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Herbaceous Vascular Flora Of Forested Seep Wetlands In Winneshiek County, Iowa, USA

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Forested seep wetlands dominated by skunk cabbage (*Symplocarpus foetidus*) occur frequently in the Canoe Creek watershed of the Upper Iowa River, but this type of wetland has not been described systematically in the upper Midwest. The goal of this study is to document the herbaceous plant flora of five seeps. Although individual seeps are small (200-500 m^2), they provide habitat for a high number of plant species. Five seeps with total area less than 0.2 ha supported more than 120 native vascular herbaceous taxa, 20 of which have a coefficient of conservatism (C-value) of 7 or higher and 23 that are obligate wetland species. Several species that were common in these habitats 100 years ago appear to have been locally extirpated or have become uncommon in the region, including *Gentianopsis crinita, Cirsium muticum, Eupatorium altissimum, Chelone glabra*, and *Micranthes pensylvanica*. Today, these plant communities are threatened by invasive plant species, high levels of deer herbivory, and destruction by human activities. We hope that by documenting their current species composition we can inspire protection of these wetlands and provide a baseline for monitoring future changes.

KEYWORDS: Iowa, wetland, forested seep, habitat conservation, biodiversity, floristics

INTRODUCTION

Forested seep wetlands have received little attention from botanists in the upper Midwest, despite the importance of wetlands in nutrient cycling, regulating water quality, and providing habitat for many specialist species of animals and plants (reviewed in van der Valk 2006, Leibowitz 2003). Small forested seeps are common in the Canoe Creek watershed of the Upper Iowa River in northeastern Iowa, and have been documented in adjacent portions of Minnesota (MNDNR 2005). Located in the northeastern portion of Winneshiek County, Iowa, the Canoe Creek watershed is a deeply dissected landscape within the Paleozoic Plateau (Prior 1991). Cold hard-water springs and seeps occur where groundwater moving through fractured limestone encounters impermeable shale beds and is forced to move laterally (Thompson et al. 1992, Nekola 1994). Seepage wetlands occur where groundwater continuously emerges and hill slopes are sufficiently shallow to create small (200-500 m^2) permanently saturated environments. The soil is a mixture of limestone cobbles and dark, rich organic matter. The seeps are too small to be mapped in county soil surveys. Conspicuous plant species such as marsh marigold (*Caltha palustris* L.), touch-me-not (*Impatiens* Meerb. sp.), and skunk cabbage (*Symplocarpus foetidus* (L.) Salisb. ex W.P.C. Barton) characterize these habitats, making them easy to find in early spring (Figure 1).

Preliminary observations suggested to us that, although they are small in area, these forested wetlands support a relatively high number of native plant species. The soil and hydrologic conditions of forested seeps provide habitat for distinct plant communities, creating islands of wetland habitat within forested landscapes (Morely & Calhoun 2009, MNDNR 2005). Studies of forest seeps in other regions of eastern North America have revealed the importance of these habitats to regional species diversity. For example, small wetlands in a forested region of southern Quebec made up less than 1% of the landscape, but contributed 45% percent of the species in the vascular plant flora of the region (Flinn et al. 2008). Similarly, Morley & Calhoun (2009) demonstrated that forest seeps in Maine greatly increased local vascular plant biodiversity and that hardwood seeps had significantly higher herbaceous plant species Shannon-Weiner diversity (H') and evenness (J) than did the surrounding upland hardwood forests.

Botanical surveys of Iowa fens by Pearson & Leoschke (1992) and Nekola (1994) demonstrated a similar pattern of high species richness within relatively small portions of the landscape. In a survey of approximately 200 fens throughout northern Iowa, Pearson & Leoschke (1992) observed rare plant species in about half of the sites surveyed. In a survey of 160 fens of northeastern Iowa, Nekola (1994) documented that 18% of the vascular plant species of Iowa occurred in habitats that comprise only 0.01% of the area of northeastern Iowa. We predicted that forested wetland seeps also provide habitat for a relatively high number of uncommon species of plants.

The objective of this study is to conduct a preliminary survey of herbaceous plant taxa in forested seep wetlands in Winneshiek County, Iowa. We assessed the conservation value of these wetlands by examining native species richness, Floristic Quality Indices (Swink & Wilhelm 1994), and comparing current species composition to habitat and abundance notes in Shimek's *1906 Flora of Winneshiek County*. We also characterized the current abiotic conditions of the seep wetlands.

Study area

The vegetation of the Paleozoic Plateau landscape of northeastern Iowa, including the study area, is a mix of hardwood forests, pastures, and row crop agriculture (Figure 1). Forests primarily occur on steeper slopes not suited for row crops. Dominant tree taxa include oaks (*Quercus rubra* L., *Q. velutina* Lam., *Q. alba* L., and *Q. macrocarpa* Michx.), ash (*Fraxinus americana* L. and *F. pennsylvanica* Marsh.), elms (*Ulmus americana* L. and *U. rubra* Muhl.), black walnut (*Juglans nigra* L.), hickories (*Carya cordiformis* (Wangenh.) K. Koch and *C. ovata*

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Fig. 1. Photographs of two seeps and environs. Top panel shows Pine Spring seep (PS) looking north, 26 May 2013. Bottom panel shows Zook West seep (ZW), 20 June 2016.

(Mill.) K. Koch), sugar maple (*Acer saccharum* Marsh.) and basswood (*Tilia americana* L.).

Vegetation patterns and land use are strongly influenced by topography and land use history, with forests on steeper slopes and row crops and perennial grasslands on flatter uplands. Prior to European settlement, frequent fires maintained prairies and oak savanna on flat interfluvial uplands, while areas of more rugged topography and areas in the lee of river courses were more protected from fire and supported oak woodlands and mixed deciduous forests (Lynch et al. 2008, Shea et al. 2014). In the mid-19th century, the

Canoe Creek watershed was largely forested (Shimek 1906, Lynch et al. 2008); by the early 1900s, much of it had been logged, resulting in soil erosion and other environmental problems (Shimek 1906).

The climate is continental with hot humid summers and cold, relatively dry winters. The mean annual temperature for Decorah (1981 – 2010) was 9°C, 23°C in July (the hottest month) and -8°C in January (the coldest month). The mean annual precipitation for Cresco, Iowa (28 km west and north of Decorah) was 92.5 cm, the mean for June (the wettest month) was 13.1 cm, and 2.49 cm for January (MRCC 2017).

We sampled vegetation and abiotic conditions in four forest seeps located in Canoe Township, and one seep located just east of the township boundary in adjacent Pleasant Township, Winneshiek County, Iowa (Figure 2). We selected these sites because we were able to obtain permission from the landowners to conduct surveys. The past land use around each site was inferred from aerial photographs taken since the 1930s available from the Iowa Geographic Map Server (2017) and interviews with the landowners (2011 – 2016). The site locations and elevations were determined from USGS 24′ topographic maps (Iowa Geographic Map Server 2017). The approximate area of each seep was determined from measurements of its length (longest dimension) and a measurement of the width perpendicular to the length.

Site descriptions

Middle Hesper seep (MH) is located at the side of a gravel road and receives groundwater emerging at the base of a forested hillside in a narrow valley. Two small rivulets of water flow through an area of saturated, hummocky muck. The south end of the seep is narrow because it is constrained by the roadbed. The area immediately around the seep was surrounded by mature hardwood forest in the 1930s. By the 1950s, the area immediately surrounding the seep was lacking trees, but aerial photographs from the 1990s show indications of more trees and shrubs in and around the seep. Today the north end of the seep is adjacent to a utility right-of-way and exposed to sunlight.

Pine Spring Creek seep (PS) is located on a north-facing hillside in the valley of a small unnamed tributary of Canoe Creek. Here water emerges in a spring partway down the hillslope and saturates soils on a relatively flat bench several meters above Pine Spring Creek (informal name). In the 1930s, a homestead stood near the seep. Since abandonment of the homestead, tree cover on the hillside has gradually increased. The forest surrounding the seep is a mixture of sugar maple, basswood, red oak, walnut, and black ash (*Fraxinus nigra* Marsh.) in the wetter area. The area around the seep had been grazed periodically, but for at least the past 10 years cattle have been excluded from the site.

Fox Hollow seep (FH) is on a narrow bench near the top of a west-facing forested slope of the Canoe Creek valley. The hydrology of the seep is impacted by a gravel road that separates several small springs from the existing wetland. Water flowing into the wetland currently seeps through the roadbed or enters through a culvert under the road. The wetland area has remained forested since the first aerial photographs taken in the 1930s. Most of the trees immediately surrounding the wetland today are mature black ash.

The remaining two seeps (ZE and ZW) are located near two small streams draining a north-facing hillside of the Canoe Creek valley. Springs emerging above the stream elevation produce small areas of saturated muck soils with wetland plant communities. Since at least the 1930s, the hillside has had a mosaic of agricultural land (hay and row crops) and forests, with forest cover on steeper slopes along the stream drainages. The forests show indications of past logging, but aerial photographs provide evidence that the slopes around the seeps have remained continuously tree-covered. Today, black ash is the dominant tree species immediately surrounding the seeps. About 10 years ago, most of the larger black ash trees in ZW were girdled with the goal of promoting wildlife habitat (landowner, personal communication).

METHODS

Plant surveys

We (primarily Weckwerth) visited each site several times during June, July, and August, 2013, to compile lists of plant taxa. Lynch made additional visits and plant collections in 2016. Tentative vascular plant identifications were made in the field, and if necessary plants were collected and identifications confirmed in the lab. The nomenclature follows *Flora of North America* (FNA 1993+) except for taxa not included in the volumes published to date. For those taxa, we used the nomenclature in the USDA PLANTS Database (USDA, NRCS 2017). Family circumscription follows the Angiosperm Phylogeny group (Stevens 2012). Voucher specimens for most species (we did not collect samples of some very common and easily identified species) were deposited in the Luther College Herbarium (LCDI).

Floristic analysis

Wetland indicator species for the Midwest region were determined from the National Wetland Plant List (USDA, NRCS 2017). We determined whether species were native or not native in Iowa according to Eilers & Roosa (1994). The coefficient of conservatism (C-value) values for species native to Iowa follow Drobney et al. (2001). C-values range from 0 –10, with higher values assigned to plant species that are restricted to the less degraded habitats, and low values for native plant species that can occupy sites degraded by human activity (Swink & Wilhelm 1994). We calculated the Floristic Quality Index by multiplying the mean C-value of each site by the square root of the total number of native taxa at the site (Swink & Wilhelm 1994). We compared species composition among sites and calculated the Jaccard's similarity coefficient (Krebs 1989) for all possible site pairs.

We compared the species documented in our surveys to species accounts in a historic flora of Winneshiek County (Shimek 1906). Shimek made specific reference to "shaded bogs" with skunk cabbage occurring on wooded slopes in river "gorges" of the Upper Iowa River watershed. He also mentioned "bogs" associated with ground water flow in the forested northern portion of the county. (He used other terms – "swamp," "wet meadow," "moist open places," "moist prairie," and "prairie bog" – to describe other types of wetlands.)

Abiotic factors

We measured percent canopy cover using a convex densiometer (Lemmon 1956). We report the average of four measurements made from near the center of the seep while facing in each of four cardinal directions (Table 1). MH seep has two distinct halves, so we measured canopy cover separately in each. We measured conductivity and pH of water flowing through seeps on 27 June 2013 with a portable meter. Measurements were taken at the primary water source for each site and in one or two locations near the center of the seep if there was sufficient water depth.

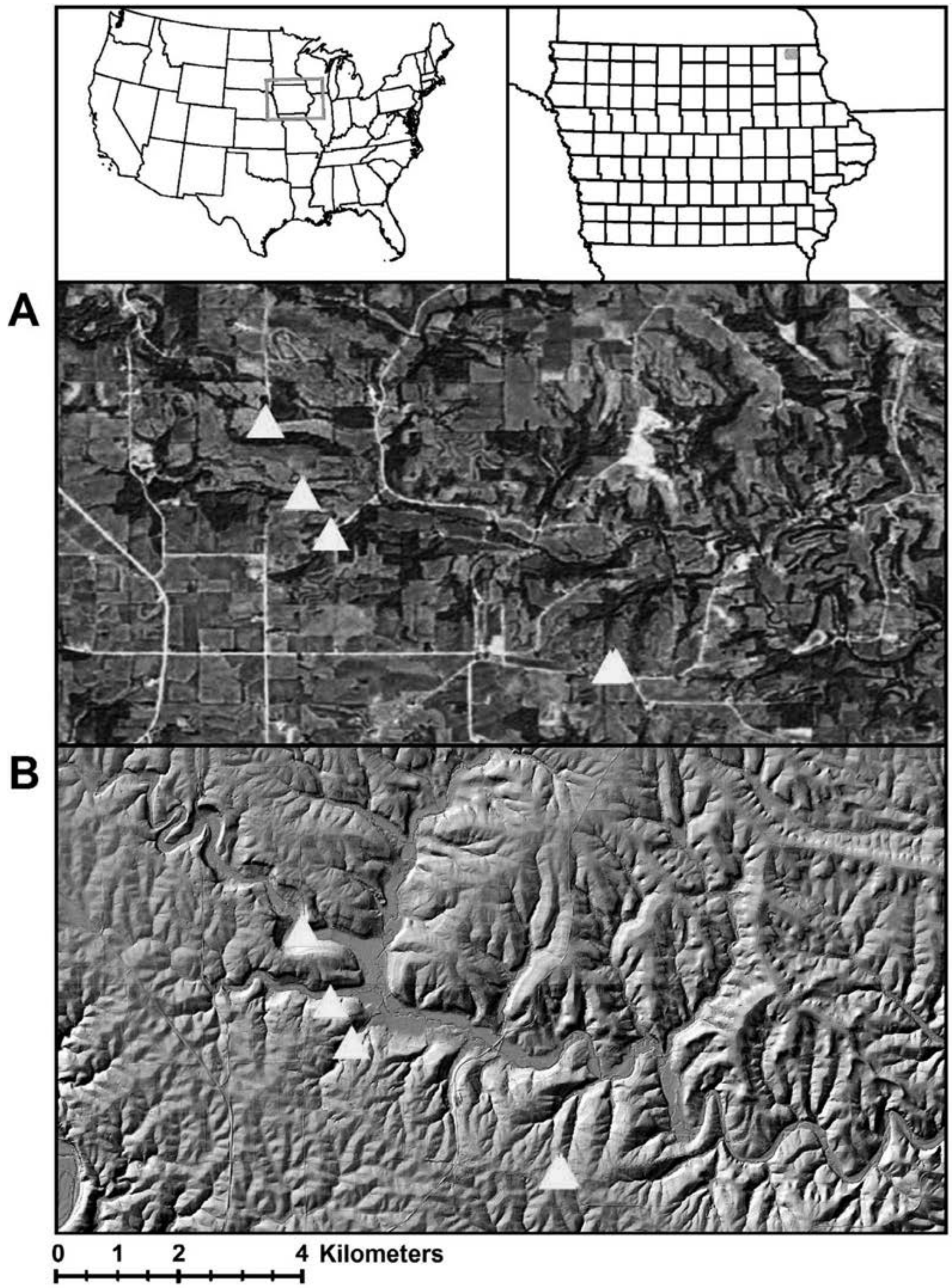

Fig. 2. The locations of five seeps surveyed in Winneshiek County, Iowa, are shown by red triangles on: A) late-spring aerial photograph showing surrounding land use (dark green = forests, light green = pasture and other perennial grasslands, brown = row crops); and B) with topography from LiDAR (Iowa Geographic Map Server). Sites from northwest to southeast: FH, PS, MH, and symbols for the ZW and ZE sites overlap.

We used two different methods to determine nitrate concentrations. In 2013, we collected 15 ml of water from the primary source and from one or two additional locations in each seep on 19 June and 23 July. Water samples were kept cool and then refrigerated until nitrate levels could be determined (within 48 hours of sample collection) using a nitrate ion probe. In the lab, we added 10mL of nitrate interference suppressor solution (Orion 930710) to each sample and measured nitrate levels with an Orion nitrate ion selective electrode. We collected water samples from each seep on 28 August 2015 and measured nitrate in the lab. We added 50% sulfuric acid in the field to stabilize samples, then measured nitrate in the lab using a HACH Test 'N Tube 835, HACH Spectrophotometer DR3900^{TM}.

Table 1. Estimated area and location of five study sites in text: Middle Hesper (MH), Pine Spring Creek (PS), Fox Hollow (FH), Zook West (ZW), and Zook East (ZE).

	MH	PS	FH	ZW	ZE
Area (m^2)	460	510	460	260	240
Elevation (m a.s.l.)	311	311	317	329	329
Latitude	43°22′26.5″N	43°22′48.0″N	43°23′25.8″N	43°21′16.4″N	43°21′17.3″N
Longitude	-91°46′48.3″W	-91°47′03.3″W	-91°47′22.6″W	-91°44′21.6″W	-91°44′18.5″W

RESULTS

We documented 137 non-woody vascular plant taxa from the five sites surveyed (Appendix I). Of the 131 taxa that we were able to identify to species, 17 are not native to Iowa, according to Eilers & Roosa (1994). Of the native plant species, 20 (17%) have a C-value of 7 or higher, meaning that they are typical of plant communities that have experienced little disturbance and are good indicators of high-quality natural areas (Swink & Wilhelm 1994). Greater than 43% of the native taxa are obligate or facultative wetland species in the Midwest, meaning that they "almost always" or "usually" occur in wetlands (USDA, NRCS 2017). Three of the non-native species documented in our survey are invasive: wild parsnip (*Pastinaca sativa* L.), garlic mustard (*Alliaria petiolata* (M. Bieb.) Cavara & Grande), and reed canary grass (*Phalaris arundinacea* L.).

Individual sites had from 46 to 68 native plant taxa, and the average C-value scores ranged from 3.6 to 4.4. FQIs ranged from 24.4 to 33.5 (Table 2). The lowest species richness and FQI value were at the two smaller sites (ZE and ZW); MH had the highest species richness, and PS had a slightly higher FQI (Table 2). The species composition of sites varied greatly. The Jacaard's similarity coefficient (S_j) for each of the 10 site pairs ranged from 0.27 to 0.49, and the average value was 0.35 (+/- 0.02 SEM). Forty-nine of the taxa (36% of the total) occurred at only a single site, 14 taxa (10% of the total) occurred at all five sites, and 15 taxa (11% of total) occurred at four of the sites (Appendix I).

In his flora, Shimek (1906) explicitly associated 15 plant taxa with the "bogs" or "shaded bogs" located in the northern part of the county (Table 3). Ten of the species that we identified were characterized by Shimek as occurring in "bogs" or "shaded bogs." We did not find three species reported by Shimek as being common in bogs: *Gentianopsis crinita* (Froel.) Ma*, Cirsium muticum* Michx., and *Eupatorium altissimum* L. Shimek (1906) specifically mentioned fringed gentian as being common in "shaded bogs" of Canoe Creek, so its absence from our sites suggests a substantial reduction in the abundance of this species over the past 100 years.

Although reported by Shimek as "common," *G. crinata* and *C. muticum* were considered rare in Iowa by the late 20th century, and *E. altissimum* is rare to infrequent in the northern part of the state (Eilers & Roosa 1994). Two taxa – *Chelone glabra* L. and *Micranthes pensylvanica* (L.) Haw. – considered by Shimek to be "common" or "not rare" occurred at only one of the sites we surveyed. We did not find *Parnassia glauca* Raf. or *Solidago uliginosa* Nutt., reported by Shimek in bogs and shaded bogs in the early 1900s. *P. glauca* typically occurs in fens and wet calcareous prairies (Pearson & Leoschke 1992, Eilers & Roosa 1994, Nekola 1994), so this species may never have been present in forested seeps. Shimek's report of *S. uliginosa* is questionable; in Iowa, this species is documented with voucher specimens only from Allamakee County (Eilers & Roosa 1994, Nekola 1994).

Average values of percent canopy cover, pH, conductivity, and nitrate concentration measured at each site are reported in Table 2. Canopy cover ranged from 26 – 88%. The pH was similar among the sites, ranging from 7.4 to 7.7. Conductivity, an indicator of the concentration of ions in solution, varied among sites from 439-527µs. Nitrate levels were below or near 1 mg/L at all sites on the dates sampled. Nitrate values measured using the nitrate probe (range: 0.19 – 0.78 mg/L) were slightly lower than those measured with the spectrophotometer (range: 0.53 – 1.04 mg/L). Values reported in Table 2 are the averages of several measurements at each site on three different sampling dates using both methods.

DISCUSSION

There is very little information available about the distribution, environmental conditions, or plant species composition of forested seeps in the upper Midwest. Forested seep habitats have been documented in the Driftless Region of Wisconsin (Epstein at al. 2002) and in southeastern Minnesota (MNDNR 2005). In a survey of wetland habitats of Iowa, Lammers & Van der Valk (1978) included "hanging bog" as a distinct type of wetland in their description of wetland types of Iowa. According to descriptions in Lammers & Van der Valk (1978), hanging bogs appear to be similar to the forested seep habitats described in Wisconsin, Minnesota, and in our surveys. Fens have received more attention in Iowa (Pearson & Leoschke 1992, Nekola 1994), and although they are also groundwater-fed, they are quite different in their species composition and environmental conditions from the forested seeps we studied.

Our survey of five forested seeps generated data that could be used to compare current environmental conditions and floristic

Table 2. Summary of plant community information and environmental data for five study sites.

	MH	PS	FH	ZW	ZE
# native plant taxa	68	61	54	47	46
Percent of non-native taxa	11.7	11.6	10.0	17.5	14.8
Percent of native taxa with C-value 7 or higher	14.7	22.9	18.5	10.6	15.2
Average C-value	3.98	4.29	4.40	3.75	3.59
Floristic Quality Index	33.0	33.5	32.4	25.7	24.4
Tree canopy cover (%)	46 & 87	26	80	88	80
pH	7.4	7.5	7.7	7.5	7.6
Conductivity (µS), average +/- s.d.	503 ± 48.8	439 ± 7.3	527± 1.4	503± 40.6	490±19.7
Nitrate (mg/L), average +/- s.d.	0.704+0.201	0.555+0.361	0.475+0.245	0.493+0.334	0.612+0.292

Table 3. Herbaceous vascular plant taxa reported in Shimek's *Vascular Flora of Winneshiek County* (1906) as occurring in "bog habitats". Habitat and abundance notes are quotes from Shimek (1906). Species names follow current nomenclature. Frequency is the proportion of the sites at which we found each of the species.

Species name	Habitat, abundance (Shimek 1906)	Frequency
Calta palustris L.	In bogs and wet meadows. Not common.	0.8
Cardamine bulbosa (Schreb. ex Muhl.) Britton, Sterns & Poggenb.	In bogs, etc.	1
Carex hystericina Muhl.	Common in bogs.	0.6
Chelone glabra L.	In bogs near Hesper. Local.	0.2
Cirsium muticum Michx.	Common in bogs near Hesper.	0
Eupatorium altissimum L.	In bogs, etc. Quite common.	0
Gentianopsis crinita (Froel.) Ma	Locally common in shaded boggy places. Canoe Creek.	0
Lycopus americanus Muhl.	In swamps and bogs. Common.	0.4
Micranthes pensylvanica (L.) Haw.	Not rare, in bogs.	0.2
Packera aurea (L.) Á. Löve & D. Löve	In bogs. Not rare.	0.6
Parnassia glauca Raf. [a]	Quite rare, in bogs near Hesper.	0
Scirpus atrovirens Willd.	Common in swamps and bogs.	0.4
Solidago uliginosa Nutt.	In bogs. Not common. Kendallville.	0
Symphyotrichum puniceum (L.) Á. Löve & D. Löve	Bogs. Common.	0.2
Symplocarpus foetidus (L.) Salisb. ex W.P.C. Barton	Common in shaded bogs.	1

[a]Shimek reported as *Parnassia caroliniana*.

composition to other sites in the region, as well as serve as a baseline against which to measure future changes. Water chemistry values from the sites we studied are typical of fens in temperate North America (Amon et al. 2002), though pH was slightly higher and nitrate values were lower.

Our results demonstrate that while the richness and rarity of vascular plant species are not as high as those documented in Iowa fens (Pearson & Leoschke 1992, Nekola 1994), forested seeps nonetheless contribute disproportionately to the species richness of the regional flora. In an area totaling less than 0.2 ha we documented 137 herbaceous vascular plant taxa, more than 87% of which are native to Iowa. A large proportion of the plants occurring in forested seeps are obligate wetland taxa, and 20 of the species have C-values of 7 or higher, indicating that they have high fidelity to these site conditions. We also observed that species composition varied considerably among sites, with close to a third of the plant species occurring at only a single site. These findings are consistent with other studies of forested wetlands in eastern North America, which show high species richness within small areas of habitat and high variability in species composition among sites (Flinn et al. 2008, Morely & Calhoun 2009). These results can be used to make a case for conservation of these habitats, which are limited in their distribution and threatened by a variety of factors.

Several taxa that were not rare 100 years ago in small "bogs" and "shaded bogs" of Winneshiek County either were not found in our surveys or occurred at a single site: *Cirsuim muticum*, *Eupatorium altissimum*, *Gentianopsis crinata, Micranthes pensylvanica*, *Parnassia glauca*, and *Symphyotrichum puniceum*. While 100 years ago not all of these species may have occurred in the sites that we surveyed, the absence of *G. crinata* is particularly interesting because it had been locally common in the Canoe Creek watershed, where our sites are located (Shimek 1906). Also notable is the fact that *Caltha palustris*, reported by Shimek as "not common," persists today in four of the five sites that we surveyed and is still frequent in north central and northeastern Iowa (Eilers & Roosa 1994).

Many of the plant taxa growing in the seeps we surveyed have likely become more limited in their distribution in northeast Iowa because of habitat loss and degradation; forested seeps may be important refuges for several taxa considered to be rare or infrequent in the region (Eilers & Roosa 1994), including *Chelone glabra* and *Silene nivea* (Nutt.) Muhl. ex Otth. *C. glabra*, once "locally common" in wetlands in the northern part of the county (Shimek 1906), is of particular interest because it is the primary host plant for the larvae of the rare Baltimore checkerspot butterfly, *Euphydryas phaeton* Drury (Bowers 1980).

In addition to contributing to regional species diversity, these seeps probably provide important ecosystem services such as regulating the flow regimes and water quality in the entire watershed (Bedford et al. 1999, Tiner 2003, Van der Valk 2006). While each of the sites we studied is small, seeps are clustered on the landscape and so are likely to have a relatively large cumulative impact on ecological functions in the watershed. Devastating floods have become increasingly frequent in the upper Midwest and this threat is predicted to continue as summer storms intensify (Pryor & Scavia 2014). Pollution from non-point sources is a chronic threat to surface waters in Iowa and the entire Mississippi River watershed. Monitoring and protecting headwater habitats, including wetlands, should be a priority as policy makers and land managers seek solutions to protect downstream communities from flooding and eutrophication (Mitsch et al. 2001).

Because forested seeps in northeast Iowa are a very small component of a landscape largely devoted to agricultural production, they are vulnerable and valuable refuges of biological diversity. Their future depends on the seemingly insignificant decisions of individual landowners. All of the sites are vulnerable to an increase in invasive species (particularly reed canary grass), run-off and fertilizer input from adjacent agricultural lands, herbivory pressure from elevated populations of white-tailed deer (*Odocoileus virginianus* (Zimmermann, 1780)), and changing climatic conditions. In sharing results from our surveys of the vascular plants in forested seep wetlands in the Upper Iowa River watershed, we hope to bring attention to their value and to stimulate interest in their protection.

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Appendix 1. Non-woody vascular plants observed in five forested seeps in Winneshiek County, Iowa, 2013 – 2016. Nomenclature follows FNA (2013+) or, for families not yet published, the USDA, NRCS (2017). A "!" indicates the species is not native to Iowa (Eilers & Roosa 1994); C-value refers to the coefficient of conservatism (Drobney et al. 2001); wetland status follows USDA indicator codes for the Midwest (USDA, NRCS 2017); site abbreviations follow those used in text.

	C-value	wetland status	MH	PS	FH	ZW	ZE
PTERIDOPHYTES							
Equisetaceae							
Equisetum arvense L.	0	FAC	1	1	1	1	1
ANGIOSPERMS							
MAGNOLIIDS							
Aristolochiaceae							
Asarum canadense L.	8	FACU			1		
EUDICOTS							
Anacardiaceae							
Toxicodendron rydbergii (Small ex Rydb.) Greene	0	FAC		1	1		
Apiaceae							
Cicuta maculata L.	7	OBL		1	1		
Cryptotaenia canadensis L.	4	FAC	1	1	1	1	1
!*Daucus carota* L.		UPL	1	1		1	1
Heracleum sphondylium ssp. *montanum* (Schleich. ex Gaudin) Briq.	4	FACW	1		1		
Osmorhiza claytonii (Michx.) C.B. Clarke	3	FACU			1	1	
Osmorhiza longistylis (Torr.) DC.	5	FACU	1	1		1	1
!*Pastinaca sativa* L.		UPL	1	1		1	1
Sanicula marilandica L.	5	FACU	1		1		
Zizia aurea (L.) W.D.J. Koch	6	FAC				1	
Apocynaceae							
Asclepias incarnata L.	4	OBL		1			
Asclepias syriaca L.	0	FACU	1	1			
Asteraceae							
Achillea millefolium L.	0	FACU	1				
Ambrosia trifida L.	0	FAC	1	1		1	1
Ageratina altissima (L.) King & H. Rob.	2	FACU				1	
!*Arctium minus* Bernh.		FACU	1	1		1	
Bidens cernua L.	2	OBL	1				
Bidens connata Muhl. ex Willd.	3	OBL	1	1			
!*Cirsium arvense* (L.) Scop.		FACU	1				
Cirsium altissimum (L.) Hill	6	UPL		1			1
Erigeron philadelphicus L.	2	FACW	1		1	1	1
Erechtites hieracifolius (L.) Raf. ex DC.	0	UPL		1			
Eupatorium perfoliatum L.	6	OBL	1	1			
Eutrochium maculatum (L.) E.E. Lamont	5	OBL			1		
Helenium autumnale L.	4	FACW		1			
Packera aurea (L.) Á. Löve & D. Löve	5	FAC	1	1			1
Polymnia canadensis L.	5	UPL			1	1	
Rudbeckia laciniata L.	4	FACW	1		1		1
Solidago gigantea Aiton	4	FACW			1		
Solidago L. sp.				1		1	1
Symphyotrichum lanceolatum (Willd.) G.L. Nesom	4	FAC			1	1	1
Symphyotrichum prenanthoides (Muhl. ex Willd.) G.L. Nesom	7	FAC	1	1		1	1
Symphyotrichum puniceum (L.) Á. Löve & D. Löve	5	OBL		1			
!*Taraxacum officinale* F.H. Wigg.		FACU	1	1	1	1	1
Balsaminaceae							
Impatiens Meerb. sp.			1	1	1	1	1
Impatiens pallida Nutt.	5	FACW				1	
Boraginaceae							
Hackelia virginiana (L.) I.M. Johnst.	0	FACU					1
Brassicaceae							
!*Alliaria petiolata* (M. Bieb.) Cavara & Grande		FAC				1	1
!*Barbarea vulgaris* W.T. Aiton		FAC	1			1	1
Cardamine bulbosa (Schreb. ex Muhl.) Britton, Sterns & Poggenb.	6	OBL	1	1	1	1	1
Cardamine pensylvanica Muhl. ex Willd.	4	FACW	1	1			

Appendix 1. Continued.

	C-value	wetland status	MH	PS	FH	ZW	ZE
Campanulaceae							
Campanula americana L.	4	FAC	1				1
Campanula aparinoides Pursh	10	OBL	1				
Lobelia siphilitica L.	3	OBL	1	1	1	1	1
Caryophyllaceae							
Silene nivea (Nutt.) Muhl. ex Otth	10	FACW	1	1	1		
Stellaria longifolia Muhl. ex Willd.	6	FACW				1	
!*Stellaria media* (L.) Vill.		FACU			1	1	
Cucurbitaceae							
Echinocystis lobata (Michx.) Torr. & A. Gray	2	FACW	1			1	
Fabaceae							
Amphicarpaea bracteata (L.) Fernald	4	FAC	1	1	1	1	1
Apios americana Medik.	4	FACW	1		1	1	
!*Trifolium pratense* L.		FACU	1			1	
Geraniaceae							
Geranium maculatum L.	6	FACU	1				
Hydrophyllaceae							
Hydrophyllum virginanum L.	3	FAC	1	1	1		
Lamiaceae							
Blephilia hirsuta (Pursh) Benth.	6	FACU	1				
!*Glechoma hederacea* L.		FACU		1	1		
Lycopus americanus Muhl.	4	OBL	1				1
Mentha arvensis L.	4	FACW	1	1	1		1
!*Mentha spicata* L.		FACW	1				1
!*Prunella vulgaris* L.		FAC		1	1		
Scutellaria lateriflora Pursh	6	OBL		1	1	1	
Menispermaceae							
Menispermum canadense L.	5	FAC			1		
Onagraceae							
Circaea lutetiana L.	5	FACU	1	1	1		
Epilobium coloratum Biehler	3	OBL	1	1		1	1
Penthoraceae							
Penthorum sedoides L.	3	OBL				1	
Plantaginaceae							
Chelone glabra L.	8	OBL	1	1	1		
!*Plantago major* L.		FAC			1		
Polemoniaceae							
Phlox divaricata L.	5	FACU	1			1	
Polemonium reptans L.	6	FAC	1		1		
Polygonaceae							
!*Fallopia convolvulus* (L.) Á. Löve		FAC				1	
!*Persicaria maculosa* Gray		FACW				1	1
Persicaria punctata (Elliott) Small	4	FACW	1			1	1
Persicaria L. sp.				1			1
Primulaceae							
Lysimachia ciliata L.	4	FACW					1
Ranuculaceae							
Anemone canadensis L.	2	FACW	1				
Caltha palustris L.	8	OBL	1	1		1	1
Clematis virginiana L.	2	FAC			1		
Ranunculus abortivus L.	0	FACW	1	1		1	1
Ranunculus hispidus Michx.	6	FAC	1		1		
Ranunculus recurvatus Poir.	7	FACW	1	1		1	1
Thalictrum dasycarpum Fisch. & Avé-Lall.	4	FACW			1		
Thalictrum dioicum L.	8	FACU	1		1		1
Rosaceae							
Agrimonia gryposepala Wallr.	3	FACU		1		1	1
Fragaria virginiana Duchesne	3	FACU	1				
Geum canadense Jacq.	2	FAC	1	1	1	1	1
Rubus idaeus L.	3	FACU					1
Rubus occidentalis L.	1		1			1	1

Appendix 1. Continued.

	C-value	wetland status	MH	PS	FH	ZW	ZE	
Rubiaceae								
Galium aparine L.	1	FACU	1	1	1	1	1	
Galium concinnum Torr. & A. Gray	7	FACU	1		1		1	
Galium triflorum Michx.	7	FACU	1	1	1		1	
Saxifragaceae								
Micranthes pensylvanica (L.) Haw.	7	OBL		1				
Mitella diphylla L.	8	FACU				1		
Urticaceae								
Laportea canadensis (L.) Wedd.	3	FACW	1	1	1	1		
Pilea fontana (Lunell) Rydb.	5	FACW	1	1	1	1	1	
Urtica dioica L.	0	FACW	1	1	1	1	1	
Violaceae								
Viola pubescens Aiton	5	FACU			1			
Viola sororia Willd.	1	FAC	1					
Viola L. sp.			1	1	1	1	1	
MONOCOTS								
Alismataceae								
Sagittaria latifolia Willd.	4	OBL		1				
Araceae								
Arisaema triphyllum (L.) Schott	4	FACW	1		1			
Symplocarpus foetidus (L.) Salisb. ex W.P.C. Barton	10	OBL	1	1	1	1	1	
Asparagaceae								
Maianthemum racemosum (L.) Link	4	FACU	1		1			
Polygonatum biflorum (Walter) Elliott	4	FACU	1					
Cyperaceae								
Bolboschoenus fluviatilis (Torr.) Soják	5	OBL		1				
Carex blanda Dewey	2	FAC	1	1	1			
Carex cf. *cephaloidea* Dewey	6	FACU	1					
Carex conoidea Schkuhr ex Willd.	10	FACW		1				
Carex gracillima Schwein.	10	FACU		1				
Carex grisea Wahlenb.	4	FAC	1			1		
Carex hystericina Muhl.	5	OBL	1	1			1	
Carex granularis Muhl. ex Willd.	3	FACW		1				
Carex cf. *radiata* (Wahlenb.) Small	7	FAC		1				
Carex rosea Schkuhr ex Willd.	6	FACU				1	1	
Carex stipata Muhl. ex Willd.	5	OBL		1	1	1		
Carex trichocarpa Willd.	8	OBL		1	1			
Carex vulpinoidea Michx.	3	FACW	1	1				
Carex L.			1					
Eleocharis palustris (L.) Roem. & Schult.	6	OBL		1				
Scirpus atrovirens Willd.	1	OBL			1		1	
Orchidaceae								
Liparis liliifolia (L.) Rich. ex Lindl.	4	FACU		1				
Liparis loeselii (L.) Rich.	7	FACW		1				
Poaceae								
Bromus pubescens Muhl. ex Willd.	9	FACU			1			
Elymus hystrix L.	5	FACU	1		1	1	1	
Glyceria grandis S. Watson	6	OBL		1				
Glyceria striata (Lam.) Hitchc.	5	OBL	1	1	1	1	1	
Leersia virginica Willd.	6	FACW	1	1				
Leersia Sw. sp.				1		1	1	
Phalaris arundinacea L.	0	FACW	1		1			
!*Phleum pratense* L.		FACU		1				
Poa cf. *pratensis* L.		FAC	1	1	1		1	
Typhaceae								
Typha latifolia L.	1	OBL	1					
unknown forb 1							1	1
unknown forb 2						1	1	
unknown grass 1					1			
unknown grass 2						1	1	