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Pontederia cordata by Pierre-Joseph Redouté, 1805. From *Les liliacées*, volume 2, color plate 72.
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[For articles in this volume, authorities are provided for scientific names of plants only for those taxa not recognized in George Yatskievych's three-volume *Steyermark's Flora of Missouri*.]

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Cephalaria transylvanica new to the flora of North America, and six species new to Missouri

NATHAN AARON[1]

ABSTRACT. — *Cephalaria transylvanica,* a tall, annual herb in the Caprifoliaceae native to the Old World, is reported from roadsides in southwestern Missouri and northwestern Arkansas. This is the first report of the species growing wild in North America. Six other species are reported new to Missouri: *Baccharis halimifolia*, *Carex pedunculata*, *Cuscuta japonica*, *Cyrtomium fortunei*, *Hydrocotyle umbellata*, and *Mosla scabra*. The status of *Mosla scabra* in eastern North America is discussed.

INTRODUCTION AND DISCUSSION

Recent field work has resulted in the discovery of seven species new to the Missouri flora, one of which – *Cephalaria transylvanica* – is also new to the North American flora. These species are discussed in detail below.

Cephalaria transylvanica (L.) Schrad. (Caprifoliaceae)

Cephalaria Schrad. includes approximately 102 annual and perennial herbaceous species native to Europe, West Asia, and Africa. The inflorescences in this genus occur as numerous tightly arranged flowers that form a capitula and can distinctly resemble inflorescences found in Asteraceae. *Cephalaria* is poorly represented in the flora of North America, with only two species known to occasionally escape cultivation. Here I report a third species, *Cephalaria transylvanica,* from Missouri and Arkansas.

I was introduced to this species in 2021 by Justin Thomas, who had noticed it along roadsides north of Springfield, Missouri. By mid-summer it is a striking annual, with distinct white, compound inflorescences at the tips of its many tall, naked branches. These plants were initially assumed to be a pincushion (*Scabiosa, Knautia*, or another related genus), but the fruits lacked the distinctly membranous, awned calyxes from which these plants derive their common name. Using Göktürk and Sümbül's 2014 taxonomic revision of *Cephalaria* in Turkey, the species keys well to *Cephalaria transylvanica* with this combination of characters: annual; fruiting involucel with 8 apical teeth; ciliate, awned bracts on a globose capitula. Two other species of *Cephalaria* occur in the US (Kartesz 2015): *Cephalaria gigantea* (Ledeb.) Bobr., a perennial, contrasted with the Missouri material, which is annual, and *Cephalaria syriaca* (L.) Scrad. *ex* Roem. & Schult., which has entire leaves, as opposed to the pinnately lobed leaves of the Missouri material. Although *Cephalaria transylvanica* is reported as being widespread and weedy in southern Europe and Turkey, the species has not been previously reported from North America.

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Fellow Missouri naturalist Blake Pagnier had also noticed this species in the region and uploaded an iNaturalist observation in 2023. In his own search for its identity, he came across an article reporting the plant along roads in northwestern Arkansas and adjacent Missouri (Ellis 2009). Ellis had taken several photographs and collections (SERNEC 2024: ANHC002358) and determined it as *Scabiosa atropurpurea* L., sweet scabious or pincushion flower. This European species is a popular cultivated annual and has escaped in several regions in the US, notably along the West Coast and the Dallas-Fort Worth area in Texas (BONAP 2024). Ellis also prepared a detailed illustration for the article, which reveals that the species is not a *Scabiosa,* since the fruits lack the distinctive awns among other morphological differences.

It is now clear that *Cephalaria transylvanica* was first collected locally by Ellis in 2008; several subsequent collections of *Cephalaria* from southwestern Missouri were also originally determined as *Scabiosa atropurpurea* (Tropicos 2024: MO-2213024). Examination of digitized images of collections of *S. atropurpurea* in the US suggests it is unlikely there are other occurrences of *C. transylvanica* misdetermined as *S. atropurpurea*. *Cephalaria transylvanica* has only been documented from degraded roadsides locally, and may be spreading via mowing given the extensive distribution along roads where it occurs. During the 2024 growing season, I observed extensive populations along many roadsides in Greene and Dade counties in Missouri. The species may have been first introduced to the country in southwestern Missouri/northwestern Arkansas. The basis for this introduction is unknown. The species does not appear to be sold by any US wildflower nurseries, although it is available online from European sources. More study is needed to monitor its spread and perhaps uncover the origin for its introduction into the flora of North America.

Voucher specimen: **U.S.A. MISSOURI:** GREENE CO.: Willard, intersection of W Jackson and US-160, common along weedy roadsides, evenly dispersed with *Lespedeza cuneata, Sorghum halepense, Dipsacus,* 37.3152ºN, 93.4448ºW, 2 August 2024, *N. Aaron 94* (MO).

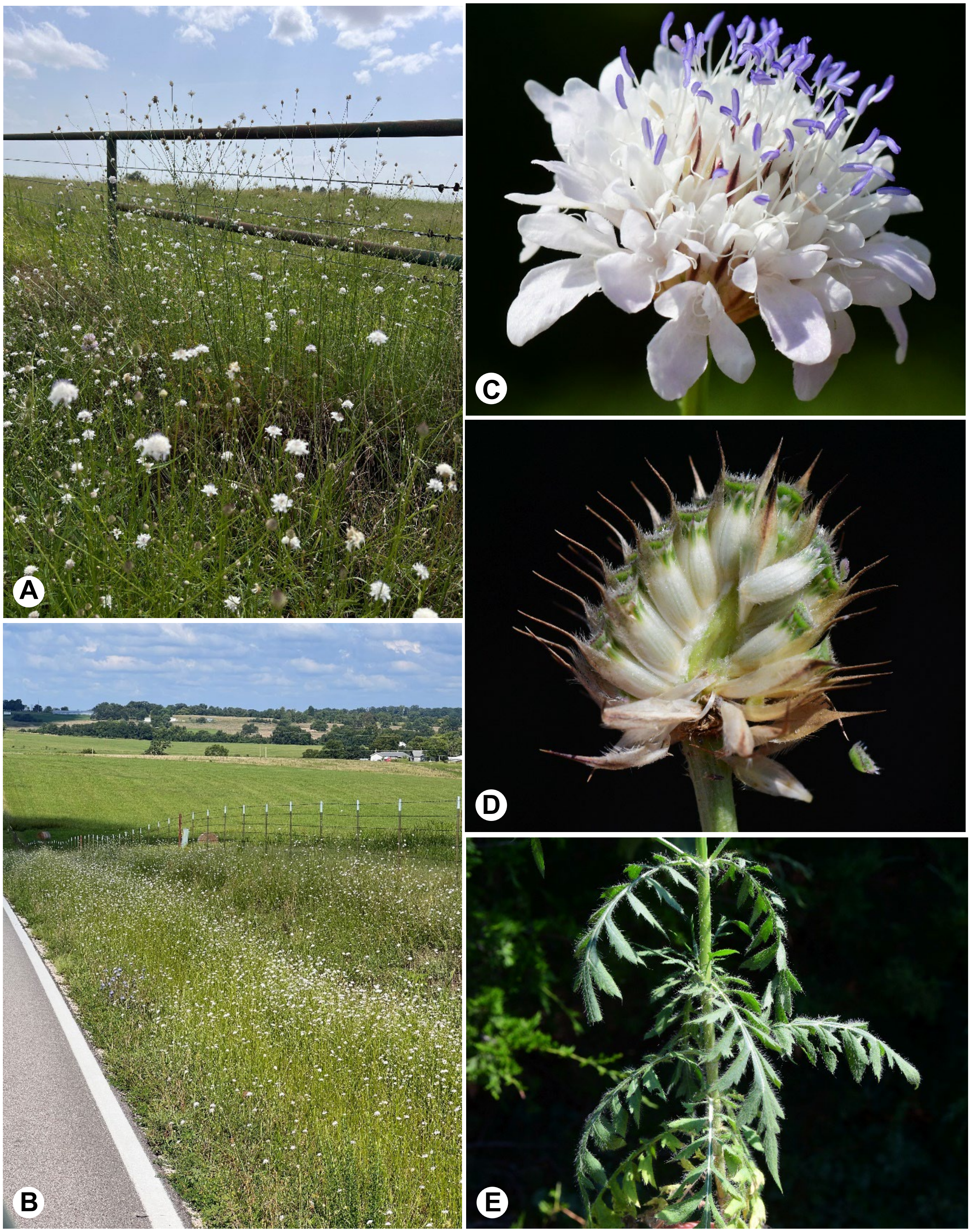

Figure 1. *Cephalaria transylvanica.* **A**. Habit. **B**. Roadside in Dade County. **C**. Inflorescence showing white corollas and purple anthers. **D**. Fruiting capitula dissected to show involucels. **E**. Leaves. *(Photos A & B by the author, C-E by Steve Turner).*

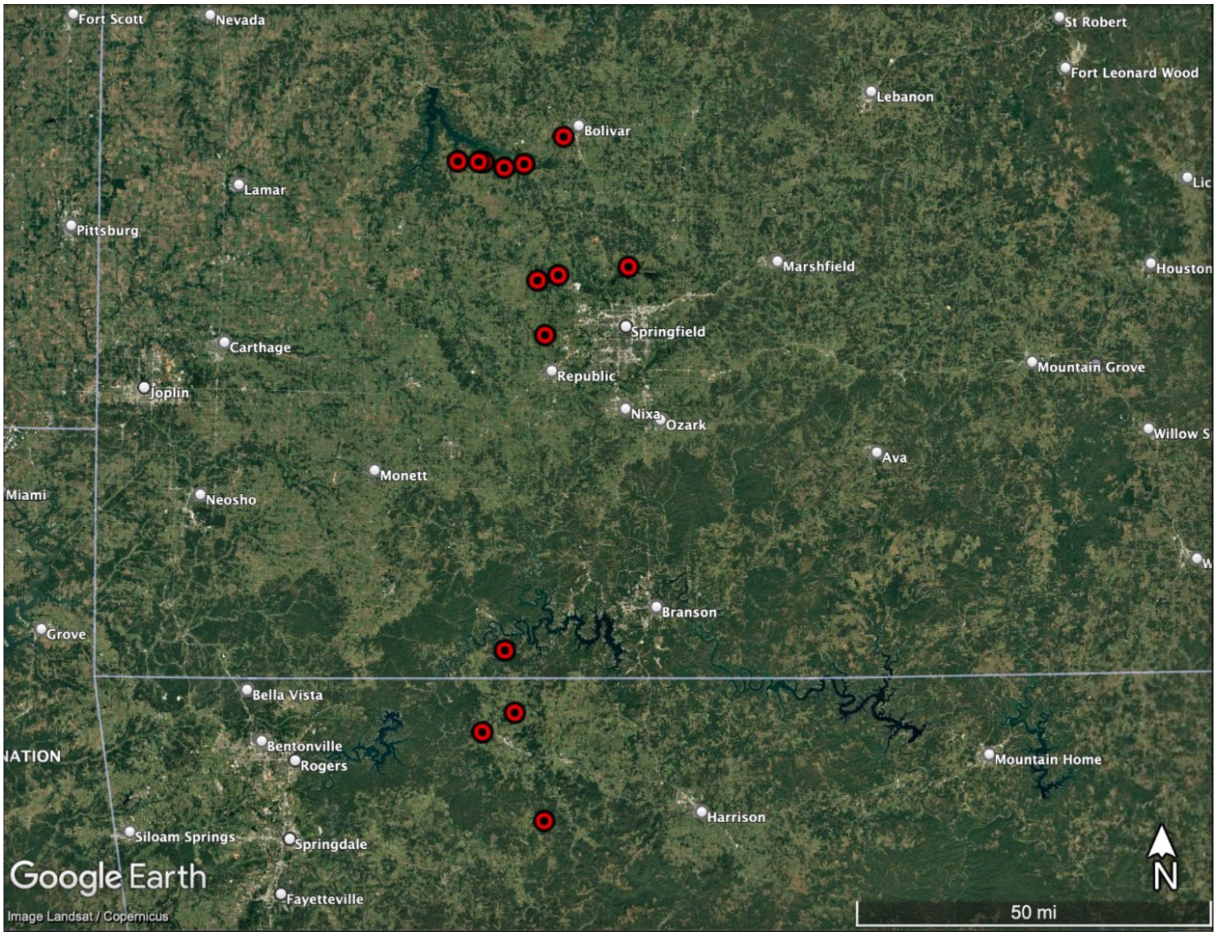

Figure 2. Known occurrences of *Cephalaria transylvanica* in Missouri and Arkansas (Map Data: Google).

Baccharis halimifolia L. (Asteraceae)

In April 2023, I found this shrub in the lake community of Indian Point, west of Branson. This small community lies on a north-south oriented ridge that gradually descends into Table Rock Lake. Historically, this ridge would have been occupied by a mosaic of calcareous glades and woodlands. Presently it is mostly developed, although there are remnants of native habitats along roadsides and between developed areas. One such remnant community exists as a narrow, fragmented glade between the main road and a wooded subdivision. *Baccharis halimifolia* occurs here, growing profusely on a ca. 0.25-acre section of degraded dolomite glade.

The site lies immediately below a small RV park and shows clear evidence of runoff or chemical spill. Other glade remnants occurring in the immediate area were searched but no additional populations of *Baccharis* were found, and it is reasonable to assume its presence is correlated with the severe disturbance occurring on the glade. This behavior is corroborated by Weakley (2024), who describes recent occurrences along the northern range of this species as introductions. As such, *Baccharis halimifolia* should be considered introduced in Missouri.

Voucher specimen: **U.S.A. MISSOURI**: STONE CO.: Calcareous glade along E side of Indian Point Rd., ca. 1000 ft. S of Stillwater Trail Rd. intersection; 100+ shrubs in 0.25-acre opening of impacted glade, with *Schizachyrium scoparium, Bouteloua curtipendula, Sporobolus clandestinus, Solidago radula, Croton willdenowii,* 36.6343ºN, -93.3450ºW, 24 July 2024, *N. Aaron 76* (MO).

Figure 3. *Baccharis halimifolia.* **A**. Habitat. **B**. Leaf detail *(N. Aaron 76)*.

Carex pedunculata Muhl. ex Willd. (Cyperaceae)

In April 2022, Justin Thomas, Neal Humke, and I conducted a survey of Leatherwood Creek, a tributary of the Jacks Fork River in Shannon County. While surveying along the bottom of a nearby drainage, a caespitose *Carex* was observed growing prolifically along a seepy ledge of a steep, north-facing embankment and was determined to be *C. pedunculata*, a northern and eastern species with the nearest records in northern Illinois and central Tennessee. The population here was estimated to be several thousand individuals, though no additional populations were found in searches of the immediate area. The seepy ledge ran for roughly 100 meters, with *Carex pedunculata* along most of its length. Associates in this damp, shaded slope just above the creek included *Asarum acuminatum* (Ashe) E.P. Bicknell, *Geranium maculatum*, *Carex timida* Naczi & B.A. Ford, and *Hepatica americana* (DC.) Ker Gawl.

Given the range of this species and the north-facing, shaded habitat in which it was found locally, it is likely this population is a relict of cooler Pleistocene climates. New populations of *Carex woodii* Dewey*,* another inhabitant of northeastern deciduous forests, were also discovered within a few hundred meters of the *C. pedunculata* site. *Carex woodii* was first documented in Missouri in 2008 ca. 30 miles to the southwest in Howell County (Thomas 2017). Another population of *Carex woodii* was found in 2020 by Susan Farrington ca. 3 miles to the east in an ecologically similar ravine along Allen Branch. I discovered a population of yet another eastern species, *C. willdenowii,* along Allen Branch in 2024; this sedge was previously known in Missouri from a single large population in Reynolds County. These deep, shaded ravines fed by numerous springs are ecological hotspots for unusual and disjunct species; more populations, and potentially new species, are likely to be revealed.

Voucher specimen: **U.S.A. MISSOURI**: SHANNON CO.: Rough Hollow, just off of Leatherwood Hollow above its confluence with Jacks Fork River; large, healthy population mostly restricted to an ephemerally seepy rim of a north-facing dolomite outcrop. 37.1020ºN, -91.5339ºW, 19 April 2022, *Thomas 2790* (hb. Thomas).

Figure 4. *Carex pedunculata.* **A**. Habitat, showing previous season's growth and new growth. **B**. Inflorescence detail.

Cuscuta japonica Choisy *var.* ***japonica*** (Convolvulaceae)

In September 2024, I discovered a population of *Cuscuta japonica* along the Gasconade River in western Phelps County. Here it parasitized a young sycamore near the abandoned boat ramp at the old MDC River Access just north of Jerome. This Asian species belongs to the subgenus *Monogynella* (Des Moul.) Peter, and is readily differentiated from all other Missouri *Cuscuta* by the singular, united style for which the subgenus is named; all other Missouri dodders belong to subgenus *Grammica* (Lour.) Peter and have two clearly differentiated styles. There is a report of *C. epithymum* (L.) L. from Christian County (BONAP 2024), which belongs to subgenus *Cuscuta,* but this collection could not be found or verified by the author. *C. japonica* is further differentiated from other Missouri dodders by the distinct brown or purple spots scattered across the stem, pedicels, and calyces; erect inflorescences that appear racemose; and basally circumsessile capsules. The Missouri population of *C. japonica* appears to be more robust than our native dodders. The distinct dark spots scattered across the plant facilitate identification regardless of the presence of flowers.

> *Voucher specimen*: **U.S.A. MISSOURI**: PHELPS CO.: S side of old MDC boat ramp along the Gasconade River, N of Jerome; in weedy, overgrown regeneration from historic flood of May 2017; host is a young *Platanus occidentalis,* 37.9347ºN, -91.9778ºW, 14 September 2024, *N. Aaron 260* (MO).

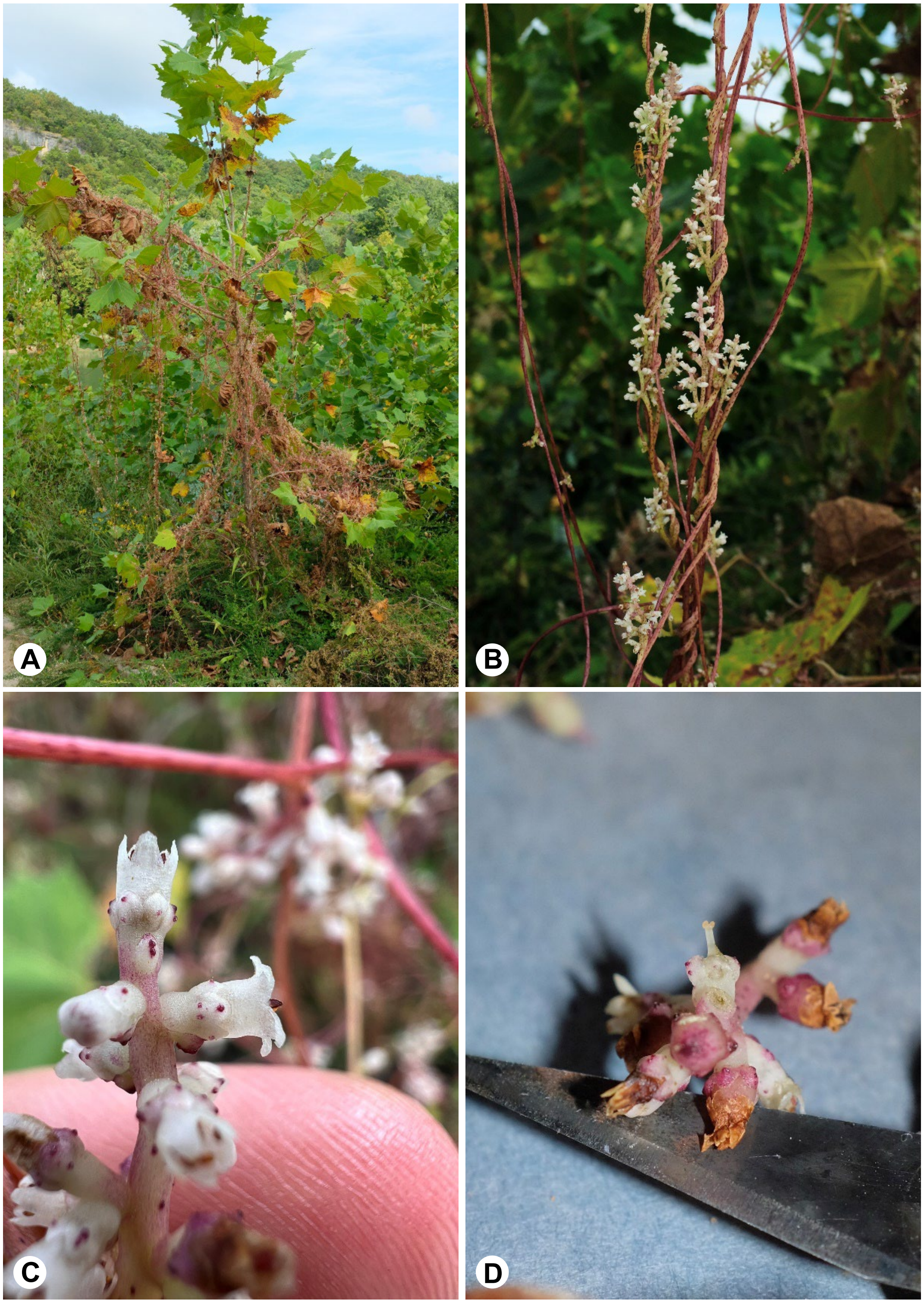

Figure 5. *Cuscuta japonica*. **A**. Habit, on *Platanus occidentalis*. **B**. Flowering. **C**. Inflorescence detail showing calyx and corolla. **D**. Detail showing fused styles *(N. Aaron 260)*.

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Cyrtomium fortunei J. Sm. (Dryopteridaceae)

Since 2020, four populations of *Cyrtomium fortunei,* Japanese holly fern, have been documented escaping cultivation in southern Missouri. This evergreen species is popular in the houseplant trade and is native to East Asia. The species has escaped cultivation sporadically in the southern and eastern US. It has been collected in the deep south since at least the 1960s (Duncan and Blake 1965) but has only recently been observed increasing its northern range, e.g. in Kentucky in 2009 (Hulsey & Meier 2011) and southern Illinois in 2013 (Benda 2018). Although it is a recent introduction to the region, all but one of the new Missouri populations occur in relatively isolated habitats.

I first encountered this fern in March 2020 in King Sink, a deep, forested sinkhole in southern Phelps County, where a single individual grew on a dolomite bench near the bottom. This site is characterized by the talus and mesic plant communities that are frequently encountered in deep Missouri sinkholes. Later that year, another individual was found about five miles to the east on a mossy dolomite outcrop in an upper drainage near Corn Creek. Both of these sites are on federal land and not near any ongoing human activity.

Two more populations were discovered in 2024. In Wayne County, David Siripoonsup found scattered individuals "on rich mesic outcrops growing in crevices" at the southwest corner of Mingo Wilderness (personal communication, 11 July 2024). A month later in Texas County, Claire Ciafré found an individual in Barn Hollow Natural Area "in cracks at the base of calcareous bluffs immediately above a spring-fed tributary of the Jack's Fork River, in a narrow gorge" (personal communication, 7 July 2024). Given the recency of the Missouri, Kentucky, and Illinois records, plus many recent observations (iNaturalist 2024), this species appears to be expanding its range northward.

I visited both Phelps County sites in October 2024 to obtain a better collection and to determine if the populations had increased in the past four years. The King Sink individual appeared to be slightly better established, and two additional small ferns were growing in crevices just beneath the parent. The fertile fronds of the mature fern appeared to be at peak fertility, with brown sporangia clearly evident around the indusia. The individual near Corn Creek did not appear to have further established itself nor create any offspring. Additionally, it appeared to have been browsed.

Cyrtomium fortunei is morphologically similar to the closely related *C. falcatum* (L.f.) C. Presl*,* known as Japanese holly fern or house-holly fern. C*yrtomium falcatum* is more popular in the ornamental trade, but is less cold hardy (George Yatskievych, personal communication, 2024). It has also escaped in the southern US, but is much more limited by cold climates. It has fewer, wider pinnae per frond than *C. fortunei*, and the margins are coarsely toothed (vs. denticulate in *C. fortunei*). Due to its comparatively wide pinnae and evergreen habit, *Cyrtomium* is unlikely to be confused with any other Missouri ferns, although there is a passing resemblance to *Polystichum acrostichoides*, to which it is closely related (Le Péchon et al. 2016).

The fact that *C. fortunei* has been present in the south for at least 60 years, but is only recently expanding northwards, suggests potential influence of climate change on this species' range. It may prove a useful model for the phytogeographical effects of warming winters.

Voucher specimen: **U.S.A. MISSOURI**: PHELPS CO.: Mark Twain National Forest, King Sink, ca. 0.3 miles SW of intersection of Hartung and Dewitt roads; one mature (fertile) and two immature plants on lower Gasconade Dolomite terrace in deep sinkhole, with *Hydrophyllum virginianum, Cystopteris bulbifera, Aquilegia canadensis, Stellaria media, Borodinia canadensis* (L.) P.J. Alex. & Wind., *Dicentra cucullaria,* 37.7951ºN, 91.9834ºW, 29 October 2024, *N. Aaron 371* (MO).

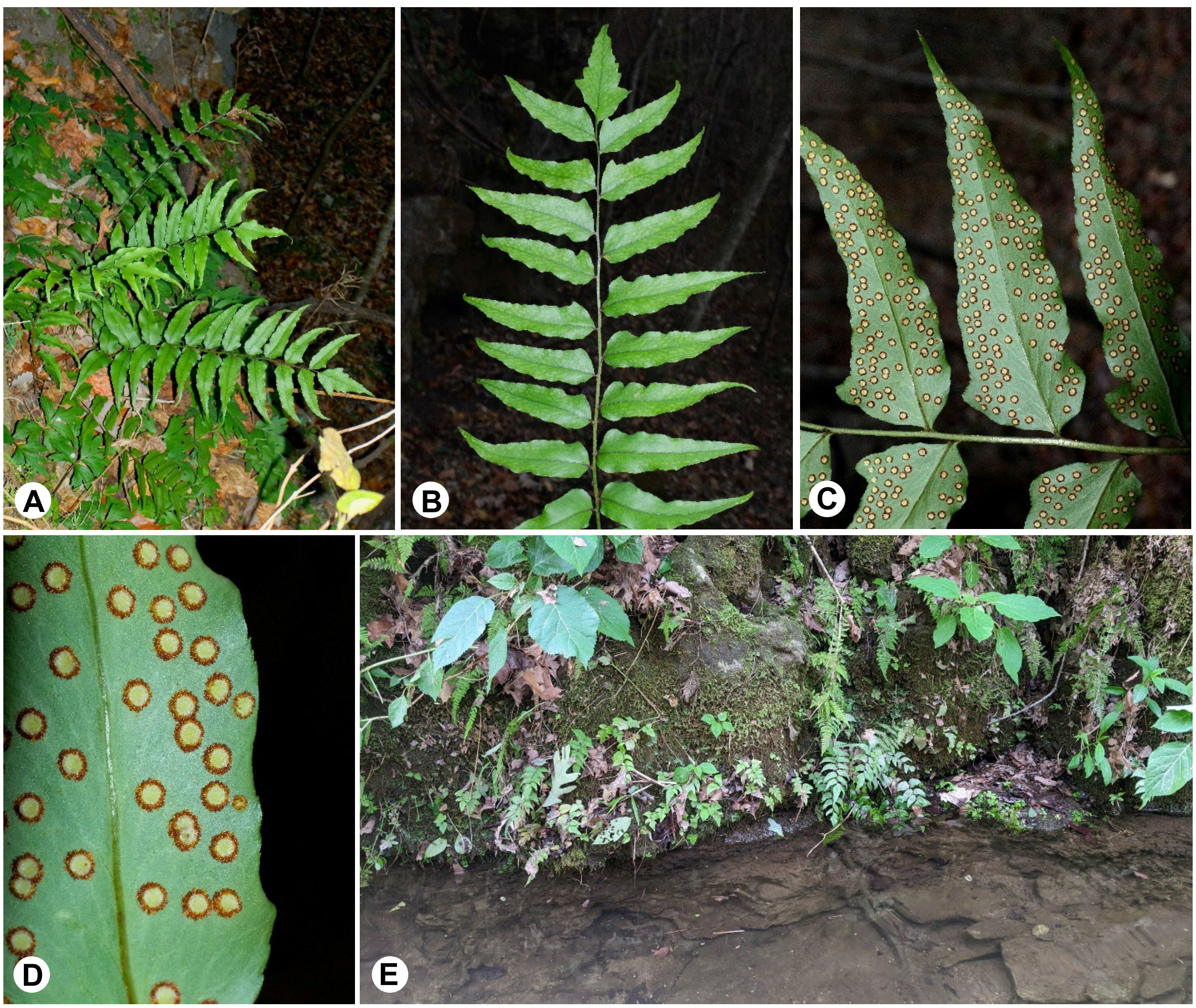

Figure 6. *Cyrtomium fortunei*. **A**. Habit. **B**. Frond. **C**. Abaxial pinnae showing sori and denticulate margins. **D**. Sori in detail, showing circular indusia and sporangia. **E**. Habit in Barn Hollow Natural Area *(Photo: Claire Ciafré)*.

Hydrocotyle umbellata L. (Apiaceae)

I collected this semi-aquatic coastal plain species in 2020, growing along the margins of Little Prairie Lake, an artificial reservoir in Phelps County. Here it is extensively distributed and a common member of the shoreline plant communities. A 2015 collection from this site by Ron Burk had been incorrectly determined as *H. ranunculoides* (Tropicos 2024: MO6669068). In *H. ranunculoides,* the sinus extends from the leaf margin to the attachment of the petiole (cordate), whereas in *H. umbellata* the leaves are peltate. *Hydrocotyle verticillata* is also known from a few populations in southern Missouri, but it is differentiated by its whorled, not umbellate, inflorescence along an extended rachis (although individuals may appear umbellate if containing only a single whorl).

This population of *H. umbellata* represents a relatively recent introduction to the area as it occurs along an artificial reservoir, and was likely introduced by waterfowl or human activity. Further introductions will likely be encountered. Given that the species is present in northern Arkansas (BONAP 2024), a native population may yet be discovered in southern Missouri. An updated Missouri key to the genus is provided below, adapted from Weakley (2024).

1. Leaves peltate.
    2. Inflorescence umbellate, leaves oriented ± vertically *H. umbellata.*
    2. Inflorescence verticillate (sometimes appearing umbellate), leaves oriented ± horizontally *H. verticillata.*
1. Leaves deeply cordate *H. ranunculoides.*

Voucher specimen: **U.S.A. MISSOURI**: PHELPS CO.: Little Prairie Lake, growing prolifically along lake margin near N parking area and boat ramp, with *Eleocharis, Justicia, Setaria, Periscaria, Lycopus, Ludwigia,* 37.9980ºN, 91.6925ºW, 29 June 2024, *N. Aaron 46* (MO).

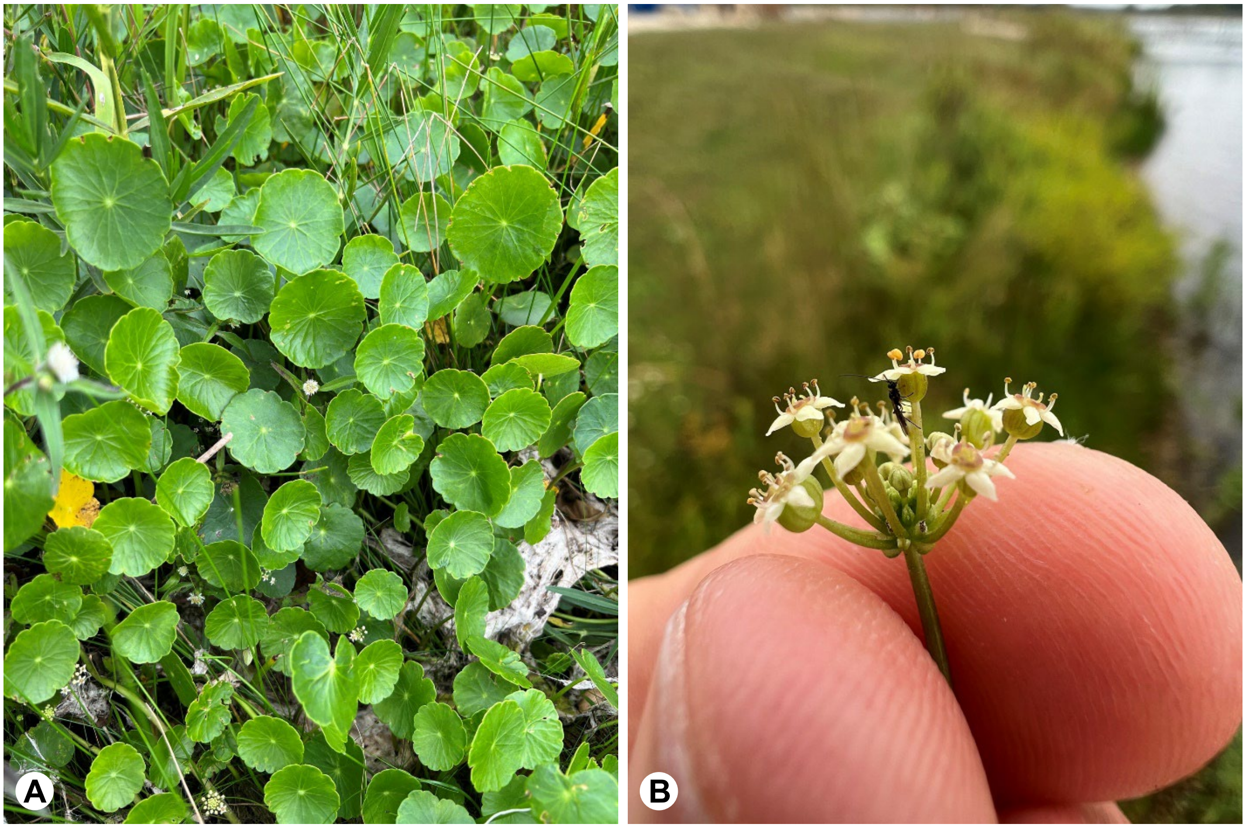

Figure 7. *Hydrocotyle umbellata*. **A**. Habit. **B**. Inflorescence

Mosla scabra (Thunb.) C.Y. Wu & H.W. Li (Lamiaceae)

Mosla scabra is an annual native to temperate and tropical Asia. In 2024, a population was found along a logging road in the Roger Pryor Backcountry in Shannon County. While only a single population of a few dozen stems was encountered, given the many miles of similar ridgetop roads it may be more widely distributed in the region. The *Mosla* was found growing intermixed with *Perilla frutescens* (beefsteak plant), its closest relative occurring in the region. *Mosla scabra* is readily differentiated from *P. frutescens* by its much smaller, narrower leaves that are not distinctly rugose, and its 2 fertile stamens (compared to 4 in *Perilla*).

This species was introduced in the southeastern United States and is recently expanding in range (iNaturalist 2024). Its exact range is uncertain, since until recently all US occurrences were considered to be *Mosla dianthera* (Buch.-Ham. ex Roxb.) Maxim, a closely related species. *Mosla dianthera* was first collected in McCreary County, Kentucky in 1939 (Keener et al. 2024). Curiously, the plants in this location were collected both as *M. dianthera* (SERNEC 2024: IND-0115061) and as *M. scabra* (synonym *M. lanceolata*) (SERNEC 2024: NCSC00022839) in late 1941. There is a lack of *M. scabra* collections through the rest of the century, and only recently have botanists begun calling some new populations *M. scabra* and correcting old collections initially determined as *M. dianthera* (Virginia Botanical Associates 2024).

Both species are accepted as occurring in the US. I have reviewed many US collections (SERNEC 2024) and observations (iNaturalist 2024) and concluded they likely all are referable to *M. scabra*. The exact status and range of the two taxa is uncertain given the confusing taxonomy of *Mosla* and morphologically variable characters used in keys. The key in *The Flora of the Southeastern United States* (Weakley 2024), based on Hsieh & Huang (1999), focuses on the number of teeth along the leaf margins. This character can be deceiving, since leaves occurring along the upper branches are often much reduced and with fewer teeth, and there appears to be plasticity in leaf morphology among individuals. Additionally, the key makes a determination between calyx lobes that are either "shallowly" or "deeply" toothed. In my examination of material, there is confusing variation in the calyx lobes, which leads to potential error. The only conclusive character is whether the surface of the nutlet is densely (*M. scabra*) or loosely (*M. dianthera*) reticulate. Hsieh & Huang (1999) provide helpful SEM micrographs of nutlets. It is likely that the other US material is the same species as the Missouri material given the similarity in leaf morphology.

However, online comparisons made with Chinese collections from the species' native range (Chinese Virtual Herbarium 2024) reveal that both leaf and calyx lobe characters are not satisfyingly sorted by Hsieh & Huang's 1999 key. Furthermore, Li & Hedge (1994) include *M. grosseserrata* Maxim. (now considered a synonym of *M. dianthera* fide [POWO 2024]), in a key couplet with *M. scabra*. This couplet focuses on the quality of stem pubescence: retrorsely fine puberulent in *M. grosseserrata*, and densely pubescent in *M. scabra.* Much of the US material reviewed appears to be intermediate between these characters, and few were densely pubescent. Two syntypes of *M. scabra* are accessible on the Chinese Virtual Herbarium (CVH [2024]: E00275749 and E00275760). Leaves of these specimens are distinctly narrowly lanceolate to narrowly elliptic, a morphology that was not replicated in any US material reviewed. The image resolution of these digitized collections did not permit inspection of the calyx lobes or stem pubescence.

Confusion notwithstanding, I believe it is most practical to default the US material to what is regarded as *M. scabra* in its native range, since the digitized recent collections reviewed on CVH (2024) appear to match. The overall taxonomy and species concepts of *M. scabra* and *M. dianthera* would benefit from critical review.

> *Voucher specimen*: **U.S.A. MISSOURI**: SHANNON CO.: Roger Pryor Backcountry 1.25mi SE of Big Creek crossing; small clump of ca. 10 stems growing between tracks of logging road, with *Perilla, Conyza, Erechtities,* 37.2970ºN, -91.3075ºW, 11 September 2024, *N. Aaron 238 & 239* (both MO).

Figure 8. *Mosla scabra.* **A**. Habit. **B**. Leaves and stem. **C**. Inflorescence. **D**. Nutlets *(N. Aaron 238)*.

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Much appreciation to Justin Thomas for proofing this report and for being an unending source of botanical and ecological inspiration. I thank Steve Turner for graciously allowing the use of his detailed photos of *Cephalaria transylvanica*. I also thank Blake Pagnier for finding the 2009 *Claytonia* article which allowed a connection to be made to the initial *Scabiosa* collections. Claire Ciafré deserves great credit for prompting me to initiate this report after she found *Cyrtomium* in Texas County earlier this year, and for allowing the use of her photos.

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Kolkwitzia amabilis locally escaped from a long-abandoned homestead in St. Louis County, Missouri

Emmett Kearns[1] and Erin O'Connell[2]

ABSTRACT. — *Kolkwitzia amabilis*, a small Asian shrub in the Caprifoliaceae known as "beauty bush," is reported escaped from an old planting at an abandoned homestead that has reverted to successional hardwood forest at Tyson Research Center, Missouri. The plant has not been cultivated at the site for at least 80 years, but was observed to have several fruiting adults, many clonal offshoots, and some seedlings. *K. amabilis* is not anticipated to be a major threat to Missouri woodland ecosystems as it has not spread far from the original site of planting in the decades since it was introduced.

Introduction

Kolkwitzia amabilis (Caprifoliaceae) is a small Asian shrub known as "beauty bush" in the United States and Europe, and "wei shi" (蝟实) in China. Beauty bush lives in temperate climates but can tolerate temperatures down to -29°C (Hortipedia 2024). Gardening websites (Hortipedia 2024) assert that cultivated beauty bush prefers sandy loam or sandy clay soil with a pH between 8 and 10. It thrives in full sun but can tolerate partial shade. *Kolkwitzia amabilis* is rare throughout its native range of central and eastern China and adjacent parts of Mongolia (**Figure 1**). In its native habitat, the flowers are attractive to many nectar-feeding insects, but bees appear to be the primary pollinators (Mao et al. 2015).

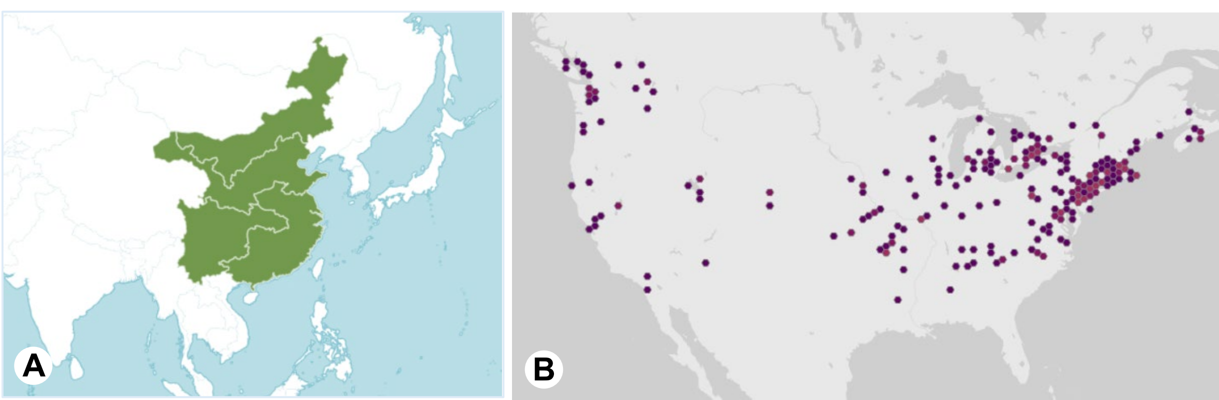

Figure 1. Native range of *K. amabilis*: **A**. in China and Mongolia (Royal Botanical Gardens 2024) and **B**. introduced range in North America (GBIF 2024).

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Beauty bush was discovered by Europeans twice: first by Father Giuseppe Giraldi, a Franciscan monk and Italian botanist working in China 1890-1895, and second in 1901 by Ernest Henry Wilson, who found it while exploring mountains in Ichang, Hubei, China (Arnold Arboretum 2024). Wilson's seed collection made its way to the United States, when it was brought to Harvard's Arnold Arboretum in 1907, but it did not flower there until 1915. Seeds were not brought to the United States from China again until 1994 (Dosmann 2010). The species experienced a boom in cultivation between the World Wars, when it became very popular as an American garden ornamental. The most common cultivars are Rosea, Pink Cloud, Jolene Jolene, and Dream Catcher (Royal Botanical Gardens 2024).

Kolkwitzia amabilis has been documented escaping cultivation in multiple US states, but sources differ on which ones (**Table 1**). Weakley (2024) lists the greatest number of states, at 12: Alabama, Arkansas, Georgia, Illinois, Indiana, Kentucky, Missouri, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia; it is listed as a "waif" in all these states rather than truly naturalized. Collectively, at least one source considers the plant to be naturalized in each of 13 states: Alabama, Colorado, Kentucky, Maryland, Massachusetts, Michigan, New Jersey, New York, Pennsylvania, Utah, Vermont, Virginia, and Wisconsin (**Table 1**). In addition, the Global Biodiversity Information Facility lists 624 occurrences of *K. amabilis* in 35 US states (**Figure 1**; GBIF 2024; note that these records likely include persisting horticultural plantings). Sixteen of those occurrences are found in Missouri, though *K. amabilis* is not included in the Flora of Missouri (Yatskievych 2006) nor noted in any Midwestern state by the Midwest Invasive Plant Network (2022). *Kolkwitzia amabilis* has subsequently been documented in Branson (Taney Co.), where it locally escaped from a garden planting, and has been growing without human care since at least 1998 (Yatskievych 2015).

Table 1. United States distribution of *Kolkwitzia amabilis* (Royal Botanical Gardens 2024; USDA Plants 2024; EEDMapS 2024; Center for Invasive Species and Ecosystem Health 2018; Native Plant Trust 2024; Virginia Botanical Associates 2024).

	States												
Source	AL	CO	KY	MA	MD	MI	NJ	NY	PA	UT	VA	VT	WI
Royal Botanical Gardens	X			X		X		X		X		X	
USDA Plants		X	X	X		X			X	X			
EED					X								X
Invasive.org							X						
Native Plant Trust	X			X		X		X	X		X	X	
Virginia Digital Plant Atlas											X		

Kolkwitzia amabilis Graebn. is also known by the synonym *Linnaea amabilis* (Graebn.) Christenh. While most commonly considered a member of the *Linnaea* clade in the Caprifoliaceae (Reznicek et al. 2011; Royal Botanical Gardens 2024; Wang 2015), the clade is sometimes considered to be its own family, Linnaeaceae (Backlund & Pyck 1998; Bell 2012). The *Linnaea* clade contains six genera: *Abelia*, *Diabelia*, *Dipelta*, *Kolkwitzia*, *Linnaea*, and *Vesalea* (Jacobs et al. 2010; Wang 2015), with *Linnaea* and *Kolkwitzia* being monospecific. Efforts to resolve the phylogeny of the clade led to the proposal of condensing all six of these genera into the *Linnaea*

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(Christenhusz 2013). However, more recent molecular studies have concluded that the clade is already monophyletic, and this rearrangement would be unnecessary (Wang 2015).

Kolkwitzia amabilis is a deciduous shrub, usually 1.8-3 m in height. Leaves occur on the upper parts of the thin branches. The leaves are opposite, petiolate, acuminate, basally rounded, pubescent (more densely so abaxially), ranging from 2.5-7.5 cm long and 2-5 cm wide, with nearly entire margins (**Figure 2**). Leaves of adults are distichous, however, the leaves of juvenile plants may be at random angles or decussate. Juvenile leaves have more serrated margins than those of adults. The flowers are light pink, or white with some pink, and have yellow or light orange dots inside the tubular corolla (**Figure 2**). They are 1-2.5 cm long and pubescent, with four stamens and found in axillary pairs (Bailey 1914; Oregon State University 2024; Royal Botanical Gardens 2024). The fruit is a hairy, one-seeded achene. Cultivated plants in Missouri flower from late April to May (Missouri Botanical Garden 2024).

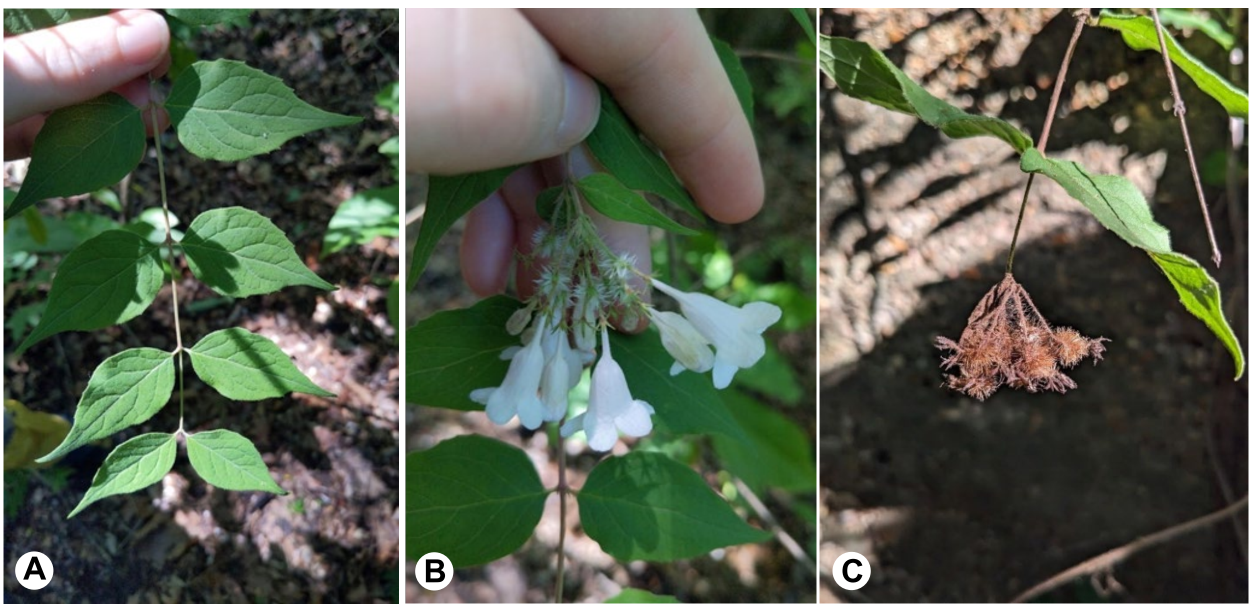

Figure 2. *K. amabilis*: **A**. leaves; **B**. flowers; and **C**. fruits. Photos: Emmett Kearns.

The flowers and fruits are recognizably different from other common Missouri shrubs, but the vegetative material could be mistaken for a honeysuckle species, such as the invasive *Lonicera maackii*. In Yatskievych (2006), *K. amabilis* would key to *Lonicera maackii*, however, the flowers of *K. amabilis* have connate corollas and are actinomorphic, while those of *L. maackii* are zygomorphic and divided. The stamens and style of *L. maackii* protrude from the corolla, while those of *K. amabilis* do not. Finally, the fruits of *L. maackii* are red berries, while those of *K. amabilis* are hairy achenes. Beauty bush is most similar in appearance to cultivated species of *Abelia*, which are part of the same *Linnaea* clade, but *Abelia* has narrow elongate fruits as opposed to the globose fruits of *Kolkwitzia*.

Discussion

We first observed beauty bush on 9 May 2024 while conducting a floristic survey of Tyson Research Center (Tyson), Washington University in St. Louis' environmental field station in St. Louis County. Tyson comprises 2,000 acres on the northern edge of the Ozarks Ecoregion and consists primarily of secondary oak-hickory forest. We found a small population of *Kolkwitzia* associated with the foundations of a previously undocumented homestead. The presence of numerous seedlings confirms that the species has spread past the original planting.

In July 2024 we counted 97 individual *K. amabilis* plants comprising 541 total stems. The plants were grouped into three age classes: adult (>1.3 m tall), sapling (0.5-1.3 m tall), and seedling (<0.5 m tall). There were 23 adult plants with an average of 6.3 stems each and an average DBH (diameter at breast height) of 14 mm (range 1-30 mm). Of these 23 adults, 18 had fruits or evidence of fruiting in 2024. There were 46 sapling class plants with an average of 6.5 stems each, and 28 seedlings with an average of 3.9 stems each. The plants were challenging to distinguish due to spreading underground shoots, with up to a meter between stems, indicating that the plant can spread clonally. Due to the presence of reproductive adults and the location of seedlings, we predicted that at least some of the seedlings germinated from the fruits, in addition to clonal offshoots from the parents, although further excavation of the site would be necessary to confirm this.

The population occurs at mid-slope in a mesic oak-hickory woodland. The canopy was composed of *Acer saccharum* (sugar maple), *Carya* spp. (hickories), *Gleditsia triacanthos* (honey locust), *Sassafras albidum* (sassafras), and *Quercus rubra* (red oak). The site has been overgrown by a dense patch of *Asimina triloba* (pawpaw), shading out most other plants. Notably, while there was a significant amount of the related invasive bush honeysuckle (*Lonicera maackii*) nearby, the *K. amabilis* and *L. maackii* did not overlap in growth. Other associated species included *Ageratina altissima* (white snakeroot), *Andersonglossum virginianum* (wild comfrey), *Euonymus fortunei* (wintercreeper), *Frangula caroliniana* (Carolina buckthorn), *Hackelia virginiana* (Virginia stickseed), and *Parthenocissus quinquefolia* (Virginia creeper).

The ancestors of Tyson's *K. amabilis* population were likely planted between 1920 and 1940, when the species became popular as an ornamental. Plat maps indicate that the land was then owned by David "The Corn King" Ranken (**Figure 3**), a prominent figure in the agricultural history of the Midwest. Ranken (sometimes spelled Rankin) was a prolific landowner, farming 23,000 acres at his peak in 1905 (Schoenfelder & Rankin 2019). He was a national leader in the switch from subsistence farming to industrial agriculture. Ranken was one of the first farmers to incorporate machinery as a way to replace labor (Irwin n.d.). With such a large amount of land, Ranken was almost certainly not managing the land in Tyson Valley himself, and an associate of his likely lived on the property.

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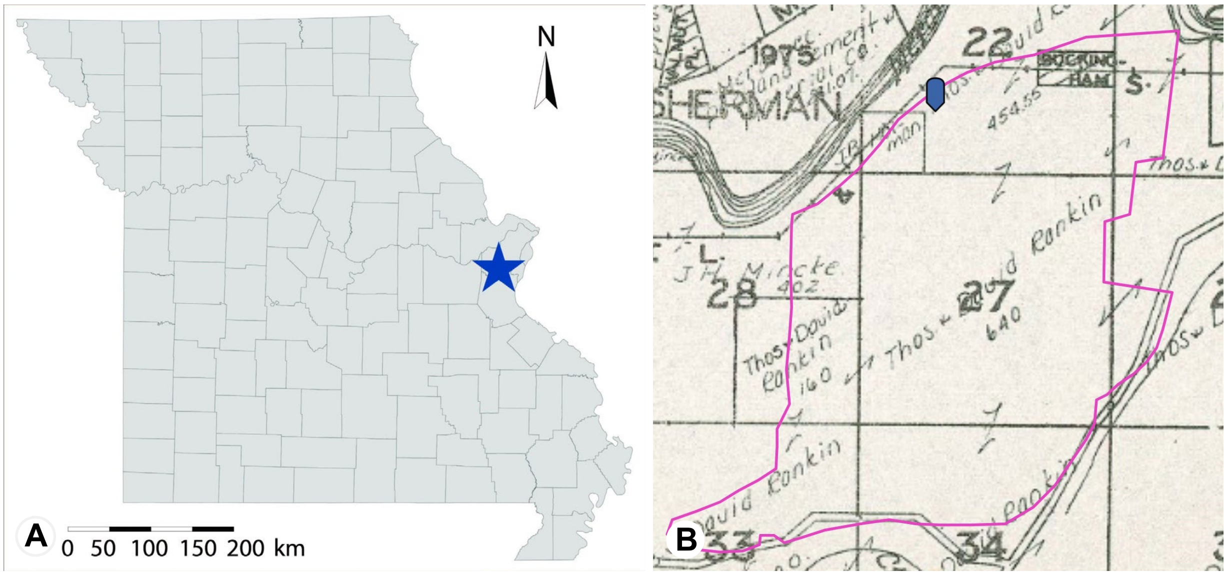

Figure 3. **A**. Tyson Research Center location within Missouri (blue star). **B**. The current Tyson Research Center property (pink outline) on a 1930 Plat Map (Hixson 1930) and the coordinates of the *K. amabilis* discovery (blue point) from the iNaturalist observation.

Historic aerial images show a clearing in the forest at the site of the homestead in 1937 (**Figure 4**). The federal government used eminent domain to purchase the property from Ranken in 1941, but the clearing remained open until 1955 according to historical images maintained by the St. Louis County GIS Center. By 1966, the forest had grown back over the area (**Figure 4**). Military maps from the 1950s do not indicate any activity in that area of the property, so the 1955 clearing is likely a remnant of prior inhabitation (Rushing 1957). We cannot confirm the exact date when the homestead was abandoned, but even if it remained in use until 1941, it has been 83 years between the most recent human caretaking of the beauty bush and its 2024 rediscovery.

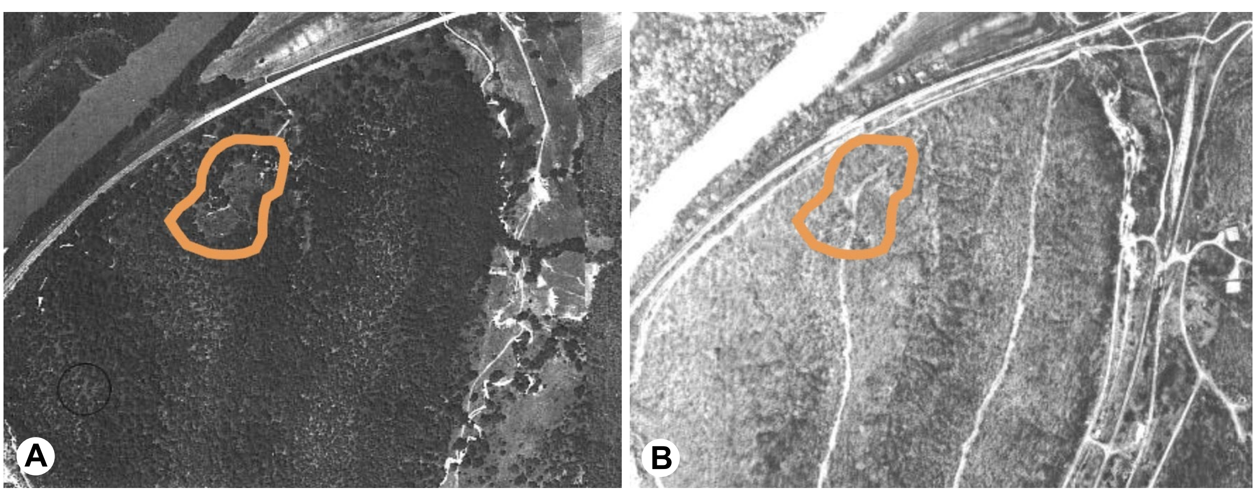

Figure 4. **A**. 1937 Aerial imagery of the clearing. **B**. 1966 aerial imagery of the same area, now forested, except for the road (Saint Louis County GIS Center).

Kolkwitzia amabilis is unlikely to become a problematic invasive in Missouri. It is rare in its native range, uncommon and sporadically distributed in the US, and during the 80 years it was free to expand at Tyson it has only spread a few meters. However, it is possible that it could remain as a relic of other abandoned historic homesteads in the state.

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A 36-year history (1978-2013) of the plant community in Pickerelweed Pond, a naturally occurring sinkhole pond in Missouri

EMILY A. GEEST[1] AND BRUCE SCHUETTE[2]

ABSTRACT. — From 1978-2013, an annual summer vegetation survey occurred at Pickerelweed Pond, a naturally occurring sinkhole pond in Cuivre River State Park near Troy, Missouri. Surveys recorded pond characteristics, plant species, and plant cover. Pond characteristics varied by year with the pond at its widest in 2011 and smallest in 1988; pond depth ranged between 30-122 cm. Over the 36-year span of the study, surveys recorded 17 plant species with the highest species richness occurring in 1994 and the lowest occurring in 1978, 1981, 1998, and 2013. Plant communities varied by year and transect direction. Along the north-south transect there were distinct clusters of years with a plant species most associated with each cluster including *Typha latifolia*, *Sparganium androcladum*, and *Utricularia gibba*. *Nelumbo lutea* and *Pontederia cordata* exhibited an inverse relationship, with *Utricularia* presence high in years that *Pontederia* presence was low, and pickerel weed presence high in years that American lotus presence was low. Multiple flora and fauna of conservation concern were recorded in the pond during the study. To our knowledge, this is the first long-term vegetation study of a sinkhole pond, an understudied wetland system.

INTRODUCTION

Sinkhole ponds only occur in areas of karst topography where dissolution of carbonate bedrock forms natural depressions (sinkholes). Seasonal or perennial wetlands can become established in these sinkholes if internal drainage becomes blocked (Homoya & Hedge 1982, Nelson 2005). The resulting wetlands are closed and isolated systems, with plant communities determined by the size, depth, water chemistry, water fluctuations, and vegetation characteristics (Nelson 2005). Seasonal flooding can occur (Bartgis 1992), with ponds filling with water from intermittent streams or direct rainfall (Homoya & Hedge 1982).

Naturally occurring sinkhole ponds are an uncommon landscape feature but have been recorded in Virginia (Ludwig et al. 1991), Maryland (Bartgis 1992), Florida (Wallis 2016), West Virginia (Bartgis 1992), Indiana, Kentucky, and Missouri (Homoya & Hedge 1982). Sinkhole ponds have always been uncommon because three conditions must be met for this feature to form: 1) it can only occur in areas where the geology supports karst topography, 2) the bedrock must dissolve to create the sinkhole, and 3) the sinkhole must become blocked to hold water in order to become a pond (Nelson 2005, Baryakh & Fedoseev 2011). During post Euro-American settlement, many of these ponds were destroyed by clearing, intense grazing, draining, converting to livestock

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watering ponds, and conversion of the vegetation (Nelson 2005). Although vegetation in sinkhole ponds often includes rare plants (Bartgis 1992), little is known about plant communities and long-term vegetation trends in these rare natural systems. To better understand sinkhole pond plant diversity and community assemblages, we present a 36-year study of vegetation in a naturally occurring sinkhole pond in Missouri.

METHODS

Study Site: Pickerelweed Pond is in Cuivre River State Park, a 2,617 ha (6,468 acre) state park in Lincoln County, Missouri. According to the *Atlas of Missouri Ecoregions* (Nigh & Schroeder 2002) the park is located in the Mississippi River Hills subsection of the Central Dissected Till Plains section of northern Missouri. The Mississippi River Hills area is characterized as a broad belt of hills where the pre-settlement vegetation was oak and mixed hardwood woodland and forest, with savannas and prairies on flatter uplands. Karst features are locally prominent (Nigh & Schroeder 2002) and — similar to the Ozark Ecoregion — this terrain is riddled with karst features including sinkholes (Leahy 2011). Historically the park's terrain was covered by dry-mesic upland woodlands, with savanna and prairie on broad ridgetops. Limestone glades and numerous features of karst topography further contribute to its resemblance to the Ozark region. Prescribed burns and woodland thinning are restoring the historical condition to much of the park's landscape (Schuette 2004, Blake 2005). Mississippian age Burlington-Keokuk limestone underlies the central portion of the park and is associated with numerous karst features, including sinkholes, caves, and springs. Additionally, a layer of Pleistocene glacial till and loess covers the limestone on the ridges (Schuette 2004).

Pickerelweed Pond is a 0.25 ha (0.61 acre) sinkhole pond on the broad north-south ridge in the central portion of the park (**Figure 1**). The pond is one of three sinkholes in close proximity. One of these sinkholes drains with no evidence of ever holding water. The second sinkhole held water and appeared as a pond on 1934 and 1942 USGS Elsberry 15' topographic maps, but by 1970 the internal drainage reopened and the pond had drained (USGS Okete 7.5 minute quadrangle, 1975). The third sinkhole is an established sinkhole pond, now called Pickerelweed Pond due to the presence of uncommon pickerel weed (*Pontederia cordata*) (**Figure 1**). Pickerelweed Pond is sinkhole pond wetland classified as a pond marsh natural community, and is considered one of best remaining examples of this rare community type (Nelson 2005). Pond marsh natural communities are ranked S1 (critically imperiled) natural communities in Missouri (MDC 2024) due to their rarity as intact habitats. In 1978, Pickerelweed Pond and its approximately 1.2 ha (3 acre) watershed was designated a Missouri State Natural Area. In 1997, the Pickerelweed Pond Natural Area was included in the surrounding landscape scale 757.6 ha (1,872 acre) Lincoln Hills Natural Area designation.

Unique flora and fauna of the pond include pickerel weed, bur-reed (*Sparganium androcladum*), slender naiad (*Najas gracillima*) – a species of conservation concern – the spatterdock darner (*Rhionaeschna mutata*), pickerel frog (*Lithobates palustris*), a state record pickerelweed longhorn bee (*Melissodes apicatus*) and the ringed salamander (*Ambystoma annulatum*) – a species of conservation concern.

Pickerelweed Pond has undergone minimal management, with two exceptions. In 1992, common cattail (*Typha latifolia*) was controlled, since common cattails were not listed in the pre-1978 description of the pond (Cuivre River State Park 1974) and its aggressive spread through the pond was threatening to dominate the pond marsh community. The stems were cut with a hand-held sickle below the surface of water, allowing the hollow stems to fill with water, thus killing the plant without the use of herbicides. The second intervention occurred in 1995, with the addition of two deer exclosures placed around portions of pickerel weed to protect plants from white-tailed deer (*Odocoileus virginianus*) herbivory (Schuette 1995). One exclosure was 7.01 m x 4.42 m (23 ft x 14.5 ft) and the other exclosure was 7.62 m x 5.79 m (25 ft x 19 ft), with a total combined area of 76.18 m^2 (840 ft^2) (Schuette 1995).

Surveys: From 1978-2013, annual vegetation surveys were conducted in July/August to record plant species, pond width, and plant cover. Two vegetation transects were placed perpendicular to each other, along cardinal directions and spanning the widest parts of the pond (**Figure 2**). Stakes were placed around the border of the pond to demarcate the positions of the transects at the high-water level. The length and width of the pond were calculated from wet edge to wet edge. Transects were walked (stake to stake) with every plant species recorded at first and last sighting along each transect, measuring the total coverage of the plant species. Beginning in 1979, the depth of the pond was measured with a ruler at the deepest point, from the top of the sediment to the water surface. In 1979, American lotus (*Nelumbo lutea*) covered a large portion of the pond. American lotus total flower count was recorded every year thereafter to measure lotus blooming abundance. Beginning in 1989, plant species density data was added to better understand the structure of vegetation occurring in the pond. Every plant species within 5 cm of the transects had density estimated in 5% intervals every 1.52 m (5 ft) along the transect. Nomenclature follows Yatskievych (1999, 2006, 2013) with plant vouchers deposited in the Missouri Department of Natural Resources, Division of State Parks Herbarium (MODNR) in Jefferson City or the Missouri Botanical Garden's Herbarium (MOBOT) in St. Louis.

Analysis: Descriptive statistics were used to analyze pond characteristics (width and depth). Due to plant species growing in overlapping clusters, to calculate frequency of occurrence, the total length of area occupied by a plant species was divided by the total length of the transect surveyed. Thus, if American lotus was recorded from 30 m (98.40 ft) through 50 m (164.00 ft) of a 200 m (656.20 ft) transect, American lotus occupied 10% of the transect (20 m/200 m = 0.1). Vegetation community measures including species richness, Shannon-Wiener diversity, and Pielou's evenness were calculated annually in package *vegan* in program R (R Core Team 2024). Generalized linear models were used to determine pond characteristics' impact on community measures using *lme4* in R (R Core Team 2024). Principle component analysis (PCA) ordination biplots were created to evaluate annual patterns in vegetation assemblages (Amoros & Bornette 1991) using CANOCO 5 (Lepš & Šmilauer 2003) with total length of transect occupied per species as a metric for comparison. Species that occupied ≤ 2.0% of total length surveyed in the study were removed to reduce biplot noise (Balmer & Erhardt 2001). Due to the overlap of transects and inherent correlation between north-south and east-west transects, each transect was analyzed independently.

RESULTS

Pond width varied over the years but averaged 42.60 m x 50.17 m (139.76 ft x 164.60 ft). The pond was widest in 2011 at 64.62 m x 59.74 m (212.01 ft x 196.00 ft) and smallest in 1988 at 11.58 m x 11.28 m (37.99 ft x 37.01 ft) with notes indicating heavy rain before the 2011 survey and an ongoing drought in 1988 (**Figure 3**). Pond depth varied from a low of 30.48 cm (12 in) in 1986 to a high of 121.92 cm (48 in) in both 2005 and 2008, with an average depth of 77.72 ± 4.02 cm (30.60 ± 1.58 in) (**Figure 3**).

Across the 36-year span of the project a total of 17 plant species were observed along the transects (**Table 1**). The highest species richness occurred in 1994 at 10 species, with the lowest in 1978, 1981, 1998 and 2013 at 5 species each (**Table 1**). Average species richness was 6.94 ± 0.26 on the north-south transect and 6.81 ± 0.26 on the east-west transect. The average species diversity and evenness was higher along the east-west transect (H: 1.49 ± 0.04; J: 0.34 ± 0.02) than the north-south transect (H: 0.66 ± 0.05; J: 0.79 ± 0.01). Pond characteristics (width and depth) had no effect on richness, diversity, and evenness for either transect (**Table 2**).

Species varied by total length of transect occupied by year, with year-to-year fluctuations in the relative dominance of certain species including American lotus, bur-reed, common cattail, rice cutgrass (*Leersia oryzoides*), pickerel weed, mild water pepper (*Persicaria hydropiperoides*), and water shield (*Brasenia schreberi*) dependent on year (**Figure 4**). American lotus flowering stems increased from 1978 until 1983 with a high of 1400 flowering stems in 1983. After 1983, surveys recorded fewer than 100 flowering stems or no flowers at all.

Plant communities varied by year and transect orientation. The north-south PCA biplot had distinct clusters of years with cluster one consisting of years 1978-1988, cluster two 1989-1999, and cluster three 2000-2013 (**Figure 5**). Each cluster of years had a plant species most associated with that cluster, including common cattails (1978-1988), bur-reed (1989-1999), and bladderwort (*Utricularia gibba*) (2000-2013) (**Figure 5**). The north-south PCA biplot had 53.13% of variation explained in the first two axes (eigenvalues: Axis I = 0.35; Axis II = 0.19). In comparison, the east-west PCA biplot had 62.89% of variation explained in the first two axes (eigenvalues: Axis I = 0.44; Axis II = 0.19) (**Figure 6**). In the east-west biplot, years 1978-1988 were most similar to one another with the rest of the years more interspersed. Bur-reed was most associated with post-1999 surveys in this biplot (**Figure 6**).

Species exhibited clear trends in cover and dominance over time, with some species increasing or decreasing in the area occupied depending on the survey years. Pre-1992, common cattails were a dominant plant present in 9.38 ± 3.14% of the north-south transect with an average density of 6.00 ± 2.04% and present in 26.58 ± 1.93% of the east-west transect with an average density of 37.04 ± 0.48%. Water shield became a dominant plant in the later years of the study, with the species occupying an average of 11.08 ± 3.52% of the north-south transect and an average of 9.08 ± 2.77% of the east-west transect in years 1-18 (1978-1995) but increasing to an average of 36.95 ± 7.53% (north-south) and 25.45 ± 4.78% (east-west) in years 19-36 (1995-2013). Similarly, water shield density increased over time from an average of 2-3% pre-2001 to 37-50% post-2001. Two species that increased and decreased in frequency over time were American lotus and pickerel weed, with American lotus high in years that pickerel weed was low, and pickerel weed high in years that American lotus was low (**Figure 7**). Other plant species only appeared for a short time throughout the study. These included barnyard grass (*Echinochloa muricata*), duckweed (*Lemna minor*), spikerush (*Eleocharis obtusa*), black willow (*Salix nigra*), rush (*Juncus* spp.), and slender naiad – and would each occupy < 10% of the transect each time.

Discussion

Over a 36 year span, the width and depth of the pond remained relatively stable, shrinking during dry summers and expanding during wet years. Vegetation community measures (species richness, diversity, and evenness) were similar over time. However, the east-west transect when compared to the north-south transect had higher species diversity and evenness on average. The differences between vegetation based on transect orientation could be due to landscape and environmental characteristics such as sunlight exposure, with the surrounding vegetation being trees that cast shadows. Even minor differences in sunlight exposure can impact vegetation growth patterns (Evans et al. 1960, Ishihara et al. 2015).

Plant communities varied by year and transect direction, with a distinct plant species associated with each cluster of years. Common cattails were associated with the early years of the survey and are a species that are known to grow in dense monocultures and aggressively dominate areas (Apfelbaum 1985). Control of *Typha* spp. has long been discussed from a wetland management perspective with research investigating herbicide treatments (Steenis et al. 1958, Bansal et al. 2019), water level and water quality manipulations (Harris & Marshall 1963, Nelson & Dietz 1966, Mallik & Wein 1986, Bansal et al. 2019), and mechanical treatments (Svedarsky et al. 2016, Bansal et al. 2019) to help control *Typha* spp. After common cattails in this study were hand-cut in 1992 they failed to re-establish for the reminder of the study (21 years), suggesting at least in this system that hand-cutting was an effective means of control.

Bur-reed had higher relative dominance during the middle years of the study. Like common cattails, bur-reed is an aquatic plant that mitigates nitrogen and phosphorus (Alsharekh et al. 2018, Bansal et al. 2019). With the removal of common cattails, it is possible that bur-reed was able to thrive as an aquatic nitrogen and phosphorus mitigating plant. However, more research is needed to understand the chemical components and potential sources of runoff that could be driving aquatic plant dynamics. For example, bladderwort did not appear in the sampling data until 2005.

Interestingly, American lotus and pickerel weed appeared to have an inverse relationship, with American lotus high in years that pickerel weed was low and pickerel weed high in years that

American lotus was low. American lotus is a rhizomatous perennial plant that grows densely and expands rapidly (Whyte et al. 1997, Burlakova & Karatayev 2007), and is known to lower oxygen concentrations in lakes (Turner et al. 2010). In comparison, pickerel weed is an obligate emergent aquatic plant (Harrell & Bohn 1996, Gettys & Wofford 2007) with a low chance of lowering oxygen concentrations to hypoxic conditions compared to other emergent plants (Bunch et al. 2010). Survey notes indicate that herbivory by white-tailed deer on pickerel weed and by American lotus borer moth (*Ostrinia penitalis*) on the American lotus impacted each plant (Schuette 1995, 1997). Extensive deer herbivory was noted on pickerel weed, beginning in 1988. As a result, pickerel weed had a lower presence in transects in the following years. Similarly, notes indicate caterpillar herbivory occurring profusely on American lotus leaves in 1995, which possibly allowed pickerel weed an opportunity to dominate the habitat in 1996 by reducing competition. However, further research is needed to better understand interspecific interactions in a pond marsh natural community system.

Sinkhole ponds are now very rare wetland communities. These features are uncommon due to the specific conditions required for their formation: the presence of karst topography, the dissolution of bedrock dissolve to create a sinkhole, followed by the sinkhole becoming blocked to form a pond (Nelson 2005, Baryakh & Fedoseev 2011). Today, many sinkhole ponds have been destroyed due to high levels of human disturbance (Homoya & Hedge 1982, Nelson 2005), leaving only a small number of intact sinkhole pond natural communities. The few remaining sinkhole ponds in relatively unaltered states continue to face significant threats.

High levels of white-tailed deer herbivory (Schuette 1995, Nelson 2005) can adversely affect certain species (Anderson et al. 2001, Horsley et al. 2003, Rossell et al. 2005). Wetlands, including sinkhole pond systems, are also prone to ongoing threats from invasive species (Pegg et al. 2022), including moneywort (*Lysimachia nummularia*) and barnyard millet (*Echinochloa crus-galli*), which occur in the park. An additional invasive species threat is the release of fish into ponds. Two ponds in the park have had mosquitofish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*), and common goldfish (*Carassius auratus*) released by unknown individuals. The release of aquatic fish into fishless ponds reduces amphibian diversity (Hecnar & M'Closkey 1997) and degrades the habitat (Tiberti & Cardarelli 2021).

Another threat to sinkhole ponds and other wetlands is increased extreme weather frequency (Čížková et al. 2013, Mitsch & Hernandez 2013) such as prolonged periods of drought and excessive rains and floods that may alter cyclical processes (Rodo 2003, Mitsch & Hernandez 2013). Inland wetlands may be even more at risk than coastal wetlands to effects from extreme weather patterns (Čížková et al. 2013). While little is known about sinkhole pond wetland systems, even less is understood about the future threats these systems face from climate change.

Overall, sinkhole ponds are rare wetland systems that have been understudied. Long-term studies, such as this 36-year survey, are invaluable for measuring complex processes that occur over long periods of time and documenting data patterns (Müller et al. 2010, Lindenmayer et al. 2012). Over the course of this study there have been no appreciable changes in the watershed, with the area surrounding the pond consisting of anthropogenic woodland, old fields, and scattered larger trees. However, the implementation of special deer hunts starting in 1996 has significantly reduced deer populations, minimizing browsing pressure on aquatic vegetation like pickerel weed and eliminating the need for deer exclosures in the pond. Similarly, mechanical removal of cattails has proven effective, with no regrowth observed. These findings emphasize the importance of continued monitoring and proactive measures to prevent unwanted species presence and improve overall habitat quality. To our knowledge, this is the first long-term vegetation study of a sinkhole pond. Our findings document vegetation patterns and highlight the unique biodiversity of sinkhole ponds, emphasizing the need for greater research on these uncommon and ecologically important systems.

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Figure 1. **A**. Pickerelweed Pond, date unknown (estimated early 1980s). **B**. Pickerel weed (*Pontederia cordata*) 2011. Photos by Bruce Schuette.

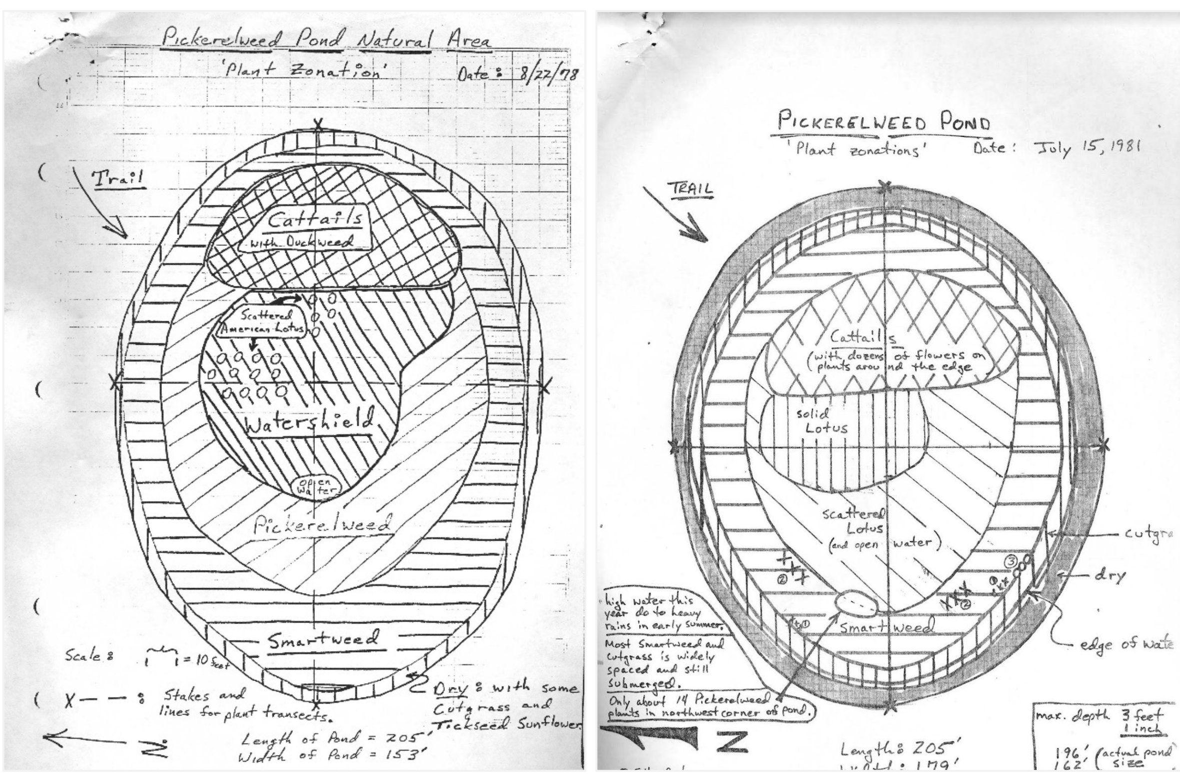


Figure 2. Hand-drawn maps to scale from Pickerelweed Pond surveys in 1978 and 1981.

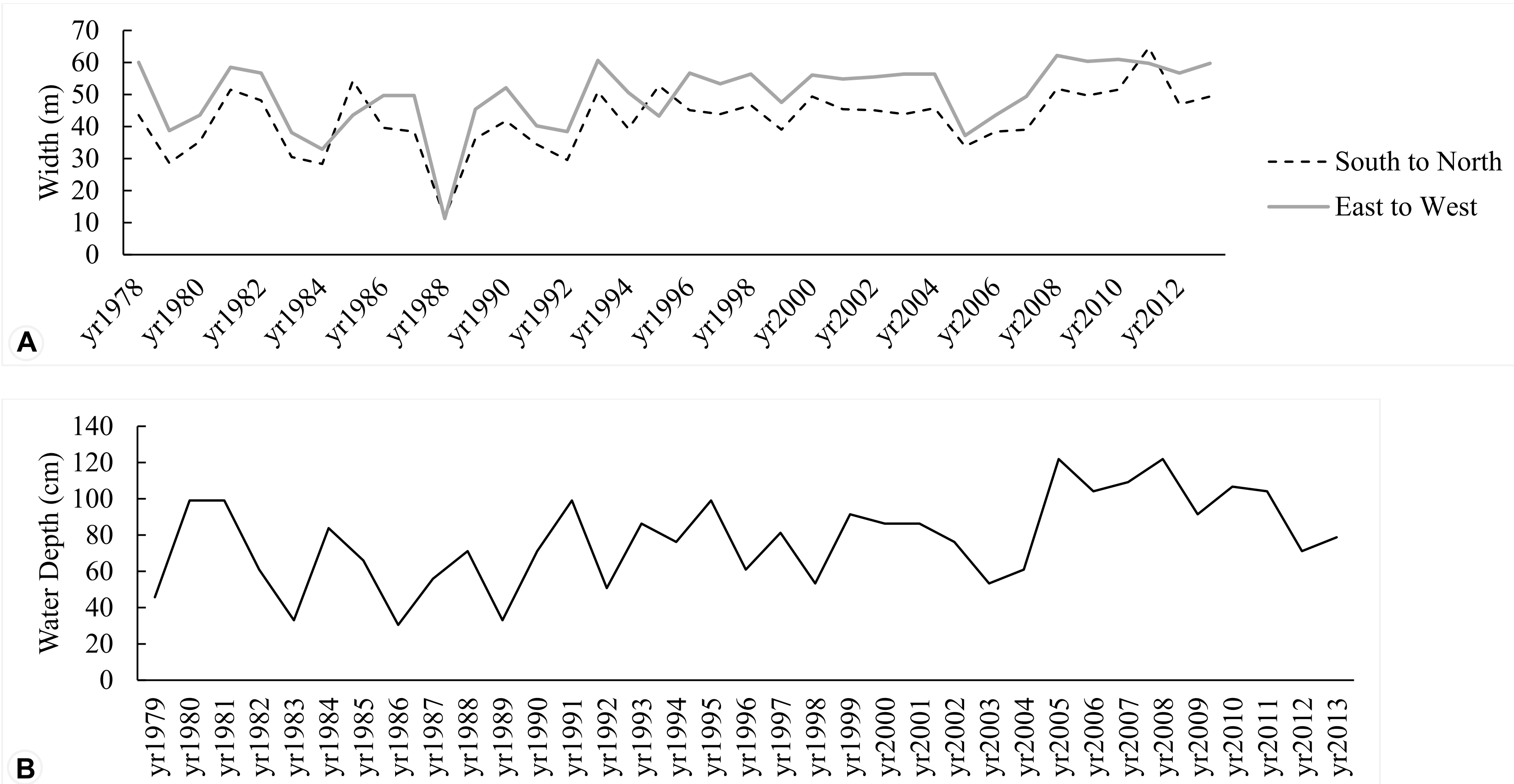


Figure 3. Total width and depth of Pickerelweed Pond in Cuivre River State Park, Troy, Missouri, USA from 1978-2013. **A**. Water was measured from the widest point south to north (SN) and east to west (EW) in August of every survey year. The pond was the smallest in 1988 (11.58 m SN x 11.28 m EW) and widest in 2011 (64.62 m SN x 59.74 m EW). Total water depth (cm). **B**. Water depth was recorded from top of sediment to surface water edge in August of each survey year. Water depth was lowest in 1986 at 30.48 cm and highest in 2005 and 2008 at 121.92 cm. Water depth was not measured in 1978.

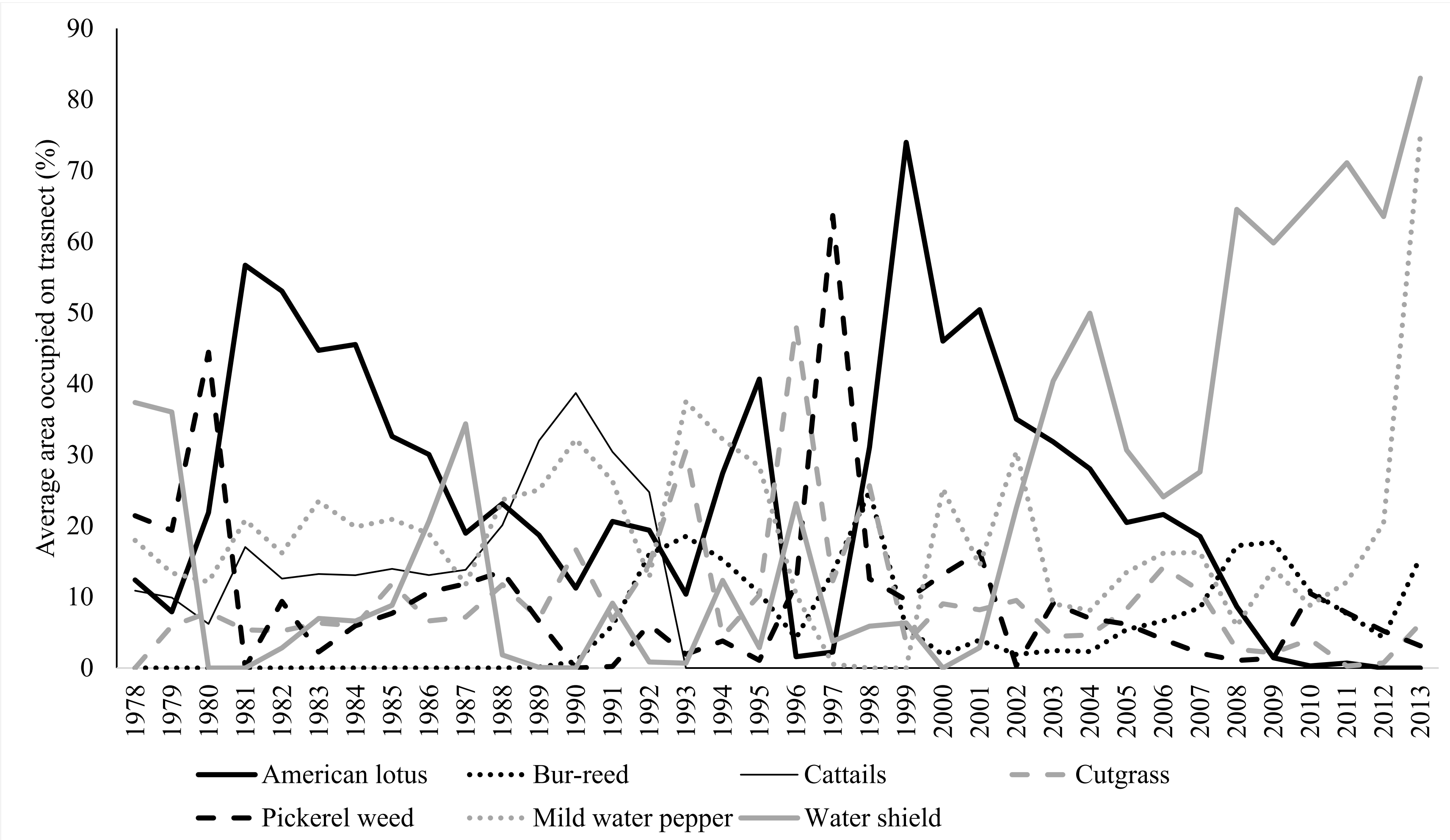


Figure 4. Average relative cover occupied by seven aquatic plant species in Cuivre River State Park, Troy, Missouri, USA from 1978-2013.

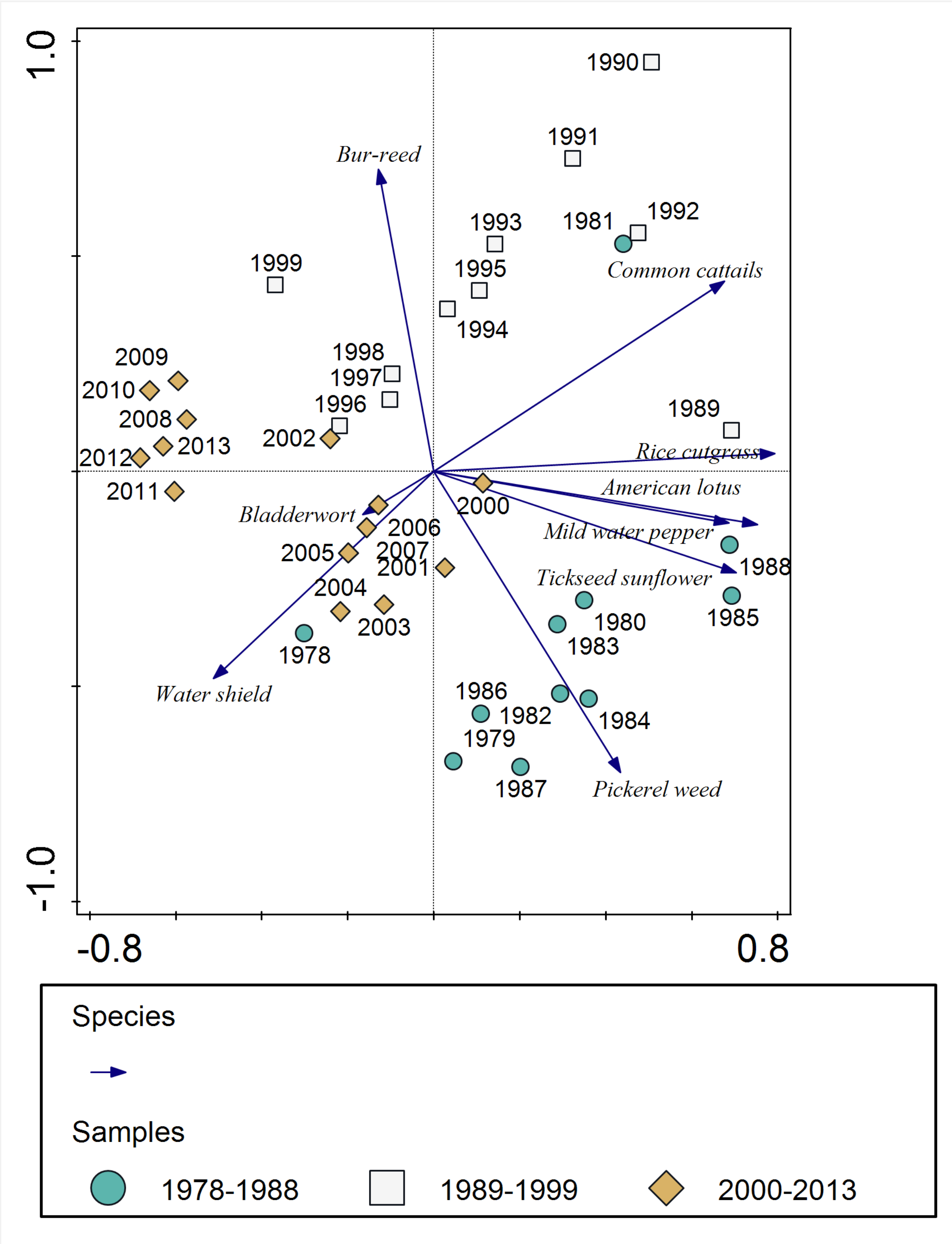


Figure 5. A principal component analysis biplot comparing vegetation community in Pickerelweed Pond in Cuivre River State Park from 1999-2013 along a north-south transect. The closer the years are clustered together, the more similar the plant communities are to one another. Axis I explained 34.60 variation with 53.13 explained in Axis II with eigenvalues 0.35 and 0.19 respectively.

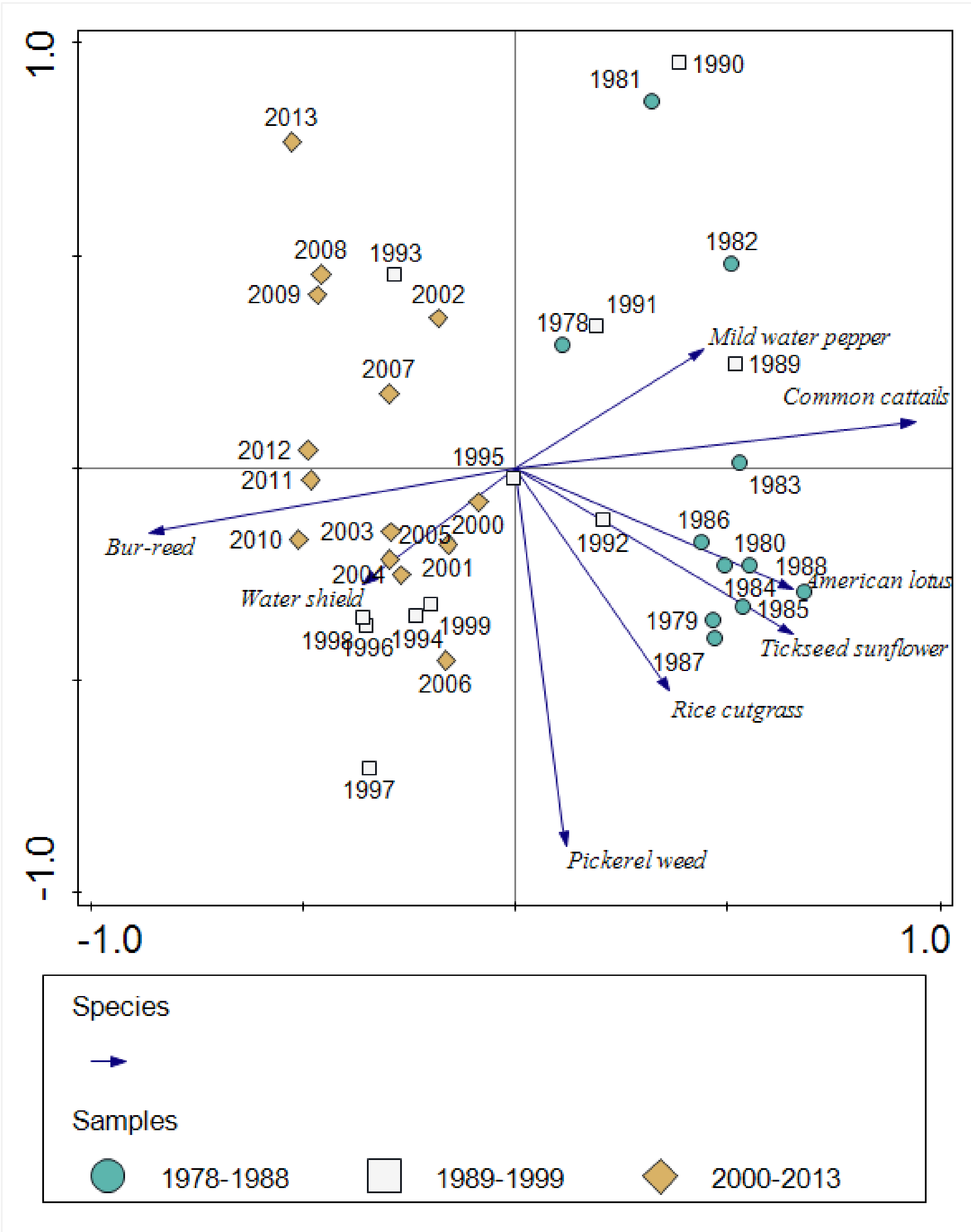
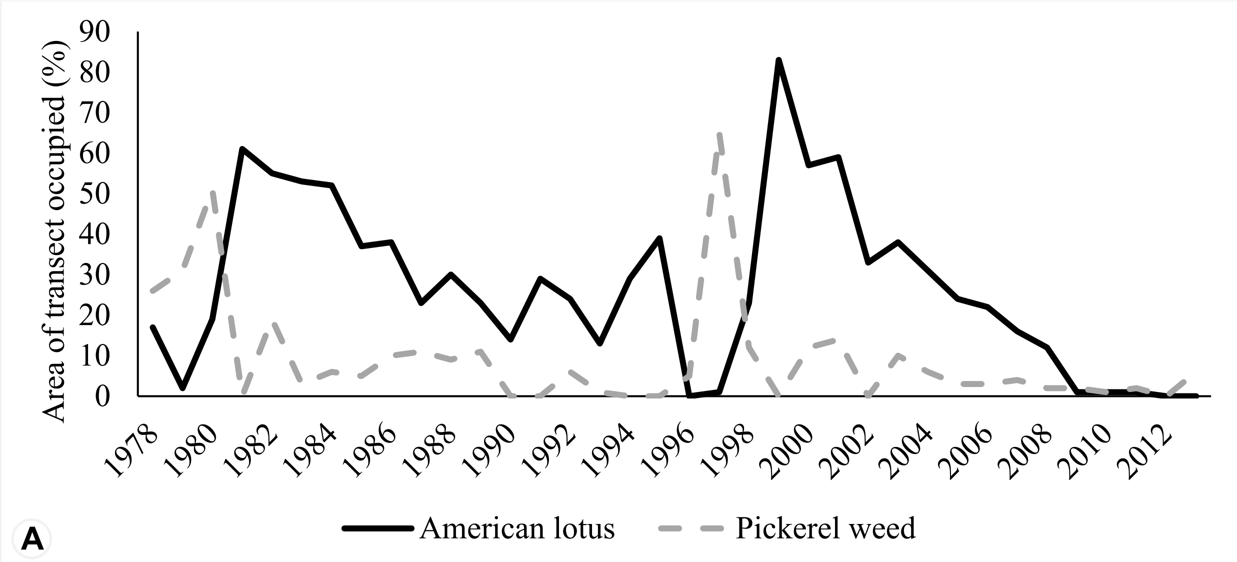


Figure 6. A principal component analysis biplot comparing vegetation community in Pickerelweed Pond in Cuivre River State Park from 1999-2013 along an east-west transect. The closer the years are clustered together, the more similar the plant communities are to one another. Axis I explained 44.34% of the variation with 62.89% explained in Axis II, with eigenvalues 0.44 and 0.19 respectively.



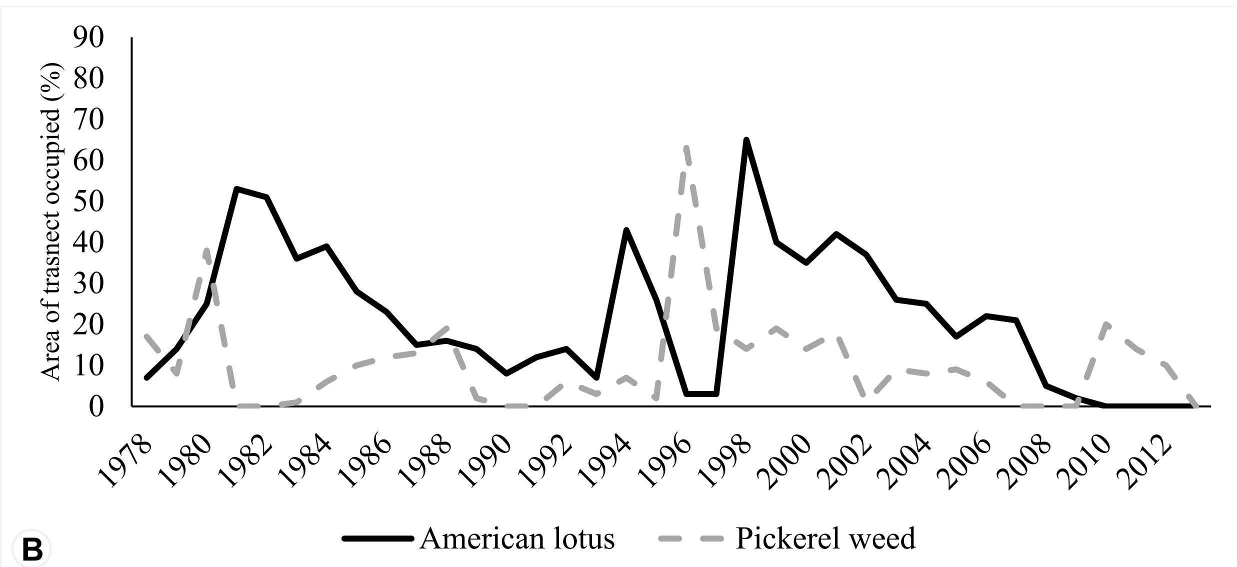


Figure 7. Total area of transects occupied by American lotus (*Nelumbo lutea*) and pickerel weed (*Pontederia cordata*) in Pickerelweed Pond in Cuivre River State Park, Troy, Missouri, USA from 1978-2013. **A**. One transect was orientated north-south across the widest portion of the pond. **B**. One transect was orientated east-west across the widest portion of the pond.

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Table 1. Seventeen plant species' presence recorded in Pickerelweed Pond, Cuivre River State Park, Troy, Missouri over 36 years (1978-2013).

	Year																																		
Species	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Pontederia cordata	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Nelumbo lutea	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Leersia oryzoides		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Persicaria hydropiperoides	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brasenia schreberi	X	X			X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	
Sparganium androcladum												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Typha latifolia	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																					
Bidens frondose		X	X		X	X	X	X		X	X	X	X	X	X		X	X		X		X			X				X	X				X		
Lemna minor								X																												
Eleocharis obtuse															X				X										X						X	
Najas gracillima																X																				
Juncus effusus																																		X	X	
Utricularia gibba																												X	X	X	X	X	X		X	
Echinochloa muricata											X	X					X	X					X	X												
Persicaria spp. (1)																	X	X					X	X		X										
Persicaria spp. (2)																	X																			
Salix nigra																																X	X	X		
Total species richness	5	7	6	5	7	7	7	8	6	7	8	9	7	8	9	7	10	9	7	7	5	6	7	8	7	7	6	7	9	8	7	8	8	9	9	5

Table 2. The effects of pond characteristics (width of pond and depth of pond) on vegetation species richness (richness), Shannon-Wiener diversity (diversity), and Pielou's evenness (evenness) using two transects (north-south orientation and east-west orientation). Generalized linear model results are presented as **β** = estimated coefficient, **SE** = standard error, **z** = z-statistic, and ***p*** = p-value.

	β	**SE**	**z**	***p***
North-south transect				
richness~width	<0.00	<0.01	0.30	0.77
diversity~width	<-0.01	0.01	-0.12	0.90
evenness~width	<-0.00	0.01	-0.13	0.90
richness~depth	<0.01	0.01	0.46	0.65
diversity~depth	<-0.01	0.02	-0.06	0.96
evenness~depth	<-0.01	0.02	-0.09	0.93
East-west transect				
richness~width	<0.00	<0.00	0.68	0.50
diversity~width	<0.00	<0.00	0.12	0.91
evenness~width	<-0.00	0.02	-0.17	0.87
richness~depth	<0.00	0.01	0.012	0.91
diversity~depth	<-0.01	0.02	-0.08	0.94
evenness~depth	<-0.01	0.02	-0.13	0.89

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Botanizing Through Barriers

BOOK REVIEW

Brave the Wild River: The Untold Story of Two Women Who Mapped the Botany of the Grand Canyon, by Melissa L. Sevigny. 2023. W. W. Norton & Company, New York, 304 pp.
[ISBN 9780393868234 (hardcover); ISBN 0393868230 (e-book)]

Reviewed by:
CLARA CHAVEZ-IVES[1]

Brave the Wild River is an enthralling chronicle of the 1938 Nevills Expedition down the Colorado River. Weaving together botanical findings, colorful landscape descriptions, and crewmember diary entries, Melissa L. Sevigny deftly guides the reader through this six-person adventure. Her work highlights the barriers faced by female scientists and provides critical insight into the historical and cultural shifts in US conservation that shape the ecology of the Grand Canyon region today.

In under 260 pages, supplemented by the occasional archival photograph, Sevigny recounts the saga of the Nevills Expedition from its ambitious conception to its excitement-filled execution and understated aftermath. The book reads like a novel, with native flora like Ocotillo (*Fouquieria splendens*) and newfound cacti like beavertail prickly pear (*Opuntia longiareolata*) as supporting characters. Detailed landscape and flora descriptions accompany each shift in the plot, showcasing the region's varied ecology in a digestible style. All botanical discussion is simplified for general readers, including an explanation of the plant pressing process and the importance of herbaria. Sevigny's ability to balance botanical characterizations with overarching cultural and historical analysis is a testament to the interconnected reality of contemporary conservation.

Every chapter includes at least a brief discussion of the gender divides that permeated the voyage and ecological fields more broadly. The trip, officially led by entrepreneur Norman Nevills, made headlines nationwide for including two female botanists from the University of Michigan: Dr. Elzada Clover and Lois Jotter. Sevigny paints a thorough picture of how their gender shaped this research, from funding to media attention to the women's later publications. She analyzes the women's unseen burdens on the expedition (e.g., the expectation that they would wake up early to cook the crew breakfast every day), as well as gender roles within botany more generally (e.g., women "were not permitted to collect any plant that couldn't be reached on a leisurely afternoon stroll"). Although not explicitly contrasted with Clover and Jotter's work,

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Sevigny underlines the masculine ideal of "conquering" the untamed wilderness of the American West that shaped the region via her discussion of the Gold Rush, dam construction, and hunting.

Brave the Wild River also explores how these cultural notions attached to the landscape have shaped conservation. Sevigny covers extensive conservation issues including the National Park Service's past perspectives on wildlife ("either a tourist attraction or a pest") and the Bureau of Reclamation's water management techniques. These analyses provide useful context on regional changes over the 85 years since the Nevills Expedition. For example, understanding that the Colorado River's water supply was viewed as infinite and untamable helps explain both the fear and backlash surrounding the excursion at the time, and the overexploited state of the waterway today.

In her discussion of the topics, Sevigny underscores the inextricable linkages between land and water management and the region's indigenous history. To begin, she explains how botany itself and the associated pressures to "discover" new species caused incalculable losses by overlooking indigenous knowledge and practices. Furthermore, she notes that the notion of national parks as pristine, preserved, and "untouched" wilderness was completely detached from the historical reality that native peoples had tended to these ecosystems for generations. Thus, Sevigny links colonization and the commodification of nature to ecological catastrophes like the Dust Bowl. With modern-day ecologists increasingly realizing the value of indigenous knowledge on topics from fire to community composition, this reminder is all too relevant.

While Sevigny delivers on her title, recounting the untold story of botanists Clover and Jotter, her final chapters feel condensed. Accounts of the women's early lives and the expedition are highly detailed, as is the rich commentary on land and water management and exciting botanical descriptions. Sevigny also briefly summarizes the women's post-voyage careers. Clover remained at the University of Michigan, travelling for research, and ultimately becoming curator of the university's botanical gardens and Professor of Botany. Meanwhile, Jotter, after marrying, earned her PhD in 1943. Following her husband's death, she became an assistant professor of biology at the University of North Carolina Greensboro in 1963.

However, while the reader learns the general trajectory of their lives, the culmination of their work from the Nevills Expedition is presented rather underwhelmingly. Such expansion isn't critical to the book, particularly for readers more drawn to the adventure than the science, but it does leave the ecologically minded reader curious for a follow-up. Given that Sevigny discusses at length the disproportionate media interest in Clover and Jotter's gender and lacking coverage of their botanical work, more than a few pages on the findings would have been apt. Nevertheless, she communicates their notable conclusions, namely that the Colorado River "wasn't as important a corridor for plant migration" as had been assumed. Furthermore, Clover and Jotter noted "four previously unknown cacti species" and the final, published plant list totaled over 400 species with "at least one specimen for every cactus species observed." While these impressive tidbits left me wanting more than a strung together collection of species and habitats, this lingering curiosity did not take away from my intrigue and engagement throughout the book.

Overall, *Brave the Wild River* is a fascinating piece of science writing that honors the invaluable botanical work of Elzada Clover and Lois Jotter on the 1938 Nevills Expedition. Melissa L. Sevigny highlights the women's resilience in the face of violent rapids and aggressive critics who played up the dangers of the journey as unladylike and consistently overlooked their scientific pursuits. The inquisitive reader may itch for more details of their discoveries and their present-day implications, but Sevigny provides plentiful biographical content, situating her storytelling amidst astute cultural critiques of historical Western conservation. This book is a must-read reminder of the importance of botanical field work, the dangers of water and wildlife mismanagement, and of the enduring influence of humans on their environment.

Instructions for Authors

Missouriensis is the Missouri Native Plant Society's electronically published, peer-reviewed, open-access scientific journal containing technical articles relevant to flora, vegetation, and natural systems of Missouri and the surrounding region. A single volume is published annually through the Society's website (https://monativeplants.org/publications/missouriensis) as downloadable pdf files either for the entire volume or individual articles. The journal is distributed to all members of the Society, multiple libraries, and is also indexed and available through the Biodiversity Heritage Library, the world's largest open-access digital library for biodiversity literature and archives.

The journal welcomes manuscripts presenting original research and insights into ecology, conservation, floristics, taxonomy, biology, biogeography, and ecological restoration related to plants and natural communities in Missouri and the surrounding region, including studies of vascular plants, bryophytes, hepatics, lichens, and fungi. Suitable topics also include native horticulture and propagation, invasive species and taxonomic research, review articles, and reviews of books relevant to these topics. Historical accounts of Missouri botany and conservation, including biographies, are also appropriate. Authors are encouraged, but not required, to be members of the Missouri Native Plant Society. There is no charge to publish pages and images.

Manuscripts should be original and not previously published or currently under consideration for publication elsewhere. All submissions to *Missouriensis* must be clearly and concisely written in English and submitted electronically to the editor as a Word or WordPerfect document, double spaced, using Times New Roman 12-point font throughout. Except for short notes, please include an abstract briefly summarizing the key points and findings of the work.

Scientific names should be italicized; authorities for names should be used only as needed for clarity and should be abbreviated following the International Plant Names Index (IPNI) or Yatskievych (1999, 2006, 2013). Unless they deviate from the names included in Yatskievych, authorities should not be used in lists or text enumerations of species, such as associates or natural community inhabitants. Except for italicization of scientific names and certain unusual and unavoidable situations, do not use different fonts, font sizes, bold, small caps, margin changes, or other formatting in the manuscript. Please refer to a recent issue of the journal for examples, including specimen citations and literature cited. Images and graphics should be submitted separately, with file names that correspond to the figure number, and not embedded in the manuscript. Figure and table captions should be submitted as separate text and not embedded in the figures; this text can be included at the end of the manuscript. All submissions are reviewed by independent reviewers with expertise in the subject matter of the manuscript. Deadline for manuscript submissions is October 1, for inclusion in the current year's volume.

IPNI (2020). International Plant Names Index. Published on the Internet http://www.ipni.org, The Royal Botanic Gardens, Kew, Harvard University Herbaria & Libraries and Australian National Botanic Gardens.

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