

Oklahoma

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Volume 19

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† Indicates an author who is deceased

Cover photo: *Dalea purpurea* Vent. (purple prairie clover) by John Cleal for the 2008 ONPS
Photo Contest

Foreword

This issue of the *Oklahoma Native Plant Record* contains articles describing the vegetation of the past and present in Oklahoma, and one that sheds light on the potential for an invasive species to further affect the native vegetation of our state.

Based on plats, bearing tree data, and line summaries from the Public Land Survey, Bruce Hoagland, Rick Thomas, and Daryn Hardwick from the University of Oklahoma describe the historical land cover along the Deep Fork River in Okmulgee County circa 1897. These records indicate the bottomland forests, Cross Timbers forests and woodlands, and tallgrass prairie in this area were already starting to be transformed by agricultural activities.

Abby Crosswhite and Adam Ryburn from Oklahoma City University conducted a vascular plant survey of the John Nichols Scout Ranch in a suburban area of Canadian County. They report that a diversity of habitats on this property (upland forest, mixed grass prairie, bottomland forest, riparian areas) provide refuge for many species no longer found in the surrounding agricultural and residential areas.

Bruce Smith provides a checklist of the woody plants he and his students at McLoud High School have identified in the McLoud oak-hickory forest near their campus. He also provides a trail map and a guided tour of the forest, in which he illustrates how to identify many of the woody plants by their leaves, buds, and bark; encourages the reader to notice the lichens, slime molds, and insect larvae on the plants; and describes the size structure of the forest. I encourage you to stop by McLoud and use his trail guide to help you enjoy and appreciate this native forest.

Eric Duell and Karen Hickman from Oklahoma State University investigate the ability of kudzu (*Pueraria montana*) to sexually reproduce in Oklahoma at the western extent of its range. Although kudzu primarily spreads by rhizomes, sexual reproduction increases genetic diversity and results in seeds that can be dispersed by animals and water, thus potentially increasing its range. Information on the relative importance of asexual versus sexual reproduction in kudzu in Oklahoma can help us monitor and manage this invasive species.

This issue's Critic's Choice essay was written by Paul Buck for the Botany Bay section of the Spring 1998 *Gaillardia*. In his essay, Paul visits a bottomland forest and describes the life he sees there on a cold and windy winter day. As this issue goes to press, we are in the midst of the COVID-19 pandemic, and many people are finding the time and opportunity to notice more of the myriad of interactions in the natural world, something Paul always beautifully encouraged us to do.

Please consider publishing your work in the *Oklahoma Native Plant Record*. It is listed in the Directory of Open Access Journals, is abstracted by the Centre for Agricultural Bioscience International, and can be accessed by researchers around the world.

Gloria Caddell
Managing Editor

HISTORICAL LAND COVER ALONG THE DEEP FORK RIVER: AN ANALYSIS OF VEGETATION COMPOSITION AND DISTRIBUTION OF THE DEEP FORK NATIONAL WILDLIFE REFUGE, OKMULGEE COUNTY, OKLAHOMA, CIRCA 1897

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Keywords: Deep Fork River, Public Land Survey, historical land cover, bearing trees

ABSTRACT

North American vegetation has been extensively modified by human activity. Restoring the landscape to past conditions is a strategy for species conservation, but this requires access to reliable data that describes those conditions. Here we use plat and bearing tree data collected during the Public Land Survey of 1897 (PLS) to describe the vegetation at the Deep Fork National Wildlife Refuge. We digitized five township plats and recorded data for all bearing trees. Of the six land cover types, forest (67%) and grassland (29%) were the most extensive. Surveyors recorded 708 individual bearing trees. Post oak (*Quercus stellata* Wangenh.) (199 stems), red oak (*Q. rubra* L.) (140), and blackjack oak (*Q. marilandica* Münchh) (92) were the most common trees. Some proportion of the trees identified as red oak were most likely black oak (*Quercus velutina* Lam.) and/or Shumard oak (*Quercus shumardii* Buckley var. *shumardii*). Eastern red cedar (*Juniperus virginiana* L.) was not recorded as a bearing tree but was recorded in the line notes. At the time of the PLS survey, the study area exhibited modification. Although the PLS began in Oklahoma in 1870, the Creek Nation was surveyed beginning in 1896.

INTRODUCTION

North American vegetation has been extensively modified or obliterated by human activity, which is certainly the case in Oklahoma. The extent and pace of these changes began to accelerate in the 19th century. Although the use of fire and clearing for settlements by the original occupants of the continent affected

vegetation (Cronon 1983), the rate accelerated following westward expansion by Euro-Americans (Flannery 2002; Goudie 2005). The result has been a significant loss of and fragmentation of habitat which exacerbates the likelihood of extinction for many species (Turner and Meyer 1991; Hanski 2011). To stem the loss of both, ecologists have turned to the practice of habitat restoration. But this begs the

question, what were the environmental conditions and habitat composition in early North American history? To address this question, many have turned to the records of the Public Land Survey (PLS), which was established by passage of the Land Ordinance on 20 May 1785 by the Continental Congress (White 1983; Brothers 1991).

The General Land Office (GLO) was responsible for conducting the PLS. The Land Ordinance required that areas in the U.S. territories be delineated into Congressional Townships of 36 mile² (9,323.96 hectares), each of which was further subdivided into 36 sections of 1 mile². Surveyors were instructed to describe the vegetation and physical features

encountered during the survey in the form of written notes and on mapped township plats (Brothers 1991; Stewart 1935). The surveyors were also required to mark "witness trees" to aid in the relocation of survey landmarks. The procedure involved measuring the distance from the survey landmark to the nearest trees: one tree in each of four quarters where section-lines intersect and one on opposite sides of the survey line for quarter sections (Figure 1). The species name (typically common name was recorded, but scientific binomials were provided by surveyors in some states), stem diameter, and distance were recorded for each witness tree (Whitney and DeCant 2001).

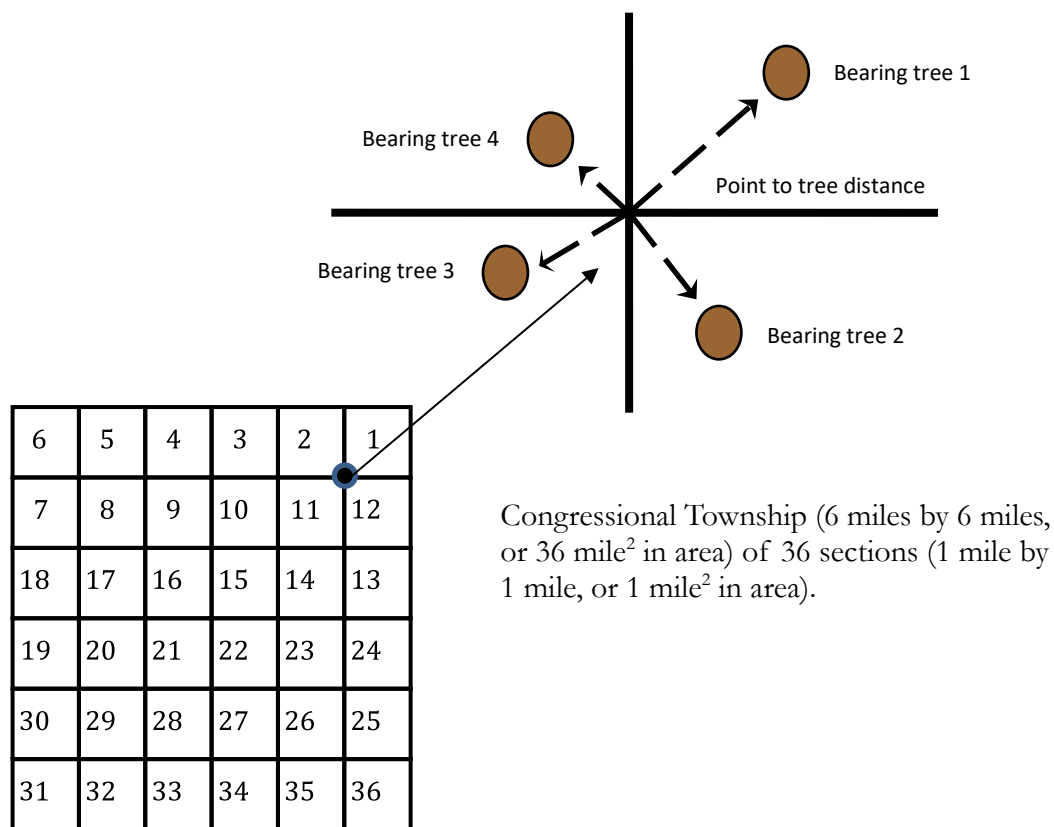


Figure 1 Process for locating bearing trees employed by surveyors of the Public Land Survey. As surveyors established quarter section lines, they were required to stop at half mile intervals and measure the distance and diameter of trees in adjacent sections and record an identification. This information was used to relocate section corners and assist settlers by providing them the legal description for their land claims.

Although the intent of the PLS was to parcel land and not to gather ecological data, these records have been useful for evaluating the composition and distribution of vegetation and land-use of the past (Bourdo 1956; Whitney and DeCant 2001). As such, the PLS data can be used to develop a baseline of environmental conditions prior to extensive Euro-American settlement and aid in the analysis of land cover change over time (Galatowitsch 1990; Schulte and Mladenoff 2001).

The PLS began in Oklahoma with the establishment of the Initial Point in the Arbuckle Mountains in 1871 (Hoagland 2006). Though lagging behind other states in the analysis of PLS data (Fagin and Hoagland 2002), recent studies have analyzed these data for locations in the Cross Timbers region. Each of these studies addressed questions about the composition and structure of Cross Timbers vegetation in the 1870s and whether native-invasive species were detectable in the data (i.e., *Juniperus virginiana* L. or *Prosopis glandulosa* Torr.). Two of these studies focused on the Arbuckle Mountains region. Shutler and Hoagland (2004) analyzed the witness tree data for Carter County in 1871 and found that only one “cedar” tree (*Juniperus ashei* Buchholz or *J. virginiana*) was reported. Fagin and Hoagland (2010) modeled the distribution of witness trees in relation to geology and soils in the Arbuckle Mountains using the PLS data from 1871 and a second PLS dataset from 1890 and discovered four individual cedars reported in the bearing tree data of the first survey and seven in the second.

Hoagland et al. (2013) analyzed PLS data from the Wichita Mountains National Wildlife Refuge and found *Juniperus virginiana* and *Prosopis glandulosa*, both a modern ecological and economic threat (Van Auken 2000), were present in the 1870s and 1890s. Thomas (2010) used the PLS plats and witness tree data to investigate the role of

rivers as landscape barriers to the spread of fire and the resulting difference in vegetation composition.

Given the ever-changing nature of bottomland and upland forest vegetation in Oklahoma, the objective of this study was to analyze PLS records for the Deep Fork National Wildlife Refuge (DFNWR) and adjacent areas to establish a baseline of landscape and vegetation conditions for refuge personnel. Although the PLS started in the 1870s in present day Oklahoma (Hoagland 2006), Creek tribal lands were not surveyed until the 1890s, by which time landscape transformation was well underway. We used qualitative data consisting of written timber descriptions, each of which lists predominant and co-occurring species and the physical setting in which the surveys were conducted. Quantitative data consisted of both bearing tree records (e.g., point-to-plant distance, diameter-at-breast height) and plats for determination of land cover types and their extent. The bearing tree data provides insight regarding the species composition and vegetation structure (e.g., basal area and stem density).

STUDY AREA

The Deep Fork National Wildlife Refuge (096°00'21.6"W to 095°54'39.6"W and 35°34'51.6"N to 35°32'24.1"N) (Figure 2) was established in 1993 to protect 3,925 ha of forested and herbaceous emergent wetlands habitats (United States Fish and Wildlife Service 2019). The ecological significance of the bottomland hardwood forests of the Deep Fork River has been long recognized (Brabander et al. 1985). The DFNWR is located in the Subtropical Humid (Cf) climate zone (Trewartha 1968), with warm (mean July temperature 27.28°C) and humid summers and relatively short and mild (mean January temperature 2.68°C) winters. Mean annual

Duck and Fletcher (1943) mapped the potential natural vegetation (or as they wrote *Game Types*) of Okmulgee County as post oak-blackjack oak forest and tallgrass prairie, with a distinct band of bottomland forest following the Deep Fork River. Duck and Fletcher describe the post oak-blackjack oak forest as “The overstory is largely composed of post oak (*Quercus stellata*), blackjack oak (*Q. marilandica*), and black hickory (*Carya texana*) with the percent of blackjack oak increasing in the composition as one moves west through the Post Oak - Blackjack Game Type. The understory is made up of little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), and other species depending upon the site.” The tallgrass prairie “consists of a mixture of such species as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), switch grass (*Panicum virgatum*), and silver beard grass (*Bothriochloa saccharoides*), in the eastern portions of the type...”

As mapped by Duck and Fletcher, the bottomland forest type extends from southeast Oklahoma to the Panhandle as one unit. In the text of the report, however, they describe regional variation in vegetation composition. The following text most closely describes the bottomland forest communities of Okmulgee County: “Typical stream growth in central Oklahoma within the Tallgrass Prairie Game Type consists of American elm (*Ulmus americana*), chinquapin oak (*Quercus muhlenbergii*), post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), hackberry (*Celtis laevigata* and/or *C. occidentalis*), chittamwood (*Bumelia lanuginosa*) [*Sideroxylon lanuginosum* Michx.], cottonwood (*Populus deltoides*), chickasaw plum (*Prunus angustifolia*), fragrant sumac (*Rhus trilobata* Nutt.) [*R. aromatica* Aiton], smooth sumac (*Rhus glabra*), and rough leafed dogwood (*Cornus drummondii*). Black oaks, pecan (*Carya illinoensis*) [*C. illinoensis* (Wangenh.) K. Koch], sycamore (*Platanus occidentalis*),

bitternut (*Carya cordiformis*) and walnut (*Juglans nigra*) are more common southward and eastward.” It should be noted that in regard to forest vegetation, many floristic elements of the eastern Oak-Hickory forest and southern bottomland forest flora are present in the study area.

The land-use history of the county has obscured some of the patterns of the historic vegetation. Clearing and conversion to agriculture of the bottomland forests along the Deep Fork River began in the 19th century, with restricted clearing following removal of the Creek Nation to Indian Territory. The rate of change accelerated following passage of the Dawes Act and the allotment of tribal lands. In the mid-20th century, land abandonment allowed some areas to return to *Quercus palustris*-*Carya illinoensis*/*Ilex decidua* and *Ulmus rubra*-*Celtis laevigata*-*Fraxinus pennsylvanica* bottomland forests (Hoagland 2000). Many hectares in the area are still used for pasturage, much of which was converted from native grasses to *Schedonorus arundinaceus* (Schreb.) Dumort. (Sparwasser et al. 1968).

MATERIALS AND METHODS

The PLS records provide three important sources of information, each of which was utilized here: township plats, witness or bearing tree records, and line summaries. The plats and the *Field Notes of the Survey* were acquired from the Bureau of Land Management (www.glorerecords.blm.gov) for the townships 12N 12E (survey date: 1897), 12N 13E (1898), 13N 12E (1897), 13N 13E (1897), and 14N 12E (1897).

Plats

Township plats (see Figure 2) were georeferenced and digitized using ArcGIS Pro. Features that were digitized from a plat were attributed to one of the following data layers: vegetation (forest, grassland, and

wetland), hydrology (streams, rivers, springs, and ponds), agriculture (cultivated fields), transportation (roads, trails, and railroads), and settlement (residences, schools, and other cultural features). Once a township was digitized, each data layer was edited, attributed, and joined with adjacent plats. FRAGSTATS (McGarigal et al. 2012) calculates landscape metrics from geospatial data and was used to determine landscape/land cover composition and patterns. For this study, area of a land cover type, number of patches, mean patch size, and patch size standard deviation were calculated. The term patch refers to individual polygons or occurrences of a land cover type. Class area is a measure of the total area occupied by a particular land cover type, number of patches is a count of individual occurrences of a given land cover type, and mean patch size is an average value of the number of patches for a land cover type.

Bearing Trees

The bearing tree data were used to determine which woody plant species were present and to calculate the stand structure metrics of basal area (BA), the proportion of stems of one species to the total number of stems (PS), and an importance value (IV). Note that biases toward larger trees have been identified in the surveyor's selection of bearing trees (Bourdo 1956). We did not calculate, however, stand density (number of stems or individual tree trunks per unit area). Previous literature employing PLS data have calculated tree density using the point-center-quarter and other "plotless" methods (Schulte and Mladenoff 2001). These methods were intended to quickly collect data using transects from points at regular intervals in distinct forest types (Cottam and Curtis 1956). The PLS collected data at intervals of 0.5 mile (804.7 m), crossing multiple plant community types and environmental gradients. In addition, the points sampled by

the PLS represent a township, an area of 36 mile² (9,323.96 hectares). Finally, it is important to remember that the PLS data were not collected to characterize ecological communities or forest stand demographics, but they are the best available data for quantitative analysis of woody plant communities of the past.

Basal area (BA) is a measure of the cross-sectional area of each tree trunk within a given area. We used tree diameter data recorded by the PLS to calculate BA according to Wenger (1984) for each species, using the formula $Area = \pi r^2$.

Relative Basal Area (RBA) was calculated as

$$RBA = \frac{\sum BA_I}{\sum BA_T} \times 100,$$

where BA_I is the total BA of a species and BA_T is the total BA of all species.

We calculated the proportion of stems (PS) as the following formula:

$$PS = \frac{\sum S_I}{\sum S_T} \times 100,$$

where S_I is the number of stems of a species and S_T is the total number of stems of all species.

The IV is a measure of the predominance of species in a dataset or at a site and in this study is the sum of $RBA + PS$.

Line Notes and Township Summaries

Line summaries provide supplemental information that facilitates the development of a thorough description of ecological conditions at the time of the survey. Unlike the bearing tree and plat data, these are narrative statements. We parsed the line descriptions into three categories: surface, vegetation, and soils. Surveyors noted the surface or topography of an area in a broad sense, using terms such as level, hilly, or rolling. The vegetation descriptions were typically a list of taxa present, with occasional notations as to which were more

common. The protocol for soil description is rather obscure and the categories undefined. Typically, a surveyor ranked the soil on a scale of 1–4 and occasionally supplied an adjective such as sandy or rocky. Rarely were other details presented. It is important to recall, however, that this information was intended to inform the

General Land Office and settlers of agricultural potential and not ecological conditions. Township descriptions presented the same three categories of information, with additional remarks about settlement and other aspects of the township as a whole.

Table 1 Landscape metrics calculated for the land cover in the townships encompassing the Deep Fork National Wildlife Refuge, Okmulgee County, Oklahoma

Landcover	Class Area (ha)	Number of Patches	Mean Patch Size (ha)	Patch Size Standard Deviation
Forest	28849.7	3.0	9616.6	13598.6
Grassland	12393.2	27.0	459.0	904.4
Agricultural fields	910.0	55.0	16.5	23.4
Wetland	643.7	13.0	49.5	91.4
Slough	47.9	4.0	12.0	12.4
Lake	75.5	26.0	2.9	3.3
Total	42920.0	128.0		

RESULTS AND DISCUSSION

Plats

Of the six land cover categories appearing on the plats, forest and woodland vegetation constituted 67% of the landcover in the study area for 1897 (Table 1). Approximately one third of the study area was grassland vegetation. No other category exceeded 3.0% of the total area. Regarding the categories presented in the map legend (Figure 3), two points need to be made. First, as noted earlier, the study area lies on the eastern flank of the post oak-blackjack oak forest (Duck and Fletcher 1943). This region is known colloquially as the Cross

Timbers, a mosaic of forest, woodland, and grassland vegetation. Second, the map category “forest and woodland” used here was not employed by the PLS surveyors. This designation was adopted because within the Cross Timbers both forest and woodland vegetation were present, probably on south and west facing slopes (Hoagland et al. 1999). A similar issue arises with the term “grassland”. The surveyors use the term prairie, but given the degree of settlement in the townships analyzed, areas of grassland were likely grazed by livestock, as were the adjacent woodlands.

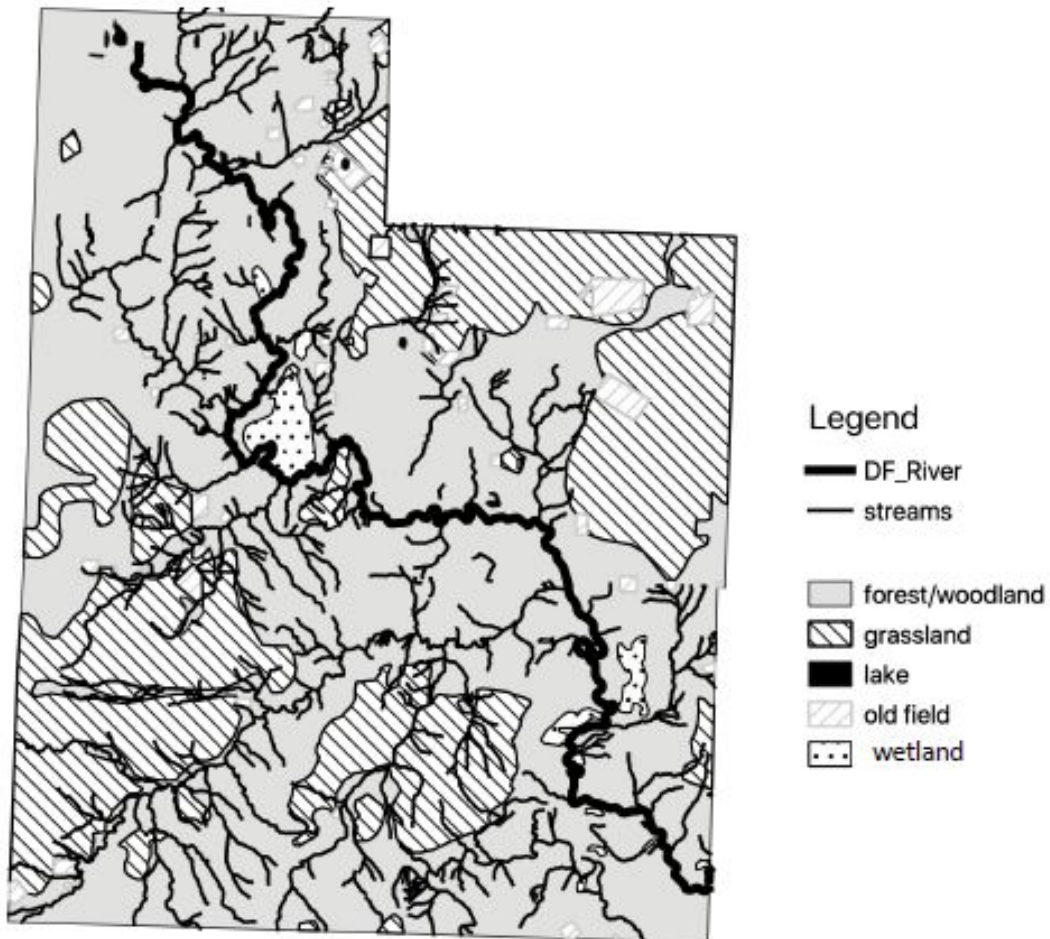


Figure 3 Land cover in the townships encompassing the Deep Fork National Wildlife Refuge, Okmulgee County, Oklahoma, 1897. The map was prepared by digitizing 5 township plats developed by the Public Land Survey in Indian Territory.

Although forest-woodland vegetation occupies the greatest area, it has the fewest number of patches, indicating it is a matrix community type. It is misleading, however, to assume this is all one type of forest. As noted by the surveyors, the area is a combination of upland and bottomland

forest. This distinction was not made when the plats were drawn, unfortunately. Grasslands were much smaller in total extent but had a greater number of patches, indicating that grasslands were embedded within the forest-woodland matrix and were likely bordered by woodlands.

There were 55 agricultural fields averaging 16.5 hectares. Most were bordered by one or more of the 83 built structures (residences or barns, though the surveyors did not denote which type) mapped in the study area. The majority of agricultural fields were in lowland locations where soils tend to be level and fertile. The 93 fenced areas typically enclosed agricultural fields and/or built structures. At this time in American history, fences were constructed to exclude livestock and protect crops (Hart and Mather 1957). Symbology on the plats indicates that the vast majority of fencing was barbed wire, with a smaller quantity of rail fencing.

Bearing Trees

Surveyors documented the occurrence of 702 stems, or individual trees, representing 22 taxa of woody plants. All taxa encountered by surveyors were also reported as occurring on the DFNWR by Hoagland and Buthod (2017) with the exception of *Q. nigra* L. and *Q. rubra* L., nor was either species reported from the adjacent Deep Fork Wildlife Management Area or Eufaula Wildlife Management Area, Deep Fork Unit (Hoagland and Johnson 2005). There are records for both species, however, in Okmulgee County in the Oklahoma Vascular Plants Database (2019). Confounding this is the high number of stems (n=140) and importance value (IV=41) for *Q. rubra*, indicating that it was a common tree at the time of the survey. Although that possibility cannot be dismissed, surveyors did not collect specimens for identification, so two matters should be considered. First, the DFNWR is on the western extent of the geographic range for *Q. rubra*, and therefore high abundance is unlikely. Second, some of the 140 individuals were possibly misidentified and in fact are *Q. shumardii* Buckley or other members of the red oak group that have been documented at the DFNWR (*Q. falcata*

Michx., *Q. palustris* Münchh., and *Q. velutina* Lam.).

Several taxa were reported to the genus level only (elm, hickory, maple, ash, birch). Identifications can be posited as to species in two instances. It is reasonable to conclude that the maple reported by surveyors is *Acer saccharinum* L., a common tree of levees and streamsides in the area, and because *A. saccharum* Marsh. is not reported from the area. The same is true of the birch, which is most likely *Betula nigra* L. Additionally, only one species of hackberry (*Celtis laevigata* Willd.) is reported from DFNWR, but *C. occidentalis* L. is also reported from Okmulgee County (OVPD 2019). Adding resolution to the identification of other trees identified to the genus level is more problematic. For example, two species of ash (*Fraxinus americana* L. and *F. pennsylvanica* Marsh.) and two species of hickories (*Carya cordiformis* [Wangenh.] K. Koch and *C. texana* Buckley) have been reported from the DFNWR. Likewise, four species of elm have been reported from the DFNWR: *Ulmus alata* Michx., *U. americana* L., *U. rubra* Muhl., and *U. pumila* L. The latter is a non-native species that was not reported from Oklahoma until 1934 (Hoagland 2019).

The high number of stems for post oak recorded by surveyors is consistent with the Cross Timbers vegetation (Hoagland et al. 1999). The typical Cross Timbers co-dominant is blackjack oak, which is third in the order of importance (Table 2). Several species reported reflect the extensive bottomland forests in the area: pecan (*Carya illinoensis*), eastern cottonwood (*Populus deltoides* W. Bartram ex Marshall), water oak (*Q. nigra*), bur oak (*Q. macrocarpa* Michx.), and *Q. palustris*. The low number of blackjack oak stems, which approach a ratio of 2:1 post oak:blackjack oak in the Cross Timbers (Rice and Penfound 1959), reflects the eastern location of the sites and the higher diversity of forest types.

Table 2 Woody plant species recorded by General Land Office surveyors circa 1897 in the townships encompassing the Deep Fork National Wildlife Refuge, Okmulgee County, Oklahoma. The scientific name was derived by the authors from the common name recorded by surveyors. BA = basal area, calculated in meters²; RBA = relative basal area; Stems = the number of individuals stems recorded by surveyors; PS = proportion of stems; IV = importance value.

		BA (m ²)	RBA	Stems	PS	IV
Post oak	<i>Quercus stellata</i>	18.53	32.80	199	28.11	60.91
Red oak	<i>Quercus rubra</i>	12.47	22.06	140	19.77	41.48
Blackjack oak	<i>Quercus marilandica</i>	5.88	10.40	92	12.99	23.40
Oak	<i>Quercus</i> spp.	5.90	10.44	52	7.34	17.79
Elm	<i>Ulmus</i> spp.	3.58	6.33	67	9.46	15.79
Hickory	<i>Carya</i> spp.	2.12	3.75	37	5.23	8.97
Water oak	<i>Quercus nigra</i>	1.80	3.19	33	4.66	7.85
Black oak	<i>Quercus velutina</i>	1.29	2.29	23	3.25	5.54
Ash	<i>Fraxinus</i> sp.	0.91	1.61	14	1.98	3.59
Bur oak	<i>Quercus macrocarpa</i>	1.03	1.82	11	1.55	3.38
Walnut	<i>Juglans nigra</i>	0.62	1.10	8	1.13	2.23
Pecan	<i>Carya illinoensis</i>	0.47	0.83	6	0.85	1.68
Hackberry	<i>Celtis</i> spp.	0.38	0.67	5	0.71	1.38
Maple	<i>Acer</i> spp.	0.32	0.57	5	0.71	1.27
Cottonwood	<i>Populus deltoides</i>	0.52	0.92	2	0.28	1.20
Persimmon	<i>Diospyros virginiana</i>	0.22	0.38	5	0.71	1.09
Birch	<i>Betula</i> sp.	0.22	0.39	3	0.42	0.82
Sycamore	<i>Platanus occidentalis</i>	0.07	0.12	2	0.28	0.40
Box elder	<i>Acer negundo</i>	0.05	0.09	1	0.14	0.23
Mulberry	<i>Morus rubra</i>	0.05	0.09	1	0.14	0.23
Pin oak	<i>Quercus palustris</i>	0.05	0.09	1	0.14	0.23
Spanish oak	<i>Quercus falcata</i>	0.02	0.04	1	0.14	0.19

Line Notes

There were 205 line notes recorded by the surveyors. Woody plant communities were described as “timber” rather than “forest” in the line notes. The term would appear alone or with the adjectives “heavy” or “scattering”, providing a subjective indication of tree density in the area. On three occasions the terms “slough”, “swamp”, and “swampy” were used to describe the vegetation along the Deep Fork River. Although these terms have multiple definitions, the surveyors were presumably referring to forested wetlands because of the accompanying phrases such as “heavy timber with dense underbrush.” Forest understory was described in terms such as “dense underbrush of briars and vines” (n=9).

Interestingly, the surveyors did distinguish between pastures (n=8) and prairies (n=75), providing evidence of active livestock grazing in the area. The terms appear together in two descriptions, “scattering timber, prairie glade, pasture” and “timber, pasture, dense underbrush, prairie.” These are also examples of how surveyors would report the vegetation encountered along the survey line in strings. Grasslands also appeared in bottomlands, as indicated by the description “timber, river bottom and heavy timber, prairie” (n=2).

The surveyors reported three trees in the line notes that do not appear as a bearing tree: cedar, dogwood, and locust. The cedar is most likely *Juniperus virginiana*. The dogwood could be either roughleaf dogwood (*Cornus drummondii* C.A. Mey), flowering dogwood (*C. florida* L.), or as recently reported from DFNWR, stiff dogwood (*C. foemina* Mill.) (Hoagland and Buthod 2017). Although both bristly locust (*Robinia hispida* L.) and black locust (*R. pseudoacacia* L.) were reported from DFNWR (Hoagland and Buthod 2017), the locust in question is most likely honeylocust (*Gleditsia triacanthos* L.), a common tree of bottomland forests.

CONCLUSIONS

The PLS records from 1897 clearly illustrate a transformation from bottomland forests, Cross Timbers forest and woodlands, and tallgrass prairie to an anthropogenic landscape. The extent of the transformation is limited, given that agricultural fields are relatively small and scattered. There are many subtleties, however, that are not revealed by the PLS records, such as the impact of livestock. Pastures, for example, were not mapped by the surveyors but were mentioned in the line notes. Livestock, both cattle and swine, likely foraged in prairie and woodland, thus impacting herbaceous species composition. The taxa represented among the bearing trees are part of the modern flora. The abundance of *J. virginiana*, a native invasive, is low, but this is not surprising considering the percentage of forested land cover. The PLS records have demonstrated utility in describing this landscape of the past, even if it is not a snapshot of the primeval forest.

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A FLORISTIC INVENTORY OF THE JOHN W. NICHOLS SCOUT RANCH, CANADIAN COUNTY, OKLAHOMA

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ABSTRACT

We conducted a vascular plant survey of the John Nichols Scout Ranch in southeastern Canadian County, Oklahoma, during the growing seasons of 2017 to 2019. Vouchered specimens were collected for 152 species in 116 genera and 49 families. The largest families represented were the Asteraceae (37 species), Poaceae (19), and Fabaceae (17). No rare species currently being tracked by the Oklahoma Natural Heritage Inventory were encountered. Twenty of the species collected were not native to the United States, of which six (*Lonicera japonica*, *Lespedeza cuneata*, *Bothriochloa ischaemum*, *Bromus tectorum*, *Sorghum halepense*, and *Tamarix chinensis*) are considered invasive. Three tree species (*Pinus taeda*, *Pistacia chinensis*, and *Taxodium distichum*) were planted in developed areas of the ranch. Species richness appears to be low when compared to surveys of similar size. We suggest that the adjacent properties used for agriculture and housing development have influenced the number of species of this suburban wilderness.

INTRODUCTION

E. O. Wilson writes in his book *Biodiversity* (1988) that “biological diversity must be treated more seriously as a global resource, to be indexed, used, and above all, preserved.” In partnership with the Last Frontier Council of the Boy Scouts of America, the Oklahoma City University Department of Biology began a project to explore the biodiversity of a 150-hectare (371-acre) suburban wilderness in southwest Oklahoma City known as the John Nichols Scout Ranch (JNSR). Managed by the Last Frontier Council, very little is known of the biodiversity of this suburban natural area that is surrounded by agriculture and housing developments. As protected lands such as the JNSR become the refuges of biodiversity, it is essential to have an

accurate picture of what species are present. By identifying species and adapting management practices to preserve biodiversity, future generations are provided a baseline of information to assess the success of those management practices. Previous studies have explored the mammal (Hackney and Stancampiano 2015) and bird (Jardine et al. 2016) diversity and habitat preferences. This study reports on the vascular plant diversity of the area.

STUDY AREA

The JNSR is located in the southeastern corner of Canadian County, Oklahoma (35°21'00" N 97°40'17" W) (Figure 1). On the southern border, the South Canadian River flows east towards Cleveland County. The elevation in the area ranges from 356 m

to 418 m. The 150-hectare (371-acre) ranch has been maintained by the Last Frontier Council since 1932. The ranch is composed of various habitats such as upland and bottomland forests, mixed prairie, and disturbed areas. Based on satellite imagery, Hackney and Stancampiano (2015) estimated that approximately 70% of the site is wooded area while the other 30% is grassland, disturbed areas, and developed areas. Disturbed and developed areas can be found throughout JNSR in sections maintained for campsites, common areas used for boy scout activities, trails, and roadsides. Throughout the year, the level of human disturbance ranges from high to none. The most human influence occurs during the spring and summer months due to scouting camps. The area is irregularly mowed for maintenance, but mowing is restricted to inhabited areas such as campgrounds and surrounding establishments.

According to the United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS 2019b), the two main soil compositions are Darnell-Noble complex and Nash-Ironmound complex (Figure 2). The JNSR is in the Central Red-Bed Plains geomorphic province characterized by Permian red shales and sandstone that form gently rolling hills and broad, flat plains (Curtis et al. 2008). Located in the Central Great Plains Level III Ecoregion, the JNSR is on the border of the Prairie Tableland and Cross Timbers Transition Level IV Ecoregions (Woods et al. 2005). The dominant potential vegetation is a combination of tallgrass prairie and

bottomland (floodplain) (Duck and Fletcher 1943).

In west-central Oklahoma from 1896–2018, the summer average temperature was $26.6 \pm 13.4^\circ\text{C}$. Winter months averaged $3.17 \pm 13.4^\circ\text{C}$. The highest temperatures occurred mostly in July with an average of 27.7°C , while the coldest temperatures occurred in January at an average of 2.00°C . Over the period, the average precipitation was 66.65 ± 34.70 cm. Precipitation reached an average low of 2.01 cm in January and an average high of 10.52 cm in May (Oklahoma Climatological Survey 2018).

METHODS

The floristic survey occurred during the growing seasons (March to November) in 2017, 2018, and 2019. Vouchers of specimens were deposited in the Oklahoma City University (OCU) Herbarium following recommendation by Palmer and Richardson (2012) for published flora. Sources used for identification included Ryburn et al. (2018), Folley (2011), McCoy (1987), Tyrl et al. (2008), and Little (2010) along with comparison to specimens present in the OCU herbarium. Duration (annual, biennial, perennial) and growth form (forb, graminoid, shrub, tree, woody vine) were determined using the PLANTS Database (USDA-NRCS 2019a) and Taylor and Taylor (1994). Classification and nomenclature are based on Angiosperm Phylogeny Group (APG III) recommendations (Stevens 2019) and the Integrated Taxonomic Information System (ITIS 2019).

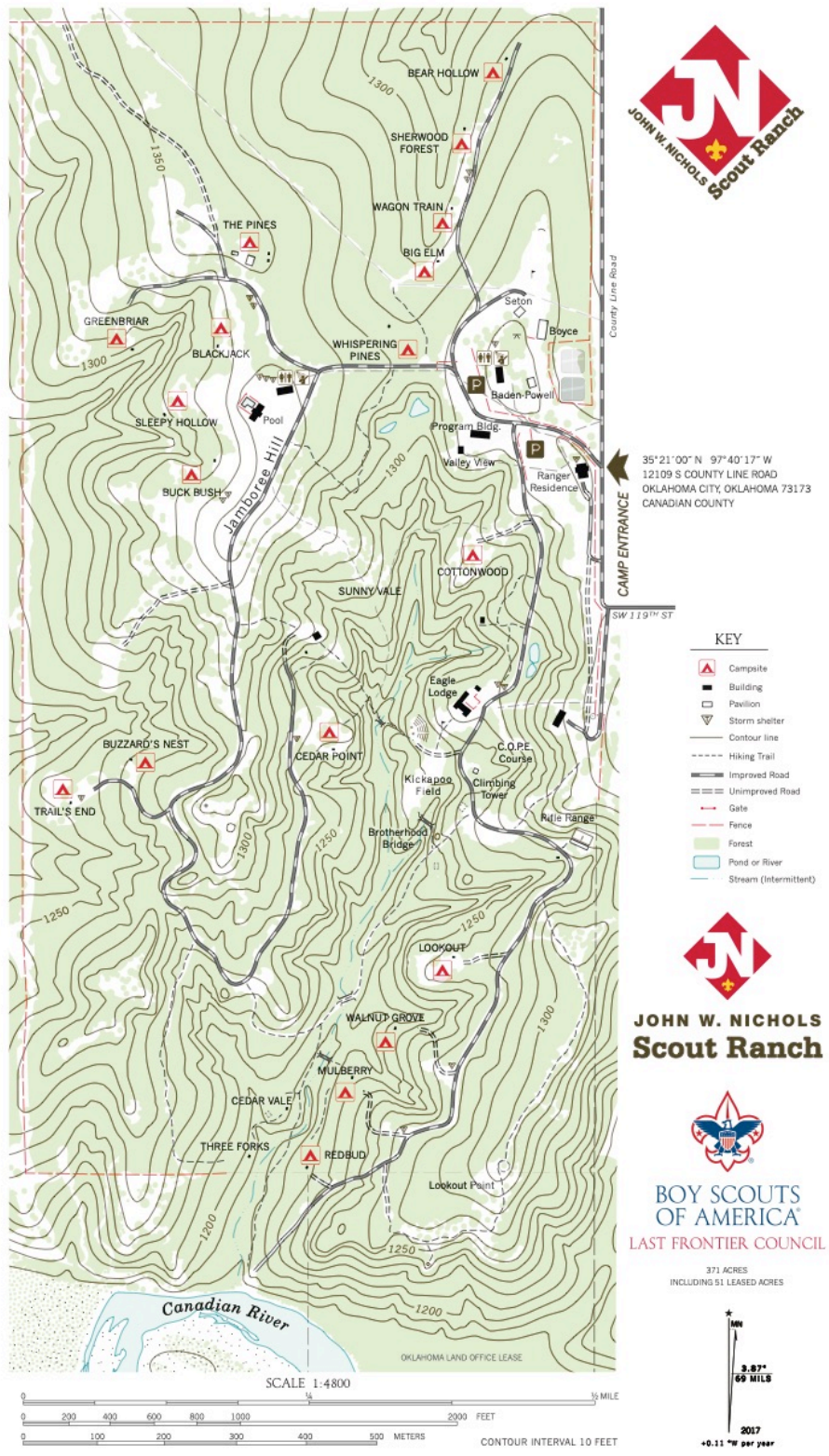


Figure 1 Map of JNSR, Canadian County, Oklahoma. Used by permission from the Last Frontier Council of the Boy Scouts of America.

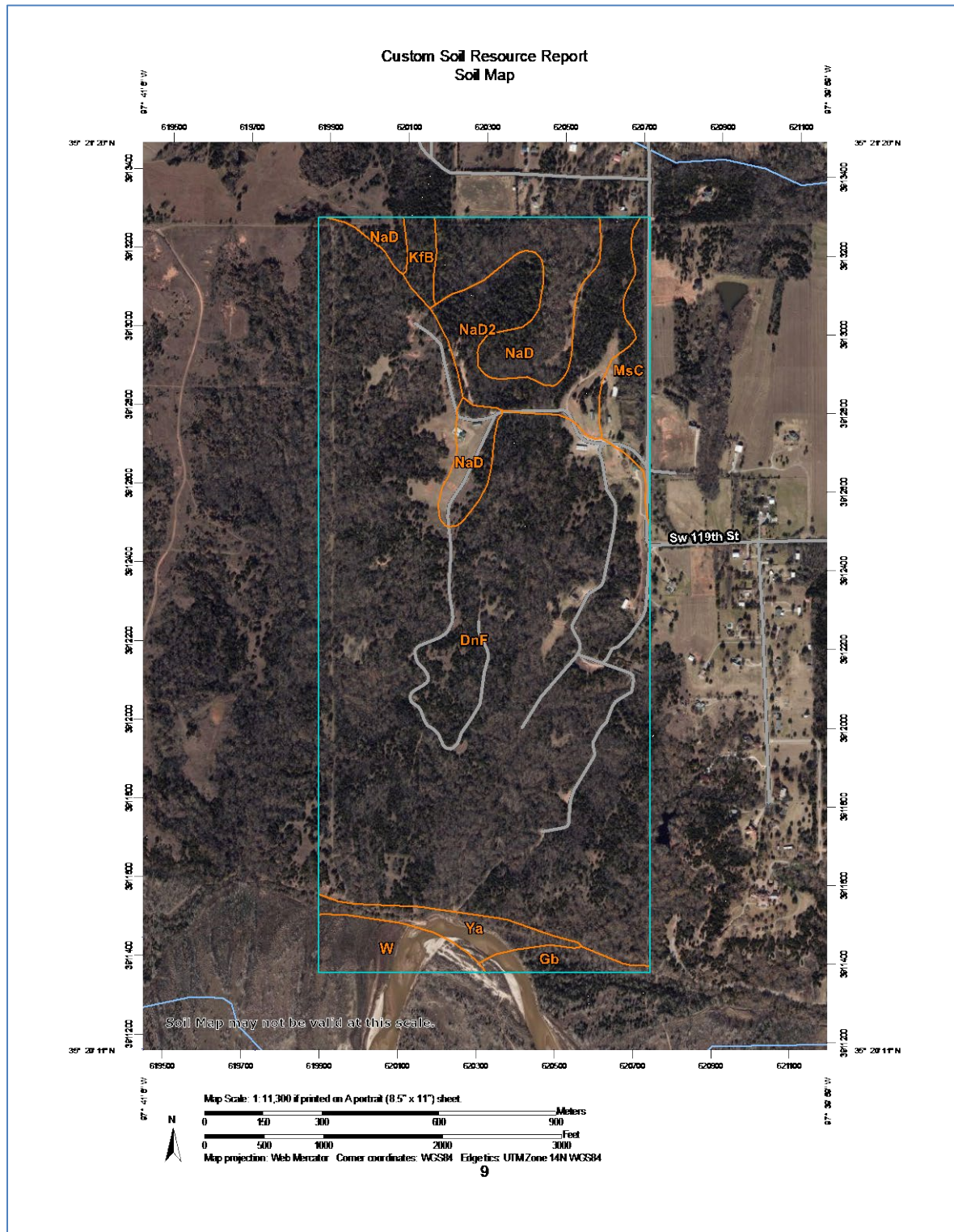


Figure 2 Soil map of JNSR by USDA NRCS (2019b). NaD/NaD2 = Nash-Ironmound, W = water, DnF = Darnell-Noble, Gb = Gracemore, KfB = Kingfisher silt, MsC = Minco silt, Ya = Yahola

Table 1 Summary of floristic collections made from John Nichols Scout Ranch (JNSR)*

Taxonomic Group	Families	Genera	Species	Native spp.	Exotic spp.
Monilophyta	1	1	1	1	0
Pinophyta	2	3	3	1	2**
Magnoliophyta					
Eudicots	38	89	121	107	14
Monocots	8	23	27	21	6
Total	49	116	152	130	22

*Table format follows Palmer et al. (1995)

***P. taeda* and *T. distichum* were planted in developed areas and were treated as exotic species in the inventory.

RESULTS AND DISCUSSION

In total, 152 species in 116 genera and 49 families were collected at JNSR (Table 1; Appendix). Among the angiosperms, three families were predominant: Asteraceae (37 species), Poaceae (19), and Fabaceae (17). One fern species (*Asplenium platyneuron*) was collected. Three species of conifers were collected and included *Juniperus virginiana*, *Pinus taeda*, and *Taxodium distichum*. It should be noted, however, that *P. taeda* and *T. distichum* were planted in developed areas of the ranch and, while native to the state, were treated as exotic species in the inventory. The largest genera present were *Symphytotrichum* and *Oenothera* with four species each. Of the 152 species collected, 20 (13.16%) were considered exotic to the United States and six of these were considered invasive species by the Oklahoma Invasive Plant Council (2019). No rare species currently being tracked by the Oklahoma Natural Heritage Inventory (2019) were encountered.

The majority of JNSR is characterized by upland forest habitat that is dominated by *Quercus stellata* and *Quercus marilandica*. Other common species included *Celtis*

laevigata, *Juniperus virginiana*, *Prunus mexicana*, *Sapindus saponaria*, *Smilax bona-nox*, and *Vitis vulpina*. Adjacent woodland margins that open into mixed prairie or disturbed areas were dominated by small tree and shrub species that included *Cercis canadensis*, *Cornus drummondii*, *Rhus glabra*, *Symphoricarpos orbiculatus*, and *Toxicodendron radicans*.

The second most abundant habitat is mixed prairie. Common mixed prairie species included *Achillea millefolium*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Bouteloua hirsuta*, *Dalea purpurea*, *Gaillardia pulchella*, *Liatris punctata*, *Oenothera speciosa*, *Opuntia humifusa*, *Rhus aromatica*, *Rhus glabra*, *Sabatia campestris*, *Schizachyrium scoparium*, *Sorghastrum nutans*, *Thelesperma filifolium*, and *Yucca glauca*.

The riparian zone along the South Canadian River that makes up the southern border of JNSR was dominated by herbaceous species, such as *Carex* spp., *Cynodon dactylon*, *Phragmites australis*, *Sorghum halepense*, and *Typha latifolia*, and intermixed with woody species, such as *Salix exigua* and *Tamarix chinensis*, as the riparian zone gives way to bottomland forest habitat. Common bottomland forest species included *Carya illinoensis*, *Catalpa bignonioides*, *Celtis laevigata*,

Populus deltoides, *Robinia pseudoacacia*, *Salix nigra*, and *Ulmus americana*.

Disturbed and developed areas can be found throughout JNSR in sections maintained for campsites, common areas used for boy scout activities, trails, and roadsides. Common species found in these disturbed areas included *Ambrosia psilostachya*, *Ambrosia trifida*, *Amphibachyris dracunculoides*, *Cynodon dactylon*, *Bothriochloa ischaemum*, *Helianthus annuus*, *Lespedeza cuneata*, *Lonicera japonica*, *Melilotus albus*, *Melilotus officinalis*, *Pinus taeda*, *Pistacia chinensis*, *Solanum elaeagnifolium*, *Sorghum halepense*, and *Taxodium distichum*.

Species richness is poor when compared to other similar sized (136–161 ha) floristic surveys (Palmer 2007). While this property provides a refuge for many species of flora and fauna, the encroaching agricultural areas and housing developments surrounding JNSR have contributed to lower plant diversity. Since urban sprawl of surrounding areas will likely continue to increase, a management plan must be established to maintain current, or improve upon, current levels of biodiversity.

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APPENDIX

List of Plant Taxa at John W. Nichols Scout Ranch, Canadian County, Oklahoma

Annotated species list with organization based on Angiosperm Phylogeny Group (APG III) recommendations (Stevens 2019). Nomenclature is based on ITIS (2019), and common names are from the USDA PLANTS Database (USDA NRCS 2019a). Duration (A=annual, B=biennial, P=perennial), and growth form (F=forb, G=graminoid, S=shrub, T=tree, V=woody vine). Duration, nativity, and growth form are from the USDA PLANTS Database (USDA NRCS 2019a). If duration varied or if more than one growth form was listed in the PLANTS Database, the duration and growth form listed for Oklahoma by Taylor and Taylor (1994) was used. Non-native species to the United States are indicated with an asterisk (*).

MONILOPHYTA

Aspleniaceae

Asplenium platyneuron (L.) Britton, Sterns & Poggenb. (ebony spleenwort) – P; F

PINOPHYTA

Cupressaceae

Juniperus virginiana L. (eastern red cedar) – P; T

Taxodium distichum (L.) Rich. (baldcypress) – P; T

Pinaceae

Pinus taeda L. (loblolly pine) – P; T

MAGNOLIOPHYTA

MONOCOTS

Amaryllidaceae

Nothoscordum bivalve (L.) Britton (crowpoison) – P; F

Asparagaceae

Yucca glauca Nutt. (soapweed yucca) – P; F

Commelinaceae

Tradescantia occidentalis (Britton) Symth (prairie spiderwort) – P; F

Cyperaceae

Carex spp. L. (sedge) – G

Eleocharis montevidensis Kunth (sand spikerush) – P; G

Iridaceae

Sisyrinchium campestre E.P. Bicknell (prairie blue-eyed grass) – P; F

Poaceae

- Andropogon ternarius* Michx. (splitbeard bluestem) – P; G
**Bothriochloa ischaemum* (L.) Keng (yellow bluestem) – P; G; I
Bothriochloa laguroides (DC.) Herter (silver beardgrass) – P; G
Bouteloua curtipendula (Michx.) Torr. (sideoats gramma) – P; G
Bouteloua gracilis (Kunth) Lag. ex Griffiths (blue grama) – P; G
Bouteloua hirsuta Lag. (hairy grama) – P; G
**Bromus tectorum* L. (cheatgrass) – A; G; I
Chasmanthium latifolium (Michx.) H.O. Yates (Indian woodoats) – P; G
**Cynodon dactylon* (L.) Pers. (Bermudagrass) – P; G
Dichanthelium oligosanthes (Schult.) Gould (Heller's rosette grass) – P; G
Dichanthelium scoparium (Lam.) Gould (velvet panicum) – P; G
Elymus canadensis L. (Canada wildrye) – P; G
Eragrostis secundiflora J. Presl (red lovegrass) – P; G
Paspalum floridanum Michx. (Florida paspalum) – P; G
**Phragmites australis* (Cav.) Trin. ex Steud. (common reed) – P; G
**Poa annua* L. (annual bluegrass) – A; G
Schizachyrium scoparium (Michx.) Nash (little bluestem) – P; G
Sorghastrum nutans (L.) Nash (Indiangrass) – P; G
**Sorghum halepense* (L.) Pers. (Johnsongrass) – P; G; I

Smilacaceae

- Smilax bona-nox* L. (saw greenbrier) – P; V

Typhaceae

- Typha latifolia* L. (broadleaf cattail) – P; F

EUDICOTS

Acanthaceae

- Ruellia humilis* Nutt. (fringeleaf wild petunia) – P; F

Anacardiaceae

- **Pistacia chinensis* Bunge (Chinese pistache) – P; T
Rhus aromatica Aiton (fragrant sumac) – P, S
Rhus glabra L. (smooth sumac) – P, S
Toxicodendron radicans (L.) Kuntze (eastern poison ivy) – P; S, V

Apiaceae

- **Torilis arvensis* (Huds.) Link (spreading hedgeparsley) – A; F

Apocynaceae

- Asclepias asperula* (Decne.) Woodson (spider milkweed) – P; F
Asclepias viridis Walter (green antelopehorn) – P; F

Asteraceae

- Achillea millefolium* L. (common yarrow) – P; F

- Ambrosia psilostachya* DC. (Cuman ragweed) – P; F
Ambrosia trifida L. (giant ragweed) – A; F
Amphiachyris dracunculoides (DC.) Nutt. (prairie broomweed) – A; F
Artemisia ludoviciana Nutt. (white sagebrush) – P; F
Cirsium altissimum (L.) Hill (tall thistle) – B; F
Cirsium ochrocentrum A. Gray (yellowspine thistle) – P; F
Cirsium texanum Buckley (Texas thistle) – P; F
Coreopsis tinctoria Nutt. (golden tickseed) – A; F
Echinacea angustifolia DC. (blacksamson echinacea) – P; F
Erigeron annuus (L.) Pers. (eastern daisy fleabane) – A; F
Erigeron strigosus Muhl. ex. Willd. (prairie fleabane) – A; F
Eupatorium serotinum Michx. (lateflowering thoroughwort) – P; F
Fleischmannia incarnata (Walter) King & H. Rob. (pink thoroughwort) – P; F
Gaillardia aestivalis (Walter) H. Rock (lanceleaf blanketflower) – P; F
Gaillardia pulchella Foug. (Indian blanket) – A; F
Gaillardia suaveis (A. Gray & Engelm.) Britton & Rusby (perfumeballs) – P; F
Helianthus annuus L. (annual sunflower) – A; F
Heterotheca subaxillaris (Lam.) Britton & Rusby (camphorweed) – A; F
Hymenopappus filifolius Hook. (fineleaf hymenopappus) – P; F
**Hypochaeris radicata* L. (hairy cat's ear) – P; F
Liatris punctata Hook. (dotted blazing star) – P; F
Machaeranthera tanacetifolia (Kunth) Nees (tanseyleaf tansyaster) – A; F
Packera plattensis (Nutt.) W.A. Weber & Á. Löve (prairie groundsel) – P; F
Pyrrhopappus carolinianus (Walter) DC. (Carolina desert-chicory) – A; F
Pyrrhopappus grandiflorus (Nutt.) Nutt. (tuberous deser-chicory) – P; F
Ratibida columnifera (Nutt.) Woot. & Standl. (upright prairie coneflower) – P; F
Rudbeckia hirta L. (blackeyed Susan) – P; F
Solidago canadensis L. (Canada goldenrod) – P; F
Solidago speciosa Nutt. (showy goldenrod) – P; F
Symphotrichum drummondii (Lindl.) G.L. Nesom (Drummond's aster) – P; F
Symphotrichum lateriflorum (L.) Á. Löve & D. Löve (calico aster) – P; F
Symphotrichum praealtum (Poir.) G.L. Nesom (willowleaf aster) – P; F
Symphotrichum subulatum (Michx.) G.L. Nesom (eastern annual saltmarsh aster) – A; F
Thelesperma filifolium (Hook.) A. Gray (stiff greenthread) – P; F
Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray (golden crownbeard) – P; F
Vernonia baldwinii Torr. (Baldwin's ironweed) – P; F

Bignoniaceae

- Campsis radicans* (L.) Seem. ex Bureau (trumpet creeper) – P; V
Catalpa bignonioides Walter (southern catalpa) – P; T

Brassicaceae

- *Capsella bursa-pastoris* (L.) Medik. (shepherd's purse) – A; F
Physaria ovalifolia (Rydb.) O'Kane & Al-Shehbaz (roundleaf bladderpod) – P; F

Cactaceae

- Opuntia humifusa* (Raf.) Raf. (devil's tongue) – P; S

Caprifoliaceae

- **Lonicera japonica* Thunb. (Japanese honeysuckle) – P; V; I
- Symphoricarpos orbiculatus* Moench (coralberry) – P; S

Caryophyllaceae

- Paronychia jamesii* Torr. & A. Gray (James' nailwort) – P; F

Cornaceae

- Cornus drummondii* C.A. Mey. (Roughleaf dogwood) – P; S

Euphorbiaceae

- Acalypha gracilens* A. Gray (slender threeseed mercury) – A; F
- Croton capitatus* Michx. (hogwort) – A; F

Fabaceae

- Cercis canadensis* L. (eastern redbud) – P; T
- Dalea aurea* Nutt. ex Fraser (golden prairie clover) – P; F
- Dalea candida* Michx. ex Willd. (white prairie clover) – P; F
- Dalea enneandra* Nutt. ex Fraser (nineanther prairie clover) – P; F
- Dalea purpurea* Vent. (purple prairie clover) – P; F
- Desmodium obtusum* (Muhl. ex Willd.) DC. (stiff ticktrefoil) – P; F
- Gleditsia triacanthos* L. (honeylocust) – P; T
- **Lespedeza cuneata* (Dum. Cours.) G. Don (sericea lespedeza) – P; F; I
- Lespedeza stuevei* Nutt. (tall lespedeza) – P; F
- **Medicago lupulina* L. (black medick) – A; F
- **Medicago sativa* L. (alfalfa) – P; F
- **Melilotus albus* Medik. (white sweet clover) – A; F
- **Melilotus officinalis* (L.) Lam. (yellow sweet clover) – A; F
- Mimosa quadrivalvis* L. (fourvalve mimosa) – P; V
- Psoraleidum tenuiflorum* (Pursh) Rydb. (slimflower scurf pea) – P; F
- Robinia pseudoacacia* L. (black locust) – P; T
- Vicia sativa* L. (garden vetch) – A; F

Fagaceae

- Quercus marilandica* Munchh. (blackjack oak) – P; T
- Quercus shumardii* Buckley (Shumard's oak) – P; T
- Quercus stellata* Wangenh. (post oak) – P; T

Gentianaceae

- Sabatia campestris* Nutt. (Texas star) – A; F

Geraniaceae

- **Erodium cicutarium* (L.) L'Hér. ex Aiton (redstem stork's bill) – A; F

Hypericaceae

- Hypericum drummondii* (Grev. & Hook.) Torr. & A. Gray (nits and lice) – A; F

Juglandaceae

Carya illinoensis (Wangenh.) K. Koch (pecan) – P; T

Lamiaceae

Clinopodium glabrum (Nutt.) Kuntze (limestone calamint) – P; F

Monarda fistulosa L. (wild bergamot) – P; F

Scutellaria incana Biehler (hoary skullcap) – P; F

Scutellaria parvula Michx. (small skullcap) – P; F

Stachys pilosa Nutt. (hairy hedgenettle) – P; F

Teucrium canadense L. (Canada germander) – P; F

Malvaceae

Callirhoe involucrata (Torr. & A.Gray) A. Gray (purple poppymallow) – P; F

Moraceae

**Morus alba* L. (white mulberry) – P; T

Oleaceae

Fraxinus americana L. (white ash) – P; T

Onagraceae

Oenothera berlandieri (Spach) Steud. (Berlandier's sundrops) – P; F

Oenothera serrulata Nutt. (yellow sundrops) – P; F

Oenothera speciosa Nutt. (pinkladies) – P; F

Oenothera suffulta (Engelm.) W.L. Wagner & Hoch (kisses) – A; F

Orobanchaceae

Castilleja indivisa Engelm. (entireleaf Indian paintbrush) – A; F

Papaveraceae

Argemone polyanthemos (Fedde) G.B. Ownbey (crested pricklypoppy) – A; F

Plantaginaceae

Nuttallanthus canadensis (L.) D.A. Sutton (Canada toadflax) – A; F

**Plantago lanceolata* L. (narrowleaf plantain) – P; F

Plantago virginica L. (Virginia plantain) – A; F

Polygonaceae

Eriogonum annuum Nutt. (annual buckwheat) – A; F

Rosaceae

Crataegus viridis L. (green hawthorn) – P; T

Geum canadense Jacq. (white avens) – P; F

Prunus angustifolia Marshall (Chickasaw plum) – P; S

Prunus gracilis Engelm. & A. Gray (Oklahoma plum) – P; S

Prunus mexicana S. Watson (Mexican plum) – P; T

Rubiaceae

Houstonia pusilla Schoepf (tiny bluet) – A; F
Stenaria nigricans (Lam.) Terrell (diamond-flowers) – P; F

Salicaceae

Populus deltoides W. Bartram ex Marshall (eastern cottonwood) – P; T
Salix exigua Nutt. (narrowleaf willow) – P; S
Salix nigra Marshall (black willow) – P; T

Santalaceae

Phoradendron serotinum (Raf.) M.C. Johnst. (oak mistletoe) – P; S

Sapindaceae

Sapindus saponaria L. (western soapberry) – P; T

Solanaceae

Solanum carolinense L. (Carolina horsenettle) – P; F
Solanum dimidiatum Raf. (western horsenettle) – P; F
Solanum elaeagnifolium Cav. (silverleaf nightshade) – P; F

Tamaricaceae

**Tamarix chinensis* Lour. (five-stamen tamarisk) – P; S,T; I

Ulmaceae

Celtis laevigata Willd. (sugarberry) – P; T
Ulmus americana L. (American elm) – P; T

Valerianaceae

Valerianella radiata (L.) Dufr. (beaked cornsalad) – A; F

Verbenaceae

Glandularia canadensis (L.) Nutt. (rose mock vervain) – P; F
Glandularia pumila (Rydb.) Umber (pink mock vervain) – A; F

Vitaceae

Vitis vulpina L. (frost grape) – P; V

A WALK THROUGH THE McLOUD HIGH SCHOOL OAK-HICKORY FOREST WITH A CHECKLIST OF THE WOODY PLANTS

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ABSTRACT

The McCloud High School oak-hickory forest is located a short distance from the McCloud High School campus. The forest has been used as an outdoor classroom for many years for high school students. This article will guide you through the forest trail and discuss several woody plants of interest at 16 landmarks. The article also includes a checklist of the 38 woody species identified in the forest.

Key words: woody plants, checklist, invasive plants, hybridization, leaf curl

INTRODUCTION

The McCloud High School forest has been an important element in my teaching career for many years. I can't remember the first time that we started using the McCloud oak-hickory forest as an outdoor classroom. I do remember Kari Courkamp doing research on tree lichens 25 years ago. Since that time there was a long period when we used it mostly to learn about the composition and structure of the forest. In the last few years, we have done a variety of projects including aging the bigger trees, bark studies, journaling, fungi hunts, creating a marked trail, and general ecology. The forest is a small oak-hickory forest just a short walk from the main high school campus. The forest is dominated by post oak (*Quercus stellata*), blackjack oak (*Q. marilandica*), and black hickory (*Carya texana*). In this article I will walk you through 16 sites along the forest trail. At each landmark I will discuss some of the woody plants that can be seen at that particular site. The article will also include a checklist of woody plants we have seen in the forest. Unless otherwise

indicated, all photos were taken by McCloud High School Botany classes over a number of years.

STUDY AREA

The forest is about 100 m (330 ft) by 76 m (250 ft) and is located near the McCloud High School campus in McCloud, Oklahoma. It is bordered by adjacent forests on the south and east. The forest has been utilized as an outdoor classroom for the high school students for many years. Observations by students include not only species present but also the condition of the plants and plant-animal interactions, such as insects causing leaves to curl (Figure 1).

RESULTS

Table 1 below summarizes the woody flora that we have recorded for the McCloud oak-hickory forest. We have identified 38 species in 31 genera and 24 families. The forest canopy is dominated by post oak, blackjack oak, and black hickory. Understory species include red mulberry

(*Morus rubra*) and hackberry (*Celtis* spp.). Common shrubs and vines include coralberry (*Symphoricarpos orbiculatus*), roughleaf dogwood (*Cornus drummondii*), greenbrier (*Smilax* sp.), and blackberry (*Rubus* sp.).

Table 1 Summary of the woody taxa in the McCloud High School oak-hickory forest

TAXONOMIC CATEGORIES	TOTAL TAXA IN THE CATEGORY
FAMILIES	24
GENERA	31
SPECIES	38

LITERATURE CITED

- Integrated Taxonomic Information System (ITIS). 2020. <http://www.itis.gov> (March 20, 2020)
USDA NRCS. 2020. The PLANTS Database. <http://plants.usda.gov> (April 11, 2020)

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Figure 1 Terminal leaflet curl. The curling may be a response to some type of larva. Forest observations are potential student projects. Each time we visit the forest, new questions are asked — creating new student projects.

CHECKLIST OF THE WOODY PLANTS OF THE MCLLOUD OAK-HICKORY FOREST

Taxa introduced to North America are indicated with an asterisk (*). Nomenclature is based on ITIS (2020). Common names are from the USDA PLANTS Database (USDA NRCS 2020), although in a few cases a common name more widely used in Oklahoma is added.

ADOXACEAE

Viburnum rufidulum Raf., rusty blackhaw (Figure 2)

ANACARDIACEAE

Rhus copallinum L., winged sumac

Rhus glabra L., smooth sumac (Figure 3)

Toxicodendron rydbergii (Small ex Rydb.) J. Greene, western poison ivy

AQUIFOLIACEAE

Ilex vomitoria Aiton, yaupon

BIGNONIACEAE

Campsis radicans (L.) Seem. ex Bureau, trumpet creeper (Figure 4)

CACTACEAE

Opuntia humifusa (Raf.) Raf., devil's-tongue, pricklypear cactus

CAPRIFOLIACEAE

**Lonicera japonica* Thunb., Japanese honeysuckle

Symphoricarpos orbiculatus Moench, coralberry

CELTIDACEAE

Celtis laevigata Willd., sugarberry

Celtis occidentalis L., common hackberry

Celtis reticulata Torr., netleaf hackberry

CORNACEAE

Cornus drummondii C. A. Mey., roughleaf dogwood

CUPRESSACEAE

Juniperus virginiana L., eastern redcedar

EBENACEAE

Diospyros virginiana L., common persimmon

FABACEAE

Cercis canadensis L., eastern redbud

FAGACEAE

Quercus marilandica Münchh., blackjack oak (Figure 5)

Quercus muehlenbergii Engelm., chinquapin oak (Figure 6)

Quercus stellata Wangerh., post oak
Quercus velutina Lam., black oak

JUGLANDACEAE

Carya texana Buckley, black hickory

MENISPERMACEAE

Cocculus carolinus (L.) DC., Carolina coralbead, Carolina snailseed

MORACEAE

Morus rubra L. red mulberry

OLEACEAE

**Ligustrum sinense* Lour., Chinese privet

ROSACEAE

Crataegus L. sp., hawthorn
Prunus mexicana S. Watson, Mexican plum
**Rosa multiflora* Thunb., multiflora rose
Rubus L. sp., blackberry

RUTACEAE

Zanthoxylum americanum Mill., common pricklyash

SALICACEAE

Populus deltoides W. Bartram ex Marshall, eastern cottonwood

SAPINDACEAE

Sapindus saponaria var. *drummondii* (Hook. & Arn.) L. D. Benson (= *Sapindus drummondii* Hook. & Arn.), western soapberry

SAPOTACEAE

Sideroxylon lanuginosum Michx. (= *Bumelia lanuginosa* [Michx.]Pers.), gum bully, chittamwood

SMILACACEAE

Smilax L. sp., greenbrier

ULMACEAE

Ulmus americana L., American elm
Ulmus rubra Muhl., slippery elm, red elm

VITACEAE

Ampelopsis arborea (L.) Koehne, peppervine
Parthenocissus quinquefolia (L.) Planch., Virginia creeper
Vitis L. sp., grape (Figure 7)



Figure 2 Rusty blackhaw, *Viburnum rufidulum*, bud in late winter or early spring



Figure 3 Smooth sumac, *Rhus glabra*. Photo by Emily Miller.



Figure 4 Trumpet creeper, *Campsis radicans*



Figure 5 *Quercus marilandica*,
blackjack oak, in late winter or
early spring



Figure 6 Chinquapin oak, *Quercus muehlenbergii*



Figure 7 Grape vine, *Vitis* sp.

A TRAIL TOUR THROUGH THE McLOUD HIGH SCHOOL OAK-HICKORY FOREST

Welcome to the McCloud High School oak-hickory forest. As I guide you through the forest trail, you will need to refer to the trail map (Figure 8) with the 16 marked sites. The trees and shrubs you see at each site are briefly described and easy to find near each marked area. Walking the trail and visiting each site should not take long; better yet, take your time and enjoy the diversity each site offers. The best times to visit the forest are the last two weeks of April and the first two weeks of October. As you walk the trail, look for lichens on tree branches (Figure 9). Many years ago, Kari Courkamp studied lichens in this forest, and this article is dedicated to her.

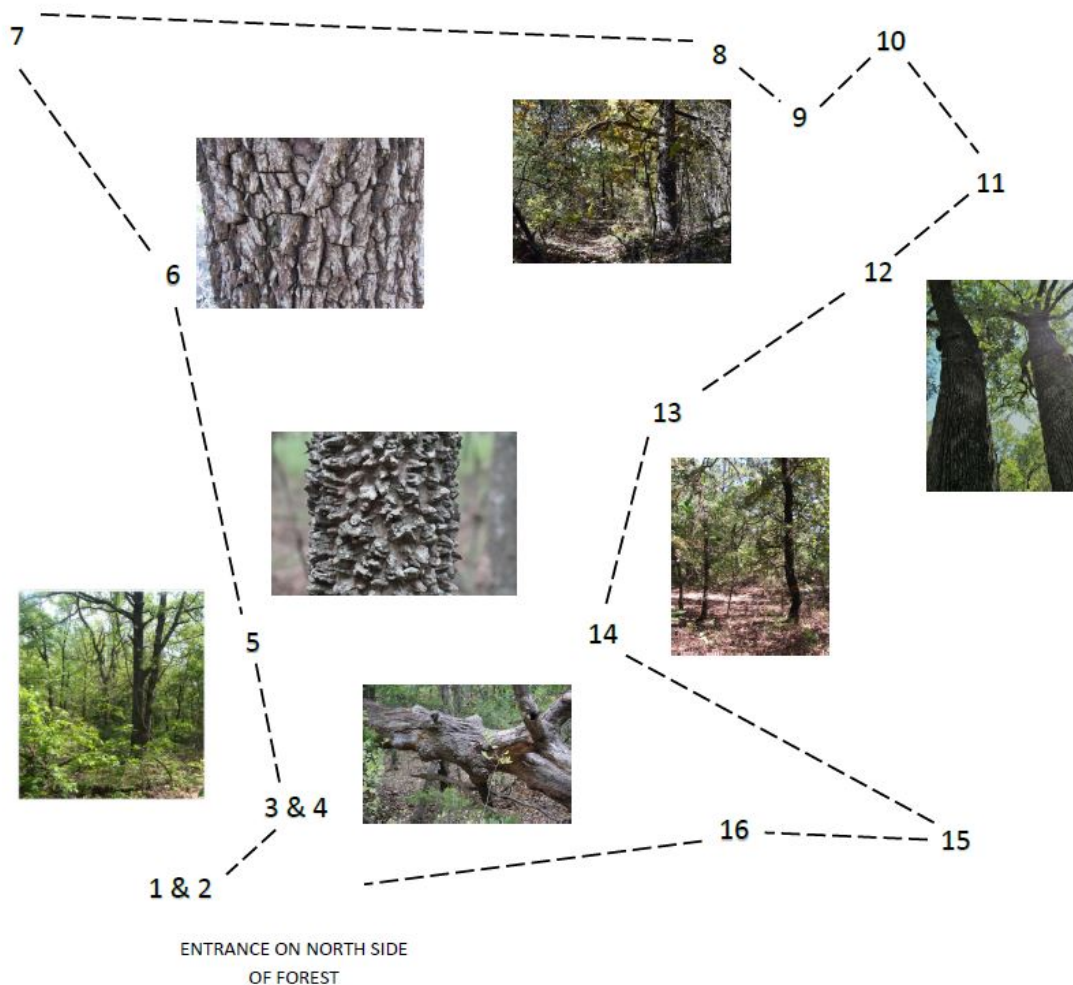


Figure 8 McCloud High School oak-history forest trail map



Figure 9 Foliose lichens on a tree branch

Landmarks 1, 2. As you enter the forest (Figure 10), about five meters from the entrance there is a small population of prickly pear cacti or devil's-tongue, *Opuntia humifusa* (Figure 11). Don't be surprised; prickly pear cacti are more common in forests than you might think. As you continue on the trail, look for a red elm, *Ulmus rubra*, on the left side (Figure 12). Table 2 gives characteristics that can be used to distinguish it from the other elm (*U. americana*) in this forest.



Figure 10 Small opening in the forest near the north side entrance

Table 2 Comparing the axillary buds and adaxial (upper) blade surfaces of the two elms in the forest

Species	Axillary buds	Adaxial blade surfaces
<i>Ulmus rubra</i>	with red hairs	scabrous
<i>Ulmus americana</i>	glabrous	glabrous



Figure 11 *Opuntia humifusa*, devil's tongue prickly pear cactus



Figure 12 Red elm (or slippery elm), *Ulmus rubra*. This is one of the two elm species we have in the forest. Red elm can be distinguished from American elm by its axillary buds and leaf blade surfaces (See Table 2). DBH = 7.0 cm

Landmarks 3, 4. Dead post oak, *Quercus stellata*. This dead tree (Figure 13) has been a good reference point for the forest trail for many years. It has recently collapsed. On the opposite side of the collapsed tree is a showy shrub known as rusty blackhaw, *Viburnum rufidulum* (Figure 14). If you visit in April, you are likely to see the rusty blackhaw in flower.



Figure 13 Dead post oak tree near the entrance to the forest



Figure 14 Rusty blackhaw, *Viburnum rufidulum*. The forest includes several individual shrubs of rusty blackhaw. Look for the rusty red color at the leaf petiole base. Photo by Bruce Smith; probably taken at Falls Creek.

Landmark 5. Hackberry population. Hackberry and sugarberry can be easily identified to the genus *Celtis* by their corky-warty bark (Figure 15) and pinni-palmate leaf veins (Figure 16). Identifying the trees to *Celtis* is not a problem, but identifying species is a real challenge due to hybridization in the genus. We will recognize three species of *Celtis* in the forest. *Celtis laevigata*, sugarberry, is the most conspicuous (Figure 17). In general, *C. laevigata* separates itself from the other species by having leaves about 3 times longer than wide compared to the other two likely species that are about 1.5 times longer than wide (Figure 18).



Figure 15 Warty-corky bark, genus *Celtis*. Photo taken by Bruce Smith at Green Leaf State Park.



Figure 16 Unknown species of the genus *Celtis*.



Figure 17 Sugarberry, *Celtis laevigata*. Note the leaves that are about three times longer than wide and the falcate apices.



Figure 18. *Celtis reticulata*, the netleaf hackberry. Note the prominent veins and thick leaves.

Landmark 6. Big hickory forest, *Carya texana*. This area of the forest has four large black hickory trees. Each tree is about the same diameter (50 cm at breast height). Black hickory can be easily identified by its heart-shaped leaf scars (Figure 19), alternate compound leaves, and dark chunky bark on the older trees. In Figure 20, note the chunky black bark with straight lines at the base of the “chunks”.



Figure 19 Terminal buds of a young black hickory tree. You might be able to see the heart-shaped leaf scars. Imagine the buds before you bearing three to five pinnately compound leaves. Spring is on its way.

Figure 20 Bark of the larger black hickory trees in the forest. The density of black hickories in the forest is relatively high. Most of them are young trees. The bark of the younger trees is gray and smooth with gray crustose lichens.



Landmark 7. Dead cottonwood, *Populus deltoides*. In the southeast corner of the forest, there is a cottonwood tree that has recently died. This species really does not fit the dry upland habitat; thus, it provides a good opportunity for teachers to discuss cottonwood ecology with their students. Walking along the south boundary fence you should see several large straight stems. These straight stems are roughleaf dogwoods, *Cornus drummondii*. These shrubs are the first to leaf out in early spring, getting an early start on photosynthesis. During the growing season they are easily identified by their simple opposite leaves and straight stems (Figure 21). Depending on the season, you might also see various herbaceous plants such as brown-eyed susan (Figure 22).



Figure 21 Roughleaf dogwood, *Cornus drummondii*. Note the straight stems and the orange larvae in a stem gall.



Figure 22 Brown-eyed susan, *Rudbeckia* in June. We have not recorded all the herbaceous plants in the forest. There are several wildflowers and grasses that we need to document.

Landmark 8. The Drain. As you continue your walk, you will see a low-lying area that we call the “drain” (Figure 23). You cannot miss seeing a large dead post oak leaning on other oak trees. Walking west through the drain you will see a yaupon holly, *Ilex vomitoria*, on your left and a small population of pricklyash, *Zanthoxylum americanum*, on the right side. Pricklyash has odd-pinnately compound leaves with sharp prickles. If you break a leaflet from the pricklyash, you should smell the citrus aromatic compounds. Go ahead and bite the leaflet and taste it on the tip of your tongue. What do you taste? As you continue your walk west along the trail, you should see several small chinquapin oak trees, *Quercus muehlenbergii*. We have not seen any large trees in the forest of this species. Also, near the drain you might see some dog vomit slime mold on a tree stump (Figure 24).



Figure 23 The “drain.” Photo by Riley Tollers.



Figure 24 Dog vomit slime mold on a tree stump near the “drain”

Landmark 9. Redbud. As you enter the “drain” from the east side, look on the right and you will see an open area with at least one redbud tree, *Cercis canadensis*.

Landmark 10. Red mulberry. Walking west out of the drain you will find two red mulberry trees, *Morus rubra*. Note the understory growth habit of these trees, their distinctive bark (Figure 25), and their large ovate leaves with acuminate apices (Figure 26).



Figure 25 Red mulberry bark. The bark has long light brown plates that flare up at the ends. With repeated visits to the forest you should recognize these trees by their bark.



Figure 26 Red mulberry, *Morus rubra*, tree under the canopy. Note the large leaves for collecting sunlight and the acuminate blade apices.

Landmark 11. Big post oak, *Quercus stellata*. Turning north and slightly west you will see a large old post oak tree (Figures 27 and 28). Post oak trees are the most frequent, have the highest density, and have the greatest basal area of any tree in the forest. In order to positively identify post oak trees use Table 3.



Figure 27 *Quercus stellata*, post oak

Table 3 Diagnostic characters to used identify post oak, *Quercus stellata*

Characteristics	Description
Associated species	Blackjack oak, coralberry, and black hickory
Terminal buds	Oaks have multiple terminal buds
Leaf arrangement	Alternate, with one leaf per node
Blade complexity	Simple
Blade shape	Obovate with lateral rounded lobes. The leaves are often described as cross-like.
Awns	Absent; post oaks are part of the subgenus of oaks known as <i>Leucobalanus</i>
Abaxial surfaces of blades	Stellate or star-like hairs
Bark	Light brown with long narrow plates (see Figure 28)
DBH	Post oaks in the MHS forest are the trees (other than black hickory) that have large diameters.



Figure 28 Post oak bark. Note the elongated light brown plates.

Landmark 12. Twin Oaks. These two old post oak trees are by far the most visited landmarks in the forest. Both are approximately 60 cm in diameter at breast height. The tree on the left side (Figure 29) has experienced some bark damage. Hopefully we will see no change in its vigor this spring.



Figure 29 Twin oaks, two old post oaks, *Quercus stellata*

Landmark 13. Mulberry-oak center. Walking north and slightly east you will see a large post oak and red mulberry growing together (Figure 30). Just a few meters north of these two trees you will find a Mexican plum, *Prunus mexicana*. Keep an eye out for this tree and other individuals of the species. In late winter and early spring, they will light up the forest with white blooms in an otherwise barren forest. Spring is coming.



Figure 30 Red mulberry (left) and post oak (right)

Landmark 14. Bent blackjack oak, *Quercus marilandica*. Traveling north and east you will see a blackjack oak that is noticeably bent (Figure 31). What caused it to bend? In the same area in the fall you might find a big bluestem grass, *Andropogon gerardii*.



Figure 31 Bent blackjack oak, *Quercus marilandica*

Landmark 15. American elm, *Ulmus americana*. This is the second elm in the forest. If you have a 10 x hand lens you can see the glabrous axillary buds.

Landmark 16. Black oak. You are almost finished with your walk. The last stop is a black oak, *Quercus velutina* (Figures 32 and 33). This oak species is common throughout the forest. They are frequent, but not large. The largest black oak tree that we have seen is only about 9 cm at breast height; compared to some of the post oak and black hickory, they are relatively small. For a comparison, Table 4 gives diameter at breast height (dbh) measurements for trees at the landmarks in this forest. In the same area, you might find a small population of western soapberry, *Sapindus drummondii*. The trees are 1–2 meters tall with slender stems. One way to identify them is by their even-pinnately compound leaves. Even if you visit this area in the winter (Figure 34), you can recognize the woody plants by many of the bark and bud characteristics pointed out in this trail guide.



Figure 32 Black oak, *Quercus velutina*, one of the two red oak species in the forest



Figure 33 Black oak, *Quercus velutina*. Note the awns on the tip of the simple leaf. Black oak is classified as a red oak due to leaf awns and other characteristics.



Figure 34 Winter scene taken several years ago in the McLoud oak-hickory forest.

Table 4 Diameter at breast height (DBH) of key tree species at different landmarks. The diameter of these trees will hopefully give you an idea of the relative size and perhaps the age of some of the trees in the forest. (DBH and age are not always well correlated.)

SITE	TREE (SPECIES)	DBH (DIAMETER AT BREAST HEIGHT)
1,2 (Near entrance)	Red elm, <i>Ulmus rubra</i>	7 cm
3,4 (Dead post oak)	Post oak, <i>Quercus stellata</i> (dead)	48 cm
5 (Hackberry)	Hackberry/Sugarberry, <i>Celtis</i> sp.	34, 25, 17 and 14 cm
6 (Big hickory forest)	Black hickory, <i>Carya texana</i>	50, 51, 52 and 57 cm
7 (Dead cottonwood)	Cottonwood, <i>Populus deltoides</i> (dead)	37 cm.
10 (Red mulberry, edge)	Red mulberry, <i>Morus rubra</i>	8 and 14.5 cm
11 (Big post oak)	Post oak, <i>Quercus stellata</i>	60 cm
12 (Twin oaks)	Post oak, <i>Quercus stellata</i>	63 and 65 cm
13 (Mullberry-Oak, center)	Red mulberry, <i>Morus rubra</i> , and Post oak, <i>Quercus stellata</i>	26 cm red mulberry and 58 cm post oak
14 (Bent Blackjack oak)	Blackjack oak, <i>Quercus marilandica</i>	30 cm
15 (American elm, north edge)	American elm, <i>Ulmus americana</i>	8 cm
16 (Black oak, north edge)	Black oak, <i>Quercus velutina</i>	9.0 cm

SEXUAL REPRODUCTION OF KUDZU (*PUERARIA MONTANA* [LOUR.] MERR.) IN OKLAHOMA

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Keywords: invasive species, kudzu, sexual reproduction

ABSTRACT

Non-native invasive plants pose major threats to biodiversity across the globe. In the southeastern United States, kudzu (*Pueraria montana* [Lour.] Merr.) was introduced as a flowering, ornamental vine. In many areas, it quickly escaped cultivation and has caused major disruption to native ecosystems. Over the past two decades, kudzu has gradually spread north and west, being found as far north as Illinois and Indiana, and as far west as Kansas and Oklahoma. Only recently has the species distribution been thoroughly assessed in Oklahoma, and these studies have found its statewide range to be more extensive than previously thought. As a result of the species being understudied in the region, the reproductive ecology of kudzu in Oklahoma has gone largely unexamined. Our research provides evidence of sexual reproduction at two sites in southeastern Oklahoma. This is the first documentation of germination of kudzu in Oklahoma. While kudzu reproduces primarily through rhizomatous vegetative growth, the production of viable seeds is essential to the maintenance of genetic diversity and is often important at range limits. This research, coupled with further plant demographic research, could provide key details surrounding the potential further spread of kudzu in Oklahoma.

INTRODUCTION

Invasion by non-native species continues to pose a major threat to native biodiversity and has been identified as a major driver of species extinctions across the globe (Clavero and García-Berthou 2005; Bellard et al. 2016). Non-native invasive plant species pose many threats to native biodiversity, including competition for resource acquisition, alterations in ecosystem functions, and shifting disturbance regimes (Dukes and Mooney 1999; Dilleuth et al. 2008; Corbin and D'Antonio 2010). Invasiveness of introduced plants is often facilitated by a wide variety of physiological and anatomical

characteristics, such as enhanced biomass production, greater root: shoot ratio, or improved seed production (Sandel and Dangremond 2012). According to Forseth and Innis (2004), there are an estimated 6,000 non-native vascular plant species in the U.S., compared to 17,000 native species.

Kudzu, *Pueraria montana* (Lour.) Merr. (Fabaceae), is an introduced, perennial, leguminous vine which can detrimentally alter the ecosystems which it invades. First introduced to the United States as a livestock forage and as an agent for erosion control on degraded landscapes, kudzu has rapidly expanded its range, out-competing native flora and altering biogeochemical processes (Mitich 2000). Due to its vine-

forming growth habit and extremely rapid growth rate (Forseth and Innis 2004), kudzu covers and shades out native trees and shrubs, often killing them in the process. Kudzu also has the ability to convert atmospheric nitrogen (N_2) into plant-available ammonium (NH_4^+). This pulse of available nitrogen alters the soil chemistry, which can result in the exclusion of plant species better adapted to low-nutrient environments. This, in turn, causes increased rates of nitrogen transformations, namely nitrification and denitrification, and thus increasing emissions of nitrous oxide (N_2O), a harmful greenhouse gas (Hickman et al. 2010). Along with the impacts on natural ecosystems, kudzu is also economically devastating. An estimated \$100–500 million is spent annually in an attempt to control kudzu and mitigate the effects of kudzu on forests and agricultural lands (Blaustein 2001).

Once believed to be restricted to parts of the southeastern U.S. because of lack of temperature tolerances, kudzu has spread outside these confines. Kudzu has been documented as far west as Nebraska, Kansas, and Oklahoma, and as far north as New York, Massachusetts, and Ontario (Waldron and Larson 2012), with populations also found throughout the midwestern states of Ohio, Illinois, and Indiana. Some of this is likely due to milder winters experienced by regions at the northern extent of the kudzu range. Climate models predict kudzu could spread even further into northern states such as Michigan and Wisconsin (Jarnevich and Stohlgren 2009; Follak 2011). Other models suggest appropriate climate for kudzu persistence along the west coast from Washington south into California and even Arizona (Bradley et al. 2010; Callen and Miller 2015).

The extent of kudzu invasion in Oklahoma has only been recently assessed. Claytor and Hickman (2015) determined kudzu to be present in 23 of Oklahoma's

77 counties, a more extensive range than previous reports from the state. While the distribution and occurrences of kudzu in Oklahoma have gained recent attention, there are currently no documentations of sexual reproduction of kudzu in the state. Kudzu is a perennial vine, capable of overwintering in a senesced state before emerging in spring via rhizomes. While seed production may not be the primary means of propagation for kudzu, the transport of viable seeds by means of water or wildlife has the potential to further the dispersal of this species, especially in localized populations on the boundaries of its current range. For these reasons, we examined the germinability of seeds collected from kudzu populations identified by Claytor and Hickman (2015).

METHODS

Legume pods were collected from three Oklahoma sites: Fittstown A, Fittstown B ($36^\circ 37.48' N, 96^\circ 38.6' W$), and Claremore ($36^\circ 17.56' N, 95^\circ 35.56' W$), which were identified by Claytor and Hickman (2015) (Figure 1). Individual seeds were then extracted from legumes. Seeds were surface-sterilized by soaking in 7% sodium hypochlorite solution for five minutes and thoroughly rinsed using distilled water (Ruiz et al. 2003). Once sterilized and rinsed, seeds were then scarified using sandpaper. Once sterilized, rinsed, and scarified, 50 seeds from each site were placed on top of germination paper fitted in the bottom of a standard (90 mm x 15 mm) petri dish. Each site was replicated six times, giving us a total of 18 petri dishes. Germination experiments were conducted in Controlled Environmental Chambers (Conviroon-PGW 36, interior dimension: $98'' W \times 54'' D \times 93'' H$, growth area: 36 ft^2 , and growth capacity: 240 ft^2) under a 14-hour photoperiod, located on the campus of Oklahoma State University in Stillwater, OK, USA. Ambient temperatures were

maintained at 24°C. Germination was considered successful once the radicle had reached approximately 2 mm in length. To avoid counting previously recorded germinations, germinated seeds were discarded following initial documentation.

Due to the non-normal distribution of our data, a Kruskal-Wallis test was performed with site as the sole factor to determine differences in germination among the three sites. To determine differences among sites, a Dunn's post-hoc test was used ($\alpha = 0.05$). All data were analyzed using R Version 3.6.1 (R Core Team 2019).

RESULTS

In our study, 86 of 900 seeds germinated. All 86 germinated seeds were collected from Fittstown, with no germination occurring in seeds collected from Claremore (Figure 2). Nearly 10% of seeds from Fittstown A germinated while germination occurred in 19% of seeds collected from Fittstown B (see Figure 2).

Germination of seeds from both Fittstown sites was significantly greater than that of Claremore ($p = 0.008$; $p = 0.012$), and there was no difference in germination between the two Fittstown sites ($p = 0.522$). From these data, we can conclude that, given appropriate conditions, kudzu is capable of sexual reproduction in Oklahoma.

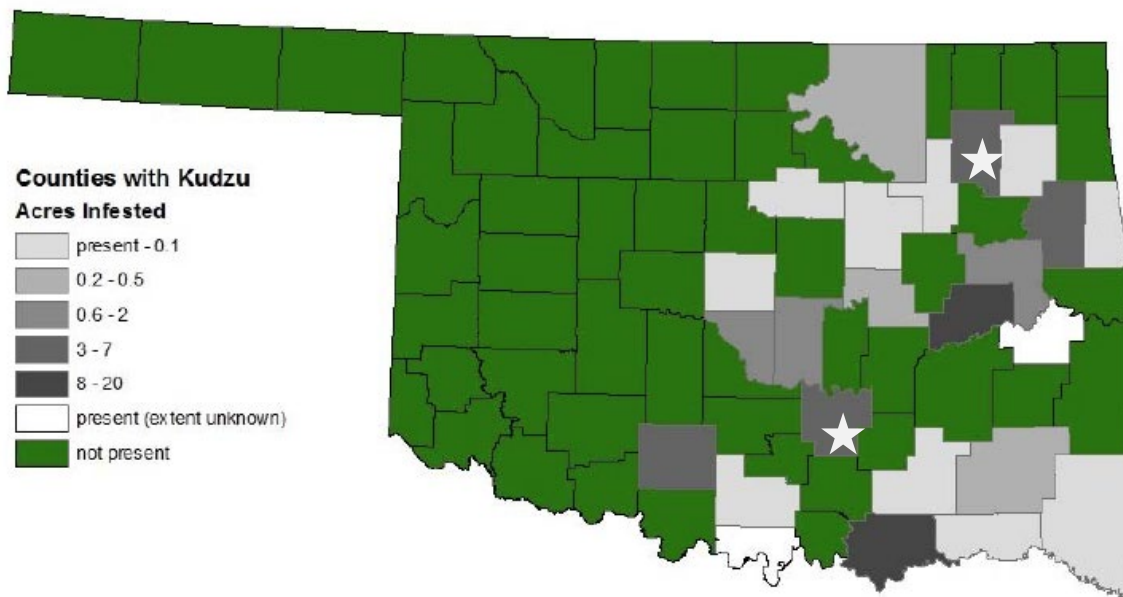


Figure 1 Map of kudzu populations in Oklahoma. Stars indicate the locations of seeds collected for the germination experiment, with Fittstown located in south-central Oklahoma and Claremore being the northeastern site. Map created by Claytor and Hickman 2015.

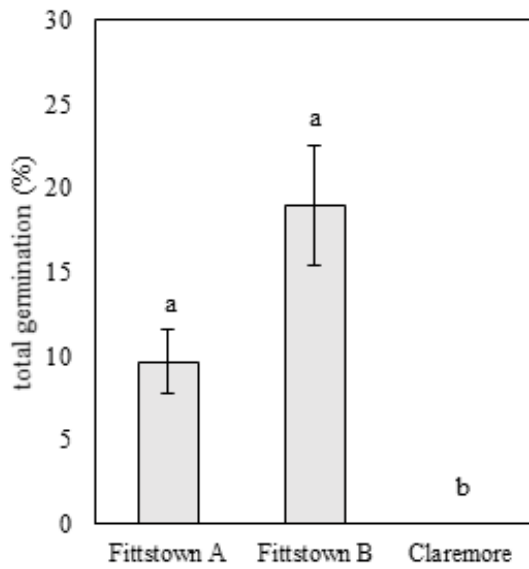


Figure 2 Germination of kudzu from three sites in eastern Oklahoma. Different letters indicate significant differences in germination between sites ($p \leq 0.05$).

DISCUSSION AND CONCLUSIONS

Current and predictive climate models suggest Oklahoma’s climate is suitable for sustaining kudzu populations in many parts of the state (Bradley et al. 2010; Callen and Miller 2015). Until now, documentation of viable kudzu seed in Oklahoma has gone unreported. Along with the data collected by Claytor and Hickman (2015), our research suggests that not only is kudzu able to overwinter in parts of the state, but it is also capable of sexual reproduction given appropriate environmental conditions.

While it has been documented that vegetative (asexual) reproduction is the primary mode of propagation in kudzu (Forseth and Innis 2004; Lindgren et al. 2013), sexual reproduction and dispersal is often important for genetic diversity and long-term population persistence in plants. In our study, only seeds collected from Fittstown successfully germinated, while no

germination was observed in seeds from Claremore. These results are supported by previous research that suggests kudzu produces relatively few viable seeds, and in some instances populations fail to produce viable seed altogether (Tsugawa 1986a, b). Our results are also supported by McClain et al. (2006), who found that 72 of 78 studied kudzu populations did not produce mature fruit at northern edges of its range. Fruit maturation and subsequent viable seed production are thought to be linked to microclimate (Pappert et al. 2000), which could be one reason why Claremore seeds did not germinate. Average annual temperatures near Fittstown are between 1.5 and 2°C warmer than Claremore, and it is possible that this difference is enough to influence germinability. Germination of seeds from Fittstown was found to be similar to seeds from other areas of the southeastern United States (10–20%), and it is suggested that germination of just a few individuals is adequate for the introduction of new genotypes and addition of genetic diversity to populations (Pappert et al. 2000).

Our study assessed three populations of kudzu for seed germinability. To fill knowledge gaps in the reproductive ecology of kudzu in Oklahoma, additional research is needed to further determine which populations are capable of sexual reproduction. Furthermore, much research is needed regarding the population demographics and genetic diversity of kudzu at the western extent of its invaded range. This will help determine the relative importance of different reproductive strategies (asexual vs. sexual), as well as potential modes of dispersal. This type of research will also aid in early detection and rapid response and potentially slow or halt the spread of this invasive species.

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*Critic's Choice Essay***SEEKING A SPECIAL PLANT**Reprinted from *Gaillardia*, Spring 1998

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I am nearing a bottomland forest, one filling the large band of a Bird Creek meander north of Tulsa. It is a typical, beautiful Oklahoma winter day. Typical in that it is overcast, the wind is from the north, a hint of moisture is in the air, and temperatures near freezing. Beautiful in the sense that no others will be out today.

The editor asked for a botany article, one featuring an interesting Oklahoma plant. I quickly accepted since the literature search is always rewarding. I enjoy discussing our native flora, and it is necessary to go into the field to gather information. Past articles have featured goldenrod, mistletoe, pokeweed, and other species. The present problem is, what species should I write about? One approach is to go into the field and wander until, by chance, the plant makes itself known.

Leaving the truck at the edge of the road, I enter the forest and immediately encounter a large lagoon, too deep to wade, and besides, it is too cold to get wet. That means a walk, which turns out to be worthwhile. Along the bank, the surface is a mat of water fern, gathered here by the persistent wind. The few openings are covered by duckweed from which several birds, startled by my intrusion, gather wing and flee to what they must perceive is a safer place. I wonder what lurks beneath the surface? There must be a multitude of insect

larvae, many active while others have started the pupation process, a prelude to the reawakening of aquatic life next spring. The lagoon is interesting, but I must move on, seeking that special plant.

The forest consists of large oaks, hickories, ash, elms, and maples. There is no sound but the wind pushing against the protesting trees, the soft impact of late-falling leaves striking the litter-covered soil, and complaints of crows objecting to my presence. The tranquil beauty compels me to stop. I settle comfortably on a fallen tree and become immersed in thought – there is something special here. Nearby I spot a tangle of vines consisting of Oklahoma's three members of the moonseed family: Carolina snailseed, moonseed, and cupseed. The striking yellowish-orange buds of poison ivy catch my eye, and close examination reveals bud scales covered with long, soft hairs. Suddenly a white-footed deer mouse, unable to stand it any longer, darts from temporary hiding near my feet for the security of its burrow a short distance away. But it is time to press on in my search of a subject for this article.

Why follow this worn path when an animal trail angles off in the direction I wish to go? The trail shows evidence of deer passing recently. The prints indicate an adult and two juveniles, perhaps a doe with her twins. In this moist area, the trail is lined

with broadleaf spanglegrass, the heavy fruiting stems forming arches. Youngsters prefer to call the grass “fish on a line”, a most descriptive name. Many of the plants here are still green; perhaps this spot has escaped a hard freeze. Beyond the wet area, I find myself surrounded by coralberry (Kansans call it buckbrush), still bearing dense clusters of the reddish fruit which give it our common name. This would be a good subject for the article, but I prefer continuing; it is difficult to give up the interactions with nature and the peaceful seclusion.

In spite of the low temperature, something is moving in the leaf litter. They are wolf spiders scurrying about, although most are under the protective leaf cover. Interestingly, none of the females are carrying egg sacs, the eggs having long since hatched and new young dispersed. These spiders live five or six years and are active through the winter. I wonder how they survive the bitter cold?

In the distance, a fallen tree has a distinct reddish glow which calls for examination. It turns out to be a beautiful mass of brightly pigmented moss sporophytes – but this is not the time for moss reproduction. Down on the belly! An up-close, hand-lens look and it is obvious each capsule is wide open, empty of spores. A delightful winter gift from Mother Nature. As I arise, I am greeted by a raucous, almost vulgar alarm cry from a Great Blue Heron as it struggles to get airborne along the edge of the creek. I move to the bank to watch the heron disappear

around a bend and find the slope covered with hop vines. Most have been frozen, but some are still green and show evidence of browsing, probably deer. While examining the hop fruits, a skunk appears, moving rapidly in my direction. It stops at the sound of my voice, stares directly at me, and seems to listen as I explain I am no threat and sincerely hope it shares my peaceful intent. After appearing to consider my comments, it continues, not toward me but at an angle, passing without so much as a “Pardon Me” and disappears into the dense mass of hop.

Space will not permit me to share all I found. There is so much more: the beautiful sulfur-yellow winter buds of bitternut hickory, logs covered with carpets of small tan puffballs, a Great Horned Owl passing soundlessly overhead, patches of leaves covered with powdery mildew, huge sycamores and cottonwoods, and spots of bright green in the leaf litter which turn out to be henbit, nettle, and groundsel – a sneak preview of what is to come.

Later, as I contemplate bur-oak fruit along the trail and marvel at the few acorns but abundance of empty fringed cups, it occurs to me it is getting darker; the sun must be setting. At the edge of the forest, I climb onto a dike, this time into a much stronger wind, heavier clouds, stinging rain, and it is colder – but still, that beautiful Oklahoma winter day.

No, I have not located that special plant I was seeking. That is bad; what will I tell the editor? On the other hand, it is good; I must return to this spiritual place and continue my search.

ONPS

EDITORIAL POLICIES AND PRACTICES

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

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Common names should be referenced to a scientific name using nomenclature that has been revised according to the Integrated Taxonomic Information Service (ITIS) database (<http://www.itis.gov>). Abbreviations of authorities for scientific names should follow *Authors of Plant Names* (Brummitt, R.K. and C.E. Powell. 1992. Richmond, Surrey, England: Royal Botanic Gardens Kew). Titles of periodicals should be abbreviated following *Botanico-Periodicum-Huntianum* and its supplement, except in historic publications when original format may be used.

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