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Oklahoma Native Plant Record

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Cover photo:
Penstemon cobaea Nutt. (cobaea beardtongue) by Sandy Graue, for the 2009 ONPS Photo Contest

Foreword

This issue of the *Oklahoma Native Plant Record* contains floristic inventories of two areas in Oklahoma County and an article on the distributions of two non-native invasive species in eastern Oklahoma. These papers provide evidence of the current distribution and status of the native flora of Oklahoma as well as non-native invasive species and how land-use changes and other anthropogenic disturbances affect their distributions. Also included is a paper on the genetic structure of a native species that evaluates whether it should be divided into its traditionally-recognized varieties.

Sarah Short's Honors Thesis at Oklahoma State University, published here with co-authors Mark Fishbein and Sierra Hubbard, documents the distributions of two non-native invasive honeysuckle species, *Lonicera japonica* (Japanese honeysuckle) and *L. maackii* (Amur honeysuckle), in the 47 counties of eastern Oklahoma. Although their study shows that the earlier-introduced *L. japonica* is currently more widespread, the authors question whether, given enough time, *L. maackii* could become as widespread or if invasive species management practices could prevent it from further negatively affecting biodiversity.

Adjoa Richardson Ahedor, Jenna Messick, Wayne Elisens, and Abigail Moore report an analysis conducted at the University of Oklahoma on *Mecardonia acuminata* (axilflower) across its range in the southeastern US. The authors determine whether the groups identified from molecular data agree with those based on geography and morphology and evaluate whether the data support the division of the species into its three traditionally-recognized varieties.

Micah Friedman and Jenna Messick from the University of Central Oklahoma conducted a vascular plant survey of the area north of Arcadia Lake in northeastern Oklahoma County. This area is dominated by Crosstimbers forest, grasslands, and wetlands. This species-rich area provides habitat for a species tracked by the Oklahoma Natural Heritage Inventory that had not been recorded in the state since the 1980s!

A second paper by Micah Friedman and Jenna Messick reports results of a vascular plant survey of the Belle Isle at Deep Fork area in the heart of Oklahoma City. The survey area included semi-natural areas consisting of mowed fields, forests, grasslands, two streams, a pond, and a section of the Deep Fork River. A third of the species were non-native, which is not surprising for an area that has been subjected to much anthropogenic disturbance.

An essay on invasive species terminology by Karen Hickman from Oklahoma State University is our Critic's Choice essay. As we continue to document and publish studies on the distributions of invasive species, it is a good reminder of the appropriate terminology to use.

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

THE DISTRIBUTIONS OF TWO INVASIVE HONEYSUCKLE SPECIES (*LONICERA MAACKII* AND *LONICERA JAPONICA*) IN EASTERN OKLAHOMA

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Keywords: habitat disturbance, urbanization, ornamentals, herbaria

ABSTRACT

Concerns about spreading non-native invasive plant species have increased in recent decades following their harmful impacts on ecosystems. Their encroachment, aided by survival and reproductive advantages, can negatively impact ecosystems and biodiversity. These effects often lead to larger long-term issues and can be difficult and expensive to manage. *Lonicera maackii* (Rupr.) Herder and *L. japonica* Thunb. are invasive honeysuckle species that can outcompete, inhibit, and reduce the populations of native species, thus threatening biodiversity in invaded regions. Both species have formed naturalized populations throughout much of the eastern United States, including Oklahoma. Both species reproduce quickly, grow prolifically, face less environmental resistance, and tolerate a wider range of environmental conditions than most native plant species. This study, based on field surveys and herbarium records, presents new information on the distribution of *L. maackii* and *L. japonica* in eastern Oklahoma. Surveys were conducted in parks and public recreation areas of all 47 counties of eastern Oklahoma. By combining herbarium data and field surveys, we found that *L. maackii* occurs in fewer counties than expected and *L. japonica* is present in nearly all counties surveyed. The results also revealed a strong positive relationship between the presence of *L. maackii* and the population size of towns. We also found a weak and non-significant relationship between the occurrence of *L. maackii* and the number of non-native species in a county.

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INTRODUCTION

Invasive species are a significant threat to Oklahoma's ecosystems, as they negatively impact native plants and animals. A non-native species is considered invasive when it threatens the health and safety of the environment, economy, or human population of its invaded region (Iannone et al. 2020). As non-native species naturalize outside of their native ranges, they are often unrestrained by competing species and environmental limitations (Keane and Crawley 2002). These advantages allow them to grow quickly, spread rapidly, and outcompete native species for resources (McEwan et al. 2010). This unchecked growth and reduced vigor of surrounding vegetation can disrupt natural processes, disturb native habitats, and decrease native biodiversity, creating a cascading negative effect on ecosystem function (Vilà et al. 2011). These impacts can be worsened when multiple non-native species invade a region (Vujanović et al. 2022). This study evaluates the extent of the spread of two species of non-native and invasive honeysuckles found in Oklahoma, *Lonicera maackii* (Rupr.) Herder and *L. japonica* Thunb. (Caprifoliaceae).

Lonicera japonica, commonly known as Japanese honeysuckle, was introduced to the United States in the early 1800s, while *L. maackii*, commonly known as Amur honeysuckle, followed in the late 1890s (Luken and Thieret 1995; Lemke et al. 2011). Both species are native to eastern Asia, including China, Korea, and Japan, and were introduced to New York with the intention of use as ornamentals, in erosion control, and as food sources for wildlife (Luken and Thieret 1996). Horticulture and habitat improvement efforts played a large role in the early spread of *L. maackii* and *L. japonica*, as planting the two species was encouraged. However, both species quickly escaped and formed naturalized populations outside of cultivated areas (Luken and Thieret 1996; Lemke et al. 2011; Keil and Hickman 2014).

In North America, *L. maackii* grows in both open and forested areas in urban and suburban regions (Luken and Thieret 1995). Multiple factors contribute to *L. maackii*'s ability to outcompete native species. This densely branched shrub exhibits leaf emergence in early spring and drops its leaves later than most native species, allowing extended photosynthetic periods and herbivory avoidance during early leaf development. This advantage allows *L. maackii* to block sunlight and crowd out surrounding understory plants (McEwan et al. 2009). Another factor contributing to the invasive potential of this species is its allelopathy, a form of chemical inhibition, to stunt the growth of surrounding plants (McEwan et al. 2010). The chemical signals accumulate in the soil and come from every part of the plant, including leaves and berries that drop to the ground. As a result, the performance of native species can be lowered, often by inhibiting the growth of native seedlings (McEwan et al. 2010).

Lonicera maackii causes issues for the habitats it invades by competing with native species for resources and space (McEwan et al. 2009). When *L. maackii* invades a habitat, it is followed by decreased native species performance and lowered habitat diversity, which can negatively impact other organisms (Cipollini et al. 2009). Invaded habitats can experience lowered bird diversity, as birds that nest in *L. maackii* increase, while the abundance of bird species that prefer other nesting sites decreases (Lynch 2016). *Lonicera maackii* presence can also increase risks of mortality and predation on birds that nest in these shrubs, as they do not provide the same protective structure that many native shrubs do (Schmidt and Whelan 1999; Borgmann and Rodewald 2004). The bright red berries of *L. maackii* are attractive to native bird species, but do not provide adequate nutrition (Ingold and Craycraft 1983).

Lonicera maackii presence as a food source also creates a preferred habitat for white-tailed deer (*Odocoileus virginianus)*, resulting in greater deer activity. White-tailed deer act as hosts for disease-carrying tick species, which increases a habitat's tick load and poses an added risk to human populations (Allan et al. 2010).

Lonicera japonica is adaptable to a wide array of habitats, soil types, and environmental conditions, but typically grows in shaded areas. In North America, it is mostly restricted to areas with higher temperatures and rainfall (Schierenbeck 2004; Lemke et al. 2011). *Lonicera japonica* has advantages contributing to its extensive spread and ability to outcompete native species. As with *L. maackii*, its leaves emerge in early spring and often last through the winter, an advantage over surrounding plants in photosynthetic opportunity and herbivory avoidance (Schierenbeck 2004; Lieurance and Cipollini 2012). This vine creates thick blankets of foliage on the ground and upon supporting plants. *Lonicera japonica* also propagates via adventitious growth, further contributing to extensive and prolific expansion (Wang et al. 2015).

Lonicera japonica causes damage to invaded regions by wrapping around supporting plants and shading foliage. As this plant grows quickly, covers large areas, and grows densely on other plants, it accesses more water and nutrients from the soil and blocks light availability, thus decreasing native species' access to adequate resources (Schierenbeck 2004; Wang et al. 2015). *Lonicera japonica* has also been found to alter the architecture of host plants, increasing the proportion of stems to leaves (Friedland and Smith 1982). These factors can inhibit the growth and productivity of native plants, posing a threat to the biodiversity of an invaded region (Wang et al. 2015).

Both honeysuckle species are found in eastern Oklahoma, where forested areas with higher temperatures and rainfall provide suitable habitat. They are not found as frequently in western Oklahoma, where the landscape shifts to drier grasslands (Keil and Hickman 2014). *Lonicera japonica* is widespread throughout eastern Oklahoma, with recent literature showing a distribution over 77% of the 47 counties (Keil and Hickman 2014). Compared to the many studies of the distribution and ecology of *L. japonica*, much less is known about the distribution of *L. maackii*, especially in Oklahoma. However, herbarium records obtained from the Texas and Oklahoma Consortium of Herbaria (TORCH) database (https://portal.torcherbaria.org; data retrieved 4 October 2023) indicate that *L. maackii* is seemingly less widespread.

Because non-native species are often underrepresented in herbaria, this study aims to complement published information and herbarium records with new survey data on the distribution of both honeysuckle species in Oklahoma. Specifically, the goal of this research is to document the occurrence of *L. maackii* and *L. japonica* throughout eastern Oklahoma at the county level, determine if there is a pattern of co-occurrence with other invasive species, and explore factors contributing to their distribution. This project will test the following hypotheses: 1) based on herbarium records, observations from iNaturalist (https://www.inaturalist.org/), and the possibility of its presence being under-reported, we predict *L. maackii* will be recorded in 50% of all counties surveyed; 2) based on herbarium records, iNaturalist observations, and published distribution maps (Keil and Hickman 2014), we predict *L. japonica* will be recorded in 90% of counties surveyed; 3) there will be a significantly positive relationship between the occurrence of *L. maackii* and the population sizes of towns; and 4) there will be a significantly positive relationship between the occurrence of *L. maackii* and the number of non-native species per county.

Figure 1 *Lonicera maackii*, habit; plants are about 1.5 m tall; photo taken at Sanborn Lake, Stillwater, Oklahoma by Sarah Short (May 9, 2023).

Figure 2 *L. maackii*, leaves and immature berries in May; photo taken at Sutton Wilderness Trail, Norman, Oklahoma by Sarah Short (May 16, 2023).

Figure 3 *Lonicera maackii*, flowers in May; photo taken at Sanborn Lake, Stillwater, Oklahoma by Sarah Short (May 9, 2023).

METHODS

Study Species

Lonicera maackii is a shrub that can grow as tall as 5 m (Figure 1). The leaves are ovate or lanceolate and their tips are acuminate (Figure 2). The leaves are also pubescent and oppositely arranged with entire margins. The flowers, which can open from April to June, grow in pairs on pedicels shorter than the leaf petioles, and have white corollas (Figure 3). When immature, the berries are green (Figure 2). In the fall, the berries ripen and become bright red (Haddock and Freeman 2019).

Lonicera japonica is a vine that can grow up to 10 m long. The oppositely arranged leaves are pubescent and oval shaped (Figure 4). The margins of the leaves are typically entire but can occasionally be lobed or serrate. The flowers grow in pairs and have white and yellow corollas that are open from April to July (Figure 5) and that are larger than those of *L. maackii*. The flowers also have a strong sweet scent. The berries are green when immature (Figure 6) and are black when ripe (Haddock and Freeman 2019).

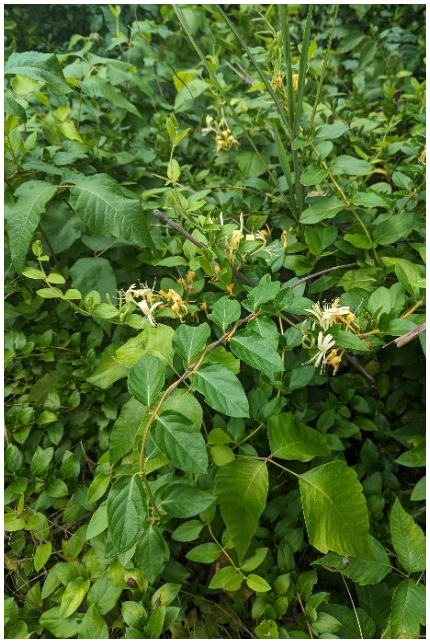

Figure 4 *Lonicera japonica,* habit; photo taken at Pennington Creek Dam, Tishomingo, Oklahoma by Sarah Short (June 15, 2023).

Figure 5 *Lonicera japonica,* flowers in June; photo taken at Lewis V. Bond Memorial Park, Coalgate, Oklahoma by Sarah Short (June 20, 2023).

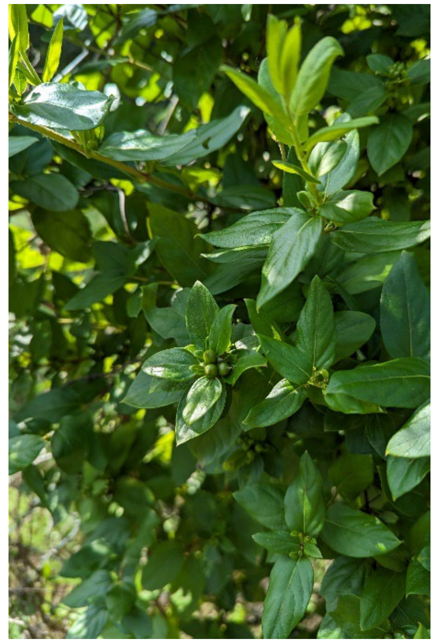

Figure 6 *Lonicera japonica,* immature berries in July; photo taken at Osage Nation Heritage Trail, Pawhuska, Oklahoma by Sarah Short (July 23, 2023).

Field Sites

The field work consisted of a survey for the presence of *L. maackii* and *L. japonica* in all 47 counties east of Oklahoma County's western border, which is at an approximate longitude of 98°W. Surveys were conducted in the largest town of each county, with two exceptions: Osage County and McCurtain County. In these counties, the second largest town was selected to locate a suitable survey site. When selecting survey sites, the following factors were considered: public accessibility, site size, and potentially suitable habitat for both species (wooded areas or forest edges). Potential sites were evaluated prior to collection, using available maps and images from Google Maps and Google Earth (https://www.google.com/maps; https://earth.google.com/web/).

Observations of *L. maackii* and *L. japonica* from iNaturalist (https://www.inaturalist.org/) were also viewed prior to collection. Due to potential misidentification and the possibility of inaccurate observation data in iNaturalist, these occurrence records were not used in the final analysis of species presence at county level. However, these observations were used as a tool to guide the selection of survey sites during the beginning stages of research. In some cases, a selected site was considered unsuitable when visited, and a replacement site was selected within the same town. In very few cases of survey within smaller towns, more than one park was surveyed (see Table 1). Within each selected town, at least one public park was surveyed.

The locations were selected to encompass a variety of natural and managed environments, including state parks, local parks, lakes, and walking trails. When selecting the locations, efforts were made to avoid locations that contained cultivated individuals of either honeysuckle species. Surveys took place from May to August of 2023.

Table 1 List of survey sites selected within one town of each county

County	Town	Survey Site	Entrance Lat/Long
Adair	Stillwell	Adair Park	35°49'56"N 94°37'28"W
Atoka	Atoka	Boggy Depot State Park	34°19'06"N 96°18'26"W
Bryan	Durant	Lake Durant Park	34°05'03"N 96°23'56"W
Carter	Ardmore	Ardmore Regional Park	34°12'26"N 97°09'30"W
Cherokee	Tahlequah	Sequoyah City Park	35°54'48"N 94°58'02"W
Choctaw	Hugo	Hugo Lake Campground	34°01'18"N 95°25'26"W
Cleveland	Norman	Sutton Wilderness Trail Park	35°14'33"N 97°25'27"W
Coal	Coalgate	Lewis V. Bond Memorial Park	34°31'20"N 96°13'08"W
Craig	Vinita	Vinita Lake Park North Park	36°40'40"N 95°07'12"W 36°38'33"N 95°09'17"W
Creek	Sapulpa	Kelly Lane Park	35°59'03"N 96°06'33"W
Delaware	Grove	Grove Springs Park	36°35'40"N 94°46'30"W
Garvin	Pauls Valley	Nature Park	34°43'54"N 97°13'14"W
Haskell	Stigler	Lake John Wells Park	35°14'05"N 95°05'43"W
Hughes	Holdenville	Stroup Park	35°05'11"N 96°23'43"W
Johnston	Tishomingo	Pennington Creek Park Pennington Creek Dam	34°14'03"N 96°40'59"W 34°14'32"N 96°40'54"W
Kay	Ponca City	Bois D'Arc Disc Golf Course	36°43'38"N 97°00'57"W
Latimer	Wilburton	Robber's Cave State Park Robber's Cave	34°58'48"N 95°21'35"W 35°00'21"N 95°20'15"W
LeFlore	Poteau	Bill J. Barber Park	35°03'49"N 94°37'43"W
Lincoln	Chandler	Bell Cow Lake Campground C	35°43'41"N 96°56'14"W
Logan	Guthrie	Mineral Wells Park	35°52'07"N 97°25'32"W
Love	Marietta	Shellenberger Park Memorial Park	33°56'31"N 97°07'35"W 33°56'31"N 97°07'35"W
Marshall	Madill	Madill City Lake	34°05'07"N 96°47'22"W
Mayes	Pryor	Pryor Creek Nature Trail	36°15'59"N 95°18'37"W
McClain	Newcastle	Lions Park Veterans Park	35°16'34"N 97°39'21"W 35°15'42"N 97°36'42"W
McCurtain	Broken Bow	Beavers Bend State Park	34°07'55"N 94°40'41"W
McIntosh	Checotah	Lake Eufaula State Park (Hummingbird Beach)	35°24'01"N 95°35'52"W
Murray	Sulphur	Chickasaw National Recreation Area (Travertine Creek)	34°30'13"N 96°58'13"W
Muskogee	Muskogee	Coody Creek Trail	35°44'14"N 95°22'36"W
Noble	Perry	Perry Lake	36°15'59"N 97°16'41"W
Nowata	Nowata	John H. Morgan Park	36°42'12"N 95°37'47"W
Okfuskee	Okemah	Okemah Lake	35°31'06"N 96°19'17"W
Oklahoma	Oklahoma City	Stars and Stripes Park	35°32'50"N 97°34'58"W
Okmulgee	Okmulgee	Okmulgee Lake & Recreation Area (Okmulgee Park)	35°37'14"N 96°03'50"W

Table 1 List of survey sites selected within one town of each county

County	Town	Survey Site	Entrance Lat/Long
Osage	Pawhuska	Osage Nation Heritage Trail	36°39'44"N 96°19'51"W
Ottawa	Miami	River View Park (Miami Parks and Recreation Bike Trail)	36°51'37"N 94°52'27"W
Pawnee	Cleveland	Feyodi Creek RV Park/ Disc Golf Course	36°16'38"N 96°26'21"W
Payne	Stillwater	Sanborn Lake	36°09'26"N 97°04'32"W
Pittsburg	McAlester	Mike Deak Walking Track	34°54'46"N 95°45'38"W
Pontotoc	Ada	Wintersmith Park	34°45'49"N 96°39'07"W
Pottawatomie	Shawnee	Glen Collins Memorial Park & Campground	34°45'49"N 96°39'07"W
Pushmataha	Antlers	Ozzie Cobb Lake	34°14'33"N 95°23'13"W
Rogers	Claremore	Claremore Lake (South Trailhead)	36°19'44"N 95°34'34"W
Seminole	Seminole	Sportsman Lake Recreation Area	35°12'31"N 96°33'19"W
Sequoyah	Sallisaw	Sallisaw City Park	35°27'53"N 94°51'40"W
Tulsa	Tulsa	Mohawk Park	36°12'29"N 95°53'59"W
Wagoner	Coweta	Roland Park	35°57'33"N 95°39'45"W
Washington	Bartlesville	Bartlesville Trails at Lake Hudson	36°48'10"N 96°01'57"W
		Johnstone Park	36°45'16"N 95°58'34"W

At each location, the area was surveyed for the presence or absence of both honeysuckle species. When present, samples were taken to prepare herbarium vouchers, which document the morphology, habitat, surrounding plant species, and geographic coordinates associated with each specimen. Additionally, the occurrence of three other non-native invasive species of interest was noted: *Ligustrum sinense* Lour., *Pyrus calleryana* Decne., and *Nandina domestica* Thunb., which are common in Oklahoma. These species were selected because, like honeysuckle, they are often intentionally planted as ornamentals and often escape cultivation. Each sample was dried and preserved for deposition in the Oklahoma State University Herbarium. Collection data for each specimen were uploaded to the TORCH database (https://portal.torcherbaria.org).

All previously documented herbarium records of *L. japonica* and *L. maackii* from the 47 surveyed counties were downloaded from the TORCH database (retrieved October 4, 2023) to determine prior knowledge of presence or absence of these species at the county level. Additionally, the herbarium records of *L. sinense*, *P. calleryana*, and *N. domestica* were downloaded to observe the occurrence of other known invasive species in Oklahoma. In addition, the total numbers of non-native species per county were obtained. Briefly, all Oklahoma records of the five invasive species of interest were downloaded and filtered to remove those with missing or erroneous coordinates. Taxonomic names were standardized against the World Flora Online Taxonomic Backbone using the R package "WorldFlora" (Kindt 2020). Remaining records were filtered for non-native species (Simpson et al. 2022; accessed via Global Biodiversity Information Facility, https://www.gbif.org/dataset/32ad19ed-6b89-447a-9242-795c0897f345), and intersected with shapefiles for the 47 counties to determine the number of non-native species per county.

Data Analysis

Using the presence and absence data from field surveys and herbarium records, the spatial distributions of *L. maackii* and *L. japonica* at the county level were visualized using Microsoft Excel. The prevalence of *L. maackii* and *L. japonica* were compared using the number of counties in which each was documented. The numbers of newly documented county occurrences for each species were determined by comparison to the numbers of herbarium records. The association between town population size, obtained from the Oklahoma 2020 Census (America Counts Staff 2021) and the presence of *L. maackii* was tested using logistic regression. Logistic regression was also used to test the association between the number of non-native species in a county and the presence of *L. maackii*. Both analyses were conducted in R, using R-Studio (RStudio Team 2020). The packages used were "ggplot2" (Wickham 2016) and "cowplot" (Wilke 2020). Regressions were considered significant if the P-value was less than 0.05.

RESULTS

Of the 47 counties visited during the field surveys, *L. maackii* was observed in 15 counties (31.9%; Figure 7). *Lonicera japonica* was found in 38 out of 47 counties (80.9%; Figure 8). The herbarium records documented *L. maackii* in eight out of the 47 counties surveyed (17%; Figure 7). The herbarium records documented *L. japonica* in 41 out of 47 counties (87.2%; Figure 8). When combining the data from both the field surveys and the herbarium records, *L. maackii* was documented in 16 out of 47 counties (34%; Figure 7), and *L. japonica* was documented in 46 out of the 47 counties surveyed (97.9%; Figure 8). A summary of the presence and absence of both species by county is presented in Table 2.

Using notes from the field surveys and herbarium records, the occurrence of three common, non-native invasive species was recorded by county (Table 2). *Ligustrum sinense* was present in 32 counties, *P. calleryana* was present in 13 counties, and *N. domestica* was present in seven counties. Of the 16 counties where *L. maackii* was present, *L. sinense* was present in 13, *P. calleryana* was present in four, and *N. domestica* was present in six.

There was a strong positive relationship between the population size of a town and the probability of *L. maackii* occurrence (Figure 9; p=0.005; df=45; deviance=41.68). However, there was only a weakly, non-significantly positive relationship between the total number of non-native species per county and the probability of *L. maackii* occurrence (Figure 10; p=0.082; df=45; deviance=56.96).

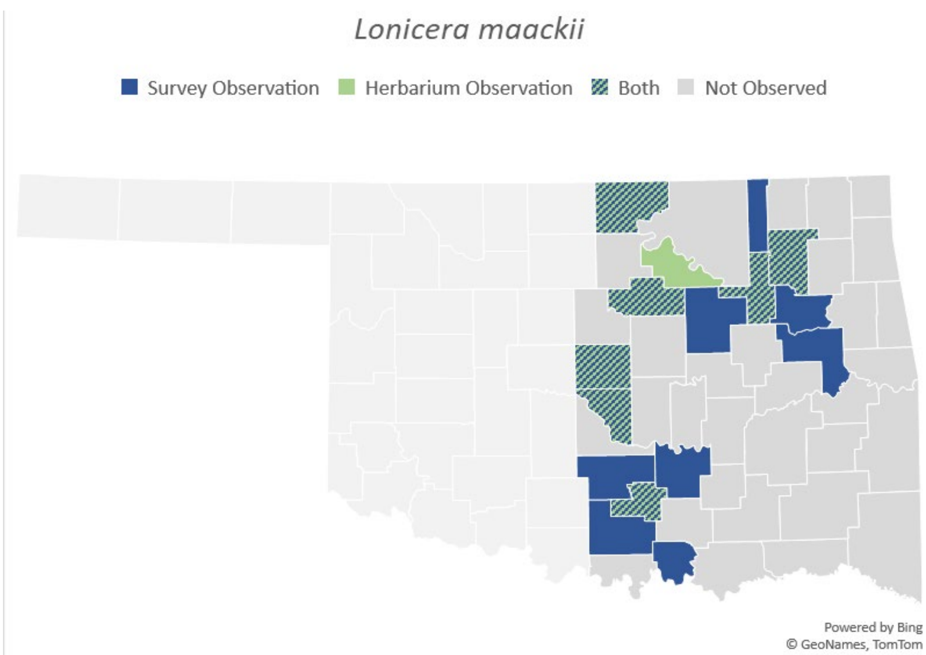

Figure 7 *Lonicera maackii* county occurrences documented by field surveys and herbarium collections

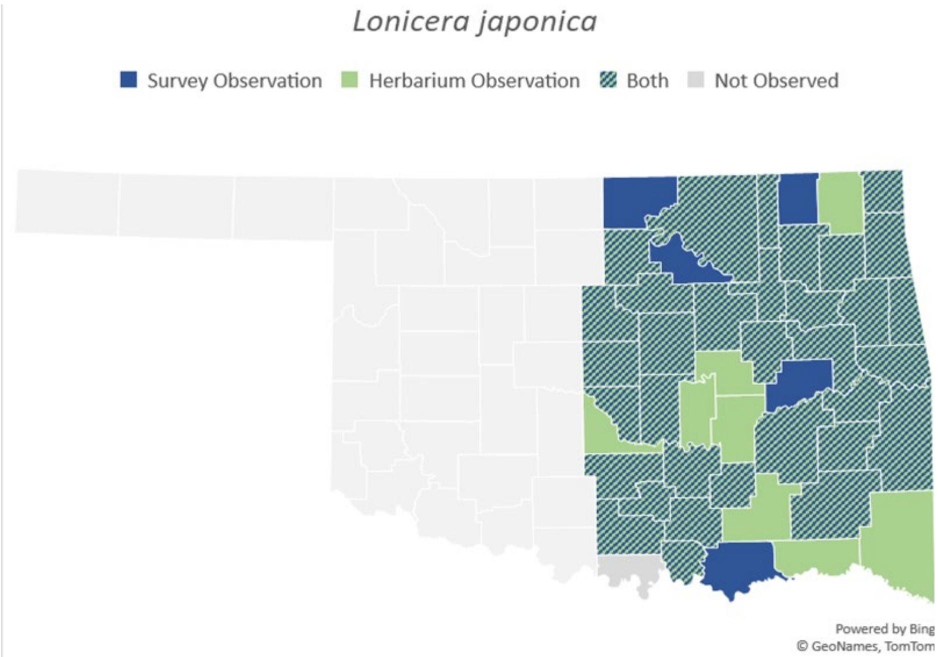

Figure 8 *Lonicera japonica* county occurrences documented by field surveys and herbarium collections

Table 2 Occurrence of invasive species associated with *Lonicera* species; X indicates the species is present.

County	*L. maackii*	*L. japonica*	*L. sinense*	*P. calleryana*	*N. domestica*
Carter	X	X	X	-	-
Cleveland	X	X	X	X	X
Creek	X	X	X	-	-
Garvin	X	X	X	-	X
Kay	X	X	-	-	-
Marshall	X	X	X	-	X
Murray	X	X	X	-	-
Muskogee	X	X	X	-	-
Oklahoma	X	X	X	X	X
Pawnee	X	X	X	-	X
Payne	X	X	X	X	X
Pontotoc	X	X	X	-	-
Rogers	X	X	X	-	-
Tulsa	X	X	X	X	-
Wagoner	X	X	-	-	-
Washington	X	X	-	-	-
Adair	-	X	X	-	-
Atoka	-	X	-	-	-
Bryan	-	X	-	X	-
Cherokee	-	X	X	X	X
Choctaw	-	X	-	-	-
Coal	-	X	X	-	-
Craig	-	X	X	-	-

Table 2 Occurrence of invasive species associated with *Lonicera* species; X indicates the species is present.

County	*L. maackii*	*L. japonica*	*L. sinense*	*P. calleryana*	*N. domestica*
Delaware	-	X	-	X	-
Haskell	-	X	X	-	-
Hughes	-	X	-	-	-
Johnston	-	X	X	-	-
Latimer	-	X	-	-	-
LeFlore	-	X	X	-	-
Lincoln	-	X	-	-	-
Logan	-	X	-	-	-
Mayes	-	X	X	X	-
McClain	-	X	-	-	-
McCurtain	-	X	X	-	-
McIntosh	-	X	X	X	-
Noble	-	X	-	-	-
Nowata	-	X	X	-	-
Okfuskee	-	X	X	-	-
Okmulgee	-	X	X	X	-
Osage	-	X	X	-	-
Ottawa	-	X	X	X	-
Pittsburg	-	X	X	X	-
Pottawatomie	-	X	-	-	-
Pushmataha	-	X	-	-	-
Seminole	-	X	X	-	-
Sequoyah	-	X	X	-	-
Love	-	-	X	X	-

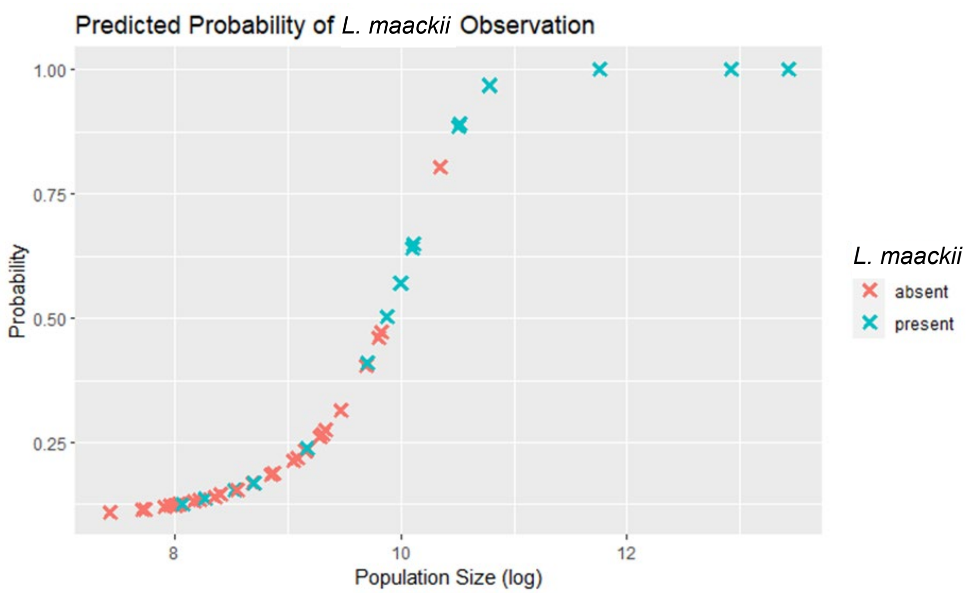

Figure 9 Probability of *L. maackii* occurrence as a function of town population size; p=0.005; df=45; deviance=41.68

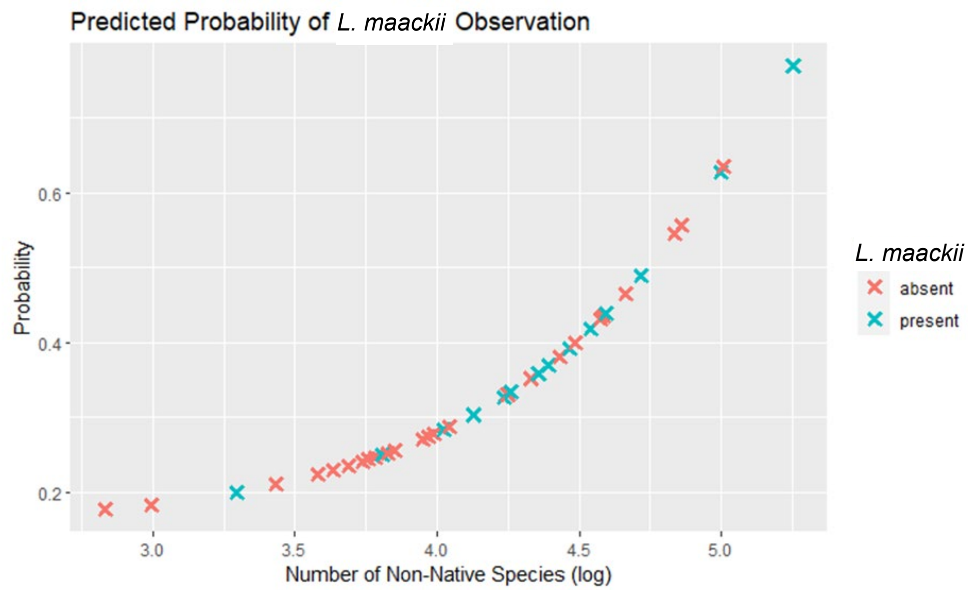

Figure 10 Probability of *L. maackii* occurrence as a function of the number of non-native species; p=0.082; df=45; deviance=56.96

DISCUSSION

This study updates and expands published information on the distributions of *L. maackii* and *L. japonica* in eastern Oklahoma. The comparative prevalence of the two honeysuckle species was predicted based on the county-level distributions documented by herbarium records and in the literature (Keil and Hickman 2014). We hypothesized that *L. maackii* would be present in 50% of the counties surveyed and that *L. japonica* would be present in 90% of the counties. Field surveys found *L. maackii* in 31.9% of the eastern Oklahoma counties, while herbarium records show observations of *L. maackii* in 17.0% of counties, including one county where *L. maackii* was not observed in the field survey. When both sources of data are combined, *L. maackii* was documented in 34.0% of eastern counties. This does not support the first hypothesis. However, the new observations recorded *L. maackii* in eight counties that were not previously known from herbarium records alone. The new observations improve our understanding of the distribution of *L. maackii* in eastern Oklahoma. Additionally, observations appeared to be concentrated around urban areas. Although *L. maackii* was found in fewer counties than expected, the persistence of *L. maackii* previously documented at the county level was confirmed, and its prevalence in eastern Oklahoma appears to have increased in recent decades. Due to this species' effects on surrounding organisms and its ability to spread by seed dispersal, its range could continue to spread into forested areas in the future if left uncontrolled (Luken and Thieret 1996). *Lonicera maackii* was expected to be less common than *L. japonica* due to the previous knowledge that *L. japonica* was widespread and frequent (Keil and Hickman 2014).

Field surveys found *L. japonica* in 80.9% of eastern Oklahoma counties, and herbarium records show the presence of *L. japonica* in 87.2% of counties, including seven counties where *L. japonica* was not observed in the field survey. The field surveys also documented *L. japonica* in five counties that were not recorded in herbarium data. When combining both sources of data, *L. japonica* has been documented in 97.9% of eastern Oklahoma counties, with Love County being the only one without evidence of occurrence. This number supports the second hypothesis, that *L. japonica* would be found in at least 90% of counties. These records provide evidence for *L. japonica* being widespread and extremely common, and the field surveys confirm what was already expected for this well documented invasive species (Keil and Hickman 2014).

Human activity contributes considerably to the establishment and effects of invasive species. Like many invasive plant species, *L. maackii* and *L. japonica* were intentionally planted. When invasives are deliberately introduced, they can spread and form naturalized populations in the surrounding areas. In the case of these human-introduced honeysuckles, seeds can be dispersed by birds and deer, aiding in their rapid spread outside of their intended area (Castellano and Gorchov 2013). Intentional planting isn't the only human activity that results in non-native species invasion, as the spread of urban areas is associated with increased activities that indirectly influence the potential of a habitat to be invaded. Habitat disturbances that result from urbanization can leave ecosystems more vulnerable to invasion by non-native species. Urban structures, such as roads and buildings, can alter habitats, decrease the sizes of forested areas, and result in habitat fragmentation. These structures also increase the amount of surface area that is impervious to rainwater. Additionally, urban areas and residential structures result in increased fire suppression (Nowacki and Abrams 2008). As a result, these changes heavily contribute to a cycle of changes to other environmental factors, including soil composition and quality, nutrient availability, light, and temperature (Flory and Clay 2009). The impacts of these factors can decrease a habitat's resistance to invasion by reducing performance of native species, providing opportunity for invasives to outcompete native plants (Flory and Clay 2009).

Considering urbanization as a factor that may increase the likelihood of *L. maackii* occurrence, we hypothesized that there would be a significant relationship between *L. maackii* occurrence and the population sizes of towns. *Lonicera maackii* was found mostly in towns with populations above 15,000 people (Table 3), which supports the prediction that this species would be present in urban and suburban areas with higher populations. Outlier occurrences were observed in towns below 15,000 people, such as Madill (population 3,914), in Marshall County. There were also cities above 15,000 people where *L. maackii* was not observed, such as Shawnee (population 31,377), in Pottawatomie County. Despite these outliers, the presence of *L. maackii* was well predicted by town or city size, and there was a significant positive relationship (Figure 9). Because of the role of horticulture in the early introduction of *L. maackii* and the presence of many landscaped areas near parks, it makes sense that *L. maackii* would be more likely to be concentrated in these areas with higher populations.

Lonicera maackii has been observed to be associated with disturbed habitats in these larger towns, as well as with other invasive species. The presence of *L. maackii* has even been suggested to promote greater abundance and diversity of invasive plants in some regions, as well as greater ecological effects through their presence (Culley et al. 2016). Of the three additional non-native species that were recorded in each county by herbarium records and field observations, *Ligustrum sinense* was the most common, with presence in 32 counties.

Table 3 *L. maackii* presence compared to population size; X indicates *L. maackii* is present.

Town	Population by Town	*L. maackii*
Oklahoma City	681,054	X
Tulsa	413,066	X
Norman	128,026	X
Stillwater	48,394	X
Bartlesville	37,290	X
Muskogee	36,878	X
Shawnee	31,377	-
Ardmore	24,725	X
Ponca City	24,424	X
Sapulpa	21,929	X
Claremore	19,580	X
Durant	18,589	-
McAlester	18,171	-
Ada	16,481	X
Tahlequah	16,209	-
Towns with population below 15,000		
Coweta	9,654	X
Pauls Valley	5,992	X
Sulphur	5,065	X
Madill	3,914	X
Cleveland	3,205	X

The other species were less common, as *Pyrus calleryana* was found in 13 counties, and *Nandina domestica* was found in six counties. *Ligustrum sinense* occurred in 13 counties where *L. maackii* was present, *P. calleryana* occurred in four, and *N. domestica* occurred in six. This pattern of abundance follows expectations, as *L. sinense* is a widely distributed and well documented invasive shrub that shares similar habitat preferences to honeysuckles (Kuebbing et al. 2014). When *L. maackii* occurs in conjunction with *L. sinense*, they have been found to drastically alter the composition and properties of soil and further exacerbate the invasion of other non-native species (Kuebbing et al. 2014). Both *P. calleryana* and *N. domestica* are considerably less documented than *L. sinense*, so it was expected to find them less frequently.

We hypothesized that the number of non-native species was predictive of the presence of *L. maackii*. Overall, there was a non-significant relationship between the number of non-native species per county and the probability of *L. maackii* occurrence (Figure 10), which did not support the fourth hypothesis, though the trend was in the predicted direction. It is possible that a stronger relationship would have been found if the number of non-native species were recorded per town surveyed rather than county, which would be at a more comparable scale.

The county level presence of the two honeysuckle species was surely underestimated through field observation due to the limitations of one person surveying a large region. Because of time constraints, survey site size, and public accessibility, the survey was quite limited for the extent of the study area. Because the survey was limited to public recreation areas in one town per county, naturalized honeysuckle populations could have been present, but undocumented, outside of the sites surveyed. Naturalized populations on private lands, highways, and roadsides were not considered. Additionally, very large parks were limited to certain portions for survey, such as campsites and walking trails.

Suitable survey sites were not found in all counties. Although research was done prior to visits to find appropriate sites, some selected parks did not have as much natural habitat as expected. Two notable cases are Vinita, in Craig County, and Marietta, in Love County. In both cases, several locations were visited, but each site was highly landscaped and did not have suitable habitat for either species.

Further surveys are needed to better document the distributions of these species in Oklahoma. In addition to more surveys across the eastern part of the state, surveys at a smaller scale could be informative. For example, performing more extensive surveys for individual towns could document not only the presence of these species, but also the abundance.

The results of this study also raise questions for future research. Despite the similarities between these two honeysuckle species, *L. japonica* has a much wider distribution in Oklahoma than *L. maackii*. Both species spread via effective seed dispersal and use their phenology to gain a competitive advantage. However, perhaps *L. japonica*'s capability of adventitious propagation or longer flowering period contributes to its wider distribution. Another factor to consider would be that *L. japonica* was introduced to the United States around 100 years earlier than *L. maackii*. With the large difference in time frame, could it be possible for the latter to become just as extensive over time, or would *L. maackii* remain more limited? If it is possible for *L. maackii* to become as extensive as *L. japonica*, it also raises concerns as to whether invasive species management practices would be able to get ahead of the spread of *L. maackii* and prevent it from worsening, given what we now know about *L. japonica*.

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GENETIC STRUCTURE OF THE *MECARDONIA ACUMINATA* (PLANTAGINACEAE) COMPLEX IN THE SOUTHEASTERN USA

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ABSTRACT

Mecardonia acuminata (Plantaginaceae) is found in the southeastern United States and has traditionally been divided into three varieties. A quantitative analysis of morphological data supported the division into the three varieties, although the ranges of the varieties found in that study were not the same as their traditional ranges. Here we use ISSR data to examine the relationships of 238 individuals from 23 locations throughout the range of *M. acuminata*. Although there is genetic structure that is congruent across different analyses, the groups recovered are not consistent with morphology or geography. The results indicate eastern-western distributions of the species with centers of diversity not only in the south but as far north as the Central Basin of the Interior Low Plateaus. The results further suggest ongoing diversification of lineages of *M. acuminata*, or the presence of widespread genes that govern the morphological traits that are traditionally used in delimitating the varieties.

INTRODUCTION

The genus *Mecardonia* Ruiz & Pav. (Plantaginaceae) contains approximately ten species native to North and South America, with its center of diversity in Brazil and Argentina and two species found in North America north of Mexico (Pennell 1946; Rossow 1987; Greppi et al. 2017; Ahedor 2019). Within the Plantaginaceae, *Mecardonia* is in the tribe Gratioleae (Albach et al. 2005; Scatigna et al. 2022), where it is sister to the Central and South American genus *Darcya*, with these two genera together sister to the remainder of the tribe (Scatigna et al. 2022). It is distinguished from the remaining members of the Gratioleae by having a five-lobed, zygomorphic, white or yellow corolla; four anthers with the thecae separated by the connective; and unequal sepals (Scatigna et al. 2022).

Mecardonia acuminata (Walter) Small has the most northern distribution of any species of *Mecardonia* and is the only one that is restricted to the United States (Ahedor 2019). It is distinguished from all other species of *Mecardonia* by having white corollas that completely lack clavate hairs (Rossow 1987) and distinguished from the other North American species, *M. procumbens* (Mill.) Small, by having erect stems and white corollas with purple veins instead of spreading or prostrate stems and yellow corollas with red veins (Ahedor 2019). It is typically found on loam soil that may be acidic or sub-acidic and is usually in ditches or near streams in pineland or deciduous woodland (Pennell 1935). It ranges from Maryland to Missouri, south to Florida and Texas (Pennell 1922; Rossow 1987; Ahedor 2019). Flowering occurs through the summer followed by formation of capsule fruits throughout the fall (Pennell 1935; Rossow 1987; Wunderlin and Hansen 2003). The South American *M. tenella* (Cham. & Schltdl.) Pennell is pollinated by three types of bees, which collect fragrance, oil, and pollen (Cappellari et al. 2009) and the flowers of *M. acuminata* are also visited by bees (A. Ahedor, personal observations).

Traditionally, *M. acuminata* has been divided into three varieties or subspecies, depending on the treatment (Pennell 1935; Rossow 1987). *Mecardonia acuminata* var. *acuminata* is the most widespread and occurs throughout most of the range of the species. *Mecardonia acuminata* var. *microphylla* (Raf.) Pennell was separated by having shorter pedicels (< 10 mm according to Rossow 1987 or < 12 mm according to Pennell 1935), wider leaves that are less cuneate at the base (Pennell 1935; Rossow 1987), and wider sepals (> 2 mm; Rossow 1987). Its range is traditionally considered to be restricted to the Coastal Plain in Georgia, South Carolina, and Florida (Rossow 1987), predominantly in areas where long-leaf pine grows (Pennell 1935). The third variety, *M. acuminata* var. *peninsularis* Pennell, is traditionally considered to be restricted to peninsular Florida and is distinguished morphologically by having smaller leaves, sepals, and corollas than var. *acuminata* (Pennell 1935); by being branched at the base, instead of being branched only above the base (Pennell 1935; Rossow 1987); and by having pedicels that are ascending instead of spreading (Rossow 1987).

Ahedor and Elisens (2015) performed quantitative morphological analyses to test these hypotheses. They found that, using the classic morphological characters, specimens corresponding to the three varieties could be identified well to the north and (in the case of var. *peninsularis*) west of their traditional ranges. A canonical discriminant function analysis plot showed the three varieties to fall into separate groups. When comparing the morphological characters between varieties, they found that var. *peninsularis* had significantly smaller leaves and a significantly greater proportion of ascending (vs. divaricate) pedicels and basal (versus mid-point or intermediate) branching than the other two varieties. Variety *microphylla* had significantly shorter flowering and fruiting pedicels than the remaining two varieties. The widespread var. *acuminata* did not show any unique traits but could be distinguished by not having the distinctive characteristics of either of the other two varieties (so having larger leaves, divaricate pedicels, mid-point or intermediate branching, and longer flowering and fruiting pedicels; Ahedor and Elisens 2015).

Here we test the morphologically delimited varieties using inter simple sequence repeat (ISSR) data. ISSR are cost-effective and highly reproducible markers (Monfared et al. 2018), which have been useful for genetic studies below the species level to determine population structure (Alansi et al. 2016) and analyze genetic variability of populations (Christopoulos et al. 2010). They have been successfully employed in the genetic characterization of the varieties of *M. procumbens* found in South America (Pérez de la Torre et al. 2010). We answer the following questions: 1) Do the ISSR data consistently divide *M. acuminata* into well-supported groups? 2) If so, do these groups correspond to the varieties delimited based on morphology? 3) If not, is there a way to delimit new infraspecific taxa that are congruent with both molecular and morphological data, or would it be better to treat *M. acuminata* as a species without infraspecific taxa?

MATERIALS AND METHODS

Sampling Strategy

Herbarium specimens of *M. acuminata* from BRIT, FLAS, GA, MO, and OKL (acronyms following Thiers (updated continuously), were initially examined to choose sampling locations of the three varieties in the southeastern USA. Varieties were identified based on characters reported by Pennell (1935), Rossow (1987), and Ahedor and Elisens (2015). In total, 238 individuals were sampled from 23 locations in seven southeastern states: Alabama, Florida, Georgia, Louisiana, Mississippi, Tennessee, and Texas (Table 1, Figure 1). No individuals were located in Oklahoma as the few habitats present had been disturbed at the time of sampling. Since Oklahoma occurs in the fringes of the range, the species is sparsely distributed compared to other states. The collected plants were also identified to variety based on Pennell (1935), Rossow (1987), and Ahedor and Elisens (2015). At 15 of the locations, the plants could be unambiguously identified as one of the three varieties, while the remaining eight locations contained individuals unambiguously identified as one of the varieties in addition to individuals that were morphologically intermediate between that variety and a second variety. In addition, several of the locations had plants that were morphologically identified as one variety but were in the traditional range of another variety. While the goal was to sample 11 individuals at each location, some locations did not have enough individuals to do that. Leaf tissues were silica-dried and stored in the freezer and voucher specimens were deposited at OKL.

ISSR Amplification and Scoring

DNA was extracted from the leaves using the modified CTAB method of Doyle and Doyle (1987). Fifty ISSR primers obtained from the University of British Columbia (UBC) were screened and seven primers that revealed both intra- and inter-location variability were selected for the study (Table 2). For each individual, ISSR regions were amplified with a single primer at a time via PCR. Total reaction mixtures of 25 μL consisted of 2.0 μL DNA, 1.5 μL of 15 μM primer, 4.0 μL of 1.25 mM dNTPs, 2.0 μL of 5U/μL Taq, 2.5 μL of 50 mM $MgCl_2$, and 1× *Taq* polymerase buffer. The PCR was performed on a MiniCycler (MJ Research Inc., South San Francisco, CA, USA) with 1.5 min at 94°C; 35 cycles of 40 sec at 94°C, 45 sec at 45°C, 1.5 min at 72°C; 40 sec at 94°C, 45 sec at 45°C and 5 min at 72°C (Wolfe and Randle 2001). All experiments included negative control reaction mixtures that had all ingredients except DNA. The PCR products were resolved on a 1.5% agarose gel in 1× TAE, with a 100 bp standard marker ladder loaded alongside to determine the size of the fragments. Gels were stained with ethidium bromide and images were visualized in UV light. Images were captured and analyzed using Kodak Digital Science ID software (Kodak, Rochester, NY, USA). Loci for each of the primers were assigned based on fragment sizes, and the ISSR data were scored as diallelic, 0 (band absent) or 1 (band present).

Table 1 Twenty-three sampling locations and 238 individuals sampled from the distribution range of *Mecardonia acuminata* in southeastern USA. Varieties represent pure varieties and intermediates. All vouchers are deposited at OKL. Location is the standard postal abbreviation for the state, followed by the parish or county within that state. The location code is given in parentheses, if different from the state and county/parish. N is the number of individuals sampled from that population.

Varieties based on morphology	Variety based on geography	Voucher	Location	Latitude (° N)	Longitude (° W)	N
peninsularis	*peninsularis*	Elisens 1061	FL Citrus	28.7295	82.2715	11
peninsularis	*peninsularis*	Elisens 1064	FL Levy	29.4415	82.6365	11
peninsularis	*peninsularis*	Elisens 1141	FL Polk	28.3109	82.0561	11
microphylla	*microphylla*	Elisens 1059	FL Liberty (FL Libe)	30.2043	84.7483	11
microphylla	*microphylla*	Elisens 1058	FL Calhoun (FL Calh)	30.4072	85.1622	11
acuminata	*acuminata*	Ahedor 112	AL Franklin (AL Fran)	34.4820	87.6490	11
acuminata	*acuminata*	Ahedor 113	AL Lawrence (AL Lawr)	34.4880	87.5007	11
acuminata	*acuminata*	Ahedor 101	LA Allen (LA Alln)	30.5185	93.0152	11
acuminata	*acuminata*	Ahedor 102	LA Beauregard (LA Beau)	30.5100	93.2328	10
acuminata	*acuminata*	Ahedor 103	TX Nacadoches (TX Naca)	31.6190	94.6832	11
acuminata	*acuminata*	Ahedor 105	TN Marshall (TN Marsh)	35.6251	86.8105	7
acuminata	*acuminata*	Ahedor 106	TN Maury (TN Maur)	35.5872	86.8975	10
acuminata	*acuminata*	Ahedor 104	TN Rutherford 1 (TN Ruth 1)	35.7394	86.5955	11
acuminata	*acuminata*	Ahedor 108	TN Rutherford 2 (TN Ruth 2)	35.6551	86.4576	7
acuminata	*acuminata*	Ahedor 109	TN Rutherford 3 (TN Ruth 3)	35.8738	86.2844	8
acuminata + peninsularis	*acuminata*	Elisens 1057	AL Covington (AL Covi)	31.1718	86.2908	11
acuminata + peninsularis	*acuminata*	Elisens 1056	MS George (MS Geor)	30.7791	88.7171	11
acuminata + peninsularis	*acuminata*	Ahedor 111	TN Rutherford 4 (TN Ruth 4)	36.0590	86.4847	11
acuminata + peninsularis	*acuminata*	Ahedor 107	TN Bedford (TN Bedf)	35.6772	86.5223	10
acuminata + peninsularis	*acuminata*	Elisens 1053	LA St. Tammany (LA St.Tm)	30.4962	90.1988	11
acuminata + microphylla	*acuminata*	Elisens 1047	LA Winn	31.7532	92.9170	11
peninsularis + microphylla	*acuminata*	Elisens 1066	GA Wilcox (GA Wilc)	31.9488	83.5589	11
peninsularis + microphylla	*acuminata*	Ahedor 110	TN Wilson (TN Wils)	36.0274	86.3673	10

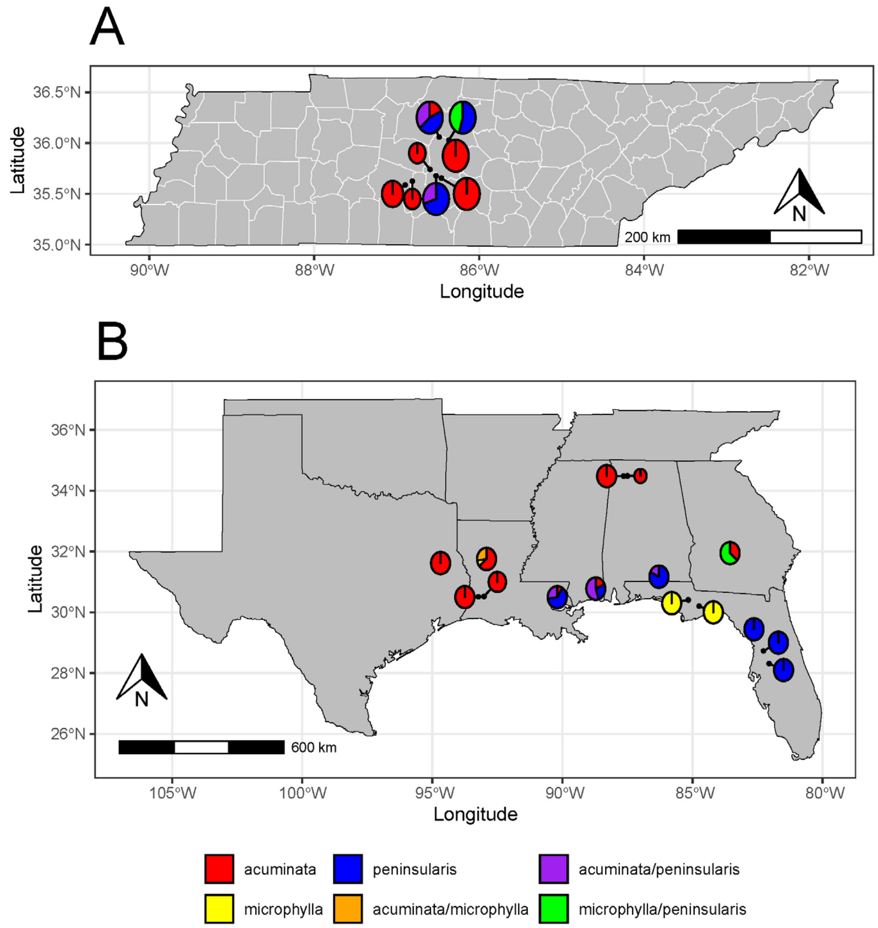

Figure 1 Map of southeastern USA showing sampled locations based on morphology. (A) Sampled locations in Tennessee. (B) Sampled locations in remaining states. Circles with a single color indicate locations with a single variety, while circles with two colors indicate locations with intermediates.

Table 2 Attributes of ISSR primers used to generate markers from 238 individuals sampled for *Mecardonia acuminata*.

Primer	Sequence	Total number of Loci (Grand Total = 94)	Range of Fragment Sizes (bp)	Number of Genotypes per Location
UBC 807	$(AG)_8T$	14	215 – 1400	4 –11
UBC 809	$(AG)_8G$	13	204 – 1500	2 – 9
UBC 812	$(GA)_8A$	15	220 – 1400	2 – 11
UBC 815	$(CT)_8G$	14	230 – 1500	3 – 11
UBC 836	$(AG)_8YA$	18	180 – 2700	3 – 11
UBC 842	$(GA)_8YG$	8	200 – 900	1 – 7
UBC 845	$(CT)_8RG$	12	260 – 1700	3 – 10

Population Genetic Statistics

The level of genetic variation was assessed per primer. The number of genotypes per primer was estimated, and the total number of ISSR loci was estimated for each sampling location. Alleles that occurred in more than half of the locations were considered common alleles, while alleles that only occurred in a single population were considered private alleles. The ISSR data were analyzed using POPGENE version 1.31 (Yeh et al. 1997) to determine allelic diversity, genetic diversity, genetic differentiation, and gene flow. Percentage polymorphism (P) was calculated as the number of polymorphic loci divided by the total number of loci obtained for a primer (Nei 1987). Nei's genetic diversity was used to estimate expected heterozygosity (H_E), and Shannon's index of phenotypic diversity was used to estimate observed heterozygosity (H_O) (Yeh et al. 1997). Levels of genetic differentiation (Nei 1972, 1973) were estimated as: average gene diversity in total (all) locations (H_T), within locations (H_S), and among locations (G_{ST}). G_{ST} measures genetic differentiation among subpopulations (locations) due to combined effects of all evolutionary forces and is ideal for non-model systems (Nei 1973). Gene flow (Nm, where N is the overall sample size and m is the fraction of immigrants per generation) was estimated as $(1/G_{ST})/4G_{ST}$ (Ellstrand and Elam 1993).

To assess isolation by distance, pairwise F_{ST} values were estimated for pairs of locations (in POPGENE). Geographic distances between each location were determined using PASSAGE 2.0 (Rosenberg and Anderson 2011). These two distance matrices were then compared using a Mantel test (Mantel, 1967) in PASSAGE.

Population Structure Analysis

Population structure was analyzed in three different ways. An analysis was performed in *adegenet* version 2.1.5 (Jombart 2008; Jombart and Ahmed 2011; RRID:SCR_000825), also using *ade4* version 1.7-18 (Dray and Dufour 2007) in R version 4.1.1 (R Core Team 2021). For these analyses, individuals were divided into two or three groups. Individuals were initially clustered with the *find.clusters* command and 50 principal components (PCs). A DAPC analysis (Jombart et al. 2010) was then performed on the clustered individuals with the optimal number of PCs as shown with the *optim.a.score* command. Ten analyses each were run with the plants divided into two or three groups. In preliminary analyses, *adegenet* placed individuals with missing data into their own group, despite the fact that these individuals came from several different populations. Therefore, the analyses presented here were run on a reduced dataset of 228 individuals, with the 10 individuals containing missing data removed.

STRUCTURE v.2.3.4 (Pritchard et al. 2000; RRID:SCR_002151) was run using the No Admixture model (Pritchard et al. 2010), following the recommendations for dominant markers such as ISSR (Falush et al. 2007). The number of groups (K) tested ranged from 1 – 23, with 10 runs for each value of K. These analyses were run with correlated allele frequencies, as recommended for closely related groups (Falush et al. 2003, 2007; Pritchard et al. 2010); an inferred value of alpha; and a burn-in of 100,000 generations followed by an analysis of 100,000 generations.

A Q-matrix was analyzed with K = 2 – 23 and visualized using STRUCTURE HARVESTER (Earl and vonHoldt 2012; RRID:SCR_017636). The variance across all iterations of each value of K was then minimized using CLUMPP (Jakobsson and Rosenberg 2007), and the optimal value of K was identified graphically using DISTRUCT (Rosenberg 2004).

Maps were made in R using ggplot2 version 3.4.0 (Wickham 2016;

RRID:SCR_014601), ggspatial version 1.1.5 (Dunnington 2022), maps version 3.4.0 (Deckmyn 2022; RRID:SCR_019296), scatterpie version 0.1.8 (Yu 2022), dplyr version 1.0.7 (Wickham et al. 2022; RRID:SCR_016708), and sf version 1.0-3 (Pebesma 2018).

Splits networks were constructed using SplitsTree6 (Huson and Bryant 2006). Two different analyses were performed, one with all of the individuals and one with the same 228 individuals used in the *adegenet* analyses. In both cases, Hamming Distances were used, and the bootstrap analysis consisted of 100 bootstrap replicates.

RESULTS

Population Genetic Statistics

Ninety-five loci were scored for all seven primers with a range of 8 (UBC 842) to 18 (UBC 836) loci per primer (Table 2). The largest fragment size range scored was for UBC 836, with 180 – 2700 bp, and the smallest range scored was for UBC 842 with 200 – 900 bp. The number of genotypes (unique banding patterns) per primer and sampling location ranged from one (no variation among individuals) to 11 (variation in all individuals).

A mean of 46.5% was obtained for percentage polymorphism (P), the lowest was 32.63% (TN Bedf and TN Maur), and the highest was 58.95% (TN Ruth 2); all these locations were in the Central Basin of the Interior Low Plateaus (Table 3). Mean genetic diversity within location (H_S) was 0.153, and total genetic diversity for all locations (H_T) was 0.239. The average genetic diversity among locations (G_{ST}) was estimated to be 0.361, and the level of gene flow (Nm) was estimated to be 0.887. Observed heterozygosity (H_O) was higher than expected heterozygosity (H_E) for all locations (Table 3), with H_O 0.231±0.034 and H_E 0.153±0.024.

The Mantel Test indicated that there was not a significant correlation between genetic and geographic distance (z = 234.796, r^2 = 0.008, t = - 0.123, p = 0.90184).

Population Structure

The networks from the SplitsTree analyses were relatively unresolved, with no groups of > 11 individuals that had bootstrap support over 10% in either analysis.

Analyses with *adegenet* showed consistent results when the individuals were divided into two groups (Figure 2). All ten replicate runs showed the same division of individuals, and all but one replicate had one PC as optimal with an identical eigenvalue and proportion of conserved variance. While there was much more variation in optimal number of PCs, eigenvalues, and proportion of conserved variance when the individuals were divided into three groups, there were still only two optimal solutions, each of which was found five times (Figure 3, Figure 4). However, none of the results corresponded to population or geography.

Bayesian clustering using STRUCTURE, and subsequent analyses using CLUMPP and DISTRUCT to estimate ΔK (following Evanno et al. 2005) revealed K = 2 as the best value, with a second optimum at K = 3 (Figure 5). Similar to the *adegenet* results, the STRUCTURE results for all ten replicate runs with K = 2 and K = 3 showed the same grouping of individuals in each run (Figure 6, Figure 7). Although none of these results corresponded to population or geography, the *adegenet* and STRUCTURE analyses in which the individuals were separated into two groups gave congruent results. In addition, both of the *adegenet* results for three groups of individuals and the STRUCTURE results for three groups of individuals gave congruent results for the populations outside of Tennessee. For the populations in Tennessee, the STRUCTURE results for three groups corresponded to one of the two *adegenet* results.

Table 3 Genetic variability at 95 ISSR loci in 23 sampling locations of *Mecardonia acuminata*. P = Percentage of polymorphic loci. Common loci are loci present in at least 52 % of locations sampled and rare alleles present in 48% of locations. H_E = Nei's genetic diversity (expected heterozygosity), H_O = Shannon's index of phenotypic diversity (observed heterozygosity).

Varieties Based on Morphology	Location	Total Loci	Common Loci	Private alleles	P	H_E (s.d.)	H_O (s.d.)
peninsularis	FL Citrus	68	60	0	52.63	0.164 (0.19)	0.25 (0.28)
	FL Levy	82	68	1	57.89	0.183 (0.19)	0.279 (0.28)
	FL Polk	55	48	0	36.68	0.119 (0.19)	0.177 (0.270)
microphylla	FL Libe	62	55	0	53.68	0.163 (0.19)	0.250 (0.27)
	FL Calh	52	49	0	48.42	0.165 (0.20)	0.244 (0.29)
acuminata	AL Lawr	51	47	0	36.84	0.132 (0.19)	0.197 (0.27)
	AL Fran	57	53	0	44.21	0.128 (0.18)	0.197 (0.26)
	LA Alln	64	54	0	36.84	0.110 (0.18)	0.169 (0.26)
	TN Bedf	53	50	0	32.63	0.125 (0.20)	0.184 (0.28)
	LA Beau	53	50	1	51.58	0.162 (0.20)	0.244 (0.29)
	TN Maur	61	55	0	32.63	0.165 (0.20)	0.247 (0.27)
	TN Ruth1	53	48	0	41.05	0.135 (0.19)	0.205 (0.27)
	TN Ruth 2	65	58	2	58.95	0.190 (0.19)	0.289 (0.28)
	TN Ruth 3	56	48	0	42.21	0.154 (0.20)	0.230 (0.28)
	TX Naca	55	50	0	47.37	0.155 (0.19)	0.234 (0.28)
acuminata + peninsularis	AL Covi	63	53	0	44.21	0.144 (0.19)	0.218 (0.28)
	MS Geor	70	52	6	55.76	0.165 (0.19)	0.254 (0.27)
	TN Ruth 4	70	62	0	56.85	0.168 (0.19)	0.258 (0.27)
	LA St.Tm	68	55	1	48.42	0.170 (0.20)	0.253 (0.29)
acuminata + microphylla	LA Winn	70	55	1	50.53	0.167 (0.12)	0.251 (0.29)
peninsularis + microphylla	GA Wilc	61	55	0	52.63	0.169 (0.19)	0.258 (0.27)
	TN Marsh	55	51	0	44.32	0.141 (0.18)	0.216 (0.27)
	TN Wils	59	51	0	43.16	0.135 (0.19)	0.206 (0.27)
Mean		**61 ± 8.15**	**54 ± 5.05**	**NA**	**46.5 ± 7.97**	**0.153±0.024**	**0.231±0.035**

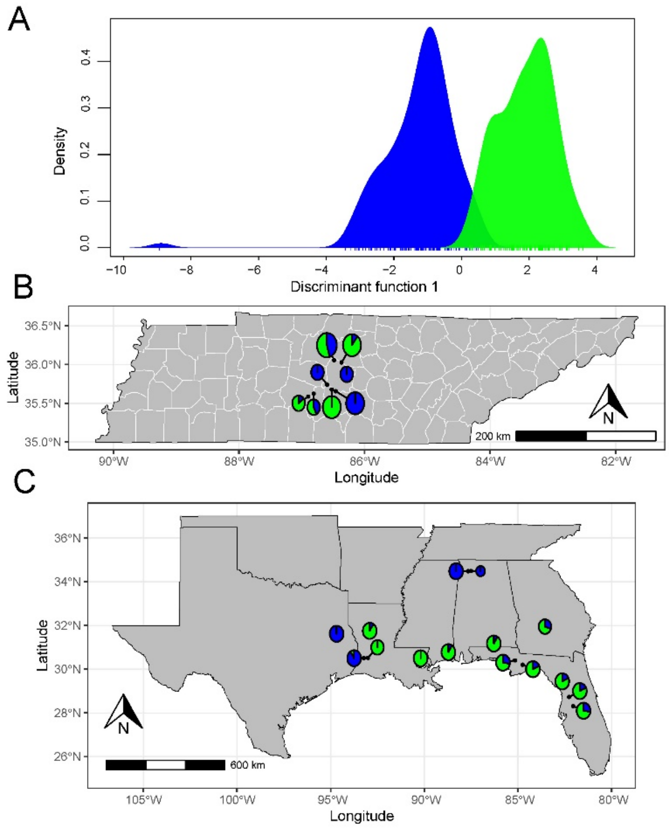

Figure 2 Results from the *adegenet* analysis of the 228 individuals without missing data, in which the plants were divided into two groups. (A) Plot from *adegenet* with the axis explaining 10.6% of the variation. (B) Distribution of the two groups within Tennessee. (C) Distribution of the two groups at the remaining sites.

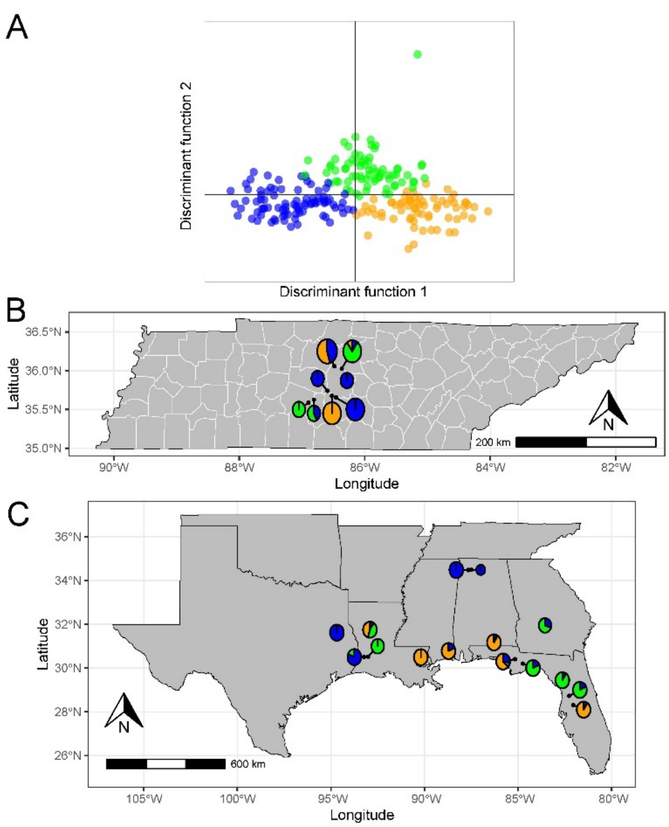

Figure 3 Results from the *adegenet* analysis of the 228 individuals without missing data, in which the plants were divided into three groups, division of individuals found in five of the ten runs. (A) Plot from *adegenet* with the division into groups explaining 33.7% of the variation. (B) Distribution of the three groups within Tennessee. (C) Distribution of the three groups at the remaining sites.

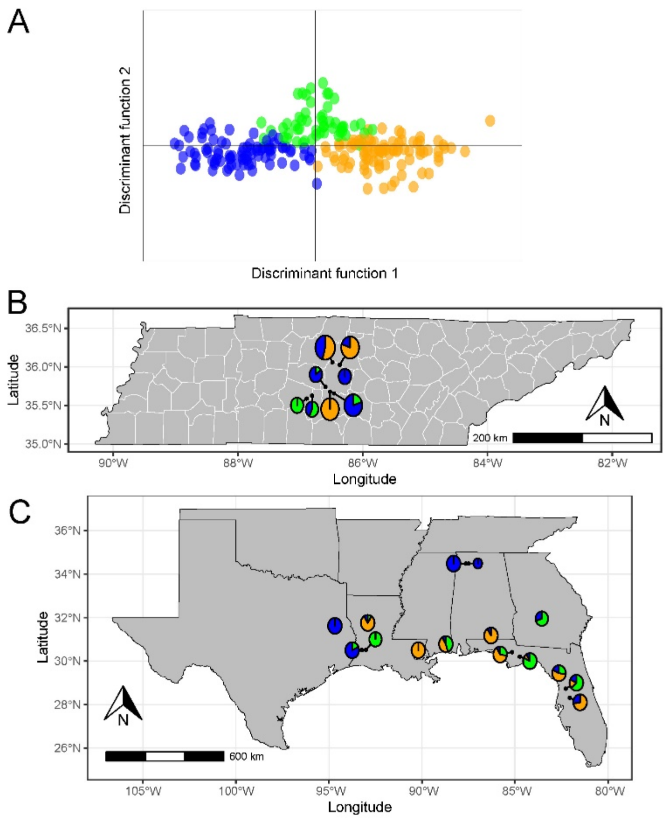

Figure 4 Results from the *adegenet* analysis of the 228 individuals without missing data, in which the plants were divided into three groups, division of individuals found in the remaining five runs. (A) Plot from *adegenet* with the division into groups explaining 37% of the variation. (B) Distribution of the three groups within Tennessee. (C) Distribution of the three groups at the remaining sites.

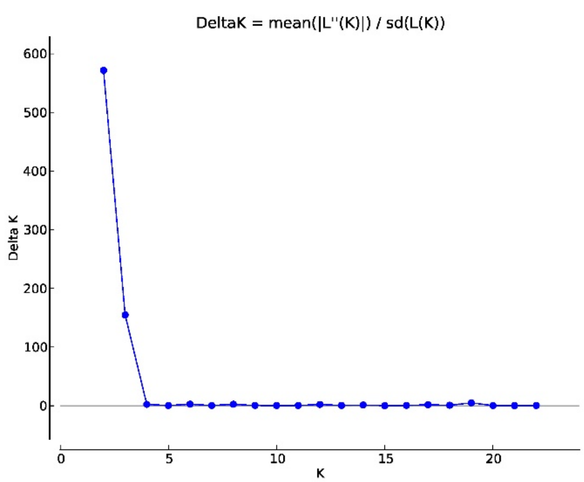

Figure 5 Delta K plot of results from CLUMPP and DISTRUCT analyses for STRUCTURE show two groups is favored for optimal value of K, with three groups being second best.

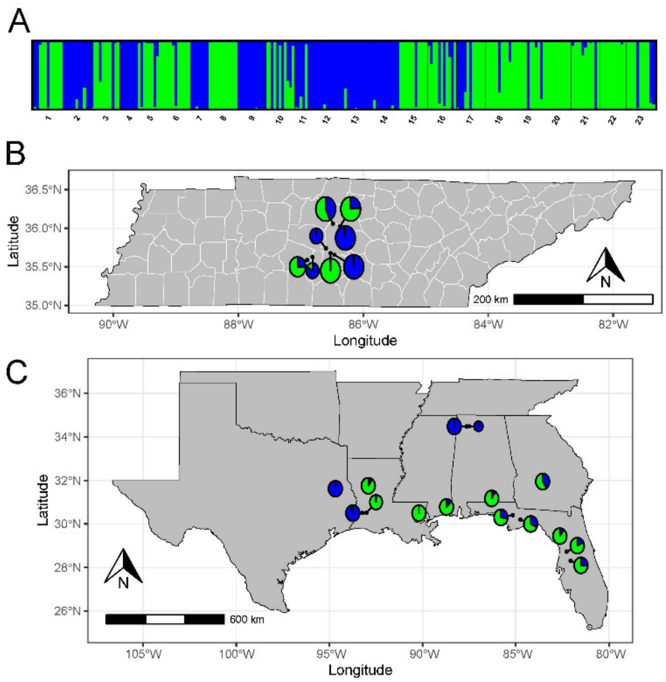

Figure 6 Results from the STRUCTURE analysis of all 238 individuals, in which the plants were divided into two groups. (A) STRUCTURE plot. (B) Distribution of the two groups within Tennessee. (C) Distribution of the two groups at the remaining sites. Populations are numbered as follows: 1: FL Calh, 2: LA Beau, 3: TN Wils, 4: AL Lawr, 5: TN Maur, 6: LA Winn, 7: TN Ruth 1, 8: TN Bedf, 9: Al Fran, 10: GA Wilc, 11: TN Marsh, 12: TX Naca, 13: TN Ruth 3, 14: TN Ruth 2, 15: AL Covi, 16: FL Libe, 17: TN Ruth 4, 18: FL Levy, 19: FL Citrus, 20: LA St. Tim, 21: MS Geor, 22: LA Alln, and 23: FL Polk.

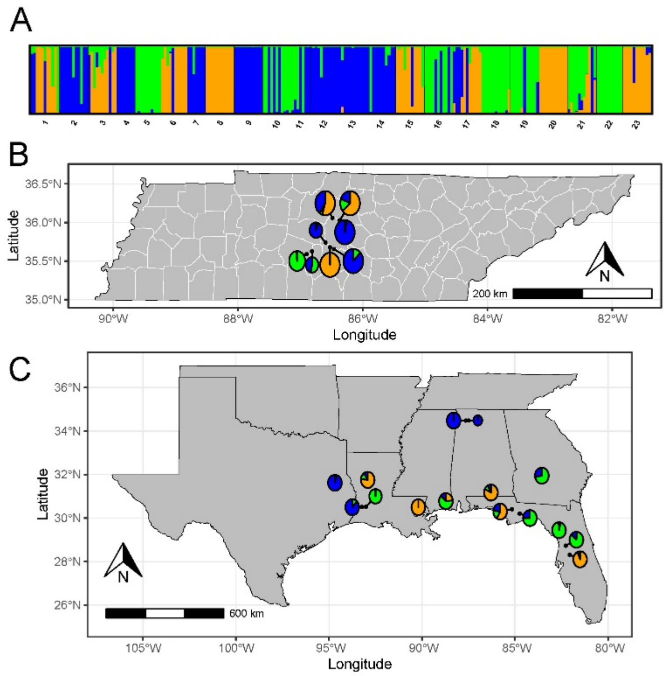

Figure 7 Results from the STRUCTURE analysis of all 238 individuals, in which the plants were divided into three groups. (A) STRUCTURE plot. (B) Distribution of the three groups within Tennessee. (C) Distribution of the three groups at the remaining sites. Populations are numbered as follows: 1: FL Calh, 2: LA Beau, 3: TN Wils, 4: AL Lawr, 5: TN Maur, 6: LA Winn, 7: TN Ruth 1, 8: TN Bedf, 9: Al Fran, 10: GA Wilc, 11: TN Marsh, 12: TX Naca, 13: TN Ruth 3, 14: TN Ruth 2, 15: AL Covi, 16: FL Libe, 17: TN Ruth 4, 18: FL Levy, 19: FL Citrus, 20: LA St. Tim, 21: MS Geor, 22: LA Alln, and 23: FL Polk.

DISCUSSION

Both *adegenet* and STRUCTURE analyses of the genetic data showed patterns that were largely congruent. However, the molecular groups were not congruent with the morphological classification of the populations. The morphological classification showed all groups outside of Georgia and Florida to be either pure var. *acuminata* or var. *acuminata* admixed with one of the other varieties. The three populations in peninsular Florida were var. *peninsularis*, the two populations in the Florida panhandle were var. *microphylla*, and the single Georgia population was intermediate between those two varieties. In contrast, the molecular results show that the two populations from northern Alabama, one population from Louisiana, the single population from Texas, and three or four of the eight populations in Tennessee form one group (either one of two groups or one of three groups, depending on the analysis). When the plants were divided into three groups, the three populations from peninsular Florida were in two different groups, as were the two populations from the Florida panhandle.

As molecular and morphological data are not congruent in *M. acuminata* and neither type of data recovers groups that are geographically coherent, we cannot support the recognition of infraspecific taxa. It may be that *M. acuminata* is in the process of diversifying, but that the new lineages have not been independent long enough to become distinct with molecular or morphological data. However, it is also possible that the genes that govern the traits that define each of the three morphological varieties are widespread throughout *M. acuminata* as a whole, making the whole species polymorphic for those traits and allowing them to predominate wherever in the range of *M. acuminata* they are most favorable. This interpretation is supported by the large number of intermediate individuals and populations and the fact that these putative intermediates are not only on the edges of the ranges of the proposed varieties, but also well within their core ranges.

The molecular data show evidence of population structure that is recoverable in two of the three analyses (with SplitsTree not showing any significant large-scale patterns). It is not clear what the cause of this signal is. It may be that there is a northern/western and an eastern/southern group, but that a lack of sampling in the northwestern corner of the range obscures this pattern. Similar east-west divisions have been found in a number of other groups from the southeastern United States (e.g., Soltis et al. 2006; Barrow et al. 2017; Myers et al. 2020). Explanations for these patterns include barriers to dispersal formed by various different major rivers in the area (e.g., Soltis et al. 2006; Wallace and Doffitt 2013; Hatmaker et al. 2018; Lyman and Edwards 2022) and recolonization from separate refugia in Texas, the Florida Peninsula, and potentially elsewhere along the Gulf coast (e.g., Barrow et al. 2017; Myers et al. 2020; Naranjo et al. 2023).

However, other groups also show either a complex molecular pattern (e.g., Wallace and Doffitt 2013) or little geographic signal in the data (e.g., Konrade et al. 2019). Given that there have been repeated cycles of glaciation throughout the Pleistocene, there would have been multiple north-south cycles of movement. Thus, we would not necessarily expect the same lineages to always retreat into the same refugia each glacial cycle. Rather, lineages that originated from one refugium could retreat into another refugium during the next glaciation, thus leading to complex patterns of the type we find here. Wallace and Doffitt (2013) hypothesized that in *Trillium*, the combination of a complex Pleistocene history, low dispersal capabilities, and discontinuous habitat patches may have led to its complex genetic patterns, as is likely the case with *M. acuminata*.

AUTHOR CONTRIBUTIONS

ARA designed the study, collected the plants, performed data analysis, and wrote the initial draft of the manuscript. JM performed data analysis. WJE assisted with study design, plant collection, and data analysis. AJM performed data analysis and wrote the final draft of the manuscript. All authors edited the manuscript and approved the final version.

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DATA AVAILABILITY STATEMENT

The datasets generated for this study can be found in the Dryad Digital Repository at https://doi.org/10.5061/dryad.4b8gthtj3.

A FLORISTIC INVENTORY OF THE NORTH SIDE OF ARCADIA LAKE, EDMOND, OKLAHOMA

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ABSTRACT

A floristic inventory was conducted on the north side of Arcadia Lake in Edmond, Oklahoma. Fieldwork was conducted from April 2022 to July 2023. The survey documented 356 plant species representing 79 plant families and 233 genera. A total of 214 species were collected, and their corresponding vouchers were deposited at the University of Central Oklahoma Herbarium (CSU). Forty-one plant species were not collected, but were observed, photographed, and uploaded to iNaturalist by the authors. One hundred and one additional plant species found in the study site were observed by the iNaturalist community and verified by the authors. One species tracked by the Oklahoma Natural Heritage Inventory was observed and vouchered. Eighty-three percent of observed species were native, while seventeen percent were non-native.

INTRODUCTION AND STUDY AREA

Arcadia Lake is in northeastern Oklahoma County, six miles east of Edmond, Oklahoma. The county is centrally located in the state. Arcadia Lake is a human-made reservoir constructed in 1984 to supply the city of Edmond with water, control flooding, and provide outdoor recreation for the surrounding communities. This land is a mixture of five Edmond city parks, Edmond's municipal water facilities, and the University of Central Oklahoma Boathouse (The City of Edmond 2024). The lake has approximately 26 miles of shoreline and 736 ha of surface area (U.S. Army Corps of Engineers 2024). Approximately 1,560 ha of recreational land surrounds the lake (Figure 1). The north side study site is approximately 274 ha, between E. 2nd Street on the north side, the lake shore to the south, N. Air Depot Boulevard on the west, and N. Post Road on the east (Figure 1). The study site ranges between the latitude 35.652685 and 35.644860 and longitude -97.407465 and -97.35392.

Arcadia Lake is within the Cross Timbers Ecoregion, which stretches from north-central Texas through central Oklahoma to its northern reaches in southern Kansas (Figure 1). The Cross Timbers is over 4.8 million hectares, approximately half of it in Oklahoma (Küchler 1964; Thomas and Hoagland 2011). It is a mixture of diverse habitats: forest, savanna, grassland, and wetland. The predominant tree species are *Quercus stellata* Wangenh. (post oak) and *Quercus marilandica* Münchh. (blackjack oak) (Duck and Fletcher 1945). Arcadia Lake falls within the temperate humid subtropical climate zone. This climate zone is characterized by hot and humid summers and cool to mild winters (Köppen 1936). Oklahoma County's average annual climate

10.22488/okstate.25.100003

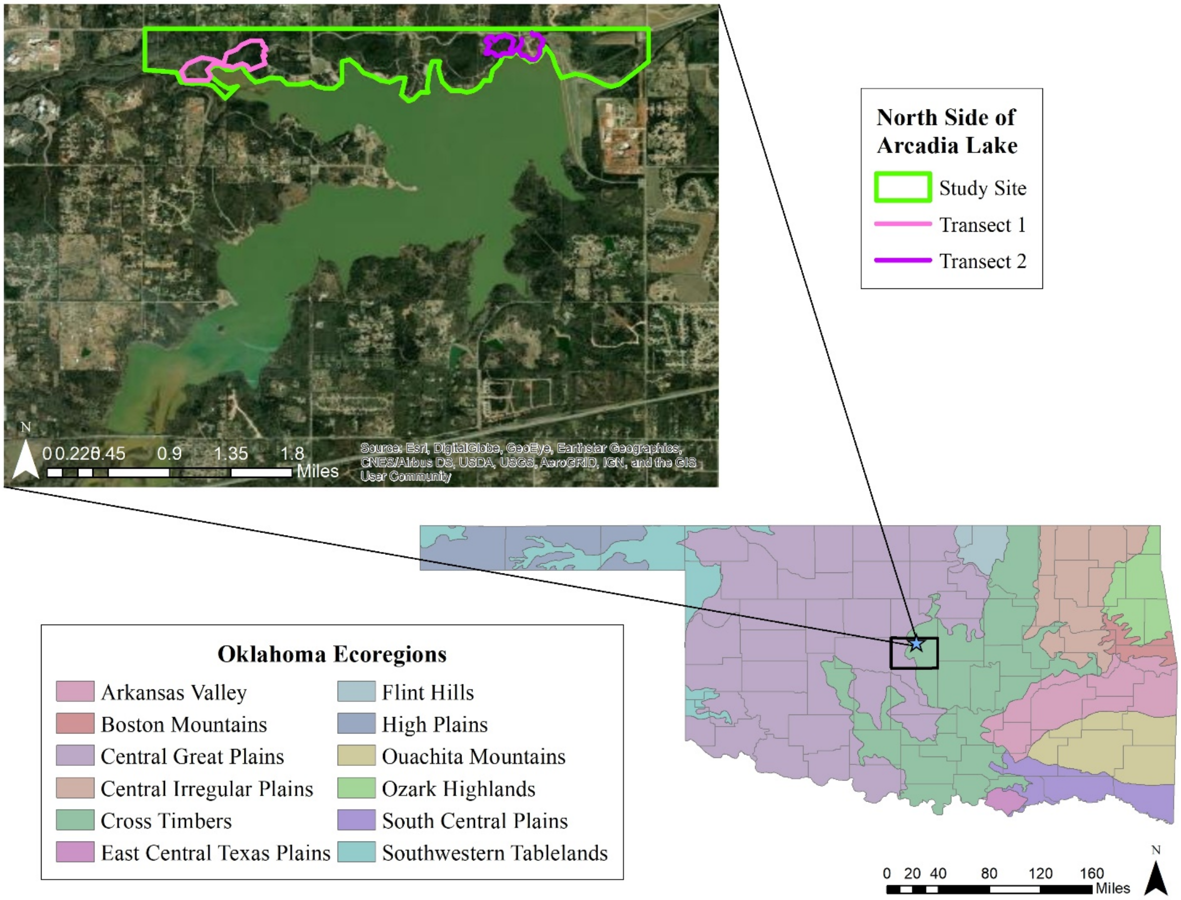

Figure 1 Oklahoma ecoregions and Arcadia Lake study site.

statistics include a growing season of 213 days, 92.4 cm of rainfall, and a temperature of 15.5°C. The average last spring freeze is April 4, and the average first fall freeze is November 2. Average annual snowfall is 17.5 cm, and average wind speed is 12.8 kph. The record high temperature is 45°C, and the record low is - 26°C. The latest recorded freeze date is April 20, and the earliest is October 21 (Oklahoma Climatological Survey 2000; Mesonet 2023).

METHODS

Fieldwork was conducted from 5 April 2022 to 24 July 2023. Twenty-nine site visits were made during this time. Site visit frequency was determined by the likelihood of flowering plants being more abundant, typically once every two weeks during the growing season (March through October) and once monthly in the winter. Two transects were established to cover as many habitat types as possible and to observe and collect as many species as possible. Transect 1 was 2.082 km and crossed through forest, grassland, and wetland habitats (Figure 1). Transect 2 was 1.718 km and crossed forest, grassland, wetland, and disturbed habitats (Figure 1). Most plants were collected along the two transects, but some were collected in the broader study area. In most cases, plants were collected while flowering and documented with an iPhone 11 camera and posted on iNaturalist. Plants not abundant (< 10) were not collected but photographed and photos uploaded to iNaturalist. After each site visit, specimens were pressed in a plant press and dried in a drying cabinet. An iNaturalist project, Flora of Arcadia Lake (https://www.inaturalist.org/projects/flora-of-arcadia-lake), was created for the entirety of Arcadia Lake. Plant species not observed during the fieldwork but found on the iNaturalist app (within the study area) were added to the overall plant species count. Only species that could be confidently identified through the image uploaded on iNaturalist were added to the species list.

Specimens and iNaturalist observations were identified using *Flora of Oklahoma: Keys and Descriptions* (Ryburn et al. 2018; Fishbein et al. 2024) and *Illustrated Flora of North Central Texas* (Diggs et al. 2000). After identification, the corresponding iNaturalist post was updated with the correct genus and species. The USDA PLANTS Database (2023) was used to determine nativity, duration, and growth habit. Nomenclature and classification follow the Integrated Taxonomic Information System (2024). All vouchers were deposited at the University of Central Oklahoma Herbarium (CSU).

RESULTS AND DISCUSSION

A total of 356 plant species representing 79 plant families and 233 genera were observed and documented on the north side of Arcadia Lake (Appendix). Two hundred and fourteen species were collected, identified, and vouchered. Forty-one were documented via iNaturalist due to low abundance on the date observed, i.e. *Agalinis heterophylla* (Nutt.) Small (prairie false foxglove) and *Hypericum hypericoides* (L.) Crantz (St. Andrew's cross). The remaining 101 were observed by iNaturalist users. Plant duration statistics include 146 annuals (41%), 195 perennials (54.8%), and 15 biennials (4.2%). The growth habits statistics were 248 forbs (69.7%), 47 graminoids (13.2%), 14 shrubs (3.9%), 12 vines (3.4%), five ferns (1.4%), and 30 trees (8.4%). The most prominent plant families observed were Asteraceae with 73 species (20.5%), Fabaceae with 30 species (8.4%), and Poaceae with 31 species (8.7%). Plant families with the most non-native species were Asteraceae (7), Poaceae (7), Brassicaceae (6), Caryophyllaceae (6), and Fabaceae (6). The total number of native species was 297 (83.4%), while 59 species (16.6%) were non-native. The 356 vascular plant species observed on the north side of Arcadia Lake constitute 13.4% of the 2,657 vascular plant species found in Oklahoma (Fishbein et al. 2024).

The current Arcadia inventory had the second greatest species richness compared to four other plant inventories in the region (Table 1). This might be due to utilizing iNaturalist observations or the large study site with varying habitats. The four nearest inventories were found in Oklahoma, Cleveland, Canadian, and McClain counties. Eleven county records were collected: *Myosotis macrosperma* Engelm., *Samolus valerandi* L., *Scleranthus annuus* L., *Trepocarpus aethusae* Nutt. ex DC., *Erigeron modestus* A. Gray, *Facelis retusa* (Lam.) Sch. Bip., *Juncus acuminatus* Michx., *Lolium multiflorum* Lam., *Carex crus-corvi* Shuttlew. ex Kunze, *Carex lurida* Wahlenb, and *Eragrostis sessilispica* Buckley (Figure 2 and Figure 3). One county record, *Dalea multiflora* (Nutt.) Shinners, was not collected but observed on iNaturalist (Figure 3). Three of these county records are non-native, *Scleranthus annuus*, *Lolium multiflorum*, and *Facelis retusa*. One species tracked by the Oklahoma Natural Heritage Inventory (2024) was observed and collected: *Mimulus ringens* L. (Allegheny monkeyflower) (Figure 4). *Mimulus ringens* has a state conservation status of SH (historically known from Oklahoma) and a global conservation status of G5 (globally secure). The Oklahoma Natural Heritage Inventory lists *Mimulus ringens* as possibly extirpated. Prior to this research, *Mimulus ringens* had been documented twice in Oklahoma County in 1940 and 1941 and seven times in all of Oklahoma, the last time being in 1988 (TORCH Data Portal 2024). According to iNaturalist (2024), *M. ringens* has had no observations in Oklahoma. Three county records, *Trepocarpus aethusae, Carex*

Table 1 The four closest plant inventories to the Arcadia Lake study site.

Study Site	County	Reference	Size of site	Number of Taxa	Percent non-native
Arcadia Lake	Oklahoma	Friedman 2024a	274 ha	356	16.6%
E.C. Hafer Park	Oklahoma	Caddell et al. 2017	49 ha	270	22.2%
John W. Nichols Scout Ranch	Canadian	Crosswhite & Ryburn 2019	150 ha	152	13.6%
University of Oklahoma's Kessler Atmospheric and Ecological Field Station	McClain	Buthod & Hoagland 2016	146 ha	361	14.7%
Belle Isle at the Deep Fork River (plant survey)	Oklahoma	Friedman 2024b	83 ha	135	32.6%

lurida, and *Juncus acuminatus*, were observed near a stream flowing into the lake surrounded by a natural wetland area (Figure 5). Many wild waterways within Oklahoma County have been decimated due to urban infrastructure projects. This may be why no prior records of these taxa have been documented.

Like many natural areas, Arcadia Lake is constantly threatened by development projects. Previous projects and developments have occurred in the vicinity of the lake, including a water treatment facility, home construction, recreation buildings, and widening of walking and biking trails. In 2022, the City of Edmond signed a deal with LandPlan Consultants to develop a master plan for development projects on Arcadia Lake. Development projects could be as simple as maintaining and building new trails or as big as building a marina, resort, restaurants, hotels, floating cabins, or a new RV park (Tomlinson 2022). It's up to citizens, land managers, the City of Edmond, conservation organizations, scientists, and the business community to decide how to manage Arcadia Lake. With 297 native vascular plant species, twelve county records, and one plant species tracked by ONHI, Arcadia Lake is a natural area worth protecting.

Figure 2 Oklahoma County records, a) *Scleranthus annuus* L., b) *Erigeron modestus* A. Gray, c) *Facelis retusa* (Lam.) Sch. Bip., d) *Trepocarpus aethusae* Nutt. ex DC., e) *Juncus acuminatus* Michx., f) *Lolium multiflorum* Lam. Photos by Micah Friedman.

Figure 3 Oklahoma County records, a) *Myosotis macrosperma* Engelm., b) *Carex lurida* Wahlenb, c) *Eragrostis sessilispica* Buckley, d) *Carex crus-corvi* Shuttlew. ex Kunz., e) *Samolus valerandi* L. (Photos by Micah Friedman), f) *Dalea multiflora* (Nutt.) Shinners. *D. multiflora* (photo by @sjcyoung 2019).

Figure 4 *Mimulus ringens* L., listed by the ONHI as possibly extirpated in Oklahoma (2024). Photo by Micah Friedman.

Figure 5 Wetland area where three county record native plant species were collected, 35.649748, -97.376541. Photo by Micah Friedman.

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APPENDIX

List of vascular plant species from Arcadia Lake, Oklahoma County, Oklahoma.

Species list with duration, growth habit, collection number, nativity, and heritage status.
A=annual, P=perennial, B= biennial; F=forb, FN=fern, S= shrub/subshrub, V=vine, G= graminoid, T=tree. If a plant was collected, Friedman's collection number follows; NC denotes a plant that was not collected but was posted on iNaturalist; iNat denotes a plant not observed by the authors but posted on iNaturalist and observed within the northside study area. Exotic species are denoted with an asterisk (*). Species tracked by the Oklahoma Natural Heritage Inventory are denoted with a dagger (†).

Acanthaceae
Ruellia humilis Nutt. (hairy ruellia); P; F; 571

Amaranthaceae
Amaranthus arenicola I.M. Johnst. (sand amaranth); A; F; NC
Chenopodium pratericola Rydb. (desert goosefoot); A; F; 470
Froelichia gracilis (Hook.) Moq. (slender snakecotton); A; F; 416

Amaryllidaceae
Allium canadense L. (Canadian meadow garlic); P; F; 556
**Allium vineale* L. (wild garlic); P; F; NC
Nothoscordum bivalve (L.) Britton (crowpoison); P; F; 498

Anacardiaceae
**Pistacia chinensis* Bunge (Chinese pistache); P; T; iNat
Rhus copallinum L. (shining sumac); P; S; 642
Rhus glabra L. (smooth sumac); P; S; 594
Toxicodendron pubescens Mill. (Atlantic poison oak); P; S; NC
Toxicodendron radicans (L.) Kuntze (eastern poison ivy); P; S/V; NC

Apiaceae
Chaerophyllum procumbens (L.) Crantz (spreading chervil); A; F; iNat
Chaerophyllum tainturieri Hook. (hairyfruit chervil); A; F; 529
**Conium maculatum* L. (poison hemlock); B; F; 585
Daucus pusillus Michx. (American wild carrot); A; F; 566
Polytaenia nuttallii DC. (prairie parsley); B; F; 545
Sanicula canadensis L. (black snakeroot); B; F; 591
Trepocarpus aethusae Nutt. ex DC. (whitenymph); A; F; 599

Apocynaceae
Asclepias tuberosa L. (butterfly milkweed); P; F; 588
Asclepias verticillata L. (whorled milkweed); P; F; iNat
Asclepias viridiflora Raf. (green comet milkweed); P; F; 617
Asclepias viridis Walter (green antelopehorns); P; F; NC
**Vinca major* L. (greater periwinkle); P; F; iNat

Aquifoliaceae
Ilex vomitoria Aiton (yaupon holly); P; S; iNat

Araliaceae
**Hedera helix* L. (common ivy); P; V; iNat
Hydrocotyle verticillata Thunb. (whorled pennywort); P; F; 435

Asparagaceae
Androstephium coeruleum (Scheele) Greene (funnel-flower); P; F; iNat
**Ornithogalum umbellatum* L. (common star-of-Bethlehem); P; F; iNat
Yucca arkansana Trel. (Arkansas yucca); P; F; iNat
Yucca glauca Nutt. (Great Plains yucca); P; F; NC

Aspleniaceae
Asplenium platyneuron (L.) Britton, Sterns & Poggenb. (ebony spleenwort); P; FN; 542

Asteraceae
Achillea millefolium L. (common yarrow); P; F; 561
Ageratina altissima (L.) King & H. Rob. (white snakeroot); P; F; NC
Ambrosia bidentata Michx. (lanceleaf ragweed); A; F; 593
Ambrosia psilostachya DC. (western ragweed); A; F; 471
Ambrosia trifida L. (giant ragweed); A; F; 474
Amphiachyris dracunculoides (DC.) Nutt. (prairie broomweed); A; F; 668
Antennaria neglecta Greene (field pussytoes); P; F; iNat
Antennaria parlinii Fernald (Parlin's pussytoes); P; F; iNat
Antennaria plantaginifolia (L.) Richardson (plantain-leaved pussytoes); P; F; 539
Artemisia ludoviciana Nutt. (silver wormwood); P; F; NC
Bidens aristosa (Michx.) Britton (bearded beggarticks); A; F; NC
Bidens bipinnata L. (Spanish needles); A; F; 472
Bidens polylepis S.F. Blake (tickseed sunflower); A; F; 481
Bradburia pilosa (Nutt.) Semple (soft goldaster); A; F; 621
**Carduus nutans* L. (musk thistle); B; F; 578
Cirsium altissimum (L.) Hilln (tall thistle); B; F; 431
Cirsium undulatum (Nutt.) Spreng. (wavyleaf thistle); B; F; 664
Conoclinium coelestinum (L.) DC (blue mistflower); P; F; 480
Coreopsis grandiflora Hogg ex Sweet (large-flowered tickseed); P; F; 575
Coreopsis tinctoria Nutt. (plains coreopsis); P; F; 389
Diaperia prolifera (Nutt. ex DC.) Nutt. (flathead rabbit tobacco); A; F; 538
Diaperia verna (Raf.) Morefield (many stem evax); A; F; iNat
Echinacea angustifolia DC. (narrow-leaved purple coneflower); P; F; 577
Eclipta prostrata (L.) L. (false daisy); A; F; 422
Elephantopus carolinianus Raeusch. (leafy elephant's-foot); P; F; 488
Erigeron canadensis (L.) Cronquist (horseweed); A; F; 644
Erigeron modestus A. Gray (plains fleabane); P; F; 602
Erigeron philadelphicus L. (Philadelphia fleabane); B; F; 555
Erigeron strigosus Muhl. ex Willd. (daisy fleabane); A; F; 587
Eupatorium serotinum Michx. (late boneset); P; F; 648

Facelis retusa (Lam.) Sch. Bip. (annual trampweed); A; F; 554
Gaillardia aestivalis (Walter) H. Rock (lanceleaf blanketflower); P; F; 444
Gaillardia pulchella Foug. (Indian blanket); P; F; iNat
Gaillardia suavis (A. Gray & Engelm.) Britton & Rusby (perfumeballs); P; F; 549
Gamochaeta pensylvanica (Willd.) Cabrera (Pennsylvania cudweed); A; F; 655
Gamochaeta purpurea (L.) Cabrera (purple cudweed); A; F; 537
Grindelia ciliata (Nutt.) Spreng. (Spanish gold); A; F; 467
Helenium amarum (Raf.) H. Rock (bitterweed); A; F; NC
Helianthus annuus L. (common sunflower); A; F; 660
Helianthus maximiliani Schrad. (Maximilian sunflower); P; F; iNat
Helianthus tuberosus L. (Jerusalem artichoke); P; F; 466
Heterotheca subaxillaris (Lam.) Britton & Rusby (camphorweed); A; F; 455
Hymenopappus scabiosaeus L'Hér. (Carolina woollywhite); B; F; 544
Krigia occidentalis (dwarf dandelion); A; F; iNat
Lactuca floridana (L.) Gaertn. (woodland lettuce); A; F; 458
Lactuca serriola L. (prickly lettuce); A; F; 643
Liatris punctata Hook. (dotted gayfeather); P; F; 475
Palafoxia rosea Bush (Cory) (rosy palafox); A; F; 432
Pluchea odorata (L.) Cass. (marsh fleabane); A; F; 453
Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt (sweet everlasting); A; F; NC
Pyrrhopappus carolinianus (Walter) DC. (Carolina desert-chicory); B; F; 658
Pyrrhopappus grandiflorus (Nutt.) Nutt. (tuberous desert-chicory); P; F; 528
Pyrrhopappus pauciflorus (D. Don) DC. (smallflower desert-chicory); A; F; iNat
Ratibida columnifera (Nutt.) Woot. & Standl. (upright prairie coneflower); P; F; 623
Rudbeckia hirta L. (black-eyed Susan); A; F; 620
Senecio vulgaris L. (common groundsel); A; F; iNat
Solidago canadensis L. (Canada goldenrod); P; F; iNat
Solidago missouriensis Nutt. (Missouri goldenrod); P; F; 456
Solidago nemoralis Aiton (field goldenrod); P; F; 484
Solidago rigida L. (stiff-leaved goldenrod); P; F; 485
Sonchus asper (L.) Hill (prickly sowthistle); A; F; iNat
Symphyotrichum divaricatum (Nutt.) G.L. Nesom (southern annual saltmarsh aster); A; F; iNat
Symphyotrichum drummondii (Lindl.) G.L. Nesom (Drummond's aster); P; F; 486
Symphyotrichum ericoides (S.F. Blake) G.L. Nesom (white heath aster); P; F; 469
Symphyotrichum oblongifolium (Nutt.) G.L. Nesom (aromatic aster); P; F; NC
Symphyotrichum subulatum (Michx.) G.L. Nesom (annual saltmarsh aster); A; F; 397
Taraxacum officinale F.H. Wigg. (common dandelion); P; F; iNat
Thelesperma filifolium (Hook.) A. Gray (stiff greenthread); A; F; NC
Tragopogon dubius Scop. (yellow salsify); A; F; NC
Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray (cowpen daisy); A; F; 651
Verbesina virginica L. (frostweed); B; F; iNat
Vernonia baldwinii Torr. (western ironweed); P; F; 647
Xanthium strumarium L. (rough cocklebur); A; F; 459

Berberidaceae

Nandina domestica Thunb. (heavenly bamboo); P; S; iNat

Bignoniaceae
Campsis radicans (L.) Seem. ex Bureau (American trumpet vine); P; V; 668

Boraginaceae
**Buglossoides arvensis* (L.) I.M. Johnst. (corn gromwell); A; F; iNat
Heliotropium tenellum (Nutt.) Torr. (pasture heliotrope); A; F; 382
Lithospermum incisum Lehm. (narrowleaf puccoon); P; F; 515
Myosotis macrosperma Engelm. (large-seeded forget-me-not); A; F; 667
Myosotis verna Nutt. (early forget-me-not); A; F; 534

Brassicaceae
**Camelina microcarpa* DC. (littlepod false flax); A; F; 540
**Cardamine hirsuta* L. (hairy bittercress); A; F; 505
**Chorispora tenella* (Pall.) DC. (crossflower); A; F; iNat
**Descurainia pinnata* (Walter) Britton (western Tansymustard); A; F; iNat
**Descurainia sophia* (L.) Webb ex Prantl (flixweed); A; F; 512
Draba brachycarpa Nutt. ex Torr. & A. Gray (short-fruited draba); A; F; iNat
Draba cuneifolia Nutt. ex Torr. & A.Gray (wedgeleaf draba); A; F; 494
**Lepidium densiflorum* Schrad. (common peppergrass); A; F; 506
Lepidium virginicum L. (Virginia pepperweed); A; F; 532
Rorippa palustris (L.) Besser (bog yellowcress); A; F; NC
Rorippa sessiliflora (Nutt.) Hitchc. (stalkless yellowcress); A; F; 614

Cactaceae
Escobaria missouriensis (Sweet) D.R. Hunt (Missouri foxtail cactus); P; S; iNat
Opuntia macrorhiza Engelm. (prairie pricklypear); P; S; NC

Campanulaceae
Lobelia cardinalis L. (Cardinal flower); P; F; 479
Triodanis holzingeri McVaugh (Holzinger's venus' looking-glass); A; F; 605
Triodanis perfoliata (L.) Nieuwl. (clasping venus's looking glass); A; F; 581

Cannabaceae
Celtis laevigata Willd. (sugar hackberry); P; T; 509
Celtis occidentalis L. (common hackberry); P; T; iNat

Caprifoliaceae
**Lonicera japonica* Thunb. (Japanese honeysuckle); P; V; iNat
Symphoricarpos orbiculatus Moench (coralberry); P; S; iNat
Valerianella radiata (L.) Dufr. (beaked cornsalad); A; F; iNat

Caryophyllaceae
**Arenaria serpyllifolia* L. (thyme-leaved sandwort); A ; F; iNat
**Cerastium glomeratum* Thuill. (sticky mouse-ear chickweed); A; F; iNat
**Cerastium pumilum* W. Curtis (dwarf mouse-ear); A; F; 508
**Holosteum umbellatum* L. (jagged chickweed); A; F; 495
**Scleranthus annuus* L. (annual knawel); A; F; 527
**Stellaria media* (L.) Vill. (common chickweed); A; F; 507

Celastraceae
**Euonymus fortunei* (Turcz.) Hand.-Maz. (wintercreeper); P; S; iNat

Commelinaceae
**Commelina communis* L. (Asiatic dayflower); A; F; 607
Commelina erecta L. (whitemouth dayflower); P; F; iNat
Tradescantia ohiensis Raf. (bluejacket); P; F; 560

Convolvulaceae
**Ipomoea hederacea* Jacq. (ivy-leaved morning-glory); A; V; iNat

Cornaceae
Cornus drummondii C.A. Mey. (roughleaf dogwood); P; S; 576

Cupressaceae
Juniperus virginiana L. (eastern redcedar); P; T; 589

Cyperaceae
Carex blanda Dewey (eastern woodland sedge); P; G; 535
Carex crus-corvi Shuttlew. ex Kunze (ravenfoot sedge); P; G; 564
Carex grisea Wahlenb. (inflated narrow-leaved sedge); P; G; iNat
Carex hyalinolepis Steud. (shoreline sedge); P; G; iNat
Carex lurida Wahlenb. (sallow sedge); P; G; 609
Cyperus croceus Vahl (Baldwin's flatsedge); P; G; 650
Cyperus echinatus (L.) Alph. Wood (globe flatsedge); P; G; 611
Cyperus squarrosus L. (bearded flatsedge); A; G; NC
Eleocharis acicularis (L.) Roem. & Schult. (needle spikerush); A; G; 429
Eleocharis obtusa (Willd.) Schult. (blunt spikerush); P; G; NC
Eleocharis palustris (L.) Roem. & Schult. (common spike-rush); P; G; iNat
Fuirena simplex Vahl (western umbrella-sedge); P; G; 396

Ebenaceae
Diospyros virginiana L. (common persimmon); P; T; 580

Equisetaceae
Equisetum hyemale A. Braun (rough horsetail); P; FN; 606
Equisetum laevigatum A. Braun (smooth horsetail); P; FN; iNat

Euphorbiaceae
Acalypha ostryifolia Riddell (hophornbeam copperleaf); A; F; 413
Acalypha virginica L. (Virginia three-seed mercury); A; F; 468
Chamaesyce maculata (L.) Small (spotted spurge); A; F; 400
Croton capitatus Michx. (hogwort); P; F; NC
**Croton glandulosus* L. (tropic croton); A; F; 411
Croton lindheimerianus Scheele (threeseed croton); A; F; iNat
Croton monanthogynus Michx. (prairie tea); A; F; 390
Euphorbia corollata L. (flowering spurge); P; F; 476
**Euphorbia dentata* Michx. (green poinsettia); A; F; 410

Euphorbia hexagona Nutt. ex Spreng. (sixangle spurge); A; F; 463
Euphorbia nutans Lag. (nodding spurge); A; F; 448
Euphorbia spathulata Lam. (reticulate-seeded spurge); A; F; 550

Fabaceae
Astragalus lotiflorus Hook. (low milkvetch); P; F; 513
Baptisia australis (L.) R. Br. (tall blue wild indigo); P; F; 551
Cercis canadensis L. (eastern redbud); P; T; NC
Chamaecrista fasciculata (Michx.) Greene (partridge pea); A; F; 421
Clitoria mariana L. (pigeonwings); P; F; iNat
Dalea aurea Nutt. ex Fraser (golden prairie clover); P; F; 645
Dalea candida Michx. ex Willd. (white prairie clover); P; F; 616
Dalea enneandra Nutt. ex Fraser (nine-anther prairie clover); P; F; 634
Dalea multiflora (Nutt.) Shinners (roundhead prairie clover); P; F; iNat
Dalea purpurea Vent. (purple prairie clover); P; F; iNat
Desmanthus illinoensis (Michx.) MacMill. ex B.L. Rob. & Fernald (Illinois bundleflower); P; S; iNat
Desmodium sessilifolium (Torr.) Torr. & A. Gray (sessileleaf ticktrefoil); P; F; 443
Gleditsia triacanthos L. (honey locust); P; T; 557
Gymnocladus dioicus (L.) K. Koch (Kentucky coffeetree); P; T; iNat
Lespedeza capitata Michx. (round-headed bush clover); P; F; NC
**Lespedeza cuneata* (Dum. Cours.) G. Don (Chinese bushclover); P; F; 451
Lespedeza virginica (L.) Britton (slender bush clover); P; F; iNat
**Medicago minima* (L.) L. (little bur-clover); A; F; iNat
Mimosa nuttallii (DC. ex Britton & Rose) B.L. Turner (catclaw briar); P; F; iNat
Mimosa quadrivalvis L. (fourvalve mimosa); P; F; 573
Neptunia lutea (Leavenw.) Benth. (yellow puff); P; F; 638
Pediomelum digitatum (Nutt. ex Torr. & A. Gray) Isely (palmleaf indian breadroot); P; F; 624
Psoralidium tenuiflorum (Pursh) Rydb. (slimflower scurfpea); P; F; 445
Strophostyles helvola (L.) Elliott (trailing fuzzy-bean); A; F; 464
Strophostyles leiosperma (Torr. & A. Gray) Piper (slickseed fuzzybean); A; F; 465
Stylosanthes biflora (L.) Britton, Sterns & Poggenb. (sidebeak pencilflower); P; F; 603
**Trifolium arvense* L. (rabbitfoot clover); A; F; 619
**Trifolium campestre* Schreb. (hop trefoil); A; F; iNat
**Vicia sativa* L. (common vetch); A; F; 517
**Vicia villosa* Roth (hairy vetch); A; F; 583

Fagaceae
Quercus macrocarpa Michx. (bur oak); P; T; iNat
Quercus marilandica Münchh. (blackjack oak); P; T; 510
Quercus muehlenbergii Engelm. (chinkapin oak); P; T; iNat
Quercus shumardii Buckley (Shumard's oak); P; T; iNat
Quercus stellata Wangenh. (post oak); P; T; 541

Gentianaceae
Sabatia campestris Nutt. (meadow pink); A; F; 615

Geraniaceae
**Erodium cicutarium* (L.) L'Hér. ex Aiton (redstem stork's-bill); A; F; 490
Geranium carolinianum L. (Carolina crane's-bill); A; F; 530

Grossulariaceae
Ribes aureum L. (golden currant); P; S; 501

Hypericaceae
Hypericum hypericoides (L.) Crantz (St. Andrew's cross); P; F; NC

Iridaceae
Sisyrinchium angustifolium Mill. (narrow-leaved blue-eyed grass); P; F; iNat

Juglandaceae
Juglans nigra L. (eastern black walnut); P; T; iNat

Juncaceae
Juncus acuminatus Michx. (tapered rush); P; G; 569
Juncus diffusissimus Buckley (slim-pod rush); P; G; 613
Juncus torreyi Coville (Torrey's rush); P; G; 393
Juncus validus Coville (roundhead rush); P; G; 610

Krameriaceae
Krameria lanceolata Torr. (trailing rhatany); P; F; 596

Lamiaceae
Hedeoma hispida Pursh (rough false pennyroyal); A; F; 568
Hedeoma reverchonii (A. Gray) A. Gray (Reverchon's false pennyroyal); P; F; 665
**Lamium amplexicaule* L. (henbit deadnettle); A; F; iNat
Monarda clinopodioides A. Gray (basil beebalm); A; F; 636
Monarda punctata L. (spotted horse mint); A; F; 635
Salvia azurea L. (giant blue sage); P; F; 477
Teucrium canadense L. (American germander); P; F; 667

Linaceae
Linum rigidum Pursh (yellow flax); A; F; NC
Linum sulcatum Riddell (grooved yellow flax); A; F; iNat

Linderniaceae
Lindernia dubia (L.) Pennell (yellowseed false pimpernel); A; F; 438

Loasaceae
Mentzelia oligosperma Nutt. ex Sims (stick-leaf); P; F; 639

Lythraceae
Ammannia coccinea Rottb. (scarlet toothcup); A; F; 439
Lythrum alatum Pursh (winged loosestrife); P; F; NC

Malvaceae
Callirhoe involucrata (Torr. & A. Gray) A. Gray (winecup mallow); P; F; 633
Hibiscus moscheutos L. (swamp rose mallow); A; F; NC
Sida spinosa L. (prickly fanpetals); A; F; 427

Mazaceae
**Mazus pumilus* (Burm. f.) Steenis (Japanese mazus); A; F; NC

Menispermaceae
Cocculus carolinus (L.) DC. (Carolina snailseed); P; V; iNat

Molluginaceae
Mollugo verticillata L. (green carpetweed); A; F; 418

Montiaceae
Claytonia virginica L. (Virginia springbeauty); P; F; NC

Moraceae
Maclura pomifera (Raf.) C.K.Schneid. (Osage-orange); P; T; NC
Morus rubra L. (red mulberry); P; T; NC

Nyctaginaceae
Mirabilis albida (Walter) Heimerl (white four o'clock); P; F; 478

Oleaceae
Fraxinus americana L. (white ash); P; T; iNat
Fraxinus pennsylvanica Marshall (green ash); P; T; iNat

Onagraceae
Ludwigia peploides (Kunth) P.H. Raven (floating primrose-willow); P; F; iNat
Oenothera berlandieri (Spach) Steud. (Berlandier's sundrops); A; F; 552
Oenothera biennis L. (common evening-primrose); B; F; 460
Oenothera curtiflora W.L. Wagner & Hoch (velvetweed); A; F; 391
Oenothera filiformis (Small) W.L. Wagner & Hoch (longflower beeblossom); A; F; 388
Oenothera glaucifolia W.L. Wagner & Hoch (false gaura); B; F; NC
Oenothera laciniata Hill (cutleaf evening primrose); A; F; 553

Ophioglossaceae
Ophioglossum engelmannii Prantl (limestone adder's-tongue); P; FN; iNat

Orobanchaceae
Agalinis heterophylla (Nutt.) Small (prairie false foxglove); A; F; NC
Castilleja indivisa Engelm. (Texas paintbrush); A; F; 394

Oxalidaceae
Oxalis corniculata L. (creeping woodsorrel); A; F; iNat
Oxalis dillenii Jacq. (slender yellow woodsorrel); P; F; NC
Oxalis violacea L. (violet woodsorrel); P; F; iNat

Papaveraceae
Argemone polyanthemos (Fedde) G.B. Ownbey (thistle poppy); A; F; 442
Corydalis aurea Willd. (golden corydalis); A; F; iNat
Corydalis micrantha (Engelm. ex A. Gray) A. Gray (smallflower fumewort); A; F; 511

Passifloraceae
Passiflora incarnata L. (purple passionflower); P; V; 449

Phrymaceae
†Mimulus ringens L. (Allegheny monkeyflower); P; F; 666

Plantaginaceae
Leucospora multifida (Michx.) Nutt. (Obi-Wan conobea); A; F; 395
Nuttallanthus texanus (Scheele) D.A. Sutton (Texas toadflax); A; F; 526
Penstemon cobaea Nutt. (cobaea beardtongue); P; F; 572
Penstemon laxiflorus Pennell (nodding beardtongue); P; F; 559
Plantago aristata Michx. (bracted plantain); A; F; 586
**Plantago lanceolata* L. (ribwort plantain); A; F; NC
Plantago patagonica Jacq. (woolly plantain); A; F; 597
Plantago rhodosperma Decne. (redseed plantain); A; F; 531
Veronica anagallis-aquatica L. (blue water-speedwell); B; F; iNat
**Veronica arvensis* L. (corn speedwell); A; F; iNat
Veronica peregrina L. (purslane Speedwell); A; F; iNat

Poaceae
Andropogon gerardii Vitman (big bluestem); P; G; iNat
Andropogon ternarius Michx. (splitbeard bluestem); P; G; iNat
Andropogon virginicus L. (broomsedge bluestem); P; G; iNat
**Bothriochloa ischaemum* (L.) Keng (king ranch bluestem); P; G; 622
Bothriochloa laguroides (DC.) Herter (silver bluestem); P; G; iNat
Bouteloua curtipendula (Michx.) Torr. (sideoats grama); P; G; 653
Bouteloua dactyloides (Nutt.) Columbus (buffalograss); P; G; 562
Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths (blue grama); P; G; iNat
Bouteloua hirsuta Lag. (hairy grama); P; G; 659
**Bromus catharticus* Vahl (rescue brome); P; G; iNat
**Bromus tectorum* L. (cheatgrass); A; G; 520
Cenchrus spinifex Cav. (coastal sandbur); A; G; 434
Chasmanthium latifolium (Michx.) Yates (inland wood oats); P; G; iNat
Chasmanthium laxum (L.) H.O. Yates (slender spikegrass); P; G; NC
Dichanthelium oligosanthes (Schult.) Gould (Heller's rosette grass); P; G; 563
Digitaria cognata (Schult.) Pilg. (fall witchgrass); P; G; iNat
Elymus glabriflorus (Vasey ex L.H. Dewey) Scribn. & C.R. Ball (southeastern wildrye); P; G; iNat
Eragrostis secundiflora J. Presl (red lovegrass); P; G; 654
Eragrostis sessilispica Buckley (tumble lovegrass); P; G; 656
**Lolium multiflorum* Lam. (Italian ryegrass); A; G; 604
**Lolium perenne* L. (perennial ryegrass); A ; G; 595
Muhlenbergia schreberi J.F. Gmel. (nimblewill); P; G; iNat

Paspalum setaceum Michx. (thin paspalum); P; G; NC
Schizachyrium scoparium (Michx.) Nash (little bluestem); P; G; iNat
**Setaria faberi* Herrm. (giant foxtail); A; G; iNat
**Setaria pumila* (Poir.) Roem. & Schult. (yellow foxtail); A; G; 649
Sorghastrum nutans (L.) Nash (Indiangrass); P; G; iNat
Sphenopholis obtusata (Michx.) Scribn. (prairie wedge grass); A; G; 582
Tridens albescens (Vasey) Wooton & Standl. (white tridens); P; G; NC
Tridens flavus (L.) Hitchc. (purpletop tridens); P; G; iNat
Vulpia octoflora (Walter) Rydb. (sixweeks fescue); A; G; NC

Polygonaceae
Eriogonum annuum Nutt. (annual buckwheat); A; F; 415
Eriogonum longifolium Nutt. (longleaf buckwheat); P; F; 426
**Polygonum persicaria* L. (lady's thumb); A; F; iNat
Persicaria punctata (Elliott) Small (dotted knotweed); A; F; 436
**Rumex crispus* L. (curly dock); P; F; 584
Rumex hastatulus Baldwin (hastate-leaved dock); P; F; 570

Primulaceae
Samolus valerandi L. (seaside brookweed); P; F; 612

Ranunculaceae
Ranunculus abortivus L. (small-flowered buttercup); B; F; iNat
Ranunculus sceleratus L. (cursed crowfoot); A; F; iNat

Rosaceae
Geum canadense Jacq. (white avens); P; F; iNat
Prunus angustifolia Marshall (Chickasaw plum); P; S; 499
Prunus mexicana S.Watson (Mexican plum); P; T; NC
**Rosa multiflora* Thunb. (multiflora rose); P; V; iNat
Rubus trivialis Michx. (southern dewberry); P; V; 579

Rubiaceae
Cephalanthus occidentalis L. (buttonbush); P; S; 216
Diodia teres Walter (rough buttonweed); P; F; 387
Diodia virginiana L. (buttonweed); A; F; 608
Galium aparine L. (catchweed bedstraw); A; F; iNat
Galium virgatum Nutt. (southwestern bedstraw); A; F; NC
Houstonia pusilla Schoepf (tiny bluet); A; F; 496
**Sherardia arvensis* L. (field madder); A; F; NC
Stenaria nigricans (Lam.) Terrell (diamond-flowers); P; F; iNat

Salicaceae
Populus deltoides W. Bartram ex Marshall (eastern cottonwood); P; T; iNat
Salix nigra Marshall (black willow); P; T; iNat

Sapindaceae
Acer negundo L. (boxelder); P; T; iNat
Acer saccharinum L. (silver maple); P; T; iNat
**Koelreuteria paniculata* Laxm. (goldenrain tree); P; T; 645
Sapindus drummondii Hook. & Arn. (western soapberry); P; T; 618

Sapotaceae
Sideroxylon lanuginosum Michx. (gum bumelia); P; T; 637

Scrophulariaceae
**Verbascum thapsus* L. (great mullein); B; F; 440

Smilacaceae
Smilax bona-nox L. (saw greenbrier); P; V; 547

Solanaceae
**Datura wrightii* Regel (sacred datura); P; F; iNat
Physalis angulata L. (cutleaf groundcherry); A; F; 446
Solanum carolinense L. (carolina horsenettle); P; F; 590
Solanum dimidiatum Raf. (western horsenettle); P; F; 558
Solanum rostratum Dunal (buffalo-bur); A; F; 441

Ulmaceae
Ulmus americana L. (American elm); P; T; 491
**Ulmus pumila* L. (Siberian elm); P; T; iNat
Ulmus rubra Muhl. (slippery elm); P; T; iNat

Urticaceae
Parietaria pensylvanica Muhl. ex Willd. (Pennsylvania pellitory); A; F; 592

Verbenaceae
Glandularia pumila (Rydb.) Umber (dwarf verbena); A; F; 533
Phyla nodiflora (L.) Greene (turkey tangle frogfruit); P; F; 425
Verbena stricta Vent. (hoary vervain); A; F; NC
Verbena urticifolia L. (white vervain); P; F; 433

Viburnaceae
Viburnum rufidulum Raf. (rusty blackhaw); P; T; iNat

Violaceae
Viola rafinesquii Greene (American field pansy); A; F; 502
Viola sororia Willd. (common blue violet); A; F; iNat
Viola villosa Walter (Carolina violet); P; F; iNat

Vitaceae
Parthenocissus quinquefolia (L.) Planch. (Virginia creeper); P; V; iNat
Vitis vulpina L. (frost grape); P; V; 565

Woodsiaceae
Woodsia obtusa (Spreng.) Torr. (blunt woodsia); P; FN; 546

FLORISTIC SURVEY AT BELLE ISLE AT THE DEEP FORK RIVER IN OKLAHOMA CITY, OKLAHOMA

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ABSTRACT

A floristic survey was conducted at Belle Isle at the Deep Fork River in northwest Oklahoma City. Belle Isle at the Deep Fork River is an urban semi-natural area that has been subjected to a wide array of anthropogenic disturbances. The goal of this study was to observe and document all vascular plant species within the research area. Thirty-four site visits yielded 135 plant species representing 44 plant families and 116 genera. Forty-four (32.6%) of observed species were non-native. All observed vascular plant species were posted on iNaturalist. Two county records were documented, and no species tracked by the Oklahoma Natural Heritage Inventory were observed. This baseline floristic data can be used for biodiversity studies and ecological assessments.

INTRODUCTION AND STUDY AREA

Belle Isle at the Deep Fork River (BIDFR) is in northwest Oklahoma City in central Oklahoma County, Oklahoma (Figure 1). Belle Isle is an area of Oklahoma City that encompasses the Wileman's Belle Isle Neighborhood, Penn Square Mall, Belle Isle Station (a shopping center), Rose Hill Cemetery, and various green spaces and semi-natural areas. The green spaces and semi-natural areas consist of mowed fields, forests, grasslands, two streams, a pond, and a 1.2 km section of the Deep Fork River. The southwest and northeast sections of the river are concrete drainage ditches, while the central area is a semi-natural river (Figure 2).

The BIDFR study area is approximately 83 ha. It is located between Pennsylvania Avenue on the west, Classen Boulevard on the east, Northwest 59th Street on the north, and Northwest 53rd Street on the south. The study site ranges between the latitude 35.531357 and 35.531140 and longitude -97.540018 and -97.540404.

BIDFR sits on the border of the Central Great Plains and the Cross Timbers ecoregions (Figure 1). The Cross Timbers stretches from north-central Texas through central Oklahoma to its northern reaches in southern Kansas (Omernik 1987). The Cross Timbers comprises over 4.8 million hectares, approximately half of which are in Oklahoma (Küchler 1964; Thomas and Hoagland 2011). The Cross Timbers is a mixture of diverse habitats: forest, savanna, grassland, and wetland. The predominant tree species are *Quercus stellata* Wangenh. (post oak) and *Quercus marilandica* Münchh. (blackjack oak) (Duck and Fletcher 1945). The Central Great Plains ecoregion is a mixed-grass prairie that extends from Nebraska south through Kansas, Oklahoma, and Texas (Omernik 1987). The mixed-grass prairie is a combination of tallgrass and shortgrass vegetation. The dominant

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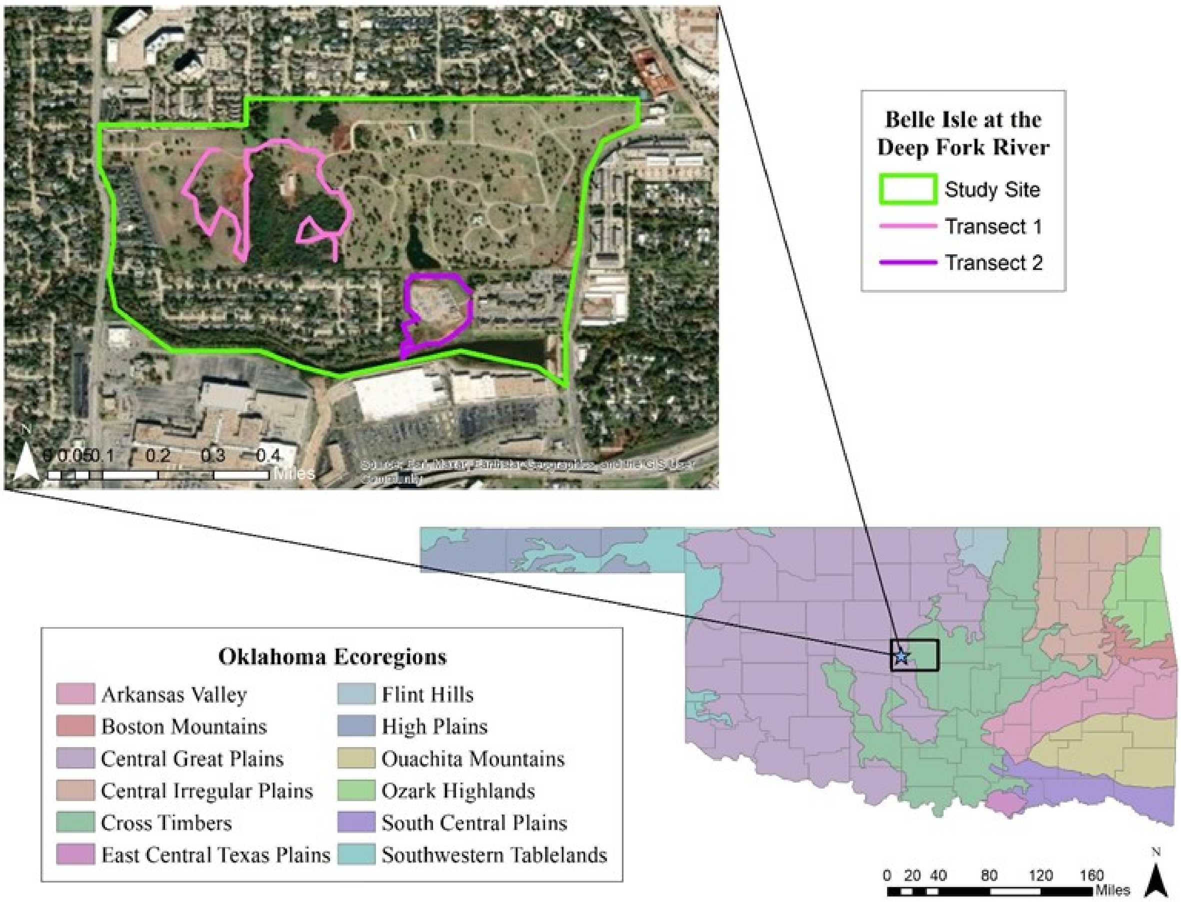

Figure 1 Oklahoma ecoregions and Belle Isle at the Deep Fork River study site.

genera are *Schizachyrium, Stipa, Elymus, Pascopyrum, Calamovilfa, Bouteloua, Sporobolus, Buchloe, Muhlenbergia, Carex, and Aristida* (Barbour and Billings 2000).

BIDFR falls within the temperate humid subtropical climate zone. This climate zone is characterized by hot and humid summers and cool to mild winters (Köppen 1936). Oklahoma County's average annual climate statistics include a growing season of 213 days, 92.4 cm of rainfall, and a temperature of 15.5°C. The average last spring freeze is April 4 and the average first fall freeze is November 2. Average annual snowfall is 17.5 cm, and average wind speed is 12.8 kph. The record high temperature is 45°C, and the record low is -26°C. The latest recorded freeze date is April 20, and the earliest is October 21 (Oklahoma Climatological Survey 2000; Mesonet 2023).

METHODS

Fieldwork was conducted from April 19, 2022 to October 23, 2023. Thirty-four site visits were made during this time. Site visit frequency was every two weeks during the growing season and once a month during winter. Two transects were designed to cover as much of the grassland, forest, and riparian habitat as possible. Transect 1 was approximately 1,329 m, and Transect 2 was 753 m (Figure 1). Most plants in the survey were observed along the two transects, but some plants were observed in the broader study area. An iNaturalist project, Belle Isle at the Deep Fork River, was created for the study site (https://www.inaturalist.org/projects/belle-isle-at-deep-fork-river).

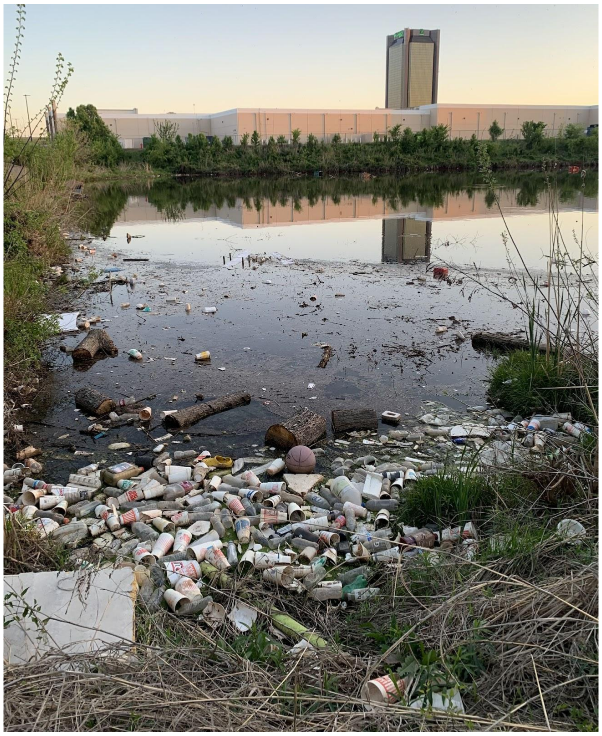

Figure 2 Semi-natural river section of Belle Isle at Deep Fork River, near Penn Square Mall. Photo by Benjamin Davis.

As each species was encountered, photos of key morphological characteristics (flower, stem, and leaves) were uploaded to iNaturalist. Only species not easily identified in the field were collected. Collected plant specimens were deposited in the University of Central Oklahoma Herbarium (CSU). All plant observations were uploaded to iNaturalist and the iNaturalist algorithm was allowed to make a suggested identification. The iNaturalist algorithm uses a vision model and nearby observations to suggest possible species identifications. This algorithm was found to be between 70 and 85% accurate when tested across all taxa. However, plant identification accuracy may be as low as 60% accurate in locales with fewer experts contributing identifications (iNaturalist 2019). All identifications were further confirmed or corrected using the *Flora of Oklahoma: Keys and Descriptions* (Ryburn et al. 2018; Fishbein et al. 2024) or the *Illustrated Flora of North Central Texas* (Diggs et al. 2000). The USDA Plants Database (2024) was used to determine nativity, duration, and growth habit. Nomenclature and classification follow the Integrated Taxonomic Information System (2024).

RESULTS AND DISCUSSION

A total of 135 individual species representing 44 plant families and 118 genera were observed and documented at BIDFR (Appendix). Forty-four (32.6%) species found at BIDFR were non-native. Plant duration statistics included 53 annuals (39.3%), 78 perennials (57.8%), and four biennials (3.0%). The growth habit statistics were 88 forbs (65.2%), 13 (9.6%) trees, 20 graminoids (14.8%), nine shrubs (6.7%), five vines (3.7%), and zero ferns. The most prominent plant families observed were Asteraceae with 29 species (21.5%), Fabaceae with 16 species (11.9%), Poaceae with 13 species (9.6%), and Cyperaceae with 6 species (4.4%). Plant families with the most observed non-native species included Fabaceae (seven species), Poaceae (six species), and Asteraceae (four species). Two county records were found: *Quercus fusiformis* Small (Texas live oak) and *Mimosa quadrivalvis* L. (fourvalve mimosa). We suspect that the *Q. fusiformis* observed is not naturally occurring and was most likely planted as the study site is outside of its range. No species tracked by the Oklahoma Natural Heritage Inventory (2024) were observed. The observed taxa constitute 5% of the 2,657 vascular plants found in Oklahoma (Fishbein et al. 2024).

Compared to four other nearby plant surveys, BIDFR had the highest percentage of non-native species and the lowest plant species richness (Table 1). This is likely due to the anthropogenic stressors affecting BIDFR: soil compaction, increased nutrient load, pollution, herbicides, pesticides, and ecosystem fragmentation. The four nearest inventories used for comparison were found in Oklahoma, Cleveland, Canadian, and McClain counties.

Table 1 The four closest plant inventories to the BIDFR study site.

Study Site	County	Reference	Size of site	Number of Taxa	Percent non-native
Arcadia Lake	Oklahoma	Friedman 2024a	274 ha	356	16.6%
E.C. Hafer Park	Oklahoma	Caddell et al. 2017	49 ha	270	22.2%
John W. Nichols Scout Ranch	Canadian	Crosswhite & Ryburn 2019	150 ha	152	13.6%
University of Oklahoma's Kessler Atmospheric and Ecological Field Station	McClain	Buthod & Hoagland 2016	146 ha	361	14.7%
Belle Isle at the Deep Fork River (plant survey)	Oklahoma	Friedman 2024b	83 ha	135	32.6%

Figure 3 Side tributary within the study area leading into the Deep Fork River, further downstream from Penn Square Mall. Photo by Micah Friedman.

Belle Isle at the Deep Fork River is a familiar landscape across US cities–a river running through a city surrounded by pockets of green space, strip malls, utility infrastructure, litter, encampments, and neighborhoods. Considering the development and ecological damage BIDFR has sustained (Figure 2), this area still provides ecological services and supports a variety of organisms (Figure 3). Understanding the plant community composition at BIDFR will add to the region's botanical knowledge and help us understand areas that have undergone significant anthropogenic stressors. This baseline floristic data can be used for tracking invasives, monitoring rare or threatened species, climate research, and future biodiversity indices.

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APPENDIX
List of vascular plant taxa from Belle Isle at the Deep Fork River, Oklahoma County, Oklahoma.

Taxa list with duration, growth habit, and nativity. * denotes an exotic taxa.
Duration is denoted by A = Annual, P = Perennial, and B = Biennial.
Growth habit is denoted by: F = forb, FN = fern, S = shrub, V = vine, T = tree, G = graminoid.
Nativity, duration, and growth habit were determined using the USDA Plants Database (USDA 2024).

Acanthaceae
Dicliptera brachiata (Pursh) Spreng. (false mint); A; F

Altingiaceae
Liquidambar styraciflua L. (American sweetgum); P; T

Amaryllidaceae
Allium canadense L. (Canadian meadow garlic); P; F
Allium drummondii Regel (Drummond's onion); P; F
**Allium vineale* L. (wild garlic); P; F
Nothoscordum bivalve (L.) Britton (crowpoison); P; F

Anacardiaceae
Pistacia chinensis Bunge (Chinese pistache); P; T
Rhus glabra L. (smooth sumac); P; S

Apiaceae
Ammoselinum popei Torr. & A. Gray (plains sandparsley); A; F
Conium maculatum L. (poison hemlock); B; F
Torilis arvensis (Huds.) Link (common hedge parsley); A; F

Apocynaceae
Asclepias viridis Walter (green antelopehorns); P; F

Aquifoliaceae
Ilex decidua Walter (possumhaw); P; S

Araceae
Lemna minor L. (common duckweed); P; F

Asparagaceae
Muscari botryoides (L.) Mill. (common grape hyacinth); P; F

Asteraceae
Achillea millefolium L. (common yarrow);P; F
Ambrosia psilostachya DC. (western ragweed); A; F
Amphiachyris dracunculoides (DC.) Nutt. (prairie broomweed); A; F
Artemisia ludoviciana Nutt. (silver wormwood); P; F
Bidens frondosa L. (devil's beggarticks); A; F
Carduus nutans L. (musk thistle); B; F

Cirsium altissimum (L.) Hill (tall thistle); B; F
Coreopsis tinctoria Nutt. (plains coreopsis); P; F
Eclipta prostrata (L.) L. (false daisy); A; F
Erigeron philadelphicus L. (Philadelphia fleabane); B; F
Erigeron strigosus Muhl. ex Willd. (daisy fleabane); A; F
Eupatorium serotinum Michx. (late boneset); P; F
Gaillardia suavis (A. Gray & Engelm.) Britton & Rusby (perfumeballs); P; F
Grindelia ciliata (Nutt.) Spreng. (Spanish gold); A; F
Helenium amarum (Raf.) H. Rock (bitterweed); A; F
Helianthus annuus L. (common sunflower); A; F
**Lactuca serriola* L. (prickly lettuce); A; F
Liatris punctata Hook. (dotted gayfeather); P; F
Packera plattensis (Nutt.) W.A. Weber & Á. Löve (prairie groundsel); P; F
Pyrrhopappus pauciflorus (D. Don) DC. (smallflower desert-chicory); A; F
Ratibida columnifera (Nutt.) Woot. & Standl. (upright prairie coneflower); P; F
Solidago nemoralis Aiton (field goldenrod); P; F
**Sonchus asper* (L.) Hill (prickly sowthistle); A; F
Symphyotrichum divaricatum (Nutt.) G.L. Nesom (southern annual saltmarsh aster); A; F
Symphyotrichum drummondii (Lindl.) G.L. Nesom (Drummond's aster); P; F
Symphyotrichum oblongifolium (Nutt.) G.L. Nesom (aromatic aster); P; F
**Taraxacum officinale* F.H. Wigg. (common dandelion); P; F
Thelesperma filifolium (Hook.) A. Gray (stiff greenthread); A; F
Xanthium strumarium L. (rough cocklebur); A; F

Bignoniaceae
Catalpa speciosa (Warder) Warder ex Engelm. (northern catalpa); P; T

Boraginaceae
**Buglossoides arvensis* (L.) I.M. Johnst. (corn gromwell); A; F

Brassicaceae
**Lepidium oblongum* Small (veiny pepperweed); A; F

Caprifoliaceae
**Lonicera maackii* (Rupr.) Herder (Amur honeysuckle); P; S

Caryophyllaceae
**Arenaria serpyllifolia* L. (thyme-leaved sandwort); A; F
Dianthus armeria L. (deptford pink); A; F

Commelinaceae
**Commelina communis* L. (Asiatic dayflower); A; F

Convolvulaceae
**Convolvulus arvensis* L. (field bindweed); P; V
Cuscuta campestris Yunck. (field dodder); P; V

Cornaceae
Cornus drummondii C.A. Mey. (roughleaf dogwood); P; S

Cyperaceae
Cyperus esculentus L. (yellow nutsedge); P; G
Cyperus squarrosus L. (bearded flatsedge); A; G
Eleocharis compressa Sull. (flat-stem spikerush); P; G
Eleocharis montevidensis A. Gray (sand spikerush); P; G
Eleocharis palustris (L.) Roem. & Schult. (common spike-rush); P; G
Schoenoplectus pungens (Vahl) Palla (three-square bulrush); P; G

Ebenaceae
Diospyros virginiana L. (common persimmon); P; T

Euphorbiaceae
Croton monanthogynus Michx. (prairie tea); A; F
Euphorbia nutans Lag. (nodding spurge); A; F
Euphorbia spathulata Lam. (reticulate-seeded spurge); A; F

Fabaceae
**Albizia julibrissin* Durazz. (Persian silk tree); P; T
Amorpha fruticosa L. (false indigo bush); P; S
Dalea candida Michx. ex Willd. (white prairie clover); P; F
Desmanthus illinoensis (Michx.) MacMill. ex B.L. Rob. & Fernald (Illinois bundleflower); P; F
Desmanthus leptolobus Torr. & A. Gray (prairie bundleflower); P; F
Gleditsia triacanthos L. (honey locust); P; T
**Lathyrus hirsutus* L. (hairy vetchling); A; F
**Medicago lupulina* L. (black medick); A; F
**Melilotus officinalis* (L.) Lam. (yellow sweetclover); A; F
Mimosa quadrivalvis L. (fourvalve mimosa); P; F
Neptunia lutea (Leavenw.) Benth. (yellow puff); P; F
Psoralidium tenuiflorum (Pursh) Rydb. (slimflower scurfpea); P; F
Robinia pseudoacacia L. (black locust); P; T
**Trifolium repens* L. (white clover); P; F
**Vicia sativa* L. (common vetch); A; F
**Vicia villosa* Roth (hairy vetch); A; F

Fagaceae
Quercus fusiformis Small (Texas live oak); P; T

Gentianaceae
Sabatia campestris Nutt. (meadow pink); A; F

Geraniaceae
**Erodium cicutarium* (L.) L'Hér. ex Aiton (redstem stork's-bill); A; F
**Geranium dissectum* L. (cut-leaved crane's-bill); A; F

Iridaceae
Sisyrinchium angustifolium Mill. (narrow-leaved blue-eyed grass); P; F

Juncaceae
Juncus torreyi Coville (Torrey's rush); P; G

Lamiaceae
**Lamium amplexicaule* L. (henbit deadnettle); A; F
Lycopus americanus Muhl. ex W.P.C. Barton (American bugleweed); P; F
Teucrium canadense L. (American germander); P; F

Lythraceae
Ammannia coccinea Rottb. (scarlet toothcup); A; F

Moraceae
Maclura pomifera (Raf.) C.K.Schneid. (Osage-orange); P; T

Oleaceae
Fraxinus pennsylvanica Marsh. (green ash); P; T
**Ligustrum quihoui* Carrière (quihoui privet); P; S
**Ligustrum sinense* Lour. (Chinese privet); P; S

Onagraceae
Oenothera suffulta (Engelm. ex A. Gray) W.L. Wagner & Hoch (roadside gaura); A; F

Oxalidaceae
Oxalis violacea L. (violet woodsorrel); P; F

Plantaginaceae
**Callitriche heterophylla* Pursh (large water-starwort); P; F
Plantago patagonica Jacq. (ribwort plantain); A; F
Plantago virginica L. (dwarf plantain); A; F
**Veronica arvensis* L. (corn speedwell); A; F
**Veronica peregrina* L. (purslane speedwell); A; F
**Veronica polita* Fr. (grey field-speedwell); A; F

Poaceae
Andropogon glomeratus (Walter) Britton, Sterns & Poggenb. (maritime bluestem); P; G
**Arundo donax* L. (giant reed); P; G
Bothriochloa laguroides (DC.) Herter (silver bluestem); P; G
**Bromus catharticus* Vahl (rescue brome); A; G
**Cynodon dactylon* (L.) Pers. (Bermuda grass); P; G
Dichanthelium oligosanthes (Schult.) Gould (Scribner's panicgrass); P; G
**Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass); A; G
Elymus canadensis L. (Canada wild rye); P; G
Eragrostis spectabilis (Pursh) Steud. (purple lovegrass); P; G
Hordeum pusillum Nutt. (little barley); A; G
**Paspalum dilatatum* Poir. (Dallis grass); P; G
Poa arachnifera Torr. (Texas bluegrass); P; G
**Secale cereale* L. (rye); A; G

Polygonaceae
**Rumex crispus* L. (curly dock); P; F

Ranunculaceae
Anemone caroliniana Walter (carolina anemone); P; F
**Clematis terniflora* DC. (autumn clematis); P; V
Ranunculus sceleratus L. (cursed crowfoot); A; F

Rosaceae
Prunus angustifolia Marshall (Chickasaw plum); P; S
**Pyrus calleryana* Decne. (callery pear); P; T
**Spiraea cantoniensis* Lour. (Reeve's spirea); P; S

Rubiaceae
**Cruciata pedemontana* (Bellardi) Ehrend. (piedmont bedstraw); A; F
Galium aparine L. (stickwilly); A; F
Houstonia pusilla Schoepf (tiny bluet); A; F
**Sherardia arvensis* L. (field madder); A; F

Salicaceae
Populus deltoides W. Bartram ex Marshall (eastern cottonwood); P; T
Salix nigra Marshall (black willow); P; T

Solanaceae
Solanum dimidiatum Raf. (western horsenettle); P; F
Solanum elaeagnifolium Cav. (silverleaf nightshade); P; F
Solanum rostratum Dunal (buffalo-bur); A; F

Verbenaceae
Phyla lanceolata (Michx.) Greene (lanceleaf frogfruit); P; F

Vitaceae
Ampelopsis cordata Michx. (heart leaf peppervine); P; V
Vitis rotundifolia Michx. (muscadine); P; V

Zygophyllaceae
**Tribulus terrestris* L. (puncture vine); A; F

Critic's Choice Essay

INVASIVE SPECIES TERMINOLOGY

Reprinted from Gaillardia, Winter 2017

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Terminology associated with invasive species can be extremely confusing and commonly misused. Through my years of teaching an ecology of invasive species class, I have found it easiest to start the students with very clear definitions, allow them time to firmly grasp those definitions and then move the discussion towards the exceptions. Noxious, invasive, nuisance, encroacher, and native-invader are five terms that need to be clearly defined and before further discussions into the important concept of invasive species can take place.

Noxious species are typically referred to as noxious weeds. These species are legally defined by federal, state, and local legislation. Noxious weeds cannot be bought, sold, traded, transported or possessed, and landowners are legally required to implement some sort of control practice (e.g. biological, mechanical, or chemical control) if found on their property. Most noxious weeds have historically been associated with agricultural production, while more recently, species listed as noxious weeds include species we have identified as invasive or nuisance.

The term nuisance is typically used in reference to aquatic nuisance species, or ANS. These species are found to be either aquatic species or species that invade areas close to aquatic systems. Species identified as ANS are also legally defined, typically at the state level through the official state ANS Management Plans. In Oklahoma, an aquatic nuisance species is one that poses both ecological and economic threats to native aquatic ecosystems. Species identified as ANS cannot be bought, sold, traded, transported or possessed. Within the past 20 years or so the federal government required states to have official ANS management plans to be eligible for federal funds to battle those aquatic nuisance species. These management plans serve as guidance documents to implement educational outreach, research, species monitoring, and prevention of spread.

In the United States, President Clinton's Executive Order 13112 provided the first formal definition of an invasive species: "an alien species which does or is likely to cause economic or environmental harm or harm to animal or human health." While both Presidents George W. Bush and Obama modified this executive order, this federal definition of invasive species remains in place. Based on this definition, used in the discipline of invasion ecology, "invasive species" is a descriptive, situational-dependent term. To be considered invasive, a species must have been introduced by humans (intentionally or accidently), subsequently established a self-reproducing population (i.e. naturalized), dispersed to secondary locations and established other sustainable populations, and have been shown to cause an impact such as harm to human health, harm to the economy, or harm to the environment. This definition is "situationally dependent" because a species

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might meet all of these requirements in one location and not in another, or experts may disagree about the extent of impacts or likelihood of causing harm. The definition is descriptive, because unlike "noxious" and "ANS", "invasive" species does not require any particular management and unless they are also on noxious weed and/or ANS lists, an invasive species can legally be bought, sold, possessed and traded. Importantly, however, an invasive species on the noxious weed list must also be controlled.

Now, let's move to the terms which I try to use very carefully in the first conversations I have with someone about invasive species: encroachers and native invaders. To clarify, noxious weeds, aquatic nuisance species and invasive species can be non-native (i.e. alien, exotic) whereas the terms encroaching and native-invader are more specifically used in reference to native species that have become problematic. A common example would be mesquite in the southwestern part of Oklahoma. Shifting management practices have prompted further range (or population) expansion and increased density of mesquite in some areas. Since it is a native species and is at undesirable levels in some areas, the term encroaching could be used as a more acceptable term for those wanting to protect the native species. To my knowledge, mesquite hasn't been planted commonly by humans, prompting its expansion; rather, management practices (e.g. overgrazing) have been instrumental in its expansion. In contrast, another problematic, native Oklahoma species, Eastern Redcedar, has been extensively planted by humans in habitats from which it was commonly not found. The success of this tree is not only tied to its extensive planting throughout Oklahoma, but also to the absence of fire in the prairie landscape. For many native plant enthusiasts, it is difficult to apply the term "invasive" to this native tree. That is why, when I first start teaching a group about invasives, I use the terms encroaching and native-invader when referencing Eastern Redcedar. However, it is important to re-emphasize that invasive species are 1) introduced by humans, intentionally or accidently; 2) capable of establishing and spreading; and 3) cause an impact, such as harm to human health, harm to the economy, and/or harm to the environment. Given the extensive planting of Eastern Redcedar in prairie landscapes; reduction in grassland obligate species in the presence of Eastern Redcedar; reduction in forage production for livestock; increased fire intensity in the presence of Eastern Redcedar, invasion ecologists can easily and correctly apply the term native-invader (or just invader) to Eastern Redcedar.

As I typically say in my classes, "what a tangled web we have" when discussing invasive species. Control of invaders can be an emotional issue, and even which words are used can result in many differences of opinion. Regardless of one's position on any particular invasive species, we must be careful to correctly use the appropriate terminology in our discussions.

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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The title page should state the affiliation and complete addresses of all authors and telephone number or email address for the corresponding author. Provide four key words not in the title. Research and technical papers should include a one-paragraph abstract of not more than 250 words. It should concisely state the goals, principal results, and major conclusions of the paper. All references, figures, and tables should be cited in the text. Site descriptions should include latitude, longitude, total area, and elevation. Measurements should be in SI units (metric). Use no headers, no footers, nor auto page numbering. Proof-read and verify taxa and taxa numbers before submission. Color photos may be submitted.

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-Peridoicum-Huntianum and its supplement, except in historic publications when original format may be used.

Authors are encouraged to submit manuscripts to the editor as an email file attachment to the email address below, preferably by August 1 for publication in December.

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Five Year Index to *Oklahoma Native Plant Record*

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In this issue of Oklahoma Native Plant Record Volume 23, August 2025:

Five Year Index to *Oklahoma Native Plant Record* – inside back cover