew at the stream edge.

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APPENDIX

Species-Habitat List, Water Canyon, Canadian County, OK

In the following table the species are listed alphabetically within groups: Trees, Shrubs, Woody Vines, Grasses. Herbaceous species have been separated into groups: those found in the stable canyons and those characteristic of newly eroded canyons. Habitats are arranged by transects. The list may be considered the beginning of a complete species-habitat list for the canyon area and serve as an aid to others who wish to study the canyons.

x – present frequently, either evenly distributed as individuals or in occasional clumps.
s – species abundant in that habitat.
i – infrequent or rare. Used when only a few plants were found in several places or many individuals occurring in only one limited area.
u – indicates the species is normally a member of the upland communities but is occurring in the mesic woods of the stable type canyon.

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
TREES																				
Acer negundo L. var. *texanum* Pax				i	x			x							x		s		s	x
Acer saccharum Marshall			x	x	i															
Catalpa speciosa (Warder) Warder ex Engelm.					x			x	x		x	x			x	x			x	x
Celtis laevigata Willd. var. *texana* Sarg.			x										x		x					
Celtis occidentalis L.				x																
Celtis reticulata Torr.			x					x												
Cercis canadensis L.	x		x	x						x	x		x				x		x	
Fraxinus pennsylvanica Marshall				x	x			x				x			x				x	
Gymnocladus dioicus (L.) K. Koch			x	x											x					
Juglans nigra L.			x	x																
Juniperus virginiana L.	x		x	x				x		s	x		x		x		x		x	
Maclura pomifera (Raf.) C.K. Schneid.																				
Morus alba L.				x																
Morus rubra L.				x																
Populus deltoids Marshall								s							i				s	
Prunus mexicana Watson																	x			
Quercus macrocarpa Michx.			x	x						x			x							
Quercus marilandica Münchh.			u							u			u							

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Quercus muehlenbergii Engelm.	s		x	x						s	u		x		x					
Quercus shumardii Buckley			x	x						x			s		x					
Quercus stellata Wangenh.			u							u			u							
Robinia pseudoacacia L.								x												
Salix humilis Marshall															i					
Salix interior Rowlee								s	s						s	s			x	x
Salix nigra Marshall	i							s	s						s	s			x	x
Sapindus saponaria L. var. *drummondii* (Hook & Arn.) L.D. Benson			i																	
Sideroxylon lanuginosum Michx.			x	x						x			x							
Ulmus americana L.	x		s		x			i		x			x				x		x	
Ulmus rubra Muhl.				x																
SHRUBS																				
Aesculus glabra Willd. var. *glabra*			u	u									u							
Cephalanthus occidentalis L.																			i	
Cornus drummondii C.A. Mey.	x		s	s							x		x				x			
Celastrus scandens L.			x																	
Euonymus atropurpureus Jacq.				x	x					x							x			
Forestiera pubescens Nutt.	x		s	s				i		x			x							
Rhus glabra L.						i	i			x	x		x	x	x		x	x	x	
Ribes aureum Pursh var. *villosum* DC.			x	x	x															
Sambucus nigra L. ssp. *canadensis* (L.) R. Bolli			x	x									x				x			
Symphoricarpos orbiculatus Moench	x		x	x		i	i	x		x	x		x	i	x		x		x	
Tamarix gallica L.								x							x				x	
Viburnum rufidulum Raf.			i	s						x	x		x							
VINES																				
Campsis radicans (L.) Seem. ex Bureau															i				i	
Cissus trifoliata (L.) L.																				
Cocculus carolinus (L.) DC.			x	x	x								x							
Melothria pendula L.																	i			
Menispermum canadense L.			x	x																
Parthenocissus quinquefolia (L.) Planch.	x		x	x							x		x				x		x	

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Passiflora lutea L. var. *glabrifolia* Fernald			i																	
Smilax bona-nox L.	s		x	s				i			x		x		i					
Smilax tamnoides L.			x	x																
Toxicodendron radicans (L.) Kuntze	s		s	s				i			i						i			
Vitis acerifolia Raf.																			i	
Vitis vulpina L.	x		x																x	
GRASSES																				
Aristida oligantha Michx.							i	i						i			i	i		
Bothriochloa saccharoides (Sw.) Rydb.						x														
Bouteloua curtipendula (Michx.) Torr.						i	i							i			i	i		
Bouteloua gracilis (Willd.) ex Kunth						i	i							i			i	i		
Bouteloua hirsuta Lag.						x	x							x			x	x		
Bromus arvensis L.				u		x	x							x			x	x		
Bromus catharticus Vahl			u											x			x	x		
Bromus pubescens Muhl. ex Willd.			x	x		x	x							x			s	x	x	
Bromus tectorum L.			u														s			
Cenchrus spinifex Cav.						x	x							x	x		i	x	x	
Chasmanthium latifolium (Michx.) Yates			x	x	s															
Cinna arundinacea L.				i																
Cynodon dactylon (L.) Pers.								x							x				x	
Dichanthelium clandestinum (L.) Gould	x																			
Dichanthelium oligosanthes (Schult.) Gould var. *scribnerianum* (Nash) Gould			u			x	x	x						x	x		x	x	x	
Digitaria sanguinalis (L.) Scop.																	x			
Echinochloa crus-galli (L.) Beauv.				i					x			x				x				x
Elymus canadensis L.						x	x							x			x	x	x	
Elymus virginicus L.	x		x	x																
Eragrostis capillaris (L.) Nees			u														x			
Eragrostis curvula (Schrad.) Nees														x			x	x		
Eragrostis secundiflora J. Presl ssp. *oxylepis* (Torr.) S.D. Koch			i														x			
Eragrostis sessilispica Buckley			u																	
Eragrostis trichodes (Nutt.) Alph. Wood														x						

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Hordeum pusillum Nutt.			u			x	x							x			s	x		
Leersia virginica Willd.		x																		
Melica nitens (Scribn.) Nutt. ex Piper																	i			
Muhlenbergia racemosa (Michx.) Britton			i	i			x										i	i		
Muhlenbergia tenuiflora (Willd.) Britton				i																
Panicum capillare L.															i					
Paspalum setaceum Michx.																			x	
Paspalum pubiflorum Rupr. ex Fourn.		x																		
Phalaris caroliniana Walter																	x			
Schizachrium scoparium (Michx.) Nash	i		i	i		s	i			i	x			x	x		x	x	x	
Setaria parviflora (Poir.) Kerguélen			x	x		x	x							x			x		x	
Sporobolus clandestinus (Biehler) Hitchc.															x					
Sporobolus cryptandrus (Torr.) A. Gray														x						
Tridens flavus (L.) Hitchc.						s	x							x	x					
Vulpia octoflora (Walter) Rydb. var. *octoflora*			u											x			x			
HERBS –- STABLE CANYONS																				
Acalypha virginica L.					i												i			
Antennaria plantaginifolia (L.) Richardson			x	x																
Arisaema dracontium (L.) Schott				x																
Boehmeria cylindrica (L.) Sw.				x	x											x				
Carex albicans Willd. ex Spreng var. *albicans*			s	s																
Carex blanda Dewey			x	x																
Carex brevior (Dewey) Mack.			x	x																
Commelina erecta L.				x																
Corallorhiza wisteriana Conrad					i															
Desmodium canadense (L.) DC.				x	x															
Desmodium glutinosum (Muhl. ex Willd.) Alph. Wood				x																
Desmodium perplexum B.G. Schub.			u																	
Draba brachycarpa Nutt. ex Torr. & A. Gray					i															
Elephantopus carolinianus Raeusch.				x	x															
Erigeron philadelphicus L.					x											i				

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Eupatorium coelestinum (L.) DC.				x																
Euphorbia glyptosperma (Engelm.) Small			u																	
Euphorbia heterophylla L.			x	x															x	
Galium aparine L.			x	x	x									x			x	x		
Galium triflorum Michx.		x			x															
Geum canadense Jacq. var. *canadense*				x					x		x									
Hackelia virginiana (L.) I.M.Johnst.			x	x																
Houstonia pusilla Schoepf			u																	
Iresine rhizomatosa Standl.					x															
Lepidium oblongum Small var. *oblongum*					x															
Lobelia cardinalis L.					x															
Monarda clinopodioides A. Gray			u																	
Myosotis verna Nutt.			u																	
Oxalis dillenii Jacq.			u																	
Palafoxia texana DC.				u																
Pediomelum digitatum (Nutt. ex Torr. & A. Gray) Isely			u																	
Penstemon laxiflorus Pennell			i																	
Phemeranthus parviflorum (Nutt.) Kiger			u																	
Pilea pumila (L.) A. Gray					x															
Plantago patagonica Jacq.			u																	
Polygonum virginianum L.				x																
Polygonatum biflorum (Walter) Elliott				x																
Portulaca oleracea L.			u																	
Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt spp. *obtusifolium*			i																	
Samolus valerandi L. ssp. *parviflorus* (Raf.) Hulten		x																		
Sanicula canadensis L. var. *canadensis*				x																
Scrophularia lanceolata Pursh				x																
Spermolepis echinata (Nutt. ex DC.) A. Heller			u																	
Stillingia sylvatica L.			u																	
Tradescantia occidentalis (Britt.) Smyth			i	i	i								i							

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Verbena urticifolia L.				x				x												
Viola missouriensis Greene			x	x	x															
HERBS – RECENT TYPE CANYON																				
Acalypha ostryifolia Riddell																			x	
Acalypha virginica L.					i														i	
Amaranthus tamariscinus (Moq.) Sauer																		x	x	
Ambrosia psilostachya DC.						x	x							x	x		x	x		
Ambrosia trifida L.						x	x	x						x	x		x	x	x	
Ammannia coccinea Rottb.																		x		
Androsace occidentalis Pursh			u										x				i			
Aphanostephus skirrobasis (DC.) Trel.						x	x							x	x		x	x	x	
Apios americana Medik.														i						
Apocynum cannabinum L.														x			x	x	x	x
Argemone polyanthemos (Fredde) G.B. Ownbey						x	x							x			x	x		
Asclepias verticillata L.			i				x								x					
Asparagus officinalis L.								i												
Bidens cernua L.																		x		
Carex emoryi Dewey															x					x
Cassia fasciculata (Michx.) Greene var. *fasciculata*						i	i										i			
Chamaesyce maculata (L.) Small														x			x			
Chenopodium album L.						x	x							x			x	x	x	
Chenopodium simplex (Torr.) Raf.																			x	
Chenopodium leptophyllum (Moq.) Nutt. ex S. Watson			u																	
Cirsium undulatum (Nutt.) Spreng. var. *undulatum*																		x		
Conyza canadensis (L.) Cronquist			u	i		x	x	x			x			x	x		x	x	x	
Corydalis curvisiliqua Engelm. ssp. *occidentalis* (Engelm. ex A. Gray) W.A. Weber						x	x										x			
Corydalis micrantha (Engel. Ex A. Gray) A. Gray																	x			x
Croton glandulosus L. var. *septentrionalis* Müll. Arg.														x	x		x		x	

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Croton lindheimerianus Scheele var. *lindheimerianus*			u			x	x							x			x			
Cucurbita foetidissima Kunth																	x			
Cyperus echinatus (L.) Alph. Wood			u																	x
Cyperus retroflexus Buckley																				x
Descurainia pinnata (Walter) Britton			u		x									x			x			
Desmodium paniculatum (L.) DC. var. *paniculatum*						x	x													
Draba reptans (Lam.) Fernald													x							
Eleocharis montevidensis Kunth									x							x				x
Equisetum x ferrissii Clute (pro sp.) [*hyemale* x *laevigatum]*									x			x				x				x
Equisetum variegatum Schleich. ex F. Weber & D. Mohr									x											
Eriogonum annuum Nutt.			u			x	x							x			x			
Euphorbia dentata Michx.																			x	
Froelichia floridana (Nutt.) Maq.						i														
Gaillardia pulchella Foug. var. *pulchella*			u			x	x										x			
Geranium carolinianum L.			u														x		x	
Grindelia papposa G.L. Nesom & Suh			x	x										x			x	x		
Helianthus petiolaris Nutt.			x	x										x	x				x	
Heterotheca subaxillaris (Lam.) Britton & Rusby			u			x	x							x				x	x	
Hymenopappus scabiosaeus L'Hér. var *corymbosus* (Torr. & A. Gray) B.L. Turner						i	i	i						i	i		i	i	i	
Juncus brachyphyllus Wiegand																				x
Juncus diffusissimus Buckley																				x
Lactuca canadensis L.				x					x						x					
Lactuca ludoviciana (Nutt.) Riddell								x											x	
Lactuca serriola L.																			x	
Lepidium virginicum L.			u			x	x							x			x			
Lespedeza frutescens (L.) Hornem.			u				x													
Lycopus americanus Muhl. ex W.P.C. Barton														x						
Marrubium vulgare L.																	i			
Melilotus officinalis (L.) Lam.						s	s							x			x	x	x	

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Mirabilis nyctaginea (Michx.) MacMill.			x											x			x	x	x	
Mollugo verticillata L.							x							x				x		
Monarda punctata L. ssp. *punctata* var. *occidentalis* (Epling) Pollmer & Steyerm.			u					x					x							
Nemophila phacelioides Nutt.														x			x	x	x	
Nuttallanthus texanus (Scheele) D.A. Sutton																			x	
Oenothera laciniata Hill.			u			x	x							x			x	x	x	
Oenothera rhombipetala Nutt. ex Torr. & A. Gray						x											x	x		
Opuntia Mill.			u														x		x	
Packera plattensis (Nutt.) W.A. Weber & Á. Löve			u																	x
Parietaria pennsylvanica Muhl. ex Willd.									x											
Penthorum sedoides L.																x				
Phacelia strictiflora (Engelm. & A. Gray var. *lundelliana* Constance														x						
Phytolacca americana L. var. *americana*			u			i	i	x										x		
Plantago virginica L.			u		i															
Pluchea odorata (L.)Cass. var. *odorata*																i				
Polygonum lapathifolium L.																x				x
Pyrrhopappus grandiflorus (Nutt.) Nutt.			u													x				
Ratibida columnifera (Nutt.) Woot. & Standl.						i	i													
Rubus (L.)								x				x								
Rumex hastatulus Baldw.																			x	
Schoenoplectus pungens (Vahl) Palla var. *pungens*																				x
Scirpus pallidus (Britton) Fernald																				x
Solanum americanum Mill									x							x				
Solanum rostratum Dunal						x	x													
Solanum dimidiatum Raf.						x	x							x			x			
Solidago gigantea Aiton															x				x	
Sonchus asper (L.) Hill									x							x				x
Sphenopholis obtusata (Michx.) Scribn.						x											x			
Strophostyles helvola (L.) Elliott															x					
Symphyctrichum divaricatum (Nutt.) G.L. Nesom								x							x				x	

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Taraxacum laevigatum (Willd.) DC.															x					
Teucrium canadense L. var. *canadense*															x					
Thelesperma filifolium (Hook.) A. Gray var. *intermedium (*Rydb.) Shinners			u			x											x			
Triodanis holzingeri McVaugh				x		x											x		x	
Typha latifolia L.									x			x				x				x
Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray ssp. *encelioides*																		x	x	
Vernonia baldwini Torr.			u																	
Veronica anagallus-aquatica L.		i			i				s			s				s				s
Viola bicolor Pursh			x	x	x								x	x			x	x	x	
Xanthium strumarium L.								x						x					x	
Yucca glauca Nutt.						x														

A CHECKLIST OF THE VASCULAR FLORA OF THE MARY K. OXLEY NATURE CENTER, TULSA COUNTY, OKLAHOMA

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ABSTRACT

This paper reports the results of an inventory of the vascular flora of the Mary K. Oxley Nature Center in Tulsa, Oklahoma. A total of 342 taxa from 75 families and 237 genera were collected from four main vegetation types. The families Asteraceae and Poaceae were the largest, with 49 and 42 taxa, respectively. Fifty-eight exotic taxa were found, representing 17% of the total flora. Twelve taxa tracked by the Oklahoma Natural Heritage Inventory were present.

INTRODUCTION

The objective of this study was to inventory the vascular plants of the Mary K. Oxley Nature Center (ONC) and to prepare a list and voucher specimens for Oxley personnel to use in education and outreach. Located within the 1,165.0 ha (2878 ac) Mohawk Park in northwestern Tulsa County (ONC headquarters located at 36°13'25.02"N 95°54'11.95"W; grounds include T20N R13E, parts of sections 10, 11, 14-16), ONC is operated by the City of Tulsa. The 325.4 ha (804 ac) Center includes over 14.5 km (9.0099 mi) of trails traversing forest, grassland, and wetland habitats.

ONC is located in the Claremore Cuesta Plains geomorphic province (Curtis et al. 2008). Quaternary sediments overlie Pennsylvanian bedrock (Johnson 2008). Soils belong to the Osage-Wynona association and are described as "deep and nearly level, poorly to somewhat poorly drained and loamy or clayey over loamy or clayey sediment (USDA Soil Conservation Service 1977). Climate is Subtropical Humid, and summers are humid and warm with a mean July temperature of 27.5° C (81.5° F). Winters are mild and short with a mean January temperature of 1.5° C (34.7° F) (Trewartha 1968). Mean annual precipitation is 106.5 cm (41.929 in), with most occurring in the spring and fall (Oklahoma Climatological Survey 2013). Elevation ranges from 170.7 to 312.1 m (560.04 ft to 1024 ft). Potential natural vegetation for the area is tallgrass prairie and post oak-blackjack oak forest (Duck and Fletcher 1943).

METHODS

The ONC trail system was walked to determine the major, generalized vegetation types that were present, and 11 collection areas (corresponding to the named trails) were established to represent these types. Sites were visited monthly from March

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through September of 2010, with additional visits made in June and September of 2011. Two specimens of each taxa encountered were collected. Exotic taxa were only collected from naturalized populations. Specimens were processed following standard procedures and deposited at the Robert Bebb Herbarium at the University of Oklahoma (OKL) and at ONC.

Manuals used for specimen identification included Steyermark (1963), Waterfall (1973), Flora of North America Editorial Committee (1993+), and Yatskievych (1999, 2006). The collections of the Robert Bebb Herbarium were consulted to confirm identifications. Origin (either native or exotic to North America), duration (annual, perennial, biennial), and growth habit (tree, shrub, subshrub, woody vine, forb, graminoid) were determined using the PLANTS Database (USDA-NRCS 2007) and Taylor and Taylor (1991). Nomenclature primarily follows the PLANTS Database. The Angiosperm Phylogeny Website, version 12 (Stevens 2001+), and the Flora of North America North of Mexico (Flora of North America Editorial Committee 1993+) were also consulted to determine where the nomenclature/taxonomy differed from USDA-NRCS; these differences are noted in parentheses in the appendix.

RESULTS AND DISCUSSION

A total of 342 vascular plant taxa (including 23 infraspecific taxa) in 75 families and 237 genera were collected at ONC (Appendix). All were angiosperms, with 85 Liliopsida taxa and 257 Magnoliopsida (Table 1). Sixty-one taxa were trees, shrubs, subshrubs, or woody vines. The Asteraceae, with 49 taxa, and the Poaceae, with 42 taxa, were the largest families. The genus with the most taxa was *Carex*, with 12 taxa. There were 236 perennials, 103 annuals, and three biennials. ONC Director Eddie Reese (pers. comm.). has reported two additional taxa (*Botrychium virginianum* in the Ophioglossaceae and *Juniperus virginiana* in the Cupressaceae), but these were not collected by the author.

Table 1 Summary of floristic collections from the Mary K. Oxley Nature Center, Tulsa County, Oklahoma

Taxonomic Group	**Taxa**	**Native**	**Non-native**
Pteridophyta	0	0	0
Coniferophyta	0	0	0
Magnoliophyta	342	284	58
Magnoliopsida	257	215	42
Liliopsida	85	69	16
Total	342	284	58

Fifty-eight exotic taxa were found, representing 17.0% of the total flora. This number is high when compared to surveys from other Oklahoma sites (Table 2), but is not surprising, given that ONC is in the Tulsa metropolitan area and receives many visitors. The Poaceae and Fabaceae families had the greatest number of exotic taxa, with 14 and 8 taxa, respectively. Twelve taxa tracked by the Oklahoma Natural Heritage Inventory (2013) were present (Table 3).

Table 2 Comparison of the ONC site with other northeastern Oklahoma sites
NA = information not available

Study site	**Reference**	**Size of site (ha)**	**Number of taxa found**	**Percentage of exotic taxa**
Mary K. Oxley Nature Center, Tulsa County	This paper	1,165.0	342	17.0%
J.T. Nickel Family Nature and Wildlife Preserve, Cherokee County	Hoagland and Buthod 2008	6,070.0	597	12.1%
Camp Cherokee Boy Scout Camp, Ottawa County	Hoagland and Buthod 2008	NA	318	10.4%
Oklahoma Centennial Botanic Garden, Osage County	Hoagland and Buthod 2007	NA	293	15.0%
Will Rogers Boy Scout Camp, Pawnee County	Hoagland and Buthod 2005	64.7	338	8.0%
Keystone Wildlife Management Area, Creek, Pawnee and Osage Counties	Hoagland and Buthod 2003	6,475.0 +	380	15.0%
Chouteau Wildlife Management Area, Wagoner County	Hoagland and Johnson 2004	402.0	181	11.6%
Oologah Wildlife Management Area, Nowata County	Hoagland and Wallick 2003	5,226.0	470	9.0%
Tallgrass Prairie Preserve, Osage County	Palmer 2007	15,410.0	1,612	12.1%

Table 3 Vascular plant taxa tracked by the Oklahoma Natural Heritage Inventory (2013). Conservation ranks are based on a scale from one to five, with a one being critically imperiled. A G rank is the rank for the taxa at a global level, while an S rank is one for the taxa at a subnational (or state) level. T ranks are rankings for infraspecific taxa (NatureServe 2013).

Taxa	**Family**	**S Rank**	**G Rank**
Lactuca tatarica var. *pulchella*	Asteraceae	S1	G5T5
Iodanthus pinnatifidus	Brassicaceae	S2	G5
Desmodium illinoense	Fabaceae	S3	G5
Desmodium pauciflorum	Fabaceae	S1	G5
Calycocarpum lyonii	Menispermaceae	S2	G5
Muhlenbergia bushii	Poaceae	S1	G5
Rumex verticillatus	Polygonaceae	S3	G5
Thalictrum revolutum	Ranunculaceae	S2	G5
Potentilla rivalis	Rosaceae	S1	G5
Dasistoma macrophylla	Scrophulariaceae	S3	G4
Smilax lasioneura	Smilacaeae	S2	G5
Urtica chamaedryoides	Urticaceae	S3	G4G5

Collection sites were located within four vegetation types:

1. Mesic Forest [MF]) (Figure 1)

This type included the Sierra Club Trail and the North Woods areas. Common taxa included *Campanulastrum americanum, Cardamine concatenata, Cercis canadensis, Cornus drummondii*, *Diarrhena obovata, Diospyros virginiana, Erythronium albidum, Eutrochium purpureum, Lindera benzoin, Osmorhiza longistylis, Polygonatum biflorum,* and *Thalictrum revolutum*. Dominant taxa included *Carya cordiformis, Quercus muehlenbergii,* and *Q. shumardii*. The most tracked taxa were found in this type.

2. Bottomland Forest [BF] (Figure 2)

This type included the Bird Creek, Green Dragon, and Red Fox trails. Common taxa included *Acer negundo, A. saccharinum, Celtis laevigata, Cinna arundinacea, Elephantopus carolinianus, Quercus palustris, Parthenocissus quinquefolia,* and *Ulmus americana*. Dominant taxa included *Chasmanthium latifolium, Fraxinus pennsylvanica,* and *Ilex decidua*.

3. Disturbed Herbaceous Vegetation [DHV] (Figure 3)

This type included the Meadowlark Prairie trail and various disturbed areas throughout ONC. Grassland elements, including *Andropogon gerardii, Panicum virgatum,* and *Sorghastrum nutans,* were present, as were more "weedy" taxa such as *Amphiachyris dracunculoides, Carduus nutans,* and *Ambrosia artemisiifolia. Desmanthus illinoenesis*, *Iva annua,* and *Rhus glabra* were dominant taxa. The greatest number of exotic taxa were found in this type.

4. Wetland and Aquatic Vegetation [WAV] (Figure 4)

This type included the Bird Creek, Blackbird Marsh, Coal Creek, Flowline, and Nelson's Oxbow trails, as well as the margins of Lake Sherry and Lake Yahola. Common taxa included *Carex lupulina, Eleocharis obtusa, Juncus effusus, Justicia americana, Limnosciadium pinnatum, Ludwigia peploides,* and *Sagittaria graminea*. *Nelumbo lutea* and *Typha angustifolia* were dominant taxa in this type.

Figure 1 Mesic forest in North Woods Loop at the Mary K. Oxley Nature Center, Tulsa County, Oklahoma

Figure 2 Bottomland forest habitat at the Mary K. Oxley Nature Center

Figure 3 Disturbed herbaceous vegetation in Meadowlark Prairie at the Mary K. Oxley Nature Center

Figure 4 Wetland and aquatic vegetation in Nelson's Oxbow at the Mary K. Oxley Nature Center

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APPENDIX
List of Vascular Plant Taxa from the Mary K. Oxley Nature Center, Tulsa County, OK

The first entry is duration (A=annual, B=biennial, P=perennial), followed by growth habit (T=tree, S=shrub, SS=subshrub, V=woody vine, F=forb, G=graminoid), vegetation type (MF=mesic forest, BF=bottomland forest, DHV=disturbed herbaceous vegetation, WAV=wetland and aquatic vegetation) and collection number. If taxonomy differs from USDA-NRCS in the Flora of North America (FNA) or the Angiosperm Phylogeny Website (APW), it is noted in parentheses ( ). Exotic taxa are denoted with an asterisk (*). Taxa tracked by the Oklahoma Natural Heritage Inventory are denoted with a dagger (†). Voucher specimens are deposited at the Robert Bebb Herbarium of the University of Oklahoma (OKL) and at Oxley Nature Center (ONC).

Magnoliophyta
Magnoliopsida
Acanthaceae
Dicliptera brachiata (Pursh) Spreng. (branched foldwing); A; F; MF, BF; O-369
Justicia americana (L.) Vahl (American water-willow); P; F; WAV; O-120
Ruellia strepens L. (limestone wild petunia); P; F; DHV; O-106

Aceraceae
Acer negundo L. (boxelder); P; T; BF; O-015; (APW:Sapindaceae)
Acer saccharinum L. (silver maple); P; T; BF; O-230; (APW:Sapindaceae)

Amaranthaceae
Amaranthus tuberculatus (Moq.) Sauer (roughfruit amaranth); A; F; DHV; O-336
Iresine rhizomatosa Standl. (Juda's bush); P; F; MF, BF; O-368

Anacardiaceae
Rhus glabra L. (smooth sumac); P; S; DHV; O-133
Toxicodendron radicans (L.) Kuntze (eastern poison ivy); P; V; MF, BF; O-033

Apiaceae
Ammoselinum butleri (Engelm. ex S. Watson) J.M. Coult. & Rose (Butler's sandparsley); A; F; DHV; O-165
Chaerophyllum tainturieri Hook. (hairyfruit chervil); A; F; MF, BF; O-019
Cryptotaenia canadensis (L.) DC. (Canadian honewort); P; F; MF; O-090
Limnosciadium pinnatum (DC.) Mathias & Constance (tansy dogshade); A; F; WAV; O-114
Osmorhiza longistylis (Torr.) DC. (longstyle sweetroot); P; F; MF; O-044
Sanicula canadensis L. (Canadian blacksnakeroot); B; F; MF; O-078
Sanicula odorata (Raf.) K.M. Pryer & L.R. Phillippe (clustered blacksnakeroot); P; F; MF; O-077
**Torilis arvensis* (Huds.) Link (spreading hedgeparsley); A; F; DHV; O-381
Zizia aurea (L.) W.D.J. Koch (golden zizia); P; F; MF; O-040

Apocynaceae
Apocynum cannabinum L. (Indianhemp); P; F; DHV; O-129
**Vinca minor* L. (common periwinkle); P; F; DHV; O-160

Aquifoliaceae
Ilex decidua Walter (possumhaw); P; S; MF, BF; O-030

Aristolochiaceae
Aristolochia tomentosa Sims (woolly dutchman's pipe); P; V; MF; O-319

Asclepiadaceae
Asclepias incarnata L. (swamp milkweed); P; F; WAV; O-343; (APW:Apocynaceae)
Asclepias syriaca L. (common milkweed); P; F; DHV; O-094; (APW:Apocynaceae)
Cynanchum laeve (Michx.) Pers. (honeyvine); P; F; DHV; O-344; (APW:Apocynaceae)
Matelea gonocarpos (Walter) Shinners (angularfruit milkvine); P; F; MF, BF; O-110; (APW:Apocynaceae)

Asteraceae
Ageratina altissima (L.) King & H. Rob. var. *altissima* (white snakeroot); P; F; MF; O-410
Ambrosia artemisiifolia L. (annual ragweed); A; F; DHV; O-351
Ambrosia trifida L. (great ragweed); A; F; DHV; O-341
Amphiachyris dracunculoides (DC.) Nutt. (prairie broomweed); A; F; DHV; O-405
Bidens polylepis S.F. Blake (bearded beggarticks); A; F; WAV; O-421
Boltonia diffusa Elliott (smallhead doll's daisy); P; F; WAV; O-413
**Carduus nutans* L. (nodding plumeless thistle); B; F; DHV; O-138
Cirsium altissimum (L.) Hill (tall thistle); B; F; DHV; O-225
Conyza canadensis (L.) Cronquist (Canadian horseweed); A; F; DHV; O-245
Conyza ramosissima Cronquist (dwarf horseweed); A; F; DHV; O-292
Coreopsis tinctoria Nutt. (golden tickseed); A; F; DHV; O-097
Dracopis amplexicaulis (Vahl) Cass. (clasping coneflower); A; F; DHV; O-108; (FNA:*Rudbeckia amplexicaulis* Vahl)
Echinacea purpurea (L.) Moench (eastern purple coneflower); P; F; DHV; O-251
Eclipta prostrata (L.) L. (false daisy); A; F; WAV; O-125
Elephantopus carolinianus Raeusch. (Carolina elephantsfoot); P; F; MF, BF; O-310
Erigeron annuus (L.) Pers. (eastern daisy fleabane); A; F; DHV; O-150
Erigeron philadelphicus L. var. *philadelphicus* (Philadelphia fleabane); P; F; DHV; O-067
Eupatorium serotinum Michx. (lateflowering thoroughwort); P; F; DHV; O-332
Eutrochium purpureum (L.) E.E. Lamont var. *purpureum* (sweetscented joe pye weed); P; F; MF; O-268a
Gamochaeta purpurea (L.) Cabrera (spoonleaf purple everlasting); P; F; DHV; O-099
Helianthus tuberosus L. (Jerusalem artichoke); P; F; MF; O-408
Iva annua L. (annual marshelder); A; F; DHV; O-315
Krigia caespitosa (Raf.) K.L. Chambers (weedy dwarfdandelion); A; F; DHV; O-053; (FNA:*Krigia cespitosa*)
Lactuca canadensis L. (Canada lettuce); A; F; DHV; O-269
Lactuca floridana (L.) Gaertn. (woodland lettuce); A; F; MF; O-313
**Lactuca serriola* L. (prickly lettuce); A; F; DHV; O-353
†*Lactuca tatarica* (L.) C.A. Mey. var. *pulchella* (Pursh) Breitung (blue lettuce); P; F; DHV; O-375; (FNA:*Mulgedium pulchellum* (Pursh) G. Don)
Packera glabella (Poir.) C. Jeffrey (butterweed); A; F; BF; O-066
Packera obovata (Muhl. ex Willd.) W.A. Weber & Á. Löve (roundleaf ragwort); P; F; MF, BF; O-008

Pluchea camphorata (L.) DC. (camphor pluchea); P; F; WAV; O-309
Pyrrhopappus carolinianus (Walter) DC. (Carolina desert-chicory); A; F; DHV; O-113
Ratibida pinnata (Vent.) Barnhart (pinnate prairie coneflower); P; F; DHV; O-385
Rudbeckia hirta L. var. *pulcherrima* Farw. (blackeyed Susan); P; F; DHV; O-121
Rudbeckia triloba L. var. *triloba* (browneyed Susan); P; F; MF; O-415
Silphium asteriscus L. var. *asteriscus* (starry rosinweed); P; F; DHV; O-271
Silphium perfoliatum L. var. *perfoliatum* (cup plant); P; F; MF; O-235
Smallanthus uvedalius (L.) Mackenzie ex Small (hairy leafcup); P; F; MF; O-350;
(FNA:*Smallanthus uvedalia* (L.) Mack. ex Small)
Solidago gigantea Aiton (giant goldenrod); P; F; DHV; O-373
Solidago speciosa Nutt. var. *rigidiuscula* Torr. & A. Gray (showy goldenrod); P; F; DHV; O-293
Solidago ulmifolia Muhl. ex Willd. var. *ulmifolia* (elmleaf goldenrod); P; F; MF; O-306
**Sonchus asper* (L.) Hill (spiny sowthistle); A; F; DHV; O-147
Symphyotrichum cordifolium (L.) G.L. Nesom (common blue wood aster); P; F; MF; O-419
Symphyotrichum lanceolatum (Willd.) G.L. Nesom (white panicle aster); P; F; MF; O-423
Symphyotrichum subulatum (Michx.) G.L. Nesom (eastern annual saltmarsh aster); A; F; DHV, WAV; O-305
**Taraxacum officinale* F.H. Wigg. (common dandelion); P; F; DHV; O-025
Verbesina alternifolia (L.) Britton ex Kearney (wingstem); P; F; MF; O-374
Verbesina virginica L. (white crownbeard); P; F; MF; O-327
Vernonia baldwinii Torr. (Baldwin's ironweed); P; F; DHV; O-220
Xanthium strumarium L. (rough cocklebur); A; F; WAV; O-406

Bignoniaceae
Campsis radicans (L.) Seem. ex Bureau (trumpet creeper); P; V; MF, BF; O-236

Boraginaceae
**Buglossoides arvensis* (L.) I.M. Johnston (corn gromwell); A; F; DHV; O-047
**Heliotropium indicum* L. (Indian heliotrope); A; F; WAV; O-328
Myosotis verna Nutt. (spring forget-me-not); A; F; BF; O-070

Brassicaceae
**Capsella bursa-pastoris* (L.) Medik. (shepherd's purse); A; F; DHV; O-012
Cardamine concatenata (Michx.) Sw. (cutleaf toothwort); P; F; MF; O-009
**Cardamine hirsuta* L. (hairy bittercress); A; F; BF, DHV; O-018
Cardamine pensylvanica Muhl. ex Willd. (Pennsylvania bittercress); P; F; DHV; O-188
†*Iodanthus pinnatifidus* (Michx.) Steud. (purplerocket); P; F; MF; O-058
Lepidium virginicum L. (Virginia pepperweed); A; F; DHV; O-172
Rorippa palustris (L.) Besser ssp. *palustris* (bog yellowcress); A; F; WAV; O-418
Rorippa sessiliflora (Nutt.) Hitchc. (stalkless yellowcress); A; F; BF; O-071

Campanulaceae
Campanulastrum americanum (L.) Small (American bellflower); A; F; MF; O-233
Triodanis biflora (Ruiz & Pav.) Greene (small Venus' looking-glass); A; F; DHV; O-100

Cannabaceae
**Humulus japonicus* Siebold & Zucc. (Japanese hop); P; F; MF; O-349

Caprifoliaceae
**Lonicera japonica* Thunb. (Japanese honeysuckle); P; V; MF, BF; O-380
Sambucus nigra L. ssp. *canadensis* (L.) R. Bolli (common elderberry); P; S; MF; O-111; (APW:Adoxaceae)
Symphoricarpos orbiculatus Moench (coralberry); P; S; MF; O-201
Viburnum rufidulum Raf. (rusty blackhaw); P; S; MF; O-054; (APW:Adoxaceae)

Caryophyllaceae
**Arenaria serpyllifolia* L. (thymeleaf sandwort); A; F; DHV; O-098
**Cerastium glomeratum* Thuill. (sticky chickweed); A; F; DHV; O-170
Sagina decumbens (Elliott) Torr. & Gray ssp. *decumbens* (trailing pearlwort); A; F; DHV; O-168
Silene stellata (L.) W.T. Aiton (widowsfrill); P; F; MF; O-112
**Stellaria media* (L.) Vill. (common chickweed); A; F; DHV; O-022

Celastraceae
Celastrus scandens L. (American bittersweet); P; V; MF; O-266
**Euonymus kiautschovicus* Loes. (creeping strawberry bush); P; S; MF; O-378

Chenopodiaceae
Chenopodium album L. (lambsquarters); A; F; DHV; O-416; (APW:Amaranthaceae)

Clusiaceae
Hypericum punctatum Lam. (spotted St. Johnswort); P; F; DHV; O-217; (APW:Hypericaceae)

Convolvulaceae
Ipomoea lacunosa L. (whitestar); A; F; DHV; O-321
Ipomoea pandurata (L.) G. Mey. (man of the earth); P; F; MF; O-264

Cornaceae
Cornus drummondii C.A. Mey. (roughleaf dogwood); P; T; MF; O-032

Crassulaceae
Penthorum sedoides L. (ditch stonecrop); P; F; WAV; O-243; (APW:Penthoraceae)

Cucurbitaceae
Melothria pendula L. (Guadeloupe cucumber); P; F; DHV; O-242

Cuscutaceae
Cuscuta gronovii Willd. ex Schult. (scaldweed); P; F; DHV; O-393; (APW:Convolvulaceae)

Ebenaceae
Diospyros virginiana L. (common persimmon); P; T; MF; O-057

Euphorbiaceae
Acalypha rhomboidea Raf. (Virginia threeseed mercury); A; F; BF; O-399
Chamaesyce nutans (Lag.) Small (eyebane); A; F; DHV; O-314
Chamaesyce prostrata (Aiton) Small (prostrate sandmat); A; F; DHV; O-250
Croton glandulosus L. (vente conmigo); A; F; DHV; O-407

**Euphorbia davidii* Subils (David's spurge); A; F; DHV; O-346
Euphorbia dentata Michx. (toothed spurge); A; F; MF; O-316

Fabaceae
**Albizia julibrissin* Durazz. (silktree); P; T; MF; O-311
Amorpha fruticosa L. (desert false indigo); P; S; WAV; O-357
Amphicarpaea bracteata (L.) Fernald (American hogpeanut); A; F; MF; O-382
Apios americana Medik. (groundnut); P; F; WAV; O-234
Cercis canadensis L. (eastern redbud); P; T; MF; O-042
Chamaecrista fasciculata (Michx.) Greene (sleepingplant); A; F; DHV; O-240
Desmanthus illinoensis (Michx.) MacMill. ex B.L. Rob. & Fernald (prairie bundleflower); P; F; DHV; O-237
†*Desmodium illinoense* A. Gray (Illinois ticktrefoil); P; F; DHV; O-329
Desmodium paniculatum (L.) DC. (panicledleaf ticktrefoil); P; F; MF; O-105
†*Desmodium pauciflorum* (Nutt.) DC. (fewflower ticktrefoil); P; F; MF; O-261
Gymnocladus dioicus (L.) K. Koch (Kentucky coffeetree); P; F; MF; O-203
**Kummerowia stipulacea* (Maxim.) Makino (Korean clover); A; F; DHV; O-355
**Lespedeza cuneata* (Dum. Cours.) G. Don (Chinese lespedeza); P; F; DHV; O-294
Lespedeza repens (L.) W.P.C. Barton (creeping lespedeza); P; F; MF; O-318
**Medicago lupulina* L. (black medick); A; F; DHV; O-426
**Melilotus officinalis* (L.) Lam. (yellow sweetclover); A; F; DHV; O-134
Robinia pseudoacacia L. (black locust); P; T; BF; O-387
Senna marilandica (L.) Link (Maryland senna); P; F; WAV; O-320
Sesbania herbacea (Mill.) McVaugh (bigpod sesbania); A; F; WAV; O-325
Strophostyles helvola (L.) Elliott (amberique-bean); A; F; DHV; O-345
**Trifolium campestre* Schreb. (field clover); A; F; DHV; O-088
**Trifolium repens* L. (white clover); P; F; DHV; O-080
**Vicia sativa* L. (garden vetch); A; F; DHV; O-173
**Vicia villosa* Roth ssp. *varia* (Host) Corb. (winter vetch); A; F; DHV; O-128

Fagaceae
Quercus macrocarpa Michx. (bur oak); P; T; MF, BF; O-300
Quercus muehlenbergii Engelm. (chinkapin oak); P; T; MF; O-267a
Quercus palustris Münchh. (pin oak); P; T; BF; O-273
Quercus rubra L. (northern red oak); P; T; MF; O-298
Quercus shumardii Buckley (Shumard's oak); P; T; MF; O-301

Fumariaceae
Corydalis flavula (Raf.) DC. (yellow fumewort); A; F; BF; O-020; (FNA:Papaveraceae)

Geraniaceae
Geranium carolinianum L. (Carolina geranium); A; F; DHV; O-162
**Geranium pusillum* L. (small geranium); A; F; DHV; O-061

Juglandaceae
Carya cordiformis (Wangenh.) K. Koch (bitternut hickory); P; T; MF; O-063
Carya illinoinensis (Wangenh.) K. Koch (pecan); P; T; MF, BF; O-048
Juglans nigra L. (black walnut); P; T; MF; O-358

Lamiaceae
**Lamium amplexicaule* L. (henbit deadnettle); A; F; DHV; O-024
**Lamium purpureum* L. (purple deadnettle); A; F; DHV; O-016
Lycopus americanus Muhl. ex W.P.C. Barton (American water horehound); P; F; WAV; O-222
Monarda fistulosa L. (wild bergamot); P; F; DHV; O-383
**Perilla frutescens* (L.) Britton (beefsteakplant); A; F; MF; O-359
Prunella vulgaris L. (common selfheal); P; F; MF; O-118
Scutellaria lateriflora L. (blue skullcap); P; F; BF; O-409
Stachys tenuifolia Willd. (smooth hedgenettle); P; F; BF; O-249
Teucrium canadense L. (Canada germander); P; F; WAV; O-210

Lauraceae
Lindera benzoin (L.) Blume (northern spicebush); P; S; MF, BF; O-014

Lentibulariaceae
Utricularia gibba L. (humped bladderwort); P; F; WAV; O-255

Lythraceae
Ammannia auriculata Willd. (eared redstem); A; F; WAV; O-254
Lythrum alatum Pursh (winged lythrum); P; F; WAV; O-259

Malvaceae
Callirhoe papaver (Cav.) A. Gray (woodland poppymallow); P; F; MF; O-117
Hibiscus laevis All. (halberdleaf rosemallow); P; F; WAV; O-256
Hibiscus lasiocarpos Cav. (rosemallow); P; F; WAV; O-246
Sida spinosa L. (prickly fanpetals); A; F; DHV; O-425

Menispermaceae
†*Calycocarpum lyonii* (Pursh) A. Gray (cupseed); P; V; MF; O-115
Cocculus carolinus (L.) DC. (Carolina coralbead); P; V; MF, BF; O-390
Menispermum canadense L. (common moonseed); P; V; MF, BF; O-223

Molluginaceae
Mollugo verticillata L. (green carpetweed); A; F; DHV; O-244

Moraceae
Maclura pomifera (Raf.) C.K. Schneid. (osage orange); P; T; BF; O-339
**Morus alba* L. (white mulberry); P; T; MF; O-389
Morus rubra L. (red mulberry); P; T; MF, BF; O-303

Nelumbonaceae
Nelumbo lutea Willd. (American lotus); P; F; WAV; O-229

Oleaceae
Fraxinus americana L. (white ash); P; T; MF, BF; O-265
Fraxinus pennsylvanica Marshall (green ash); P; T; BF; O-051
**Ligustrum vulgare* L. (European privet); P; S; MF, BF; O-267

Onagraceae
Gaura longiflora Spach (longflower beeblossom); A; F; DHV; O-352
Ludwigia peploides (Kunth) P.H. Raven (floating primrose-willow); P; F; WAV; O-278
Oenothera villosa Thunb. (hairy evening-primrose); P; F; DHV; O-348

Oxalidaceae
Oxalis corniculata L. (creeping woodsorrel); P; F; DHV; O-164
Oxalis dillenii Jacq. (slender yellow woodsorrel); P; F; MF; O-089

Passifloraceae
Passiflora incarnata L. (purple passionflower); P; F; DHV; O-241
Passiflora lutea L. (yellow passionflower); P; F; MF, BF; O-107

Phytolaccaceae
Phytolacca americana L. var. *americana* (American pokeweed); P; F; MF; O-131

Plantaginaceae
**Plantago lanceolata* L. (narrowleaf plantain); P; F; DHV; O-296
Plantago rugelii Decne. (blackseed plantain); P; F; MF, DHV; O-127
Plantago virginica L. (Virginia plantain); A; F; DHV; O-119

Polemoniaceae
Phlox divaricata L. (wild blue phlox); P; F; MF, BF; O-065

Polygonaceae
**Polygonum aviculare* L. (prostrate knotweed); A; F; DHV; O-417
Polygonum hydropiperoides Michx. (swamp smartweed); P; F; WAV; O-274; (FNA:*Persicaria hydropiperoides* (Michx.) Small)
Polygonum lapathifolium L. (curlytop knotweed); A; F; WAV; O-295; (FNA:*Persicaria lapathifolia* (L.) Gray)
Polygonum pensylvanicum L. (Pennsylvania smartweed); A; F; WAV; O-297; (FNA:*Persicaria pensylvanica* (L.) M. Gómez)
Polygonum punctatum Elliott (dotted smartweed); A; F; WAV; O-219; (FNA:*Persicaria punctata* (Elliott) Small)
Polygonum tenue Michx. (pleatleaf knotweed); A; F; DHV; O-126
Polygonum virginianum L. (jumpseed); P; F; MF; O-212; (FNA:*Persicaria virginiana* (L.) Gaertn.)
Rumex altissimus Alph. Wood (pale dock); P; F; WAV; O-046
**Rumex crispus* L. (curly dock); P; F; DHV; O-079
†*Rumex verticillatus* L. (swamp dock); P; F; WAV; O-181

Portulacaceae
Claytonia virginica L. (Virginia springbeauty); P; F; DHV; O-005; (APW:Montiaceae)

Ranunculaceae
Clematis pitcheri Torr. & A. Gray (bluebill); P; V; BF; O-248
**Clematis terniflora* DC. var. *terniflora* (sweet autumn virginsbower); P; F; BF; O-403; (FNA:*Clematis terniflora* DC.)
Ranunculus micranthus Nutt. (rock buttercup); P; F; DHV; O-163

Ranunculus sceleratus L. var. *sceleratus* (cursed buttercup); A; F; BF; O-069
†*Thalictrum revolutum* DC. (waxyleaf meadow-rue); P; F; MF; O-109

Rosaceae
Agrimonia pubescens Wallr. (soft agrimony); P; F; MF; O-257
Crataegus viridis L. (green hawthorn); P; T; BF; O-179
Geum canadense Jacq. (white avens); P; F; MF; O-139
Geum vernum (Raf.) Torr. & A. Gray (spring avens); P; F; BF; O-068
†*Potentilla rivalis* Nutt. (brook cinquefoil); P; F; WAV; O-384
Prunus hortulana L.H. Bailey (hortulan plum); P; T; BF; O-184
Prunus mexicana S. Watson (Mexican plum); P; T; BF; O-095
Prunus serotina Ehrh. (black cherry); P; T; BF; O-140
**Pyrus calleryana* Decne. (Callery pear); P; T; BF; O-331
**Pyrus communis* L. (common pear); P; T; MF; O-010
Rosa setigera Michx. (climbing rose); P; V; MF; O-101
Rubus argutus Link (sawtooth blackberry); P; SS; DHV; O-182

Rubiaceae
Cephalanthus occidentalis L. (common buttonbush); P; S; WAV; O-205
**Cruciata pedemontana* (Bellardi) Ehrend. (piedmont bedstraw); A; F; DHV; O-060
Galium aparine L. (stickywilly); A; F; DHV; O-037
Galium circaezans Michx. (licorice bedstraw); P; F; MF, BF; O-149
Houstonia pusilla Schoepf (tiny bluet); A; F; DHV; O-004
**Sherardia arvensis* L. (blue fieldmadder); A; F; DHV; O-059

Rutaceae
Zanthoxylum americanum Mill. (common pricklyash); P; S; MF; O-299

Salicaceae
Salix nigra Marshall (black willow); P; T; WAV; O-178

Sapotaceae
Sideroxylon lanuginosum Michx. ssp. *lanuginosum* (gum bully); P; T; BF; O-324

Scrophulariaceae
†*Dasistoma macrophylla* (Nutt.) Raf. (mullein foxglove); A; F; MF; O-258; (APW:Orobanchaceae)
Gratiola neglecta Torr. (clammy hedgehyssop); A; F; WAV; O-072; (APW:Plantaginaceae)
Lindernia dubia (L.) Pennell (yellowseed false pimpernel); A; F; DHV; O-253; (APW:Linderniaceae)
Mimulus alatus Aiton (sharpwing monkeyflower); P; F; WAV; O-238; (APW:Phyrmaceae)
**Veronica arvensis* L. (corn speedwell); A; F; DHV; O-171; (APW:Plantaginaceae)
Veronica peregrina L. (neckweed); A; F; DHV; O-174; (APW:Plantaginaceae)
**Veronica polita* Fri. (gray field speedwell); A; F; BF; O-003; (APW:Plantaginaceae)

Solanaceae
Physalis angulata L. (cutleaf groundcherry); A; F; DHV; O-333
Physalis longifolia Nutt. (longleaf groundcherry); P; F; DHV; O-342
Solanum americanum P. Mill. (American black nightshade); P; F; BF; O-400
Solanum carolinense L. (Carolina horsenettle); P; F; DHV; O-103

Ulmaceae
Celtis laevigata Willd. (sugarberry); P; T; MF, BF; O-183
Ulmus americana L. (American elm); P; T; BF; O-002
Ulmus rubra Muhl. (slippery elm); P; T; BF; O-036

Urticaceae
Boehmeria cylindrica (L.) Sw. (smallspike false nettle); P; F; MF; O-202
Laportea canadensis (L.) Weddell (Canadian woodnettle); P; F; MF; O-260
†*Urtica chamaedryoides* Pursh (heartleaf nettle); A; F; MF; O-006

Valerianaceae
Valerianella radiata (L.) Dufr. (beaked cornsalad); A; F; DHV; O-038; (APW:Caprifoliaceae)

Verbenaceae
Phryma leptostachya L. (American lopseed); P; F; MF; O-231; (APW:Phrymaceae)
Phyla lanceolata (Michx.) Greene (lanceleaf fogfruit); P; F; WAV; O-086
Verbena urticifolia L. (white vervain); P; F; MF; O-228

Violaceae
Viola bicolor Pursh (field pansy); A; F; DHV; O-001
Viola missouriensis Greene (Missouri violet); P; F; BF; O-169
Viola pubescens Aiton var. *pubescens* (downy yellow violet); P; F; MF; O-062
Viola sororia Willd. (common blue violet); P; F; MF, BF; O-017

Vitaceae
Ampelopsis cordata Michx. (heartleaf peppervine); P; V; MF, BF; O-136
Parthenocissus quinquefolia (L.) Planch. (Virginia creeper); P; V; MF, BF; O-360
Vitis cinerea (Engelm.) Engelm. ex Millard (graybark grape); P; V; MF, BF; O-082
Vitis vulpina L. (frost grape); P; V; MF; O-155

Liliopsida
Alismataceae
Alisma subcordatum Raf. (American water plantain); P; F; WAV; O-211
Sagittaria graminea Michx. (grassy arrowhead); P; F; WAV; O-277
Sagittaria platyphylla (Engelm.) J.G. Sm. (delta arrowhead); P; F; WAV; O-388

Araceae
Arisaema dracontium (L.) Schott (green dragon); P; F; MF; O-116

Commelinaceae
Commelina erecta L. (whitemouth dayflower); P; F; DHV; O-322

Cyperaceae
Carex brevior (Dewey) Mack. (shortbeak sedge); P; G; DHV; O-192
Carex caroliniana Schwein. (Carolina sedge); P; G; WAV; O-186
Carex cherokeensis Schwein. (Cherokee sedge); P; G; BF; O-189
Carex davisii Schwein. & Torr. (Davis' sedge); P; G; BF; O-200
Carex granularis Muhl. ex Willd. (limestone meadow sedge); P; G; DHV; O-177
Carex hyalinolepis Steud. (shoreline sedge); P; G; BF; O-195

Carex leavenworthii Dewey (Leavenworth's sedge); P; G; DHV; O-197
Carex lupulina Muhl. ex Willd. (hop sedge); P; G; WAV; O-159
Carex muehlenbergii Schkuhr ex Willd. var. *muehlenbergii* (Muhlenberg's sedge); P; G; DHV; O-166
Carex retroflexa Muhl. ex Willd. (reflexed sedge); P; G; DHV; O-193
Carex scoparia Schkuhr ex Willd. var. *scoparia* (broom sedge); P; G; WAV; O-154
Carex tribuloides Wahlenb. var. *sangamonensis* Clokey (blunt broom sedge); P; G; WAV; O-085
Cyperus acuminatus Torr. & Hook. ex Torr. (tapertip flatsedge); P; G; WAV; O-073
Cyperus echinatus (L.) Alph. Wood (globe flatsedge); P; G; DHV; O-209
Cyperus strigosus L. (strawcolored flatsedge); P; G; DHV, WAV; O-275
Eleocharis obtusa (Willd.) Schult. (blunt spikerush); A; G; WAV; O-213
Eleocharis palustris (L.) Roem. & Schult. (common spikerush); P; G; WAV; O-398

Iridaceae
Sisyrinchium angustifolium Mill. (narrowleaf blue-eyed grass); P; F; DHV; O-052

Juncaceae
Juncus acuminatus Michx. (tapertip rush); P; G; WAV; O-158
Juncus brachycarpus Engelm. (whiteroot rush); P; G; WAV; O-075
Juncus diffusissimus Buckl. (slimpod rush); P; G; WAV; O-074
Juncus effusus L. (common rush); P; G; WAV; O-135
Juncus interior Wiegand (inland rush); P; G; DHV, WAV; O-087
Juncus tenuis Willd. (poverty rush); P; G; DHV; O-152

Lemnaceae
Lemna minor L. (common duckweed); P; F; WAV; O-280; (APW:Araceae)
Spirodela polyrrhiza (L.) Schleid. (common duckmeat); P; F; WAV; O-279; (APW:Araceae)
Wolffia columbiana Karst. (Columbian watermeal); P; F; WAV; O-281; (APW:Araceae)

Liliaceae
Allium canadense L. (meadow garlic); P; F; DHV; O-124; (APW:Amaryllidaceae)
Camassia scilloides (Raf.) Cory (Atlantic camas); P; F; DHV; O-064; (APW:Asparagaceae)
Erythronium albidum Nutt. (white fawnlily); P; F; MF; O-007; (APW:Liliaceae)
**Liriope spicata* (Thunb.) Lour. (creeping liriope); P; F; MF; O-204; (APW:Asparagaceae)
Nothoscordum bivalve (L.) Britton (crowpoison); P; F; DHV; O-026; (APW:Amaryllidaceae)
Polygonatum biflorum (Walter) Elliott (smooth Solomon's seal); P; F; MF; O-045; (APW:Asparagaceae)

Poaceae
Andropogon gerardii Vitman (big bluestem); P; G; DHV; O-227
Arundinaria gigantea (Walter) Muhl. (giant cane); P; G; BF; O-302
Bothriochloa saccharoides (Sw.) Rydb. (silver bluestem); P; G; DHV; O-371
**Bromus catharticus* Vahl (rescuegrass); A; G; DHV; O-029
Bromus pubescens Muhl. ex Willd. (hairy woodland brome); P; G; MF, BF; O-076
**Bromus racemosus* L. (bald brome); A; G; DHV; O-122
**Bromus sterilis* L. (poverty brome); A; G; DHV; O-081
Chasmanthium latifolium (Michx.) Yates (Indian woodoats); P; G; MF, BF; O-207
Cinna arundinacea L. (sweet woodreed); P; G; BF; O-326
**Cynodon dactylon* (L.) Pers. (Bermudagrass); P; G; DHV; O-304
Diarrhena obovata (Gleason) Brandenburg (obovate beakgrain); P; G; MF; O-215

Dichanthelium malacophyllum (Nash) Gould (softleaf rosette grass); P; G; MF; O-148
Digitaria ciliaris (Retz.) Koeler (southern crabgrass); A; G; DHV; O-268
**Echinochloa colona* (L.) Link (jungle rice); A; G; DHV; O-347
Echinochloa muricata (P. Beauv.) Fernald (rough barnyardgrass); A; G; DHV, WAV; O-218
**Eleusine indica* (L.) Gaertn. (Indian goosegrass); A; G; DHV; O-239
Elymus villosus Muhl. ex Willd. (hairy wildrye); P; G; MF; O-144
Elymus virginicus L. (Virginia wildrye); P; G; MF, BF; O-224
**Eragrostis cilianensis* (All.) Vign. ex Janchen (stinkgrass); A; G; DHV; O-376
Eragrostis hypnoides (Lam.) Britton, Sterns & Poggenb. (teal lovegrass); A; G; WAV; O-307
Eragrostis lugens Ness (morning lovegrass); P; G; DHV; O-370
**Eragrostis pilosa* (L.) P. Beauv. (Indian lovegrass); A; G; DHV; O-252
Festuca subverticillata (Pers.) Alexeev (nodding fescue); P; G; MF; O-083
Hordeum pusillum Nutt. (little barley); A; G; DHV; O-028
†*Muhlenbergia bushii* Pohl (nodding muhly); P; G; BF; O-414
Panicum anceps Michx. (beaked panicgrass); P; G; MF, WAV; O-206
Panicum dichotomiflorum Michx. (fall panicgrass); A; G; DHV; O-356
Panicum rigidulum Bosc ex Nees (redtop panicgrass); P; G; WAV; O-334
Panicum virgatum L. (switchgrass); P; G; DHV; O-226
**Paspalum dilatatum* Poir. (dallisgrass); P; G; DHV; O-157
Paspalum floridanum Michx. (Florida paspalum); P; G; DHV; O-354
**Poa annua* L. (annual bluegrass); A; G; DHV; O-021
**Poa pratensis* L. (Kentucky bluegrass); P; G; DHV; O-198
Poa sylvestris A. Gray (woodland bluegrass); P; G; MF; O-050
**Schedonorus pratensis* (Huds.) P. Beauv. (meadow fescue); P; G; DHV; O-102
Setaria parviflora (Poir.) Kerguélen (marsh bristlegrass); P; G; DHV; O-221
**Setaria pumila* (Poir.) Roem. & Schult. (yellow foxtail); A; G; DHV; O-372
Sorghastrum nutans (L.) Nash (Indiangrass); P; G; DHV; O-323
**Sorghum halepense* (L.) Pers. (Johnsongrass); P; G; DHV; O-208
Tridens flavus (L.) Hitchc. (purpletop tridens); P; G; DHV; O-270
Tridens strictus (Nutt.) Nash (longspike tridens); P; G; DHV; O-420
Tripsacum dactyloides (L.) L. (eastern gamagrass); P; G; DHV; O-137

Smilacaceae
Smilax bona-nox L. (saw greenbrier); P; V; MF, BF; O-091
†*Smilax lasioneura* Hook. (Blue Ridge carrionflower); P; V; MF; O-093
Smilax rotundifolia L. (roundleaf greenbrier); P; V; BF; O-185
Smilax tamnoides L. (bristly greenbrier); P; V; MF, BF; O-056

Typhaceae
**Typha angustifolia* L. (narrowleaf cattail); P; F; WAV; O-156

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SMOKE-INDUCED GERMINATION IN *PHACELIA STRICTAFLORA*

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ABSTRACT

Seedlings of *Phacelia strictiflora* A.L. de Jussieu (Hydrophyllaceae) germinate profusely after major fires in the Cross Timbers forest of Oklahoma and rarely at other times and places. Seed germination was greatly enhanced under laboratory conditions by exposure to a water suspension of smoke chemicals. This is the first report of smoke enhancement of germination in a native Oklahoma plant species. Many plant species grow abundantly after disturbances including fires, but smoke enhancement of germination allows *P. strictiflora* to grow abundantly after fires and only rarely after other kinds of disturbance.

INTRODUCTION

Seeds of some plant species rarely germinate except after fires. These species grow in ecological communities that depend upon a fire cycle for regeneration. Examples include the chaparral (Keeley and Fotheringham 1998a; Keeley et al. 2012), the shrublands of Western Australia (Dixon et al. 1995; Thomas et al. 2007; Turner et al. 2009), and the South African fynbos (DeLange and Boucher 1990). Germination after fire may confer a great advantage on seedlings because the adult plants often form a dense cover against which the seedlings would be unable to successfully compete for light, water, and nutrients. Post-fire germination also allows seedlings to benefit from a flush of mineral nutrients provided by the ashes. Moreover, in fire-cycle communities, seeds may require exposure to one or more chemical components of smoke in order to germinate. In some cases, these chemicals may be oxidizing gases such as NO_2 (Keeley and Fotheringham 1998b), while in other cases they may be a group of butenolides known as karrikins, which are growth regulators produced by the combustion of cellulose (Flematti et al. 2004; Chiwocha et al. 2009; Dixon et al. 2009).

In many cases, profuse germination after fires may result mainly from the sudden and greater abundance of light, water, and nutrients at the ground level, rather than from exposure to smoke chemicals. Many forms of disturbance other than fire also provide flushes of these resources. In this paper, we report that seed germination of *Phacelia strictiflora* A. L. de Jussieu (Hydrophyllaceae) is very strongly enhanced by smoke and rarely occurs without smoke stimulation. We also present evidence that post-fire germination of *P. strictiflora* seeds is not simply due to availability of a flush of resources or to stratification. This is the first report of

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smoke enhancement of germination in a native Oklahoma plant species.

Phacelia strictiflora is a native Oklahoma plant species that is a close relative of the chaparral *P. grandiflora,* in which smoke strongly enhances germination (Keeley and Fotheringam 1998a). *P. strictiflora* grows in poor soils in the south central United States. In Oklahoma, *P. strictiflora* is normally a rare spring annual in the Cross Timbers forest, which is noted for its poor soils. However, after major summer fires, *P. strictiflora* may grow and bloom profusely, forming nearly a monoculture in some areas, in the following spring (Figures 1, 2). The strong association between fire and germination led us to hypothesize that smoke chemicals greatly enhance the germination of *P. strictiflora* seeds.

MATERIALS AND METHODS

We collected seeds from mature, dry *Phacelia strictiflora* plants in a postfire area of the Blue River Wildlife Conservation Area maintained by the Oklahoma Department of Wildlife Conservation, near the junction of State Highway 7 and the Blue River in Bryan County (34º 21.50' N, 96º 35.41' W). A wildfire destroyed most of the adult trees in 2011. We collected seeds of mature, senescent plants in May 2012 from ten different 25 m^2 areas within the burned forest. We stored the dry seeds in plastic bags in the laboratory, at first at room temperature and later in a refrigerator, but we did not moisten the seeds except in the stratification treatment (see below). We used a dissecting microscope to carefully select healthy seeds (plump and free of discoloration) to use in the following experiments.

Figure 1 *Phacelia strictiflora* at the Blue River Wildlife Conservation Area the April following the 2011 fire.

Figure 2 Abundant post-fire growth of *Phacelia stricitflora* in the Cross Timbers forest at the Blue River Wildlife Conservation Area in April 2012.

We first explored the likely range of conditions that may induce germination of *P. strictiflora* seeds. We exposed seeds to a broad range of conditions, including: heat and smoke from a grill in which we burned dried branches of *Q. stellata;* ground ashes; physical scarification with sandpaper; a 3 mg/ml solution of Miracle-Gro® complete fertilizer; a 5% solution of Colgin brand Liquid Smoke®; sulfuric acid (diluted to pH = 3); and ammonium hydroxide (diluted to pH = 10). We used 30 petri plates, each with 20 seeds, for a total of 600 seeds. We kept all petri plates on racks underneath fluorescent lights in a temperature-controlled laboratory for a month.

For the two main experiments, we produced an aqueous suspension of smoke molecules in the following manner. We placed 150 ml (5.07 oz) of water in the reservoir of a commercial hookah pipe and burned post oak wood in the bowl. We drew smoke through the water using a nasal aspirator for three hours, during which time we replenished the oak wood as it burned. The result was a water suspension that was visibly amber and smelled like smoke. We diluted some of this suspension to half-strength, and some of it to quarter-strength. We kept the three dilutions in refrigerated test tubes sealed with parafilm to discourage the diffusion of volatile smoke chemicals and performed the experiments during storage of the water suspension.

In the first of these experiments, we compared stratified with unstratified seeds. We stratified some seeds by keeping them for a month in a refrigerator in moist paper towels inside of open plastic bags. For each of the following conditions, we then prepared four petri plates, each with 25 stratified seeds kept under the following conditions:

- Distilled water (control)
- Quarter-strength smoke solution
- Half-strength smoke solution
- Full strength smoke solution

We did the same with petri dishes of unstratified seeds. The result was a sample of 400 stratified seeds (in sixteen plates) and 400 unstratified seeds (in sixteen plates), for a total sample size of 800 seeds. We kept all petri plates on racks underneath fluorescent lights in a temperature-controlled laboratory for a month. As needed, we added distilled water to the plates, but no additional smoke solution.

In the second of these experiments, we used only unstratified seeds that had been stored in a refrigerator. We placed two control plates, two quarter-strength plates, two half-strength plates, and two full strength plates, each with 25 seeds, under the fluorescent lights (n = 200) and in darkness (a drawer adjacent to the lights; n = 200), for a total sample size of 400 seeds. Temperature under the lights was slightly higher (26º C, 78.8º F) than temperature in darkness (22º C, 71.6º F).

We analyzed the germination results using a chi-square analysis. We could not use a parametric test because in many of the petri dishes no seeds germinated. The preponderance of zeroes made parametric analysis invalid.

RESULTS

None of the 600 seeds germinated in the initial studies. From this we concluded that seed dormancy in *Phacelia strictiflora* prevented germination in response to a flush of nutrients or a change in pH. We also concluded that dormancy of *P. strictiflora* seeds could not be easily broken by heat or physical abrasion.

In the experiment that compared stratified with unstratified seeds, no control seeds germinated, and only one seed germinated when exposed to full-strength smoke suspension. The greatest germination occurred in half-strength and quarter-strength smoke suspension (Table 1). This pattern was significant for both stratified

(p = 0.001) and unstratified (p = 0.001) seeds, analyzed separately. Not only did stratified seeds display lower total germination than unstratified seeds, but they germinated more slowly. Unstratified seeds began to germinate after 7 days, while stratified seeds did not begin to germinate until 21 days.

Contrasting with the preliminary experiments, the experiment that compared seeds exposed to light and darkness resulted in 11 of the 50 dark control seeds germinating. However, no seeds germinated in full-strength smoke suspension, and the greatest germination still occurred in half-strength and quarter-strength smoke suspensions, as in Experiment 1 (p = 0.001) (Table 2). Overall germination was greater in darkness than in light (p = 0.001)

Table 1 Number and percentage of stratified and unstratified *Phacelia strictiflora* seeds that germinated. Each treatment contained 100 seeds (n = 800).

	Unstratified seeds	Cold-stratified seeds
Full-strength smoke suspension	0 (0%)	1 (1%)
Half-strength smoke suspension	54 (54%)	16 (16%)
Quarter-strength smoke suspension	37 (37%)	5 (5%)
Control	0 (0%)	0 (0%)

Table 2 Number and percentage of *Phacelia strictiflora* seeds that germinated in the light and the dark. Each treatment contained 50 seeds (n = 400).

	Light	Dark
Full-strength smoke suspension	0 (0%)	0 (0%)
Half-strength smoke suspension	13 (26%)	21 (42%)
Quarter-strength smoke suspension	13 (26%)	27 (54%)
Control	0 (0%)	11 (22%)

DISCUSSION AND CONCLUSIONS

Very few control seeds of *Phacelia strictiflora* germinated. We cannot explain why 11 control seeds germinated in darkness in the final experiment, while no control seeds germinated in previous experiments. One possibility is that smoke chemicals diffused through the air from plates with smoke suspensions into some control plates, since all the plates were in the same drawer. But we have observed that a few *Phacelia* seedlings germinate in the field in years without fire. Even the post-fire herbaceous plants of the chaparral have a low level of seed germination under control conditions; a few control seeds germinated in seven of twelve chaparral species (including *P. grandiflora*) investigated by Keeley and Fotheringam (1998a). We have nevertheless demonstrated a strong smoke enhancement of *P. strictiflora* seed

germination, similar to that of post-fire species in fire-dependent ecological communities.

Half- or quarter-strength smoke suspension greatly enhanced seed germination. The failure of seeds to germinate upon exposure to the full-strength suspension agrees with the conclusions of Drewes et al. (1995) that high concentrations of smoke chemicals can inhibit germination. The possibility that the seeds require exposure to light in order to respond to smoke (Todorović et al. 2005) was not supported in this species by our experiments. Greater germination in the dark in the final experiment may have resulted from the slightly lower temperature. Growth chambers with full temperature control were not available for this research.

We demonstrated that cold stratification was unnecessary as well as insufficient for germination. In southern Oklahoma, many annual species germinate and grow during the mild winters, and the same may be true of *P. strictiflora*. In fact, cold stratification appeared to mildly inhibit germination.

In the tallgrass prairie of North America, recurring fires destroy woody vegetation and promote the re-growth of perennial grasses and forbs. However, smoke enhances germination in only about one-third of prairie species (Jefferson et al. 2008). This may be due to the fact that most post-fire re-growth in the tallgrass prairie comes from the re-sprouting of perennials rather than the germination of seeds. Seed germination in prairies often occurs after soil disturbance by animals. The Cross Timbers forest is an ecotonal community between the eastern deciduous forest and the tallgrass prairie. However, even though its common name is "prairie phacelia," *P. strictiflora* appears to be more common in deciduous forest than in prairie habitats.

Butenolides such as karrikins may stimulate germination and promote seedling vigor even in species of plants, including agricultural plants, that do not require them (Stevens et al. 2007; Ghehebriot et al. 2008; Lindon and Menges 2008; Nelson et al. 2009; Hong and Kang 2011). Unlike these species, however, smoke enhancement of *P. strictiflora* germination appears to be strong enough to effectively limit its growth to post-fire conditions. In this way, *P. strictiflora* more closely resembles the post-fire plant species of fire-dependent ecological communities than it does the other plant species of the deciduous forest.

A seed bank, produced by postfire growth after previous fires, is the only likely explanation of the massive postfire growth of *P. strictiflora* in 2012. Too few individuals grow without fire to permit such profuse germination without a persistent seed bank. The seed bank remains largely, but not completely, dormant until a fire occurs. Further, we have observed massive blooms of *P. strictiflora* only in Cross Timbers forests growing on granite substrate, but no such blooms in forests growing on limestone. The thinner soils that develop over granite may have, over time, favored the growth of *P. strictiflora*, allowing it to build up a seed bank in those soils. Investigation of the *Phacelia* seed bank is an opportunity for future research.

Smoke enhancement of seed germination has not been reported for other native Oklahoma plant species. We have observed another species, *Selenia aurea* (Brassicaceae), growing abundantly after the same fire that promoted the mass flowering of *P. strictiflora,* but the possibility that *S. aurea* benefits from or requires smoke for germination has not been investigated.

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Critic's Choice Essay

A CAVALCADE OF FIELD BOTANISTS IN OKLAHOMA – CONTRIBUTORS TO OUR KNOWLEDGE OF THE FLORA OF OKLAHOMA

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As members of the Oklahoma Native Plant Society (ONPS) well know, Oklahoma has a tremendous diversity of vascular plants—174 families, 854 genera, and approximately 2,600 species—that reflects the ecogeographic diversity present within the state's borders (Tyrl et al. 2008). Our knowledge of this flora is the result of contributions by numerous individuals for more than 450 years. Some simply recorded their observations of the state's flora as they passed through; whereas, others made systematic surveys and documented their work by actually collecting plants for voucher specimens to be deposited in herbaria.

These individuals and the contributions that they have made to our knowledge of the plants and vegetation of Oklahoma are the subject of this essay. Its title and concept are rooted in a presidential address given by H.I. Featherly in 1942 to the Oklahoma Academy of Science and a master's thesis by Wanona Henson, one of his graduate students (Henson 1941; Featherly 1943). We have unabashedly adopted their approach and excerpted some of their thoughts about the state's first field botanists in our synopses. As they did, we present our individuals more or less chronologically. Each synopsis comprises a brief biographical sketch and the botanical contribution(s) they made. When specific plants are cited, currently accepted scientific names are used unless otherwise noted. Common names are taken from Taylor and Taylor (1994), Tyrl and coworkers (2008), Folley (2011), and USDA, NRCS (2013).

Francisco Vásquez de Coronado—Our cavalcade of field botanists begins with Coronado, whose 1540–1542 expedition in search of the fabled city of gold is the first documented trek by Europeans across the plains and prairies later to become Oklahoma. Coronado was not a botanist nor was there a botanist with his group. He did not make a list of the plants that he saw on his expedition, but he did describe the general appearance of the country. Describing his journey northward through Oklahoma, he wrote in his report to Emperor Charles V of Spain: *"…there is not any kind of wood in all these plains, away from the gullies and rivers which are very few."* (Dale and Rader 1930).

Figure 1 Putative route of Coronado's travel in Oklahoma (Buchanan and Dale 1939).

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It is thought that his route northward was along the 98th Meridian. He possibly passed between the Wichita and Arbuckle Mountains, through the El Reno area, and on north to the Arkansas River (Buchanan and Dale 1939; Figure 1 above).

Hodge (1907) suggested that his route was perhaps closer to the 100th Meridian which marks the western boundary of the body of Oklahoma (Figure 2). His return from Quivira in modern-day Kansas, a city that he thought was going to be a source of wealth but was actually a village of semi-nomadic Plains Indians, ran along the course of what was later to be known as the Cimarron Cut-Off of the Santa Fe Trail.

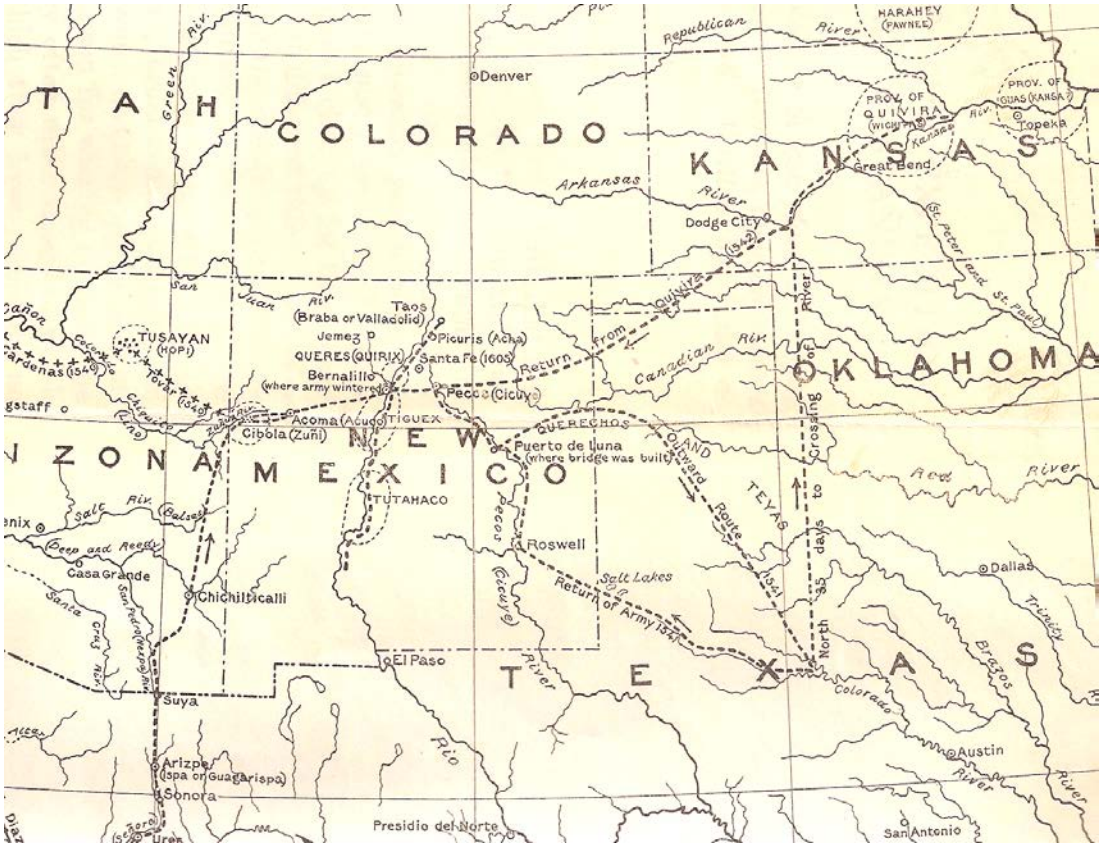


Figure 2 Putative route of Coronado's travel in Oklahoma (Hodge 1907).

Juan de Oñate—In 1601, Juan de Oñate, governor of New Mexico, led another expedition into the North, also in search of Quivira. The map he drew of his route shows that he also crossed Oklahoma (Bolton 1916). Entering the state from the west at about 36° N in Ellis County, he followed the Canadian River (which he named the Magdalena), angled to the northeast, and exited at about 98° W near Manchester in Grant County. Like Coronado, de Oñate was not a botanist and did not have one with him. However, in his report of the journey (1601), he described the surrounding landscape—sand dunes, extensive level plains, deep ravines, and broken hills. These are now known as the geomorphic provinces: Western Sand Dune Belts, Central Redbed Plains, Western Sandstone Hills, and Cimarron Gypsum Hills (Curtis and Ham 1972). He also cited the edible plants his group encountered.

For example, he wrote:

> *And the fruits gave no less pleasure, particularly the plums, of a hundred thousand different kinds, as mellow and good as those which grow in the choicest orchards of our land. They are so good that although eaten by thousands they never injured anybody. The trees were small, but their fruit was more plentiful than their leaves, and they were so abundant that in more than one hundred and fifty leagues, hardly a day passed without seeing groves of them, and also grapevines such that although they hid the view in many places they produced sweet and delicious grapes.*

De Oñate undoubtedly was describing thickets of sand plums (*Prunus angustifolia*). After crossing the Cimarron River, he wrote:

> *…for many leagues…the fields there were covered with flowers of a thousand different kinds, so thick that they choked the pasture. The cattle of this territory must eat the flowers far better than ours are wont to, because wherever they were there were multitudes of cattle.*

James Biddle Wilkinson—The person credited with the first official description of the ecogeography of Oklahoma was Lieutenant J.B. Wilkinson, a member of the Zebulon Pike Expedition of 1806 and 1807 to explore the poorly defined south and west boundaries of the Louisiana Purchase where it abutted the region claimed by Spain (Jackson 1966). Pike left Fort Bellefontaine near St. Louis; followed the Missouri, Osage, and Republican Rivers; and eventually traveled overland to reach the Arkansas River near the present day town of Great Bend, Kansas. On October 28th, 1806, Pike divided his group into two parties and assigned Lt. Wilkinson and five men the task of following the Arkansas River downstream to its junction with the Mississippi River. On December 31, the party passed the mouth of the Poteau River at the eastern edge of Oklahoma (Buchanan and Dale 1939). Wilkinson made extensive notes on the geographic and topographic features of the country through which he passed. He also made brief notes on the vegetation and some of the plants he encountered, but he did not make a formal list of the plants seen. His report, included in Pike's (1810) report of the expedition to the government, was the first description of a part of Oklahoma by an American (Dale and Rader 1930).

George C. Sibley—A brief acknowledgement of George Sibley's observations of one of Oklahoma's most interesting ecogeographic sites is appropriate. Appointed in 1808 as the head trader at the Indian Factory at Fort Osage, Missouri, he led a party of interpreters and Osage scouts on a two-month exploration in May 1811, intended to improve relations between the Kansa and the Pawnee Indians and to examine the hunting grounds of the Osage Indians (Tyson 2009). During his visit with the Osage at villages along the Arkansas River near the mouth of the Verdigris River, Sibley traveled to the Great Salt Plains. Calling the area the "Grand Saline," he described the plains by writing:

> *This beautiful white dazzling surface (bordered by a fringe of verdant green) has the effect of looming, as the sailors call it, producing to the unpracticed eye, much delusion.*

As de Oñate had done, he feasted on sand plums and recorded in his diary:

> *…barren sand hills (not red sand) on the sides of which are here and there a few dwarf plum bushes not over thirty inches high from which we gathered abundance of very large delicious red plums.* (Sibley 1927)

Sibley also noted in his diary that, according to the Osage Indians accompanying him, he was the first white man to visit the area. He also visited an area he called the "Rock Saline" that is probably the salt springs near the

Blaine Escarpment on the upper Cimarron River (Tyson 2009).

Thomas Nuttall—An Englishman from Yorkshire, England, Thomas Nuttall (Figure 3) is generally acknowledged to be the first botanist to visit what is now Oklahoma (Featherly 1943). Although he had no formal education, he published papers and books in botany, geology, and zoology. He was among the first individuals to champion the use of a natural classification for plants in the United States, and he authored a botany textbook (Lawrence 1951; Graustein 1967). His two volume *A Manual of the Ornithology of the United States and of Canada*, published in 1832 and 1834, was the first systematic treatment of North American birds.

Figure 3 Thomas Nuttall. Harvard University Portrait Collection.

Nuttall's principal biographer Jeannette E. Graustein (1967) gives a most comprehensive and informative account of his early life and career which forms the basis for the following comments. At 14 years of age, Nuttall began an apprenticeship as a printer for his uncle in Liverpool. He apparently spent his Sundays and spare time reading books on the natural history, botany, and geology of The Pennines (an irregular chain of hills in Northeast England) and botanizing with surgeon and botanist John Windsor. As an apprentice printer, Nuttall was likely involved in the printing of the Liverpool museum's catalogue of plant and animal specimens, arranged according to the Linnean system of classification.

When Nuttall's seven-year apprenticeship ended in 1807, he refused to join his uncle's printing company and decided to pursue a career in natural history. Why he chose to travel to North America is unknown, although Graustein suggested that he may have been influenced by his reading of Francois André Michaux's 1805 *Travels to the Westward of the Allegheny Mountains in the States of The Ohio, Kentucky and Tennessee in the Year 1802* and/or Alexander von Humboldt and Aime Bonpland's 1805 *Essai sur la Géographie des Plantes*. Regardless of the reason, his career as a naturalist began in 1808 when he immigrated to Philadelphia. There, he met the famous American botanist Benjamin Smith Barton who started him on his career as an explorer and botanist. He began collecting plants for Barton and for Philadelphia University; his first field work was in the salt marshes of Delaware and Chesapeake Bay in 1809 (Thwaites 1905; Reveal 1998). Barton asked him to botanize in the Great Lakes Region in the summer of 1810. While doing so, he joined an expedition of John Jacob Astor's American Fur Company and in 1811 began making his way up the Missouri River eventually reaching Fort Mandan in present day North Dakota. Although Lewis and Clark had traveled this way previously, many of their plant specimens had been lost. Thus, those collected by Nuttall on this trip were species new to science.

On October 2, 1818, Nuttall left Philadelphia to explore "the Southwest" — modern day Arkansas and Oklahoma. Four fellow members of the American Philosophical Society, to which Nuttall had been elected in 1817, made donations to defray the expenses of the trip (Lottinville 1980). He traveled overland to Pittsburgh, down the Ohio and Mississippi Rivers to the

Arkansas River, and then up to Fort Smith, which he reached on April 24, 1819. He began collecting in the spring meadows, and in the course of a few weeks he collected about a hundred new species, including the familiar *Nemastylis geminflora* (celestial lily), *Callirhoe digitata* (finger poppy mallow), *Collinsia violacea* (violet blue-eyed Mary), and *Verbena bipinnatifida* (prairie verbena) (Nuttall 1821; Graustein 1967). His collecting companion was Dr. Thomas Russell, who was the surgeon at Fort Smith. Unfortunately he died of a fever four months after Nuttall met him. *Monarda russeliana* Nutt. (Russell's beebalm) honors him.

In mid-May, Nuttall accompanied a Major Bradford, six soldiers, and two Cherokees south to the Red River. His route, experiences, and botanical observations are described in detail in his journal (1821) and by Geiser (1956). Bradford was instructed to order any white settlers he found off land granted to the Osage Indians (Graustein 1967). Their route took them along the Poteau River, near Cavaniol (Cavanal) and Sugar-Loaf Mountains, and across Winding Stair Mountain in the Ouachita Mountains—or as they were called then, the Mazern Mountains—to the Kiamichi and Red Rivers (Figure 4).

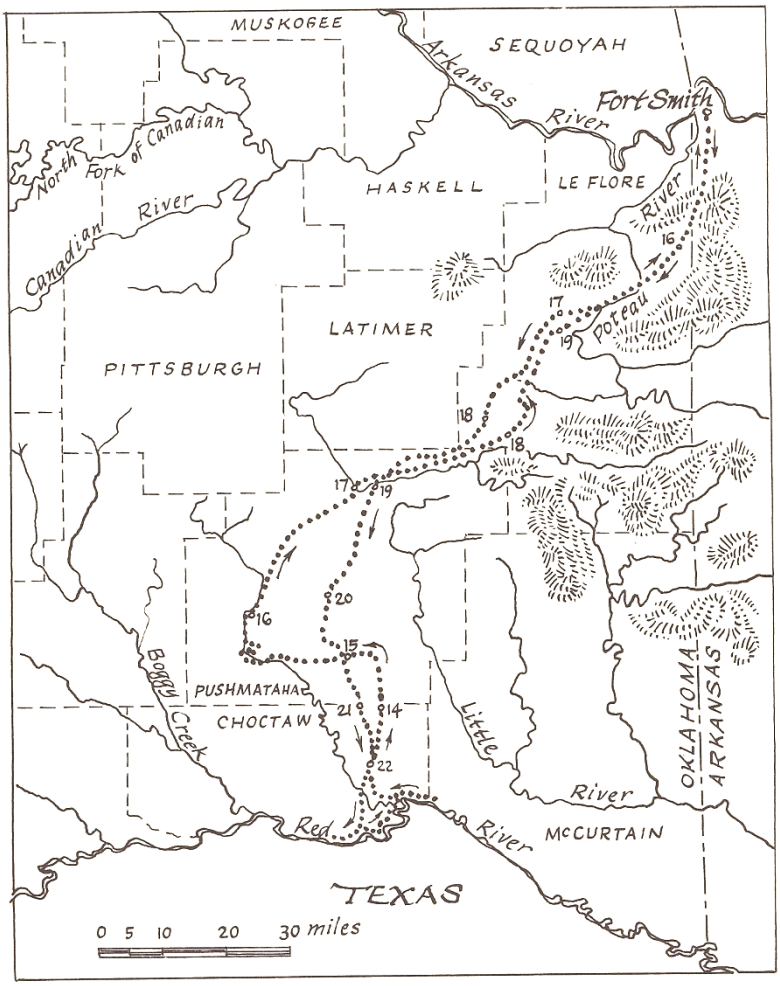


Figure 4 Route of Nuttall's travel to the Kiamichi and Red Rivers (Lottinville 1980). Courtesy of the University of Oklahoma Press.

As always, Nuttall diligently and poetically made observations of the landscape and on May 23 wrote:

> *The change in the soil in the great Prairie of the Red river now appeared obvious. It was here that I saw the first calcareous rock charged with shells, &c. since my departure from the banks of the Ohio. Nothing could at this season exceed the beauty of these plains, enameled with such an uncommon variety of flowers of vivid tints possessing all the brilliancy of tropical productions.*

Bradford's party remained in the vicinity of the Red River for three days before they started back to Fort Smith. Nuttall, however, lingered behind to collect several new plants, got lost, and never again rejoined Bradford. He took a wrong turn in the trail, went miles in the wrong direction, spent the night at a settler's house (who had just been ordered by Bradford to leave his home), lost his horse who wandered away in the night, stayed with another settler family for three weeks, and on June 14 started back to Fort Smith in the company of three hunters from the Red River settlements. Apparently Nuttall wasn't too disconcerted at being left behind, as he collected new species for 19 days. On June 4 he wrote in his journal:

The singular appearance of these vast meadows, now so profusely decorated with flowers, as seen from a distance, can scarcely be described. Several large circumscribed tracts were perfectly gilded with millions of the flowers of Rudbeckia amplexicaulis *bordered by other irregular snow white fields of a new species of* Coriandrum (now Biflora americana*, prairie bishop*).

On June 6, he wrote: *"Today I went five or six miles to collect specimens of the Centaurea* (now *Plectocephalus americanus*, basket-flower)*, which as being the only species of this numerous genus indigenous to America, had excited my curiosity."* In terms of species new to science, familiar showy representatives discovered by Nuttall include *Penstemon cobaea* (large prairie beardtongue), *Platanthera leucophaea* (eastern prairie fringed orchid), *Sabatia campestris* (prairie rose gentian), *Oenothera speciosa* (showy evening primrose), *Marshallia caespitosa* (Barbara's buttons), and *Rudbeckia maxima* (giant coneflower).

Nuttall stayed at Fort Smith until July 6. He hitched a ride on a boat with traders going up the Arkansas River to a trading post which had been established at the mouth of the Verdigris River (Figure 5). On July 14, he reached the Verdigris and the Bougie (Bogy) Trading Post. Nuttall was a careful observer of the country through which he was passing and described it in detail. Much of our understanding of what the vegetation was like before European settlement can be attributed to his descriptions. For example, he wrote on July 13:

> *The variety of trees which commonly form the North American forest, here begin very sensibly to diminish. We now scarcely see any other than the smooth barked cottonwood, the elm, the box-elder (*Acer negundo*), the curled maple (*Acer dasycarpon*), and ash; all of them reduced in stature. From hence the forest begins to disappear before the prevailing plain."*

On July 17, he traveled by canoe about 50 miles up the Grand River with two companions to visit a salt works (springs) and reached it two days later. While his traveling companions continued their journey up the river, Nuttall, using a compass to maintain his heading, walked alone overland across the prairie to the trading post. On July 20 he wrote: *"Twenty miles of this route was without any path, and through grass three feet deep, often entangled with brambles, and particularly with the tenacious 'saw-brier' (*Schrankia horridula*)."* *Schrankia horridula* is now *Mimosa quadrivalvis*, catclaw sensitivebriar. He spent one night in the open prairie without fire, food, or water.

An interesting aside is that Nuttall, the night before setting out on his walk, dosed himself with "…*about a pint of a strong and bitter decoction, of the Eupatorium cuneifolium*…" in

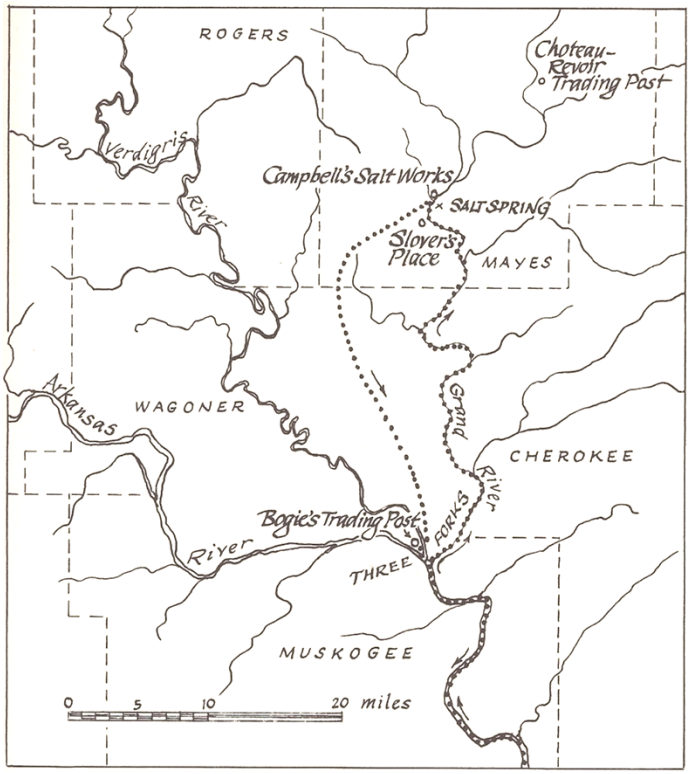
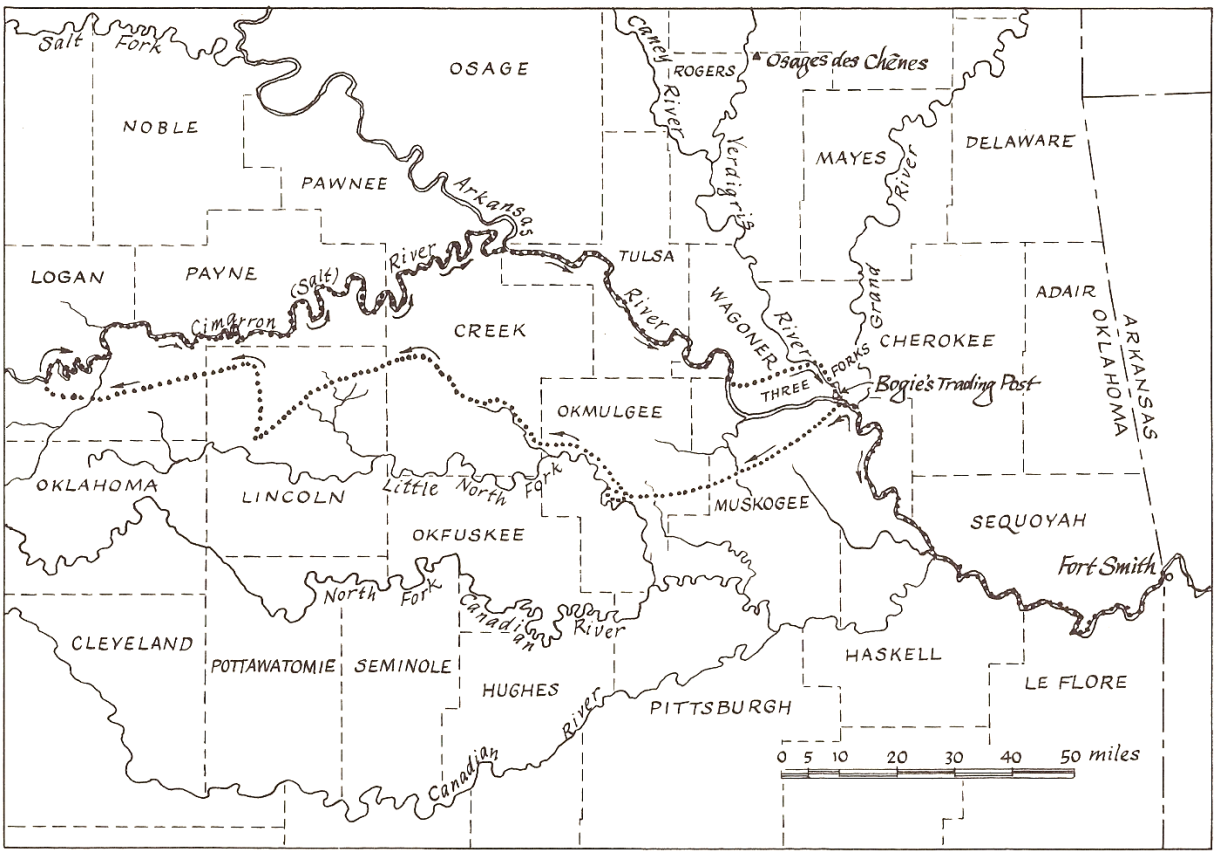


Figure 5 (left) Route of Nuttall's travel to the three rivers junction (Lottinville 1980). Courtesy of the University of Oklahoma Press.

Figure 6 (below) Route of Nuttall's travel to central Oklahoma (Lottinville 1980). Courtesy of the University of Oklahoma Press.



response to a *"…slight attack of intermittent fever…"* Because *E. cuneifolium* does not occur in Oklahoma, it is likely that his decoction comprised one of the other species of the genus present in the area (Lottinville 1980; Lawson 2004).

A cherished goal of Nuttall was to botanize in the Rocky Mountains. To avoid the circuitous course of the Arkansas River mapped by Wilkinson and Pike, he decided to follow the Cimarron River westward and return via the Red River (Figure 6; Graustein 1967; Lottinville 1980). On August 11, he left the Bougie Trading Post at the mouth of the Verdigris River accompanied by an experienced hunter-trapper named Lee who had previously traveled west to the Rockies (Lottinville 1980). On horseback, they traveled overland from the Arkansas River to the Little North Fork of the Canadian River (now called the Deep Fork River), followed it for a while, and again traveled overland to the Cimarron River and westward. As they traveled, Nuttall recorded his observations of the changing landscape and botanized.

The trip was quite an ordeal for Nuttall because three days into the journey (August 14) on the banks of the Deep Fork, he suffered a relapse of the remittent fever he had contracted while at the trading post at the mouth of the Verdigris River. He became desperately ill, often was delirious, ran high fevers, lost his appetite, and became increasingly weak. Lee thought he was going to die and suggested turning back. Nuttall resisted returning and talked Lee into going farther west. To make matters worse, the area was in the midst of a heat wave and drought and thus the scarce water in the streams was "…*always stagnant and often putrid.*" In addition, the two men and their horses were plagued by blowflies and their maggots. They finally reached the Cimarron River on September 3 and followed it westward until September 8 when the ailing Nuttall gave in and agreed to give up his quest to reach the Rocky Mountains. He and Lee started downstream in a canoe built by Lee. They likely only traveled as far west as Guthrie in Logan County (Lottinville 1980). Lottinville's conclusion is based on Nuttall's journal entry on September 3: "*A few days journey to the west, Mr. Lee informs me, that there are extensive tracts of moving sand hills, accompanied by a degree of sterility little short of the African deserts.*" Lee is obviously referring to the Western Sand Dune Belt geomorphic province with its characteristic Quaternary sands deposited on the north and east sides of the Cimarron River (Curtis and Ham 1972).

Even while sick and struggling to return to the trading post, Nuttall was recording the discovery of new species, such as *Happlopappus ciliata* (wax goldenweed, now *Grindelia ciliate*, *Eriogonum annuum* (annual buckwheat, and *Tidestromia lanuginosa* (woolly tidestromia). On September 15, Nuttall finally reached the Bougie Trading Post. "…*In a very feeble state, again visited by fever, and a kind of horrific delirium…*", he was nursed by Bougie for a week and then traveled down the Arkansas River to Fort Smith. He continued to be sick and weak, and in late April he returned to Philadelphia (Graustein 1967).

Upon his return, his patrons urged him to write an account of his travels based on his daily journal entries. He reluctantly agreed to do so and in November of 1821 published his *A Journal of Travels into the Arkansa Territory, During the Year 1819 with Occasional Observations on the Manners of the Aborigines*. He dedicated the book to the four individuals who financed the trip. In 1834, he read a paper before the American Philosophical Society in which he listed 550 species from Arkansas and Oklahoma. The list was subsequently published in 1837 (Nuttall 1837). Based on the number of species in the families Asteraceae (sunflowers) and Fabaceae (legumes) described by Nuttall, Geiser (1956) estimated that about 9.6% of Oklahoma's plant species were given names by him. Indeed, 31 of the state's 850 genera and 211 of its 2,465 species were described by him (Tyrl et al. 2010). In addition, 13 Oklahoma species have the specific epithet *nuttallii* or

nuttalliana honoring him, as does the genus *Nuttallanthus*.

The 1837 publication of Nuttall's species list is considered to be the first documented collection of the state's flora (Johnson and Milby 1989). His contributions to our knowledge of the flora of Oklahoma and North America is perhaps best summarized by the famous taxonomist Asa Gray who wrote (Ewan 1969) in 1844:

> *…no botanist has visited so large a portion of the United States, or made such an amount of observations in field and forest. Probably few naturalists have ever excelled him in aptitude for such observations, in quickness of eye, tact, in discrimination and tenacity of memory.*

Figure 7 Edwin James. Photo courtesy of Hunt Institute for Botanical Documentation, Carnegie Mellon University, Pittsburgh, Pennsylvania.

Edwin James—In 1820, Major Stephen H. Long's expedition to the Rocky Mountains passed east through Oklahoma along the Canadian River (Goodman and Lawson 1995). Commissioned by President James Monroe in 1818, the purpose of the expedition was to find the sources of the Platte, Arkansas, and Red Rivers in the Rocky Mountains and to gather scientific information. The party included a zoologist, a naturalist, and a botanist. A replacement for a Dr. William Baldwin who died in Missouri in the initial stages of the trip, Edwin James (Figure 7) was the expedition's botanist, geologist, and surgeon (Ewan 1950). Twenty-three years old, he kept a journal of his observations that was the basis for his three volume *Account of an Expedition from Pittsburg to the Rocky Mountains…in the Years 1819, 1820 Under the Command of Major Stephen H. Long…,* published in 1823 (James 1823).

As Benson (1968) and Goodman and Lawson (1995) have noted, the significance of James's work is that he returned with hundreds of plant specimens from areas—Nebraska, Colorado, New Mexico, Texas, and Oklahoma— that hadn't been visited before by botanists. His collections encompassed the central grasslands, the coniferous woodlands and forests of the Rocky Mountains, and for the very first time the alpine zones of the Colorado Rockies. They also stress that his accomplishments are quite remarkable considering that he was only in the field for one hundred days and was transporting his specimens via packhorses. Well over 100 of the plants he collected were new to science. He had quite a sharp eye for different species. When he reported the first occurrence of a plant in his journal, the location often later proved to be the eastern or western limit of that species' distribution. In addition to collecting and listing the species he encountered, James entered almost daily observations of the vegetation and geography of the area through which the expedition passed, thus giving us a description of what the landscape was like before European settlers and accompanying alien plants began to change it.

James published a partial plant list in 1825, but it was the famous taxonomist John Torrey who published most of James's discoveries. In three lengthy publications, Torrey described the new species and honored James by naming several for him (Torrey 1824a, 1824b, 1827). Illustrative of

this honor are two Oklahoma species: *Eriogonum jamesii* (James's wild buckwheat) and *Paronychia jamesii* (James's nailwort).

As determined by Goodman and Lawson (1995), Long's party crossed the 100th Meridian on August 18, 1820 and entered modern-day Ellis County in the area of Antelope Hills. Their route across the state followed the Canadian River to its junction with the Arkansas River, which they then traveled down to Fort Smith, Arkansas and exited Oklahoma on September 13 (Figures 8, 9).

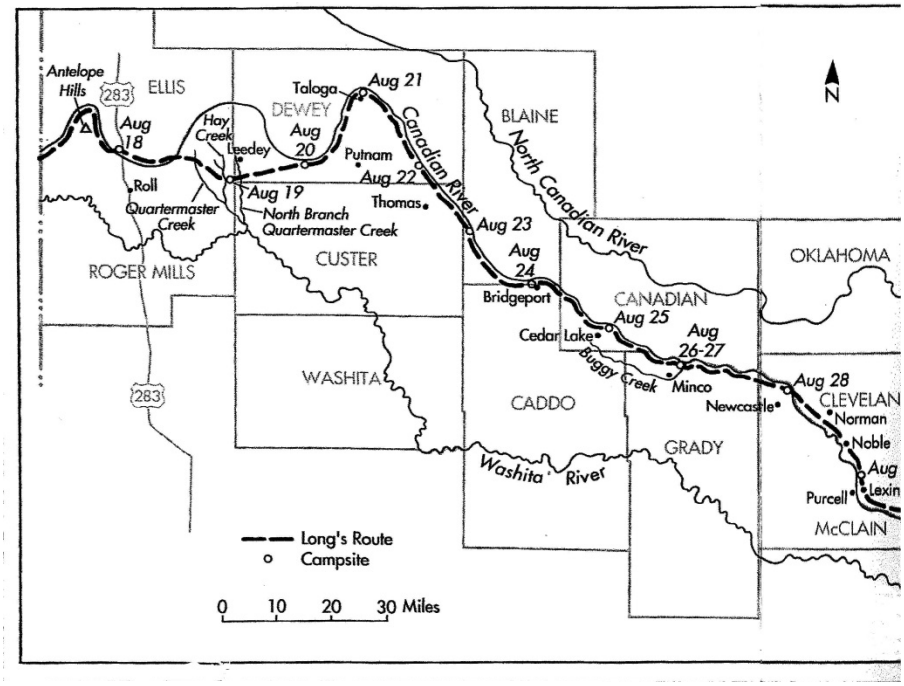


Figure 8 Western half of route of Long expedition through Oklahoma (Goodman and Lawson 1995). Courtesy of the University of Oklahoma Press.

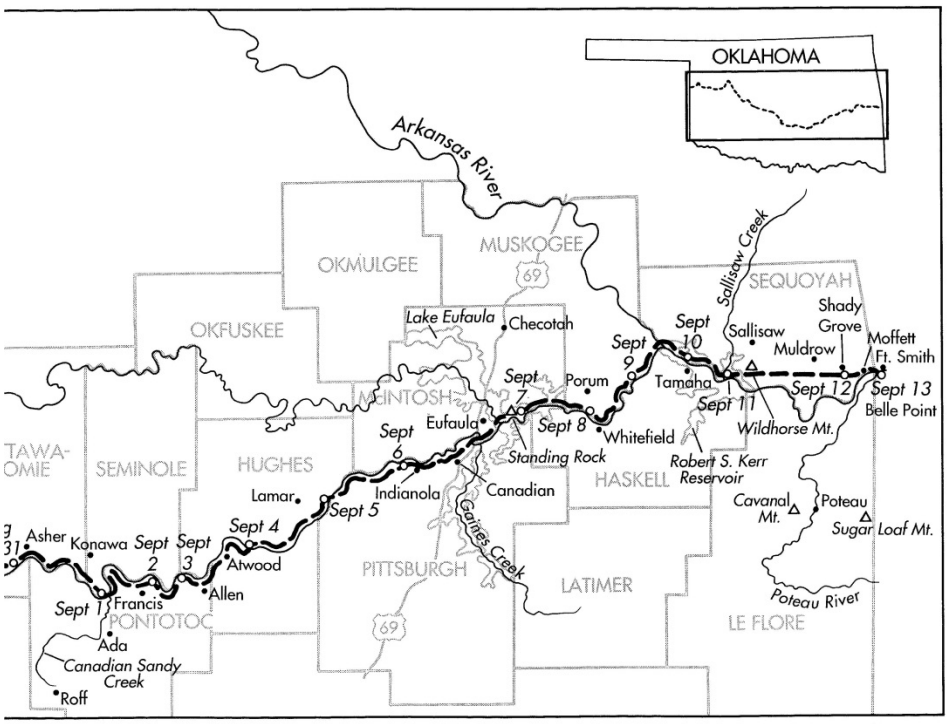


Figure 9 Eastern half of route of Long expedition through Oklahoma (Goodman and Lawson 1995). Courtesy of the University of Oklahoma Press.

Goodman and Lawson (1995) provide the most comprehensive list of James's collections. Of the many species collected by James in Oklahoma, representatives familiar to ONPS members include the following: *Cornus drummondii* (rough-leaf dogwood), *Asimina triloba* (pawpaw), *Plectocephalus americanus* (basket flower), *Elephantopus carolinianus* (leafy elephant-foot), *Monarda punctata* (spotted beebalm), *Cercis canadensis* (redbud), *Oenothera speciosa* (pink ladies), and *Nemastylis geminiflora* (celestial lily)

Washington Irving and Charles Joseph Latrobe—In 1832, Washington Irving, often described as America's first internationally known author, and Charles Latrobe visited Oklahoma and made observations of its flora and vegetation (Figures 10, 11). Irving is, of course, best known for his short stories such as *The Legend of Sleepy Hollow* and *Rip van Winkle*, but he was also a prolific writer of essays, biographies, and travelogues (Thoburn and Wells 1955).

Figure 10 Washington Irving. Copy daguerreotype by Mathew Brady, reverse of original by John Plumbe, from U. S. Library of Congress's Prints and Photographs Division.

An Englishman, Latrobe was the first lieutenant-governor of the colony of Victoria in Australia and played an important role in the development of Melbourne's infrastructure (Wright and Shirk 1955). Of importance to us, is that he was also a naturalist, being interested in plants, geology, beetles, and butterflies.

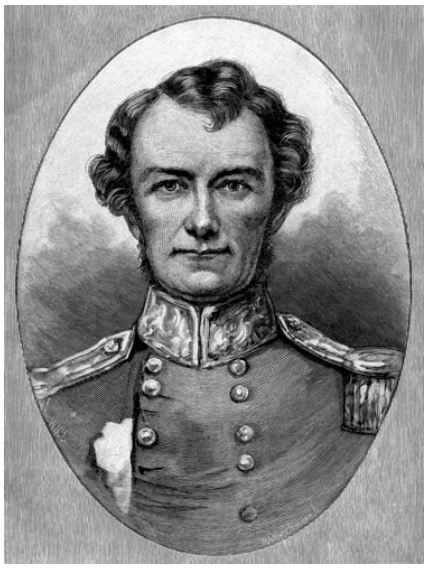


Figure 11 Charles Joseph Latrobe. Portrait from Royal Melbourne Hospital archives, Melbourne, Victoria, Australia.

Their trip to Oklahoma was the result of a series of fortuitous meetings. As described by McDermott (1944), Irving and Latrobe met and became friends while traveling by ship from Europe to New York early in the spring of 1832. They apparently regaled themselves with the possibility of visiting the Far West and engaging in buffalo hunts and other adventures. On a subsequent boat trip from Buffalo, New York to Detroit in August 1832, they by chance met Henry Leavitt Ellsworth. Appointed by President Andrew Jackson as one of three commissioners for Indian tribes in Arkansas and Oklahoma, he was on his way to Fort Gibson in Indian Territory and invited them to join him. His task was "…*to study the country, to mark the boundaries, to pacify the warring Indians, and in general, to establish order and justice*." (Williams and Simison 1937).

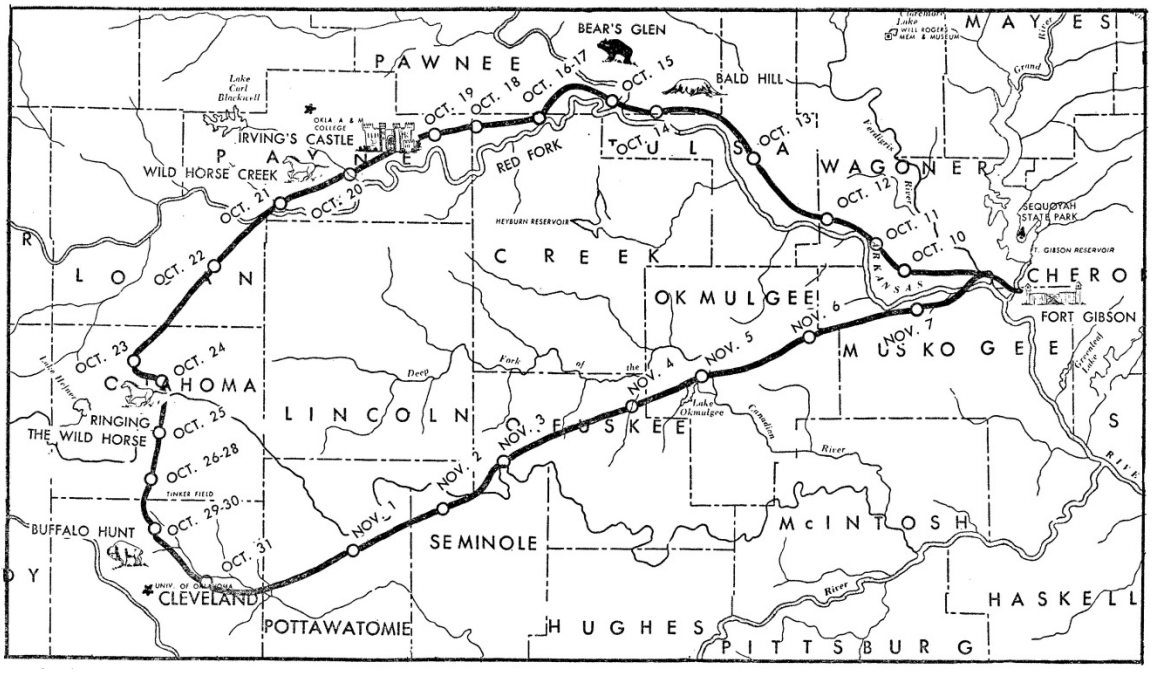


Figure 12 Route of the Ellsworth-Irving-Latrobe expedition through central Oklahoma (Wright and Shirk 1955).

When the three men arrived at Fort Gibson, Ellsworth discovered that there had been bureaucratic problems in communication. He wasn't expected, the other two commissioners and commission secretary hadn't arrived, and a military escort had been prematurely sent off, so no formal work could be done (McDermott 1944). He decided to lead an expedition into Indian Territory to examine the country for settlement by the Civilized Tribes being relocated from the East. He appointed Irving to serve as the expedition secretary. Although Irving was not the leader, this expedition is today commonly referred to as "Irving's Tour" or the "Irving Expedition," most likely because of his fame as an author (Wright and Shirk 1955).

On October 10, they left Fort Gibson and over the course of the next four weeks made a loop through central Oklahoma (Figure 12). Irving described this exploration in his book *Tour on the Prairies,* which was published in 1835. Latrobe's account of the journey, also published in 1835, appeared in the form of six letters in his book *The Rambler in North America*. Ellsworth wrote just one, 116-page letter, dated November 17, 1832, to his wife telling her of his trip with Irving and Latrobe (Thoburn and Wells 1955). The letter was published in book form—*Washington Irving on the Prairie or A Narrative of a Tour of the Southwest in the Year 1832*—by Williams and Simison (1937). It is a more straight-forward account of the trip, in contrast to the more literary style publications of his companions. Each gives details not found in the other two works, and one really needs to read all three accounts to gain a complete understanding of what occurred and what they saw.

The significance of this trip is not in the plants collected, but rather in their descriptions of the landscape through which they passed and their different interpretations of it. For example, after having traversed the Cross Timbers during a period of stormy weather, Irving and his companions emerged upon the tallgrass prairie near the Canadian River in the vicinity of Norman. Irving wrote in his journal:

...we emerged towards mid-day from the dreary belt of the Cross Timber, and to our infinite delight beheld 'the great Prairie,' stretching to the right and left before us. We could distinctly trace the meandering course of the Main Canadian, and various smaller streams, by the strips of green forest that bordered them. The landscape was vast and beautiful. There is always an expansion of feeling in looking upon these boundless and fertile wastes, but I was doubly conscious of it after emerging from 'our close dungeon of innumerous boughs

In Letter XV, naturalist Latrobe described the Cross Timbers by writing:

The dark brown horizon which appeared before us as we emerged from the deep bed of the river was known to be the Cross Timbers, a broad belt of dwarf oak forest, rarely interrupted by prairie, extending across the country, from the Red Fork to the Great Canadian, in the direction of North and South. Its mean breadth, by the report of the Indians, was twelve or fourteen miles, and it was now our object to cross it in a south-westerly direction. None of our party I think will ever forget that hilly stony region with its almost impenetrable forest of the closest and harshest growth, whose low rugged branches black and hard as iron with the alternate extremes of frost and fire, cost us many a fierce scramble and struggle on our passage both to and from the Canadian.

In the Cross Timbers themselves, no animal but the bear could find sustenance. They were as, I have before said, composed entirely of oak, of which I enumerated seven distinct species, besides varieties; from the diminutive pin-oak, bearing acorns at two years growth, to the large-cupped burr-oak. Properly speaking there is no undergrowth but a coarse grass. From this iron-bound region, we generally contrived to escape towards night-fall, and to seek for a resting place in one of those spots of verdure in the vallies where the fading green and yellow foliage of the cotton-wood popular formed a pleasing contrast to the leafless oak, and held out promise of our obtaining the indispensable necessaries of wood and water.

Beside the above-mentioned popular, together with hickory, walnut and willows, and the black and honey locust, we found a rich under-growth of dogwood, persimmon, haws, vines with sweet and sour grapes—Chickasaw plums of various colours—sassafras, and abundance of green-briar or tear-blanket as it is familiarly called—besides sumac, the delight of the bear at this season.

Thompson B. Wheelock, Nathan Boone, and James W. Abert—Observations of Oklahoma's vegetation, albeit not always in great detail, were also made by officers on military expeditions through Indian Territory and surrounding areas. In the summer of 1834, First Lieutenant Wheelock kept an official journal (Wheelock 1834) of an expedition conducted by U.S. Army Dragoons under the command of Colonel Henry Dodge. They traveled in a loop from Fort Gibson, southwest to the Red River in Marshall County, west to the Wichita Mountains and North Fork of the Red River in Kiowa County, and back to Fort Gibson. As an aside, George Catlin, renowned for his paintings of Native Americans, accompanied the group and made numerous sketches and observations (Shirk 1950). Wheelock recorded his observations of the prairies, forests, and bottomlands through which the dragoons passed, in some instances noting the species. On June 28, he wrote: *"…character of timber, in general, small—post oak and black jack, and some trees of Bois d'Arc, a wood valuable to Indians for bows—a yellow, elastic wood of great tenacity*." He, of course, was describing *Maclura pomifera*, a member of the Moraceae or mulberry family, also known as Osage orange, bowood, and hedgeapple.

The youngest son of the famous Kentuckian Daniel Boone, Nathan Boone was a career military man who had commanded one of the companies on the 1834 Dodge expedition and was the first commander of Fort Wayne on Spavinaw Creek in

northeastern Oklahoma in 1838 (Fessler 1929; Foreman 1941). In 1843, he led a detachment of Dragoons from Fort Gibson, up the Arkansas River into central Kansas and back overland through western Oklahoma to the Cimarron River, before returning to Fort Gibson. In doing so, he visited the Great Salt Plains, the Glass Mountains, and the sand hills and dunes on the north sides of the Cimarron and Canadian Rivers. As Wheelock had done, Boone recorded his observations of the ecogeography and flora of the area. On May 19 in modern day Osage County, he recorded:

> *Noticed on the prairie the wild indigo with a blue, and also with a white flower; the sensitive plant, the polar plant, a rosin weed. This plant is a tall plant perhaps 7 feet high, with a fan-shaped leaf which ranges generally north and south, affording a tolerable compass to the traveler over the prairie. A quantity of rosin is secreted at each joint which might render its cultivation desirable; its taste is strongly resinous, and the horse is very fond of it.*

Boone's "polar plant" is undoubtedly *Silphium laciniatum*, commonly known as compass plant because of the orientation of its large basal pinnatifid or laciniate leaves. His observations of how his horse relished eating it are also astute. It is highly palatable and avidly sought out by livestock. Its presence and relative abundance is a classic indicator of grazing pressure. His "wild indigo" with blue flowers is likely *Baptisia australis,* which occurs as either scattered plants or small, localized populations and is characteristic of the later stages of plant succession in tallgrass prairies, as is *Silphium* (Tyrl et al. 2008).

Like the Long Expedition of 1820, a reconnaissance expedition led by Lieutenant Abert in 1845 traversed the state from west to east along the Canadian and Washita Rivers through lands occupied by the Kiowa and Comanche Indians (U.S. Senate 1846). As Everett noted (2009), he kept a journal of his observations in which he described and profusely illustrated the ecogeography, flora, and fauna of the area. In addition, he surveyed the locations of timber, water, and prairie grass, often including their exact latitude and longitude. His description of the sand dune belts on the north sides of the rivers illustrates the detail of his observations. His September 20 entry says:

> *To the southeast we traced the river by the high ridge of land which loomed up through the haze. Its bed spreads out to the width of 300 or 400 yards, and, being composed of deep sands, so absorbs the water that nothing can be discovered but a mass of fine, white silicious particles moving in the breeze…The strong wind heaps the sand upon the banks, forming constantly changing hillocks and often advancing inwards like the dunes on the seacoast. The course of the streams may be traced for miles on a windy day, by the drifting clouds of sand which hang over their beds…Today we found plenty of the oak and cotton-wood. The bottoms were filled with grape vines and plum trees, and we passed several groves of hackberry; and the plains were varied with a beautiful species of 'Labiatae'.*

Samuel Washington Woodhouse—Serving as both a surgeon and naturalist, Samuel Woodhouse (Figure 13) was one of several acting-assistant surgeons in the army who accompanied expeditions exploring the continent's interior and surveying potential railroad routes west (Ewan 1950). In 1849 and 1850, he was a member of two expeditions conducted by the U.S. Army Corps of Topographical Engineers sent to survey and mark the north and west boundaries of the Creek Nation in Indian Territory. Brevet Captain Lorenzo Sitgreaves led the first survey, and First Lieutenant Israel Woodruff led the second. Their surveys are often referred to as the Creek Boundary Expedition or the Sitgreaves-Wodruff Expedition (Figures 14 – 16).

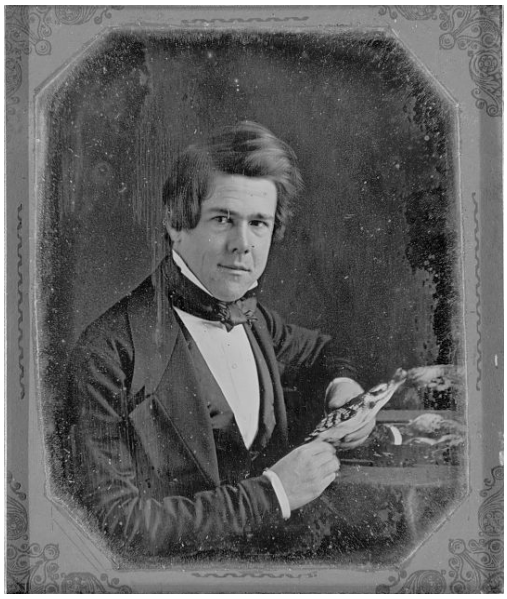


Figure 13 Samuel Washington Woodhouse in 1847. United States Library of Congress Prints and Photographs Division.

A member of the Academy of Natural Sciences of Philadelphia, Woodhouse was a true naturalist who collected plants, mammals, birds, reptiles, insects, and mollusks and deposited them in the Academy's museum in which he worked (Tomer and Brodhead 1992). In each of these groups, he discovered and described species new to science. The specific epithet *woodhousei* used for species of birds, toads, snakes, tree-borers, and plants honors him. Woodhouse collected 709 plant specimens on the first trip and 757 specimens on the second; albeit many were duplicates. His journals contain numerous entries about his collecting, pressing, and identifying the plants. As other early surgeon-botanists in Oklahoma did, he eventually submitted his plants to John Torrey to verify their identity. Many are now deposited in the herbarium of the New York Botanical Garden (Tomer and Brodhead 1992). His reports of the natural history of the two surveys were incorporated in Sitgreaves's and Woodruff's official reports, finally published together in 1858 (U.S. House of Representatives 1858). Woodhouse (1852) also wrote an unpublished summary of the two expeditions.

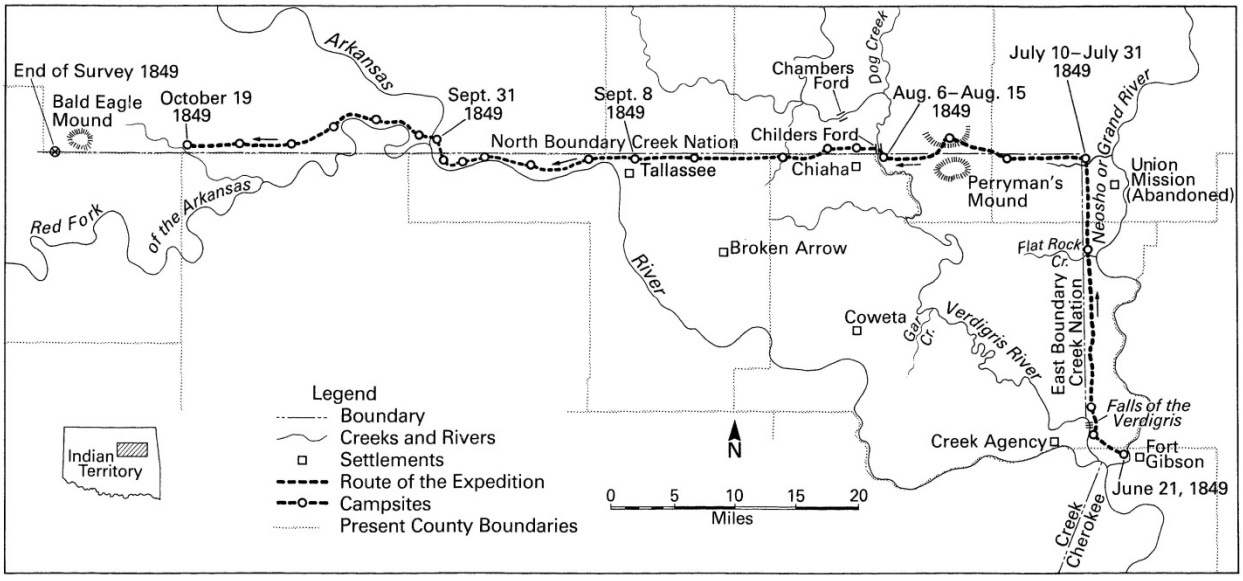


Figure 14 Route of the first Creek Boundary Survey Expedition, June 21 to October 19, 1849. Map drawn by Bill Nelson (Tomer and Brodhead 1992). Courtesy of the University of Oklahoma Press.

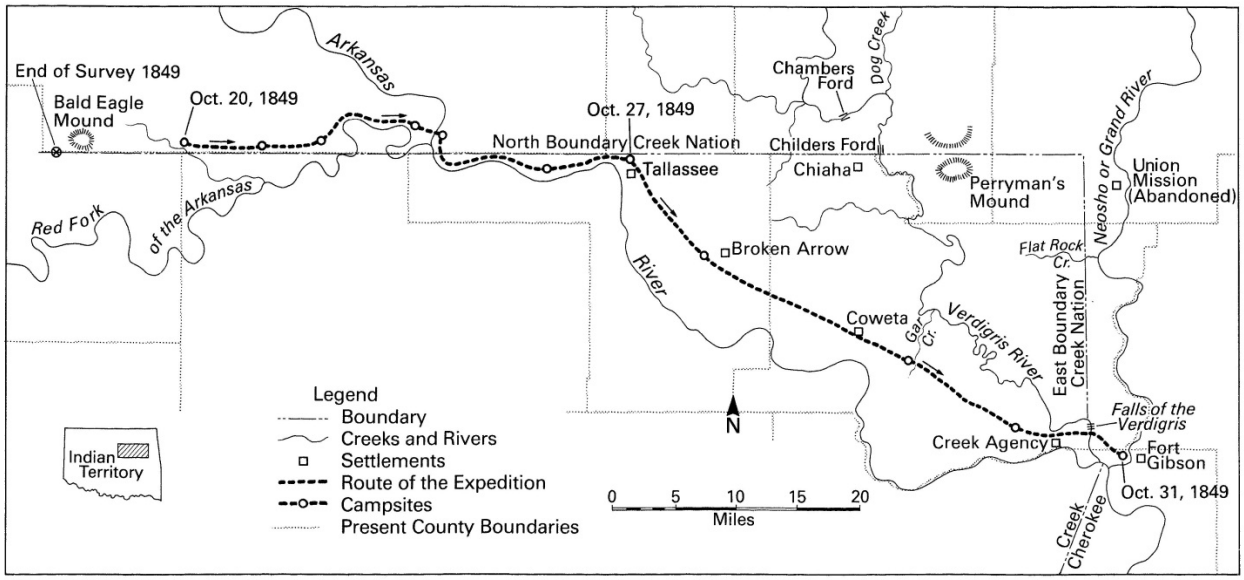


Figure 15 Route of the first Creek Boundary Survey Expedition, October 20 to November 1, 1849. Map drawn by Bill Nelson (Tomer and Brodhead 1992). Courtesy of the University of Oklahoma Press.

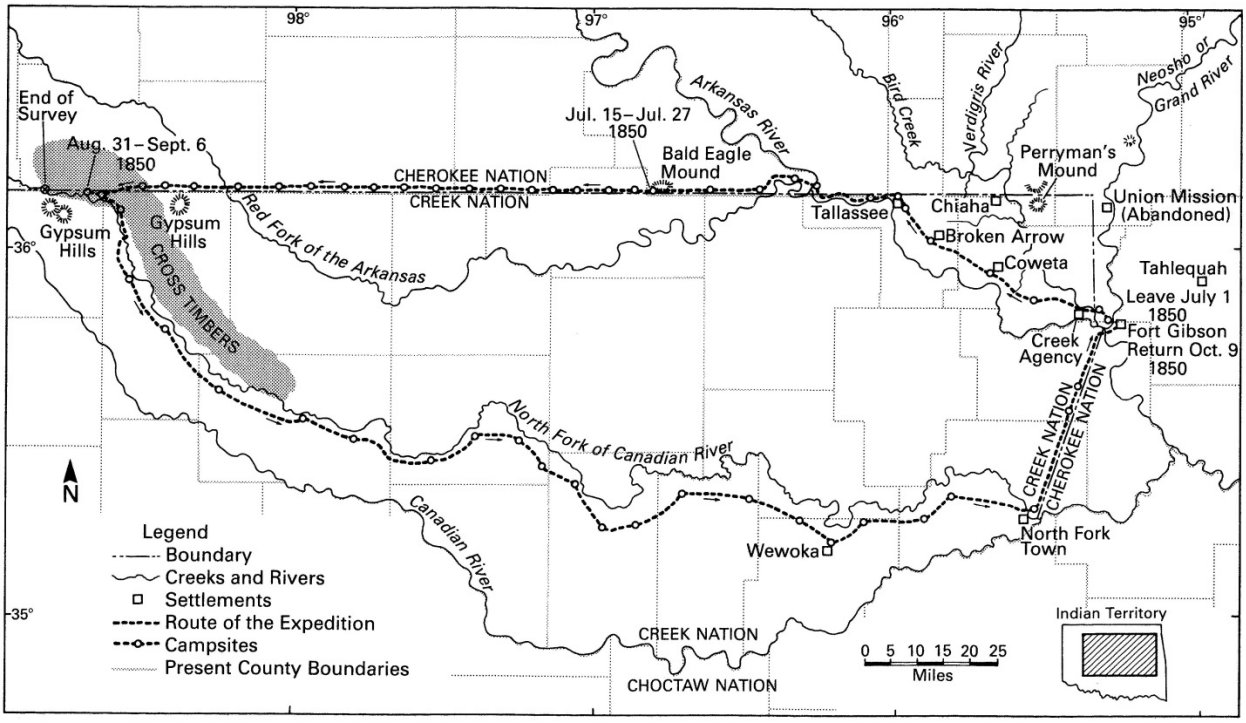


Figure 16 Route of the second Creek Boundary Survey Expedition, July 1 to October 9, 1850. Map drawn by Bill Nelson (Tomer and Brodhead 1992). Courtesy of the University of Oklahoma Press.

George Getz Shumard—Both a surgeon and a geologist, George Getz Shumard was a member of the (Captain R.B.) Marcy Expedition assigned the task of finding the source of the Red River in the summer of 1852. In addition to collecting rocks, minerals, soils, fossils, and shells, Shumard collected about 200 species of plants, half of which were collected within the boundaries of modern day Oklahoma (Winkler 1915; Jeffs and Little 1930). He sent his collections to John Torrey who determined their identities and had some of the rare ones illustrated. The list of Shumard's plants appears in Marcy and McClellan's report to Congress (U.S. Senate 1853). Representative species familiar to ONPS members are *Tephrosia virginiana* (goat's rue), *Rhus aromatica* (lemon sumac), *Polygala alba* (white milkwort), *Callirhoe involucrata* (purple poppy mallow), and *Pediomelum esculentum* (breadroot scurf-pea).

As an aside, it is interesting to note that Shumard also collected the first fossil described in modern day Oklahoma—*Goniatites choctawensis*, an ammonite characteristic of the late Middle Mississippian. As the specific epithet implies, it was discovered in the Choctaw Nation in Pittsburg County near the now defunct settlement of Brushey (Branson 1959).

Marcy's expedition explored the Red River and its North Fork from the mouth of Cache Creek in Cotton County to the 100th Meridian on the western edge of modern Beckham County (Dale and Rader 1930). In his report (U.S. Senate 1853), he recorded his observations of the surrounding landscape. On May 18, he wrote:

> *As we advance, the country, away from the borders of the water-courses, becomes more barren, and woodlands are less frequently met with; indeed, upon the river there is no other timber but cotton wood (*Populus angulata*,) and elm (*Ulmus americana*) and these in very small quantities; for the most part the valley of the river along where we passed to-day is entirely destitute of trees.*

On May 22, he and his party followed a tributary of the Red River and wrote:

> *This stream, which I have called Otter creek, (as those animals are abundant here,) rises in the Wichita Mountains, and runs a course south 25 degrees west. There are several varieties of wood upon its banks, such as pecan, black walnut, white ash, elm, hackberry, cotton-wood, wild china, willow, and mezquite; and among these I noticed good building timber. The soil in the valley is a dark loam and produces a heavy vegetation.*

As had Juan de Oñate and George C. Sibley before him, Marcy recorded his pleasure in eating the native plums and grapes. On May 29, he wrote:

> *We find blackberries, raspberries, gooseberries, and currants growing upon the mountains; and this is the only locality west of the Cross Timbers where I have seen them. Grapes and plums are also abundant here, as elsewhere, upon Upper Red river. The grapes are rather smaller than our fox grapes, are sweet and juicy when ripe, and I have no doubt would make good wine; they grow upon small bushes about the size of currant-bushes, standing erect like them, and are generally found upon the most sandy soil, along near the borders of the streams. The plums also grow upon small bushes from two to six feet high, are very large and sweet, and in color vary from a light pink to a deep crimson; they are the Chicasaw plum, (*Prunus chicasa [= *P. angustifolia*]).

John Milton Bigelow—The military expedition of Lieutenant Amiel Weeks Whipple to survey a potential route for a transcontinental railroad in 1853 was also accompanied by a surgeon-botanist. Following the route explored by Marcy, the survey party passed through central Oklahoma, and Dr. John Milton Bigelow collected about 125 species within the state (Featherly 1943). As had Shumard, he sent his specimens to John Torrey for identification (Torrey 1856). In addition to collecting plants, he made detailed observations of the

ecogeography of the passing landscape and eventually created a hypothetical line transect of the vegetation types from the Mississippi River to the Pacific Ocean (Featherly 1943). The plants he collected and his observations were published in five parts as part of the "Whipple Report" in 1856 (U.S. Senate 1856). The significance of his work is perhaps best illustrated in Torrey's introduction to his part of the "Report":

> *His ample collections were brought home in perfect order, and the following report affords abundant proof of the zeal and success with which he labored. A number of new genera and more than sixty new species have been discovered by Dr. Bigelow and he has added much valuable information upon many heretorfore imperfectly known plants.*

In a letter written to Asa Gray in July 1854 as he was working on Bigelow's plants, Torrey wrote that Bigelow's collection was "…*twice as large as Beckwith's and Pope's* [collectors with other survey parties] *put together…"* and that the quality of the pressed plants was such that they were "…*a pleasure to study*." (Waller 1942).

Bigelow is honored by numerous species with the specific epithet *bigelovii*, including two Oklahoma species: *Poa bigelovii* (Bigelow's bluegrass) and *Bidens bigelovii* (Bigelow's beggarticks). An interesting aside is that he made the first collection of guayule, a shrubby member of the Asteraceae or sunflower family, subsequently described and named *Parthenium argentatum* by Asa Gray (Waller 1942). During World War II, it was extracted from *Hevea* trees in Southeast Asia and used as a substitute for rubber. Today it is a source of hypoallergenic latex for medical devices and a potential source of biofuel.

Timothy E. Wilcox—In 1875–1877, "several hundred" species were collected in western Oklahoma by Wilcox, an Army surgeon and botanist. The plants he collected were identified by Alphonso Wood, the author of several botany textbooks widely used in the 1800s. Among the Wilcox collections was a plant that Wood thought was new to science. When he published (1878) his list of Wilcox's species, Wood named it *Grindelia nuda* (curlytop gumweed). However, today it is considered (Strother and Wetter 2006) to be conspecific with *G. squarrosa* (curlycup gumweed).

George Dexter Butler—Although trained as a lawyer and admitted to the bar in Iowa, George Butler became a teacher in the state of Arkansas and in Indian Territory (Jepson 1928). He began collecting plants primarily in Atoka County and in particular in the Limestone Gap area, with most of his specimens collected in 1877. He sent his plants for verification of his identifications to George Engelmann in St. Louis, with whom he had been corresponding, and in 1878 published his species list (Butler 1878). Of interest is his recognition that he had encountered a new species of *Isoëtes* (quillwort). Engelmann honored him with the binomial *I. butleri* Engelm. (Engelmann and Butler 1878). Butler subsequently moved to California where he began collecting plants in the Siskiyou Mountains. He eventually made one of the most comprehensive inventories of the mountains, with his specimens being cited by many other taxonomists (Jepson 1928).

Mark Alfred Carlton and Charles Stiles Shelton—An additional 400 species were collected in 1891 by Carlton and Shelton in the Indian and Oklahoma Territories. A list of them was published by J.M. Holzinger in 1892. A botanist at the Kansas Agricultural Experiment Station and later the first president of the American Society of Agronomy, Carleton collected plants from mid-April through September in an area bounded by the Arkansas and Canadian Rivers and the Arkansas, Colorado, and New Mexico borders. In this publication (Carleton 1892), he described the plants characteristic of different ecogeographic conditions—sandy

soils, gypsum hills, salt marshes, and sandstone outcrops.

As a plant collector for the U.S. National Museum of Natural History, Shelton spent his time in the southern half of the state, from the Sans Bois Mountains in Latimer County through McAlester, Stonewall, Caddo, and Colbert, west to Anadarko, the Washita River, Cache, and the Wichita Mountains (Holzinger 1892).

Ernest Everett Bogue—After completing his undergraduate work in horticulture and forestry and graduate work in botany and entomology, Ernest Bogue (Figure 17) became head of the Department of Botany & Entomology at Oklahoma Agricultural & Mechanical College (OAMC) in 1896. During his four-year tenure, he published *Weeds of Oklahoma* (1899), *Native Oklahoma Plants* (1900a), and *An Annotated Catalog of the Ferns and Flowering Plants of Oklahoma* (1900b).

Figure 17 Ernest Everett Bogue. Photo courtesy of the Special Collections and University Archives, Edmon Low Library, Oklahoma State University.

His publication on weeds was an update of an 1895 bulletin by James Neal that listed more than 70 weeds classified by Neal as "aggressive," "timid," or "occasional." In his edition, Bogue wrote synopses of the morphology and problems characteristic of each weed and illustrated them with line drawings and photographs. He declared *Ambrosia psilostachya* (western ragweed) to be the state's worse weed, followed by *Solanum rostratum* (buffalo bur) and *Digitaria sanguinalis* (crabgrass). He also commented on the need for weed control by writing: "*Too many farmers in the Territory are neglecting the weed question. The rich new soil is not very foul until crops have been grown for a few years."*

In his OAMC bulletins (1900a, 1900b) on Oklahoma's native plants, Bogue gave "…*the scientific and common names of and notes on about 750 plants growing without cultivation in the territory."* This list was based on four years of plant collecting by Bogue and those supervised by him. He did not include species from Indian Territory because he thought he had insufficient information (1900b). In *Native Oklahoma Plants* (1900a), he gives an overview of the ecogeography of the areas in which he collected and makes observations about the ecology of various species. These observations, like those of his predecessors, give us an idea of what the state was like in the early years of settlement by Europeans.

Albert Heald Van Vleet—Most visitors strolling the Van Vleet Oval on the University of Oklahoma's campus are likely unaware of the many accomplishments of the man for whom the mall is named. Van Vleet (Figure 18) was the university's first faculty member to have a doctorate, the first head of its Department of Biology (1898), the first dean of its Graduate College (1909), and the first Territorial Geologist and Chief of the Territorial Geological and Natural History Survey(1899)(Wardner 1939; Goodman and Lawson 1978). The Department of Biology evolved into the Departments of Zoology, Botany and Microbiology, and Geology; whereas, the Survey gave rise to the modern Oklahoma Geological Survey and Oklahoma Biological Survey.

He believed that the university should have a complete collection of the plant and animal life of the territory and state, and in 1900 he began taking collecting trips throughout the territory. He published his *A List of the Ferns and Flowering Plants of Oklahoma* (1901) and *Plants of Oklahoma* (1902), the latter listing 838 species as present in the university herbarium (Jeffs and Little 1930; Goodman and Lawson 1978). Unfortunately, a disastrous fire on January 6, 1903 destroyed much of the university, including the herbarium. Van Vleet began collecting anew, only to have most of his new collections burned in a second fire in 1907. Goodman and Lawson (1978) provide itineraries of his collecting trips in 1900, 1903 after the fire, and 1905.

Figure 18 Albert Heald Van Vleet. Portrait from 1916 Sooner Yearbook, University of Oklahoma.

George Walter Stevens—We traditionally cite the doctoral dissertation of George Walter Stevens (Figure 19) as the first formal taxonomic study of the state's plants. In 1903, he became the head of the biology department at the State Normal School, now Northwestern Oklahoma State University. In addition to being a dynamic teacher, he was an avid plant collector, and it is said that he always planned his vacations with the objective of exploring some new region of Oklahoma and other states (Henson 1941).

Figure 19 George W. Stevens (Goodman et al. 1978). Photo courtesy of Anna B. Fisher and Oklahoma Academy of Science).

In 1913, he was appointed the Director of the State Botanical Survey and during the growing season of that year was in the field almost continually on collecting trips throughout the state (Figures 20–24). Goodman and coworkers (1978) noted that Stevens was probably the first individual to collect plants in Red Rock Canyon near Hinton in Caddo County, the second—following M.A. Carlton in 1891—to collect near Black Mesa in Cimarron County, and the third to collect at the Glass Mountains near Orienta in Major County and the Great Salt Plains near Jet in Alfalfa County—after Carlton in 1891 and Van Vleet in 1900.

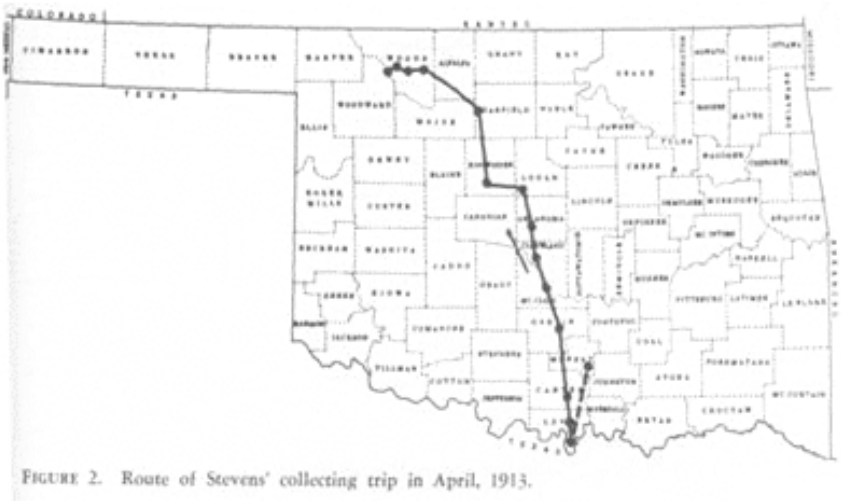


Figure 20 Route of collecting trip of G.W. Stevens in April 1913 (Goodman et al. 1978). Courtesy of Oklahoma Academy of Science.

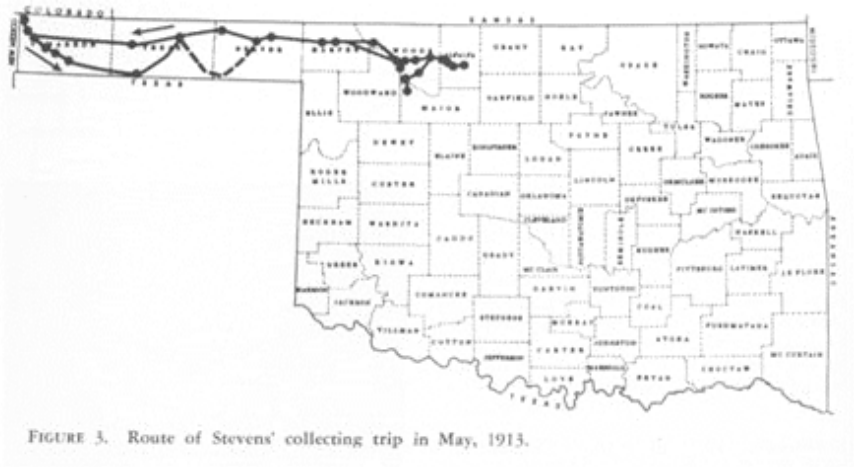


Figure 21 Route of collecting trip of G.W. Stevens in May 1913 (Goodman et al. 1978). Courtesy of Oklahoma Academy of Science.

Figure 22 Route of collecting trip of G.W. Stevens in June 1913 (Goodman et al. 1978). Courtesy of Oklahoma Academy of Science.

Figure 23 Route of collecting trip of G.W. Stevens in July 1913 (Goodman et al. 1978). Courtesy of Oklahoma Academy of Science.

Figure 24 Route of collecting trip of G.W. Stevens in August and September 1913 (Goodman et al. 1978). Courtesy of Oklahoma Academy of Science.

With the exception of the extreme southeast corner, Stevens traversed the state, accumulating thousands of specimens which were deposited in the herbaria at the University of Oklahoma, Oklahoma State University, and Harvard University. In addition, many specimens were distributed through herbarium exchange programs to herbaria elsewhere in the United States and world. Indeed, his distinctive labels (Figure 25) are encountered everywhere. While working in the herbaria at the Royal Botanic Gardens in England and Australia, Tyrl encountered his specimens.

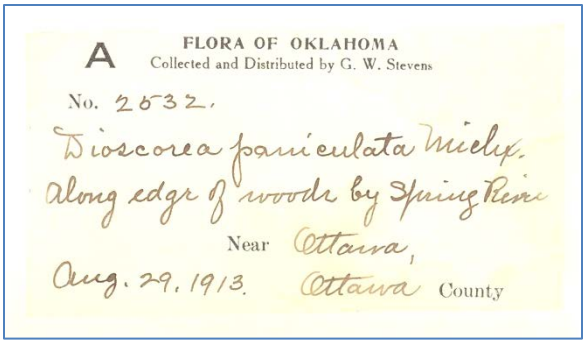


Figure 25 Herbarium specimen label of G.W. Stevens collection

The plants collected by Stevens and other collectors (several of them former students) were the basis of his Harvard University 1916 doctoral dissertation titled *The Flora of Oklahoma*. Never formally published, this *Flora* included keys and generic descriptions but lacked descriptions for the more than 1,600 species included in it (Goodman et al. 1978). He did comment on the abundance and distribution of several species. When he defended his dissertation, he was introduced to the examining committee by a Professor Robinson, who said (Henson 1941):

> *Gentlemen, this candidate, Mr. George Walter Stevens, whom I present from my department is the most versatile candidate that I have ever presented before this board—indeed, the most versatile man along scientific lines that I have ever known.*

Today, Stevens in honored by *Nama stevensii* (Steven's nama or Steven's fiddleleaf), a gypsophilic species in the Hydrophyllaceae encountered in the Cimarron, Weatherford, and Magnum Gypsum Hills geomorphic provinces of the state.

William Christopher Prier—A professor and eventual head of the biology department at Northeastern State College in Tahlequah, Prier was an avid collector of the grasses and plants of the Cherokee Hills (Henson 1941). His master's thesis (1923a) and a derived publication (1923b) were on grasses; his collection, the most complete for the state at the time of his death in 1927, was purchased by OAMC and deposited in the college's herbarium (Featherly 1943). For some reason, he reversed the initials in his professional name, and thus his publications and distinctive herbarium labels bear the name "C.W. Prier."

Louis Herman Pammel—Perhaps best known for his *Manual of Poisonous Plants* (1911), Louis Pammel made three visits to Oklahoma in 1888, 1921, and 1929 (Featherly 1943). After his second visit, he wrote a short report titled *A Day Near Muskogee Oklahoma* (1923) in which he enumerated the species collected in the bottomlands and uplands and the new introduced species not present in 1888. He also described the changes in Muskogee as a city and the appearance of the nearby Canadian and Arkansas Rivers and limestone bluffs.

Royal Edgar Jeffs—Although trained as a plant physiologist at the University of Iowa, Royal Jeffs made a contribution to our knowledge of the flora as curator of the herbarium at the University of Oklahoma, 1925 to 1933. He made numerous collecting trips with Albert Van Vleet and his students, including Elbert Little (Henson 1941). In 1930, he and Little published a checklist of the state's ferns and seed plants, which listed 1,944 species and was based on their collections, the unpublished dissertation of G.W. Stevens (1916), and H.I. Featherly's (1928) checklist of Oklahoma's grasses. Of interest are their discussions of areas in the state to be searched for new species, distributional ranges of various species to be clarified, and the need for detailed studies of county floras. Jeffs subsequently published (1931) a key to the species of the checklist, with the exception of the grasses and sedges.

Thomas R. Stemen and W. Stanley Myers—As science teachers at Central High School in Oklahoma City, Thomas Stemen and Stanley Myers felt the need to have a manual for the identification of plants to be used by students in their biology and botany classes. In 1929 they published *Spring Flora of Oklahoma with Key* in which they described 90 families, 265 genera, and 476 species. This book was followed in 1937 by *Oklahoma Flora,* which encompassed 147 families, 640 genera, and 1,626 species, plus illustrations and abbreviated morphological descriptions. Unfortunately, they did not include the grasses, sedges, and rushes—a significant segment of the state's flora comprising

approximately 116 genera and 534 species (Tyrl et al. 2010). This omission is somewhat surprising because Featherly (1928)noted in his checklist of grasses that they had made extensive collections of grasses in the Oklahoma City area. The book was severely criticized (Fernald 1938) for the absence of the graminoids and problems in taxonomic concepts, nomenclature, and key construction. However, despite its shortcomings it does represent the first attempt to make identification of Oklahoma's plants easy for the layman.

Arthur Irving Ortenburger—Although referred to as the "Father of Oklahoma Herpetology" and a faculty member in the Department of Zoology at the University of Oklahoma, Arthur Ortenburger extensively collected plants throughout the state while conducting a series of expeditions for the University of Oklahoma Biological Survey in the 1920s and 1930s (Carpenter 2000). He documented (1928a, 1928b) the plants he encountered on several of his trips.

Robert Bebb—Robert Bebb (Figure 26) was a grain receiver's agent in Illinois prior to his purchase of a floral business in Muskogee in 1910. Quite an accomplished businessman, he was also an avid botanist and naturalist. Most of his spare time was spent in botanizing and identifying plants (Foreman 1942). After his retirement from the floral business in 1936, he botanized full-time primarily in eastern Oklahoma, but also in Illinois, Indiana, Minnesota, Texas, California, and the Rocky Mountains (Hopkins 1943a).

He corresponded with and sent specimens to botanists and herbarium curators throughout the country including those at the U.S. National Herbarium, the Gray Herbarium, various state universities, and especially the University of Oklahoma where he formed a close friendship with Milton Hopkins who was curator of the herbarium (Foreman 1942). On June 5, 1939, George Lynn Cross, the head of the Department of

Figure 26 Robert Bebb. Photo courtesy of Wayne Elisen, Bebb Herbarium, University of Oklahoma.

Botany at the University of Oklahoma, wrote Bebb saying:

> *The entire eastern part of the state is rich floristically . . . and collections from [the area are] sparse, so that anything that you can contribute to our knowledge of the flora of those counties will be most acceptable.*

Bebb certainly took Cross at his word and amassed a private herbarium of approximately 30,000 specimens which he subsequently willed to the University. On May 5, 1942, the university's regents renamed the herbarium in his honor (Hopkins 1943b). Bebb's collections were especially valuable at the time because they came from an area of the state which been little botanized, extended the ranges of plants into new regions, and included species previously unknown in the flora or not previously found south of the Ozark Highlands in Missouri and Arkansas (Foreman 1942).

William E. Bruner—The first formal classification of Oklahoma's vegetation was published (1931) by William Bruner, an ecologist. A Nebraskan, he taught in the

Department of Botany at the University of Oklahoma for four years (1922–1926) after earning his masters degree. Returning to Nebraska to work on his doctorate, he published a detailed description of Oklahoma's ecogeography—geology, soils, climate—and the plant associations present. The William E. Bruner Hall of Science on the campus of the University of Nebraska at Kearney honors him.

William Franklin Blair and **Theodore Huntingon Hubbell**—Although W. Blair was a mammalogist and T.H. Hubbell an entomologist by training, they contributed to our early understanding of the state's vegetation. Following field work across the state in the 1930s, they recognized the need to define and describe the major biotic areas of Oklahoma and in 1938 published a paper in the *American Midland Naturalist*. They defined 10 biotic districts and for each listed the principal plant associations present, with characteristic plant species and ecogeographic conditions.

Henry Ira (HI) Featherly—Our early knowledge of Oklahoma's grasses is due to the work of H.I. Featherly (Figure 27), an ecologist and taxonomist at Oklahoma Agricultural & Mechanical College (later Oklahoma State University) from 1925 to 1958. Collaborating with the noted agrostologists A.S. Hitchcock and Agnes Chase at the U.S. National Herbarium, he documented the state's grass flora in papers published in the *Proceedings of the Oklahoma Academy of Science* (1928, 1930) and bulletins of the Oklahoma Agricultural Experiment Station (1938, 1946). Most notable is his 1946 *Manual of the Grasses of Oklahoma* which provided keys for identification, morphological descriptions, and illustrations for 301 grasses. He also documented the state's fern flora (Featherly and Russell 1939). In addition to his teaching and extension responsibilities, Featherly was instrumental in the establishment of the OSU Museum of Natural and Cultural History and was its first curator. As noted in our introduction, he was President of the Oklahoma Academy of Science in 1942 and gave the traditional presidential address at the luncheon that is the foundation of this essay.

Figure 27 H.I. Featherly. Photo courtesy of the Special Collections and University Archives, Edmon Low Library, Oklahoma State University.

Lester G. Duck and **J.B. Fletcher**—Although wildlife biologists in the Division of Wildlife Restoration and Research of the Oklahoma Game and Fish Commission, Duck and Fletcher(1943, 1945) produced a vegetation map of Oklahoma that it is the most widely recognized of all Oklahoma classifications of vegetation (Figure 28). It comprises 14 vegetation types called "game types" because the authors' intent was to describe habitats of game and fur-bearing animals in the state. The classification, descriptions, and map are the product of field mapping correlated with prior studies of vegetation, geology, soils, climate, and land use in relation to game animal populations (Tyrl et al. 2008).

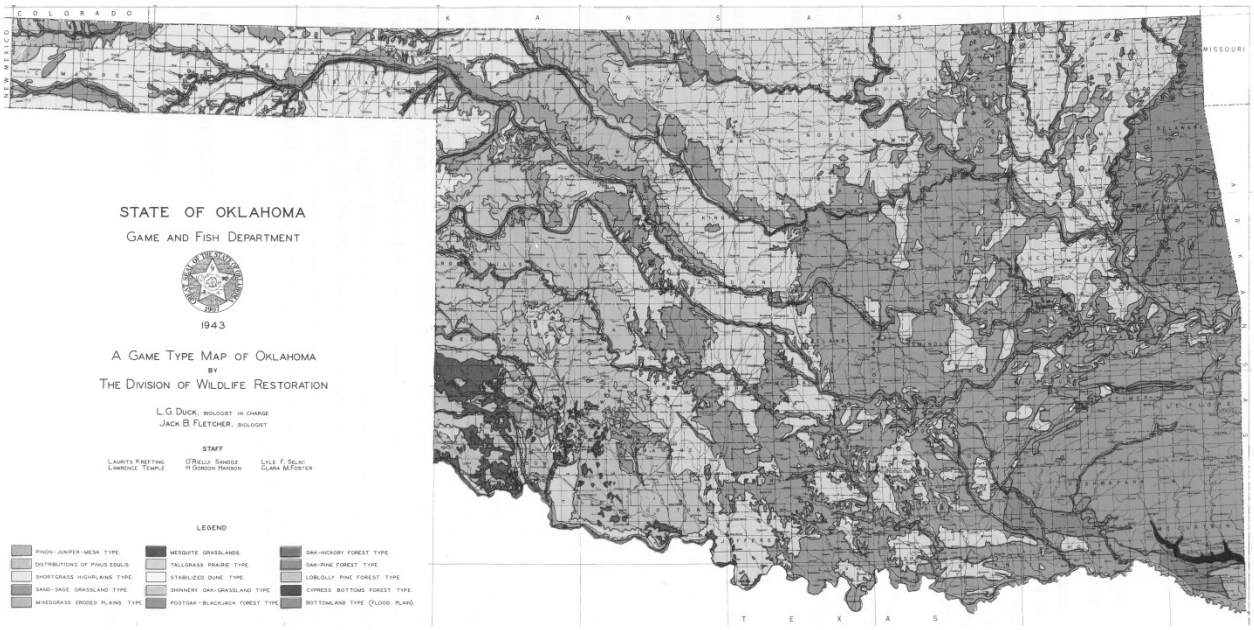


Figure 28 Duck & Fletcher's A Vegetation (Game Type) Map of Oklahoma. Original reprinted by the Oklahoma Biological Survey with the permission of the Oklahoma Department of Wildlife Conservation.

Elbert Luther Little, Jr.—Although born in Fort Smith, Arkansas, Elbert Little (Figure 29) said that he was proud to be "an Okie from Muskogee," having grown up there (Anonymous 1993). After earning B.A. degrees in botany and zoology at the University of Oklahoma and M.S. and Ph.D. degrees at the University of Chicago, he worked for the Oklahoma Forest Commission in Broken Bow in southeastern Oklahoma and taught at Southwestern State College in Weatherford. Little eventually became a dendrologist with the U.S. Forest Service in Washington D.C. where he worked for 34 years, becoming Chief Dendrologist (Anonymous 1993).

Little's legacy to Oklahoma comprises, in part, numerous journal articles on the state's plants and interesting botanical areas (see Kelting and Penfound 1953; Milby 1977) and his numerous talks at the technical meetings the Oklahoma Academy of Science. The author of more than 23 books and 150 handbooks, bulletins, and technical papers, he is perhaps best known for his five editions of

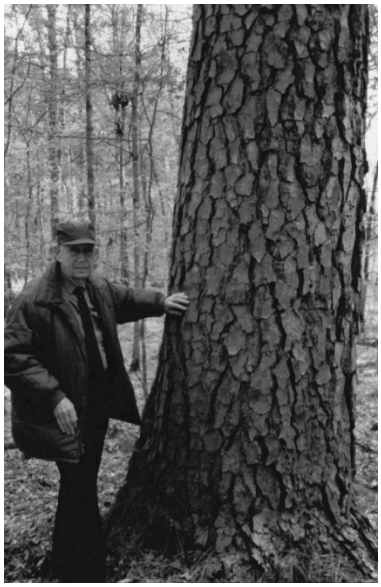


Figure 29 Elbert L. Little, Jr. Photo courtesy of Wayne Elisens, Bebb Herbarium, University of Oklahoma.

Forest Trees of Oklahoma (2000) in which he provided morphological descriptions, illustrations, and distributional maps for 164 species. Importantly, he also provided keys, based mainly on leaves and twigs, for their

identification. At the national level, his two-volume *Audubon Society Field Guide to North American Trees* (1980a, 1980b) continues to be a popular reference.

While working for the Oklahoma Forest Commission in McCurtain County in 1930, he established a series of experimental plots. Returning to the plots in the 1980s, he was able to document changes in the forest and individual species during those 50 years. Figure 29 shows him standing beside one his marked trees—*Pinus echinata* (shortleaf pine).

Umaldy Theodore Waterfall—Most likely the person who has published more journal articles on the flora of Oklahoma than any other individual (see Kelting and Penfound 1953, Milby and Penfound 1965; Milby 1977), U.T. Waterfall (Figure 30) earned his B.S. at Oklahoma Agriculture & Mechanical College in 1935 and M.S. (1942) and Ph.D. (1956) at the University of Oklahoma. In 1949, he joined the botany department at OAMC as curator of the herbarium.

Figure 30 U.T. Waterfall. Photo courtesy of the Oklahoma State University Department of Botany.

Waterfall's interest in the flora of Oklahoma began in the 1930s, and by 1939 he had collected about 1,000 herbarium sheets. While completing his master's degree and teaching in the Oklahoma City public schools, he took field trips on weekends and school breaks to collect plants, eventually collecting throughout the state and traveling approximately 140,000 miles (Waterfall 1969). In 1940, he began reporting his discoveries in a series of papers published primarily in the journals *Rhodora* and the *Proceedings of the Oklahoma Academy of Science*. In 1952, he published *A Catalogue of the Flora of Oklahoma* in which he listed 141 families, 741 genera, and 2,543 species, varieties, and forms.

Recognizing that there was an immediate need for a means of identifying these taxa, he immediately began writing taxonomic keys for their identification, making them available to students in his plant taxonomy classes at OSU. He personally typed and published four editions of *Keys to the Flora of Oklahoma*; the first edition appeared in 1960 and the fourth in 1969 (Figure 31). Later "editions" are only reprints of the fourth edition. Simultaneously with publication of these keys, he began to write diagnostic descriptions of each taxon. Unfortunately, this manuscript was not completed before his death in 1971. Waterfall's *Keys* was the principal means of identifying plants in Oklahoma for more than 30 years and was used by both state scientists and countless numbers of students. With permission of his heirs, it was combined with *Key to the Vascular Plant Families of Oklahoma* in the book *Identification of Oklahoma Plants* (Tyrl et al. 1994a, 1994b).

In addition to his work on the flora of Oklahoma, Waterfall was considered an expert on the genus *Physalis* (ground cherry) in the Solanaceae or nightshade family, the subject of his doctoral dissertation (Waterfall 1958). He collected extensively in Mexico, and his specimens are deposited in herbaria throughout the country. Waterfall also influenced the many students from botany, range science, agronomy, and forestry who took his plant taxonomy and agrostology classes. He was famous for his field trips on which he wore knee-high laced boots, drove county roads at high speeds—not worrying whether students in the following vehicles were keeping up—climbed fences, and

botanized while rapidly striding across the prairies (Charles B. McDonald, personal communication).

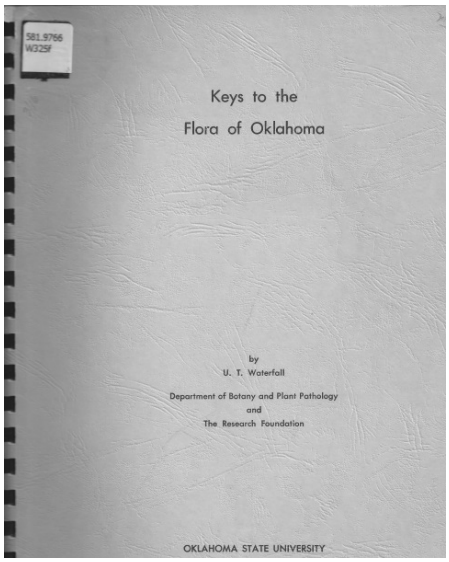


Figure 31 Well-worn cover of the first edition of *Keys to the Flora of Oklahoma.*

Charles Sparkman Wallis—Anyone examining specimens in the herbaria at the University of Oklahoma (OKL) and Oklahoma State University (OKLA) will undoubtedly encounter specimens bearing labels with the heading "Plants of Oklahoma Ozarks" and the collector name "C.S. Wallis." A high school teacher before WWII and an instructor at Conners State Agricultural College afterwards, Charles Wallis collected plants in the Ozark Plateau and Boston Mountains geomorphic provinces in northeastern Oklahoma. He completed a survey of the plants of Cherokee County, with the exception of the graminoids (grasses, sedges, and rushes) that was the basis for his master's thesis (Wallis 1953). Upon its completion, he realized the need to expand his survey to encompass the entire Oklahoma Ozarks. His initial collection of some 1,400 specimens expanded to about 7,000 and was described in a doctoral dissertation at Oklahoma State University, with U.T. Waterfall serving as his adviser (Wallis 1959). In his dissertation and two publications (Waterfall and Wallis 1953, Wallis 1958), he reported 24 additions (species, varieties, and forms) to the state flora from the Oklahoma Ozarks. His specimens were deposited in the herbaria at Oklahoma State University and Southern Methodist University. In 2001, his personal collection of 7,000 specimens was donated by his son to the Bebb Herbarium at the University of Oklahoma.

Francis Hobart Means—Our knowledge of the flora of the northern portion of the Ouachita Mountains geomorphic province—between the Sans Bois and Kiamichi Mountains in Latimer, LeFlore, and Pushmataha Counties—begins with the work of Frank Means. While an instructor of botany and agronomy at Eastern Oklahoma State College in Wilburton, he began studying and collecting the area's flora. He eventually amassed a collection of some 4,200 specimens which served as the foundation for his doctoral dissertation completed under the direction of U.T. Waterfall at Oklahoma State University (Means 1969).

George J. Goodman—The author or coauthor of several books and multiple journal articles, including his numerous "Notes on Oklahoma Plants" published in the *Proceedings of the Oklahoma Academy of Science*, George Goodman (Figure 32) was curator of the herbarium at the University of Oklahoma from 1933 to 1936 and again from 1945 to 1975.

During his tenure, the herbarium more than doubled in size from approximately 80,000 specimens to 173,000. In addition to actively collecting the state's flora, he named and described 36 taxa new to science (Rice and Cross 1990). In 1958, he published his *Spring Flora of Central Oklahoma.* As the title indicates, it was restricted in both area and season. Used in his plant taxonomy classes, it comprised keys for the identification of 680 species and infraspecific taxa. As a major professor for graduate students, he mentored several state taxonomists, including U.T.

Waterfall, Doyle McCoy, and Constance Taylor, also described in this paper. Four plant taxa are named for him, and upon his retirement as curator, the university's Board of Regents named the foyer of the Robert Bebb Herbarium in his honor.

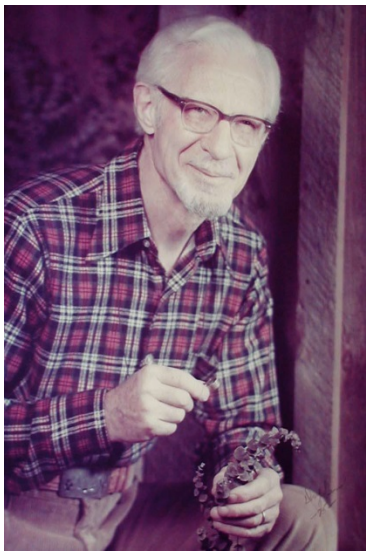


Figure 32 George J. Goodman. Photo courtesy of Wayne Elisen, Bebb Herbarium, University of Oklahoma.

Doyle Allen McCoy—The author of a popular series of field guides for Oklahoma plants used by many ONPS members, Doyle McCoy (Figure 33) was said to be "…*obsessed with wildflowers when most people still called them weeds*." (Bilger 1991). Beginning his academic career in a two-room schoolhouse near Chickasha, he subsequently earned his doctorate at Oklahoma State University in 1953 under the guidance of U.T. Waterfall. His dissertation topic was a survey of the plants of Pontotoc County.

His teaching career began at Ada High School, followed by positions at East Central University in Ada and Cameron University in Lawton. In his profile of McCoy, Burkhard Bilger (1991) describes him as being passionate about introducing students and the public to Oklahoma's native plants by leading field trips and giving lectures to garden clubs and civic groups—striving to get people to appreciate them and to even plant them. In 1968, he published *A Study of Flowering Plants*. Envisioned as an aid for his students who were beginning to identify plants, this book was essentially a mini, plant taxonomy textbook, comprising chapters covering phytographic terms, principles of classification, methods of collecting plants, use of taxonomic keys, a bibliography of manuals and floras, and "Keys to the Flora of a Region Extending From South-Central Oklahoma to West-Central Texas."

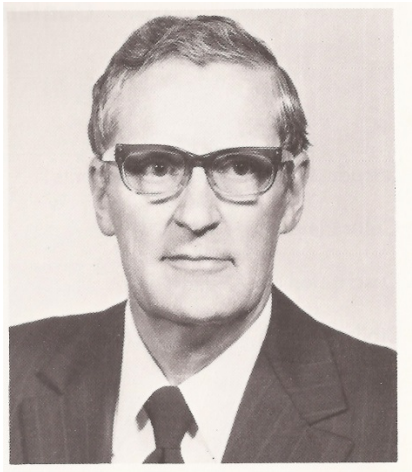


Figure 33 Doyle McCoy. Photo courtesy of D.A. McCoy.

Traveling about the state in a Datsun pickup truck and carrying a 35 mm camera, large trash bin, and a sheet of black velvet, Doyle photographed Oklahoma native plants "up close and personal." He assembled 300 of his photos and, accompanied by brief synopses of their morphological characters, geographical and ecological distribution, and flowering times, personally published *Roadside Flowers of Oklahoma* in 1976. "*I took a chance and ordered 5,000 copies and went around to bookstores leaving them on consignment—no one really knew how they would go*," Doyle said (Bilger 1991). This initial printing quickly did "go", and another 8,000 copies were ordered in 1978. A second volume appeared in 1978, followed by *Roadside Wild Fruits of Oklahoma* (1980), *Roadside Trees and Shrubs of Oklahoma* (1981),

and *Oklahoma Wildflowers* (1987). This series of field guides represents the first photographic documentation of the state's flora and is especially valuable because of the diagnostic quality of photographs; they have been used by tens of thousands of individuals interested in Oklahoma's wildflowers.

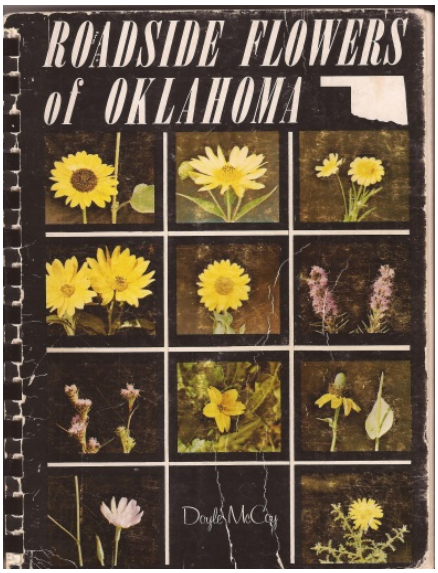


Figure 34 Well-worn cover of *Roadside Flowers of Oklahoma* so familiar to ONPS members.

Bilger (1991) recounted Doyle thought that perhaps his proudest accomplishment was the designation of *Gaillardia pulchella* (Indian blanket) as Oklahoma's state wildflower on March 20, 1986 (Figure 35). For several years, he had lobbied the legislature to substitute *G. pulchella* for *Phoradendron secotinum* (mistletoe) as our state flower. Finally, he convinced the legislature to once again call mistletoe Oklahoma's floral emblem and designate Indian blanket as Oklahoma's state wildflower. Interestingly, mistletoe originally had been designated the "Flora Emblem of the Territory" on February 11, 1893 and then "Floral Emblem of the State" in 1910 (Featherly 194–). Popular use had converted "state emblem" into "state flower."

Figure 35 *Gaillardia pulchella* (Indian blanket), Oklahoma's state wildflower. Photo courtesy of Mike Nelson.

Torbert H. (T.H.) Milby—An individual who has contributed significantly to our knowledge of the flora and vegetation of Oklahoma, not by his field work but rather by his bibliographic endeavors, is T.H. Milby, retired Professor of Bibliography of University Libraries and Professor of Botany at the University of Oklahoma. As Rice and Cross (1990) noted, Milby joined the faculty in 1961 as a librarian, completed his Ph.D. in botany, developed an interest in enumerative botanical bibliography, and eventually published two papers (Milby and Penfound 1965; Milby 1977) and the book *Oklahoma Botanical Literature* (Johnson and Milby 1989). In addition, he also coauthored *Proceedings of the Oklahoma Academy of Science: Index to Volumes 1–65, 1920–1985* (Milby and Hough 1988). The importance of these publications is that they provide immediate access to the wealth of information that has accumulated about the state's plants. He also coauthored *Oklahoma Landscapes: A Century of Change* (Milby et al. 2008) which pictorially documents, in a series of "before" and "after" photos with accompanying explanatory text, how some areas of the state have changed dramatically and other areas have remained essentially unchanged.

Paul F. Nighswonger—Our knowledge of the plants present in the northwestern corner of the body of the state is the result of extensive collecting by Paul Nighswonger, a

longtime Professor of Biology at Northwestern Oklahoma State University (NWOSU) in Alva. His goal was to document the flora of Woods County and surrounding areas. In doing so, he amassed a collection of more than 1,900 specimens that he deposited in the university's herbarium. Like G.W. Stevens, his predecessor at NWOSU, he collected duplicate specimens and sent them to more than nine other herbaria throughout the United States. He was one of the founders of the *Flora of Oklahoma* project—an effort by state taxonomists to write and publish a modern floristic treatment for the state's vascular plants—and for several years served on its Editorial Committee. Many ONPS members will fondly remember him leading field trips in Woods County whenever the society's annual meetings or Wildflower Workshops were held in Alva.

Forrest Lee Johnson—Recognized by his coworkers to be perhaps the most knowledgeable person about the bottomland forests of Oklahoma, Forrest Johnson was a research biologist for the Oklahoma Biological Survey from 1975 until his death in 1999. After receiving his B.S. degree in chemical engineering and pursuing careers in engineering, farming, and high school teaching, he earned his M.S. and Ph.D. in plant ecology at the University of Oklahoma. He authored or coauthored numerous journal articles on the ecology of the state's forest communities and various tree species. His writing also included two notable books, *Oklahoma Botanical Literature* (Johnson and Milby 1989) and *Oklahoma Landscapes: A Century of Change* (Milby et al. 2008), and the website *Catalog of the Woody Plants of Oklahoma: Descriptions and Range Maps* (Johnson and Hoagland 1999).

In addition to his ecological research and writing, Forrest was an untiring plant collector of the state's flora, often being in the field almost the entire growing season. He also was a major participant in the U.S. Army Corps of Engineers Construction Engineering Research Laboratory (CERL) plant surveys of military installations across the country and in practically all biomes (J.R. Estes, personal communication). His collections of voucher specimens contributed substantially to the Bebb Herbarium's holdings.

Lawrence (Larry) K. Magrath—Following completion of his doctoral dissertation on the native orchids of the prairies and plains of North America, Larry Magrath (Figures 36, 37) began a 35-year career teaching at the University of Science and Arts of Oklahoma in Chickasha. As curator of the university's herbarium, he collected thousands of plants throughout the state and increased its size to an estimated 22,000 sheets. He was well known for his keen eye in spotting "different" appearing plants and the discovery of species previously unknown to occur in the state. He was especially diligent in collecting duplicate specimens which were subsequently distributed to herbaria throughout the country.

Figure 36 Lawrence K. (Larry) Magrath. Photo courtesy of Ingrid Shafer.

An expert on orchids, Larry wrote numerous journal articles on their geographic distribution, published *Native Orchids of Kansas* (1971), coauthored the family treatment of the

Orchidaceae in the *Flora of North America* (Romero-González et al. 2002), authored or coauthored six generic treatments in the same work, and in the 2001 premiere issue of this journal published his *Native Orchids of Oklahoma,* which comprised keys, photographs, descriptions, and distribution maps. He was one of the founders of the *Flora of Oklahoma* project—an effort by state taxonomists to write and publish a modern floristic treatment for the state's vascular plants. In addition to contributing and editing the treatments of different families, he took primary responsibility for the Orchidaceae (18 genera and 33 species) and served as the project's secretary and treasurer for many years.

Larry contributed to the public's awareness of Oklahoma's wildflowers by his enthusiastic participation in ONPS programs and field trips, the Wildflower Workshops series, and the Oklahoma Junior Academy of Science. He is honored by the binomial *Schoenoplectiella ×magrathii*, Magrath's bulrush, the name of an interspecific hybrid that he found in the midst of a mixed population of *S. hallii* and *S. saximontana* in the Wichita Mountains in Comanche County (Smith and McKenzie 2013).

Figure 37 Larry Magrath, Patricia Folley, Charles Lewallen, and Jim Norman on a field trip to Round Mountain in LeFlore County in 2007. Photo courtesy of Patricia Folley.

A little known fact to most people, Larry was artistic, using plants as themes in his three-dimensional visual art and his poetry. This poem, "Lady's Slipper," is among many written by Larry and published in poetry journals.

Lady's Slipper

In a forest cathedral,
Made by no man's hand, fashioned of trees,
Some great and some small,
I walked in awe upon the softest of carpets,
Woven upon no loom in softly filtered pale green light,
Shot through with rays of gold and purest white
While round me sounded the sweetest,
Most innocent hymns of all,
Sung by God's small feathered creatures.
Then I saw it standing tall,
Swaying slightly in the gentle breeze,
Stem and leaves of emerald green
With a golden slipper at its tip,
The golden lip rimmed round with red,
A miniature cathedral of light
With a staminode for a pulpit.
God's hands have touched all,
But with this perfect creation
His hands must have lingered long.
How else account for such beauty
As the lady's slippers
One and all?

R. John and Constance (Connie) E.S. Taylor—The intertwined professional careers of John and Connie Taylor (Figure 38) have certainly enhanced our knowledge of the flora of Oklahoma. After meeting in the Bebb Herbarium and subsequently marrying, both earned their doctorates in the Department of Botany and Microbiology at the University of Oklahoma and became professors of biology at Southeastern Oklahoma State University (Anonymous 1994). In addition to individually publishing numerous journal articles on the taxonomy and distribution of Oklahoma species (see citations in Johnson and Milby 1989), they jointly published *An Annotated List of Rare or Infrequently Collected Vascular Plants*

that Grow in Oklahoma (1978) and three editions of *An Annotated List of Ferns, Fern Allies, Gymnosperms and Flowering Plants of Oklahoma* (1989, 1991, 1994). The latter book (Figure 39) provides a list of the scientific names of the state's species plus their authors, common names, synonyms, nativity, longevity, habit, and general geographic distribution. Together, John and Connie conducted an active collecting program, and their accessions number in the tens of thousands, with duplicate specimens deposited both in state and national herbaria.

Figure 38 John and Constance (Connie) Taylor. Photo courtesy of Wayne Elisen, Bebb Herbarium, University of Oklahoma.

John was a dedicated field botanist and established the SEOSU Herbarium in 1969 using his private collection and those of Connie, Don Hazell, and James Lester; in 1993 it comprised more than 80,000 sheets (Anonymous 1994). In addition to his plant collecting in Oklahoma—with the goal of recollecting every species known to grow in the state— he worked in Alaska, the Rocky Mountain states, western Canada, Mexico, and Costa Rica. Named in his honor are *Elaphoglossum tayloranum* (Taylor's tongue-fern) and *Castilleja tayloriorum* (Taylor's Indian paintbrush), two Costa Rican species new to science collected by Connie and him in 1972 (Anonymous 1994).

In addition to collecting plants with John, Connie independently conducted systematic studies of the composite genera *Solidago* (goldenrod) and *Euthamia* (goldentop). In doing so, she described (Taylor and Taylor 1983) *Solidago altiplanities* (high plains goldenrod), an Oklahoma species new to science. Her extensive knowledge of Oklahoma members of the Asteraceae, or sunflower family, was embodied in her *Keys to the Asteraceae of Oklahoma* published in 1997, which subsequently was incorporated into the *Illustrated Flora of North Central Texas* (Taylor 1999).

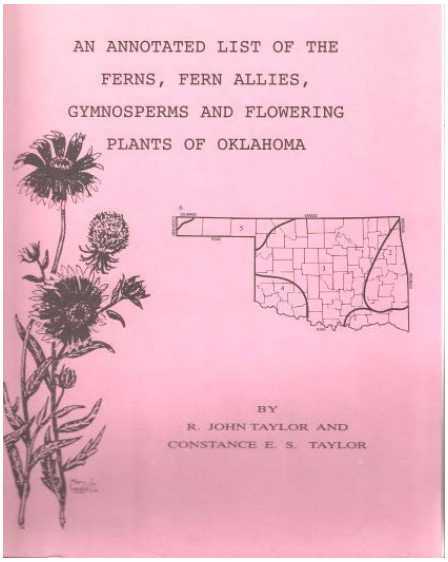


Figure 39 Third Edition of *An Annotated List of Ferns, Fern Allies, Gymnosperms and Flowering Plants of Oklahoma* used by many ONPS members.

Connie is also one of the founders of the *Flora of Oklahoma* project—an effort by state taxonomists to write and publish a modern floristic treatment for the state's vascular plants. In addition to taking primary responsibility for the Asteraceae, she has drafted and edited keys and descriptions for the genera of many other families.

Her unstinting service in various state organizations has contributed to public

awareness of Oklahoma's biodiversity. In addition to repeatedly being a field trip leader on ONPS and Wildflower Workshop outings, she has served as president of ONPS, the Oklahoma Ornithological Society, and the Oklahoma Academy of Science. In 1998, she received the ONPS's Anne W. Long Award for Promotion of Native Plants in Oklahoma in recognition of her contributions to the society and state.

Paul Buck—The individual perhaps best known for botanizing in Oklahoma—whether leading ONPS field trips, conducting ecological research, or collecting the state's flora—is Paul Buck (Figure 40), Professor of Botany at the University of Tulsa (TU) for many years. Following service in the Navy at the end of the Second World War and duty as a policeman in Tulsa, he earned his bachelor's and master's degrees at the University of Tulsa. His major was botany and his minor was zoology. His master's thesis dealt with the ecology of a tallgrass prairie in northeastern Oklahoma. Completed in 1962, his doctoral program was at the University of Oklahoma where he again opted for botany with a minor in zoology. His dissertation, a study of the relationships of woody vegetation to geology and soil in the Wichita Mountains Wildlife Refuge, was subsequently published in the journal *Ecology*. After completing his doctorate, Paul returned to his alma mater, the University of Tulsa, as an Assistant Professor of Botany and taught a variety of courses. In addition, he taught summer field courses for many years at The Rocky Mountain Biological Laboratory in Gothic, Colorado, one of the most famous field stations in North America.

Paul was a botanist with diverse interests. He published numerous scientific articles on a wide range of topics—ecology of woody vegetation, interspecific hybridization, and plant succession. Notable is his collaboration with TU colleague Estelle Levetin resulting in a series of journal articles on allergenic plants in Oklahoma. His research and writings contributed significantly to our understanding

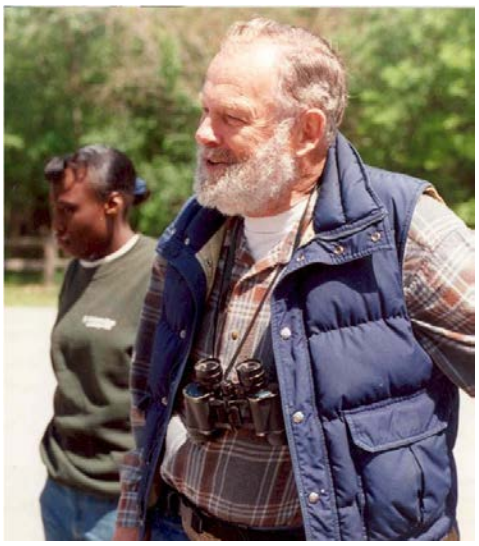


Figure 40 Paul Buck. Photo courtesy of Lou Ann Buck.

of the flora and vegetation of Oklahoma. His two editions (1983, 1991) of *Distribution and Identification of Woody Plants of Oklahoma in the Winter Condition* have been used by countless individuals becoming acquainted with the woody flora of the state (Figure 41).

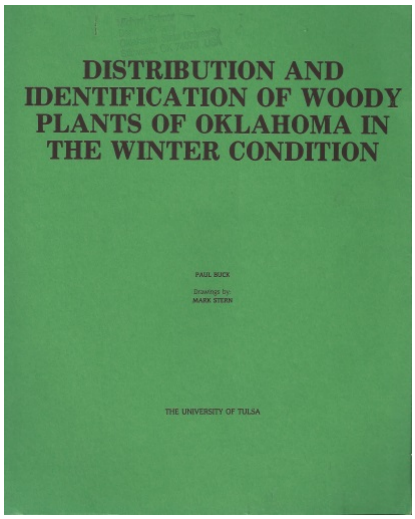


Figure 41 *Distribution and Identification of Woody Plants of Oklahoma in the Winter Condition* used by state scientists, students, and members of ONPS.

Paul was instrumental in the formation of a consortium of state taxonomists and ecologists to write a modern manual for

identification of the state's vascular flora—*The Flora of Oklahoma* project. In addition to writing, editing, and proofing the treatments of families and genera, especially the woody taxa, he took primary responsibility for the glossary and served as the project's treasurer for many years. In addition to his traditional writing as a scientist, Paul also was a disseminator of knowledge and made botanical phenomena meaningful to the general public via his quarterly column titled "Botany Bay" in the *Gaillardia*, the newsletter of the Oklahoma Native Plant Society, an organization that he played an instrumental role in forming. As an active member, he led innumerable field trips for the society and repeatedly served as a board member and the chair of various *ad hoc* committees. He also was involved in the creation of *Color Oklahoma,* an organization within ONPS dedicated to beautifying state highways with wildflowers.

Paul had a profound influence on many individuals. As a teacher, scientist, and field trip leader, he gave countless students, colleagues, and members of the public an appreciation of Oklahoma's plants and vegetation. His impact is reflected in the numerous awards and honors bestowed upon him: the ONPS Anne W. Long Award for Promotion of Native Plants, the ONPS Service Award, the Oklahoma Academy of Science (OAS) Service Award, and the OAS Teaching Award. On November 3, 2006, the academy paid tribute once again by sponsoring *The Natural History of Oklahoma: A Symposium Honoring Dr. Paul Buck* and bestowing upon him a Lifetime Achievement Award for his contributions to the advancement of science in the state (Tyrl 2006).

Patricia (Pat) Folley—When asked about her contributions to our knowledge about the flora of Oklahoma, Patricia Folley (Figures 37, 42) modestly replied, "*I haven't done very much, but I have had fun.*" Those of us who have worked with her and/or used her wildflower guide, know that her statement is certainly not accurate.

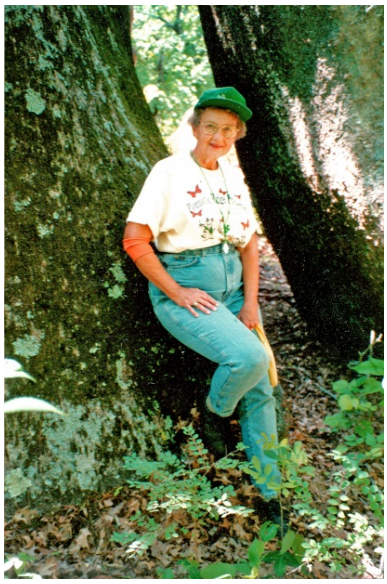


Figure 42 Patricia Folley in the field in 1997.

Pat traces her interest in Oklahoma's wildflowers back to her childhood. When she was 10 years old, her family moved to a home on the outskirts of Oklahoma City where she first began looking at the wildflowers and trying to identify them. Marriage, children, and a career as a logistics management specialist for the U.S. Air Force kept her busy until the 1980s. She then enrolled in a short course on plant identification taught by Jim Estes at the University of Oklahoma, who subsequently offered her the opportunity to work in the Bebb Herbarium when she retired. She gladly accepted the offer and learned to identify plants using taxonomic keys while working on the herbarium's backlog of unidentified specimens. She gratefully acknowledges the assistance of Estes, George Goodman, and Staria Vanderpool who helped her until she was able to work independently. Upon retirement, she also began volunteering for The Nature Conservancy to conduct surveys and to collect and identify plants throughout the state, from Beaver's Bend in the extreme southeast to Black Mesa at the end of the Panhandle. She has collected more than 2,100

specimens and many duplicates that have been distributed to herbaria throughout the country.

In 1992, Pat was invited to join the *Flora of Oklahoma Project* as a member of the editorial committee and a trustee. She undertook the task of mastering the more than 90 species of *Carex* in the state—a task almost all taxonomists shy away from—as well as the other 14 genera and 95 species of the Cyperaceae in Oklahoma. While doing field work and writing keys and descriptions for the flora project, she was also working hard to make ONPS a success. She served as a board member, chapter chair, president (twice), editor of the *Gaillardia* (the society's newsletter), a columnist writing the *Botanist's Corner,* and a field trip leader.

In 2011, Pat authored *The Guide to Oklahoma Wildflowers* (Figure 43), a compilation of wildflower photos which is most certainly a worthy successor to Doyle McCoy's series. Perhaps she was motivated by her encounter with a city librarian who dismissed her request for a picture book to help her identify the wildflowers when she was young and investigating wildflowers on the edge of Oklahoma City. She began drawing pictures of her plants and then began photographing them long before she began formal collecting. She has since amassed a large collection of 35 mm slides that have been the basis of popular slide shows at schools and meetings of ONPS, garden clubs, and civic groups.

Pat's contributions have been formally recognized as she has received both the ONPS Anne W. Long Award for Promotion of Native Plants and the ONPS Service Award for outstanding contributions, as well as the Conservation Award from the Oklahoma chapter of The Nature Conservancy. Although she sometimes describes herself as an "amateur botanist" because of her lack of formal training in plant taxonomy, Pat is most definitely not an amateur.

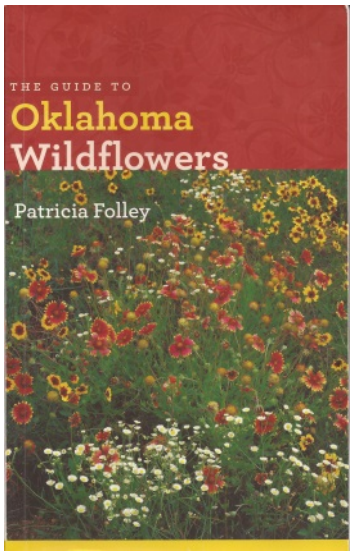


Figure 43 *The Guide to Oklahoma Wildflowers.*

Bruce W. Hoagland and Amy K. Buthod—As research scientists for the Oklahoma Biological Survey, Bruce Hoagland and Amy Buthod have conducted numerous surveys of various areas throughout the state and in doing so have collected more than 26,000 herbarium specimens between them. The results of their work—more than 30 papers— have appeared in this journal, the *Proceedings of the Oklahoma Academy of Science,* and a variety of regional and national journals. While conducting their field work, they have discovered, independently or jointly, 15 species previously unknown to occur in the state.

Bruce has a joint appointment between the Survey and the Department of Geography and Environmental Sustainability at the University of Oklahoma. Both a geographer and a plant ecologist, he authored (2000) a classification of the state's vegetation—the first since that of Duck and Fletcher (1943)—using the framework developed by the Federal Geographic Data Committee in 1997. In addition to being a botanical specialist for the Survey and collections manager of the Bebb Herbarium, Amy is also a heritage botanist for the Oklahoma Natural Heritage Inventory and in charge of tracking and monitoring populations of the state's rare plant species.

Collaborating with Ian Butler, Wayne Elisens, and Ron Tyrl; Bruce and Amy were the recipients of a National Science Foundation grant for the development of the *Oklahoma Vascular Plants Database* (OVPD) and website (http://www.oklahomaplantdatabase.org/). Derived from Bruce and Amy's previous database work on the *Atlas of the Flora of Oklahoma* project, the OVPD provides convenient and rapid access to the information associated with collections of Oklahoma plants deposited in *all* state herbaria. Label information is recorded, as well as taxonomic annotations, thus allowing users to extract and sort information, such as species distributions, localities, habitats, and phenology, as well as generating county floras and lists of specimens collected by various individuals (Figure 44). Prior to the development of the database, this information had to be laboriously extracted by examination of specimens in each of the state's herbaria.

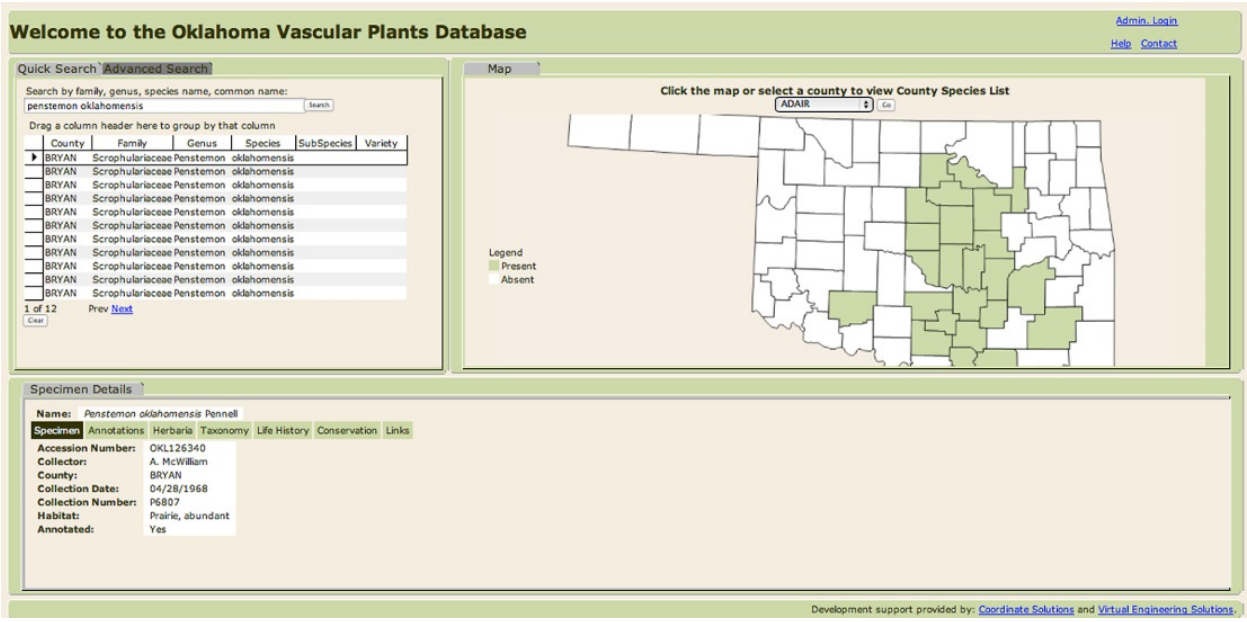


Figure 44 Opening screens of the Oklahoma Vascular Plants Database.

The Flora of Oklahoma Editorial Committee—As has been mentioned in several of the preceding synopses, botanists from throughout the state undertook in 1983 the writing of a modern floristic treatment for Oklahoma's vascular plants. For two decades, the last edition of U.T. Waterfall's *Keys to the Flora of Oklahoma* (1969) had been the primary taxonomic reference for identifying plants. During this time, numerous taxonomic revisions of families and genera had been published, and many nomenclatural changes had been made. Additional native taxa had been discovered, and taxa introduced to the state had naturalized (Tyrl et al. 2010). Thus, the need for an up-to-date treatment was recognized.

Initial steps included the establishment of an editorial board, formation of a non-profit corporation, development of an editorial format, production of a computerized database for family descriptions, solicitation of contributors, and in 1992 initiation of research and writing. In order to provide students and other individuals with taxonomic keys and descriptions as quickly as possible, the editorial board employed essentially the same approach as that of Waterfall and

decided to complete sequentially a key to families, descriptions of families, keys to the genera of each family, keys to the species of each genus, and finally the descriptions of genera and their species. *Keys to the Vascular Plant Families of Oklahoma* appeared in 1994 (Tyrl et al. 1994a). It was originally intended to be used in conjunction with Waterfall's *Keys* for genera and species until the new manual could be completed. Unexpectedly, the last copies of Waterfall's book were sold, and his heirs chose not to print it again. They kindly granted Flora Oklahoma, Inc. permission to print and combine it into a single work with the *Keys to Families,* so that students and other users could continue to have a readily available means of identifying Oklahoma plants. In order to recognize the monumental effort of Waterfall, the editorial board decided to leave his treatment intact and published *Identification of Oklahoma Plants* (Tyrl et al. 1994b) as a book with two independent parts.

In the late 1990s, revised versions of *Identification* were printed each semester in response to feedback from students and other users as to their efficacy. Finally in 2001, keys to all genera and species were completed by the editorial committee, and the first iteration of *Keys and Descriptions for the Vascular Plants of Oklahoma* appeared (Figure 45; Tyrl et al. 2010). At present, genera and species descriptions are being written. As before, previously written keys are revised, and the taxonomy and nomenclature of various families and genera are revised as needed.

Because of teaching responsibilities and other professional commitments, work on the project is slow but steady. The editorial committee (Figures 46-49) meets one Saturday a month in the Bebb Herbarium at the University of Oklahoma for a day-long session of examining specimens, writing, and editing. Committee members prepare drafts of keys and descriptions to be reviewed by the committee as a whole. In the fall of 1983, the committee comprised 10 botanists. At present, it comprises 12 ONPS members quite familiar to many of you: Susan Barber,

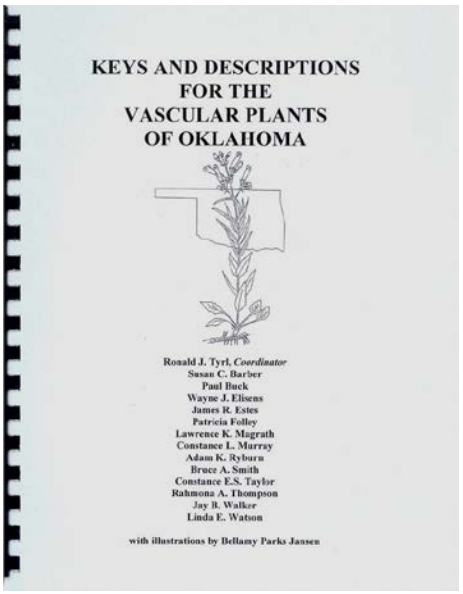


Figure 45 August 2010 revision of *Keys and Descriptions for the Vascular Plants of Oklahoma.*

Wayne Elisens, Jim Estes, Pat Folley, Connie Murray, Adam Ryburn, Bruce Smith, Connie Taylor, Rahmona Thompson, Ron Tyrl, Jay Walker, and Linda Watson. Founding members Paul Buck and Larry Magrath were major contributors to the project until their deaths (see Figures 46–49).

Figure 46 (from left) Susan Barber, Rahmona Thompson, Wayne Elisens, Larry Magrath, and Paul Buck, members of the editorial committee, at work on a Saturday morning in the Bebb Herbarium.

Figure 47 Connie Taylor and Larry Magrath, members of the editorial committee, at work on a Saturday morning in the Bebb Herbarium.

Figure 48 (from left) Ron Tyrl, Susan Barber, and Rahmona Thompson, members of the editorial committee, at work on a Saturday morning in the Bebb Herbarium.

Figure 49 Paul Buck and Pat Folley, members of the editorial committee, at work on a Saturday afternoon in the Bebb Herbarium.

Other Collectors in Our Cavalcade—As the preceding review of field botanists in Oklahoma has hopefully made obvious, our knowledge of the state's flora and vegetation is the result of endeavors by many individuals with quite diverse backgrounds. Some individuals have conducted floristic surveys of counties, geological areas, or botanically interesting areas; others have surveyed particular plant groups. We acknowledge that our list of contributors is by no means complete; many others have contributed as well. Bibliographies on the vegetation of Oklahoma (Kelting and Penfound 1953; Milby and Penfound 1965; Milby 1977; Johnson and Milby 1989) cite individuals and their work only through 1975. Unfortunately, a more recent compilation of publications has not been made. Given the ecogeographic and floristic diversity that characterizes our state, our cavalcade of field botanists in Oklahoma will undoubtedly continue.

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