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Morphological and Ecological Investigations of Species of Bulrush (Scirpus) in Illinois

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MORPHOLOGICAL AND ECOLOGICAL INVESTIGATIONS OF CRYPTIC SPECIES OF BULRUSH (*SCIRPUS*) IN ILLINOIS.

BY

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Abstract

Two closely related species of bulrush, *Scirpus atrovirens* (Green bulrush) and *Scirpus georgianus* (Georgia bulrush), are widely distributed in Illinois. They are difficult to separate in the field, but readily distinguishable under magnification in the lab. These two species have been found in moist meadows, shallow marshes, edges of wet forests, and ditches. The objective of this study was to evaluate the morphological and ecological distinctness of the species with the aim toward discovering and describing other features to distinguish them reliably. Eighty plants of *Scirpus atrovirens* and 80 of *Scirpus georgianus* were examined. Fifty *S. atrovirens* and 50 *S. georgianus* were collected in the field at different counties in Illinois. Thirty *S. atrovirens* and 30 *S. georgianus* specimens were measured from Stover-Ebinger Herbarium at Eastern Illinois University in Charleston, IL, University of Illinois in Champaign herbarium, and the Morton Arboretum in Lisle, IL. Parameters measured on both species were spikelet length/width (mm), culm width (mm), rachilla length (mm), scale length/width (mm), plant height (cm), and achene length/width (mm). A t-test performed showed a significant difference between the species in spikelet length and width, rachilla length, scale length and width, culm width, and achene length and width. There was no significant difference in plant height. *Scirpus atrovirens* was larger in several morphological characteristics than *S. georgianus.* Analysis of field data showed that within 30 m of *S. atrovirens,* 61 different plant species were found. Thirty- four different plant species were found within 30 m of *S. georgianus.* Only five plant species were found within 30 m of both *S. atrovirens* and *S.* georgianus: Glyceria *striata, Phalaris arundinacea, Agrostis alba, Juncus dudleyi,* and *Carex lupulina*. Soil data was examined for numerous collections sites. Seventy- nine percent of *Scirpus atrovirens* examined occurred in silty loam, while 88% of *Scirpus georgianus* examined occurred in silty loam. There were 31 families that were found

within 30 m of *S. atrovirens*, and 16 families that were found within 30 m of *S. georgianus.* Poaceae had the highest percentage (29%) of plant species found within 30 m of *S. georgianus.* Cyperaceae had the highest percentage (24%) of plant species found within 30 m of *S. atrovirens.* Herbaceous perennials had the highest percentage (51%) of each type of plant species found within 30 m of *S. atrovirens.* Herbaceous perennials had the highest percentage (76%) of each type of plant species found within 30 m of *S. georgianus.* Native species had the highest percentage (90%) present compared to non native species (10%) of plant species found within 30 m of *S. atrovirens.* Native species had the highest percentage (85%) present compared to non-native species (15%) found within 30 m of *S. georgianus.* The Sorensen Index was used to measure the similarity in communities between *S. atrovirens* and *S. georgianus.* The Sorensen Index between the aggregate communities around each of the two species was 0.3. The Sorensen Index of 0.3 from this study indicates that the plant community was significantly different between the two species. *Scirpus atrovirens* and *Scirpus georgianus* are different from each other morphologically and ecologically.

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Introduction

Two closely related species of bulrush, *Scirpus atrovirens and Scirpus georgianus,* are widely distributed in Illinois. The two species are in Cyperaceae. Both are obligate wetland species and important in wetland delimitations and wetland restorations. The presence of either *S. atrovirens* or *S. georgianus* would indicate that a plant community is a legally regulated wetland. Both species have been regularly used in wetland restoration work in the Midwest. They are difficult to distinguish in the field, but readily distinguishable under magnification in the lab.

Aquatic and wetland vascular plants range from small sundew plants to large river and lake inhabiting pondweeds. Aquatic plants have developed similar special modifications to aid survival in a wet environment (Correll and Correll 1975). Such adaptations for certain plant species include presence of both underwater and floating leaves, deeply dissected leaves, thick waxy leaves, and specialized pollination mechanisms (Correll and Correll 1975). The ecosystems of aquatic and wetland habitats consist of characteristic ecotypes for each kind of system (Ssegawa and Kalema 2008).

The genus *Scirpus* consists of a large number of aquatic, grass- like species and is commonly known as bulrush. The genus has about 35 species, found mostly in temperate regions of Northern Hemisphere. The greatest diversity is in North America, where 12 species occur; there are 11 species in China and 5 in Europe (Liang & Tucker, 2009). These species are often planted to inhibit soil erosion and to provide habitat for waterfowl and other wildlife (Schuyler 1967). They usually have clusters of small, brown spikelets. The genus *Scirpus* is diagnosed by a combination of the following characteristics.The rachilla is a diminutive axis of a spikelet that

bears the florets. The achene is a small, dry, indehiscent one-seeded fruit. The achene does not receive a typical supply of vascular tissue (Chute 1930). It usually only has a single trace. A culm is the stem of any type of plant. A spikelet is a small or secondary spike having a varying number of reduced flowers each subtended by one or two scale-like bracts. Bristles are a stiff hairlike structure on plants. The filament of a plant is a slender stalk that bears and holds the pollen sacs (anthers). A complete description follows, based on Schuyler (1967) and Liang & Tucker (2009).

Green bulrush (*Scirpus atrovirens)* occurs in every county of Illinois. Habitats include wet prairies, wet clay prairies, wet sand prairies, wet dolomite prairies, sloughs in drier prairies, openings in floodplain forests, marshes, sedge meadows, seeps, edges of ponds and rivers, and drainage ditches (Flora of North America 2002). Grasslike leaves are broad linear and yellow green to dark green with rough edges (Mohlenbrock 1963). The blooming period occurs during early to mid-summer. The root system consists of rhizomes and fibrous roots (Schuyler 1967). There are many spikelets that are 5-10 mm long and 1-3 mm wide, and the pollination is by wind (Larridon et al 2011). The achene is tan to nearly white. There are as many as to 8 leaves per culm, and the culm is green and glabrous. The outer scale of each flower is ovate. The leaves are alternate and the venation of the leaf blades is parallel (Zhang et al. 2004). The stems are 3-angled, leafy, and 0.5-1.5 m long (Henrickson and Herbst 1988).

Georgia bulrush (*Scirpus georgianus)* has been found in moist meadows, shallow marshes, edges of wet forests, and ditches. It is a monocot with simple leaf type and an alternate leaf arrangement. It grows in dense, low tufts as high as 1.5 meters in height. The leaves are 6-12 per culm. The leaf blade is flat or rolled inwards at the edges. The leaf blade is 6-13 mm wide. Georgia bulrush spikelets are in clusters of 4-35. The inflorescence is terminal and branched at the tip of the plant (Zhang et al. 2004). Bristles are attached at the base of the achene. The

achenes are pale brown to almost white. Georgia bulrush filaments often persist long after the anthers have been shed (Mohlenbrock 2002). *Scirpus georgianus* occasionally hybridizes with *S. atrovirens* and *S. hattorianus* (Reutemann et al 2012).

Limited research has been done on *S. atrovirens* and *S. georgianus* regarding how the two species can be distinguished using various types of data. The objective of this study was to evaluate morphological and ecological distinctness of the species *S. atrovirens* and *S. georgianus* with aim toward discovering and describing other features to distinguish them reliably in the field.

Materials and Methods

The field collection and survey of this study was conducted in June-October 2012 and 2013 (Table 1). Fifty *S. atrovirens* and 50 *S. georgianus* were collected in the field at different counties in Illinois including Alexander, Bond, Boone, Carroll, Champaign, Clark, Clay, Clinton, Coles, Cook, Crawford, Cumberland, Douglas, Edgar, Edwards, Effingham, Jackson, Jasper, Jo Daviess, Kendall, Lake, LaSalle, Lawrence, Livingston, Macoupin, Marshall, Marion, Mason, McHenry, Mercer, Moultrie, Ogle, Pope, Richland, Rock Island, Saline, Schuyler, Shelby, Vermilion, Wabash, Washington, Whiteside, Will, Williamson, Woodford, and Union (Figure 1). The location site, latitude and longitude, soil type, and number of *S. atrovirens* and *S. georgianus* at each site were recorded (Table 2). Every *Scirpus atrovirens* and *Scirpus georgianus* found at each site was collected. The county, herbarium, collector number, and USDA soil was recorded (Table 3). The latitude and longitude or the township range section of a specimen was recorded as well (Table 3). The summary of occurrence of *Scirpus atrovirens* and *Scirpus georgianus* on various soil type was recorded (Table 4). The species were later examined under a dissecting microscope (AmScope model SM-3BZ-80S) to record the

morphological characteristics. Eighty plants were examined for *Scirpus atrovirens* and *Scirpus georgianus*, respectively, including 30 specimens of each species used for measurement from Stover-Ebinger Herbarium at Eastern Illinois University in Charleston, IL, University of Illinois in Champaign herbarium, and the Morton Arboretum in Lisle, IL (Table 3). All measurements were recorded using an ocular micrometer at 30 X magnification. Parameters measured on both species were spikelet length/width (mm) (Figure 2), culm width (mm) (Figure 3), rachilla length (mm) (Figure 4), scale length/width (mm) (Figure 4), plant height (cm), and achene length/width (mm) (Figure 4). These parameters are correlated with being associated with *Scirpus* to distinguish characteristics. Measurements were taken on the middle for each parameter on every specimen *S. atrovirens* and *S. georgianus.* The specimens were pressed, and dried at 45C for 3-5 days, and stored in a steel herbarium cabinet after being collected. The plant species within 30 m of *S. atrovirens* and *S. georgianus* was recorded (Table 5). The morphological characteristics of the two species were compared using a t-test to determine significant differences. The means and standard errors were calculated for the morphological characteristics. The floristic quality index and the Sorensen index were calculated as well.

Results

Scirpus atrovirens was found mainly in the northern part of Illinois, while *Scirpus georgianus* was found mainly in the southern part of Illinois (Figure 1). There were 15 counties where both *S. atrovirens* and *S. georgianus* were located. Those counties were Clark, Clinton, Cook, Douglas, Effingham, Lawrence, Macoupin, Mason, Pope, Saline, Vermilion, Wabash, Washington, Will, and Woodford (Figure 1). *Scirpus atrovirens* had a larger mean spikelet length 8.1 ± 0.2 than *S. georgianus* 4.2 ± 0.2 (Figure 5). *Scirpus atrovirens* had a larger mean spikelet width 5.5 ± 0.1 than *S. georgianus* 2.8 ± 0.1 (Figure 6). *Scirpus atrovirens* had a larger

mean rachilla length 4.4 ± 0.1 than *S. georgianus* 3.1 ± 0.1 (Figure 7). *Scirpus atrovirens* had a larger mean scale length 1.8 ± 0.1 than *S. georgianus* 1.4 ± 0.1 (Figure 8). *Scirpus atrovirens* had a larger mean scale width 0.9 ± 0.1 than *S. georgianus* 0.7 ± 0.1 (Figure 9). *Scirpus atrovirens* had a larger mean culm width 6.5 ± 0.1 than *S. georgianus* 4.3 ± 0.1 (Figure 10). Plant height did not show a significant difference between the two species (Figure 11). *Scirpus atrovirens* had a larger mean achene length 1.2 ± 0.1 than *S. georgianus* 0.7 ± 0.1 (Figure 12). *Scirpus atrovirens* had a larger mean achene width 0.7 ± 0.1 than *S. georgianus* 0.4 ± 0.1 (Figure 13).

The plant communities/habitats that *S. atrovirens* was found included wetlands, open grassy fields, marshes, edge of streams, floodplain forest, edge of lake, flatwoods, lowland field, streambank, and wet depression (Table 2). The plant communities/habitats that *S. georgianus* was found included open grassland, prairie restoration, floodplain forest, wet field, edge of deciduous forest, edge of pond, mesic upland, and mesic woodland (Table 2). Seventy- nine percent of *Scirpus atrovirens* examined occurred in silty loam, while 88% of *Scirpus georgianus* examined occurred in silty loam (Table 4).

Sixty one different plant species were found within 30 m of *S. atrovirens,* and 34 different plant species that were found within 30 m of *S. georgianus* (Table 5). Only five plant species: *Glyceria striata, Phalaris arundinacea, Agrostis alba, Juncus dudleyi,* and *Carex lupulina* were common (Table 5). There were 16 families that were found within 30 m of *S. georgianus* (Figure 14), and 31 families that were found within 30 m of *S. atrovirens* (Figure 15). Poaceae had the highest percentage (29%) of plant species found within 30 m of *S. georgianus* (Figure 14). Asteraceae had the second highest percentage (15%) of plant species found within 30 m of *S. georgianus* (Figure 14). Cyperaceae had the highest percentage (24%) of plant species found within 30 m of *S. atrovirens* (Figure 15). Asteraceae had the second highest percentage (10%) of

plant species found within 30 m of *S. atrovirens* (Figure 15). Herbaceous perennials had the highest percentage (51%) of each type of plant species found within 30 m of *S. atrovirens* (Figure 16). Sedges had the second highest percentage (24%) of each type of plant species found within 30 m of *S. atrovirens* (Figure 16). Herbaceous perennials had the highest percentage (76%) of each type of plant species found within 30 m of *S. georgianus* (Figure 17). Trees had the second highest percentage (9%) of each type of plant species found within 30 m of *S. georgianus* (Figure 17). Native species had the highest percentage (90%) present compared to non native species (10%) of plant species found within 30 m of *S. atrovirens* (Figure 18). Native species had the highest percentage (85%) present compared to non-native species (15%) found within 30 m of *S. georgianus* (Figure 19).

Discussion

There was a significant difference found in some morphological characteristics between Green bulrush and the Georgia bulrush. Spikelet length, spikelet width, rachilla length, scale length, scale width, achene length, achene width, and culm width were all larger in *Scirpus atrovirens* compared to *Scirpus georgianus.* A few parameters were correlated as well. A large achene length/width tended to have a large scale length/width, as a small achene length/width tended to have a small scale length/width. *Scirpus atrovirens* was indicative of being found within 30 m of Cyperaceae and Asteraceae. Herbaceous perennials and sedges were the type of plants found near *S. atrovirens. Scirpus georgianus* was indicative of being found within 30 m of Poaceae and Asteraceae. Herbaceous perennials and trees were the type of plants found near *S. georgianus.* Both species were surrounded by native plants. Most collections of both species

occurred on silty loam, and no difference in habitat with regard to soil could be shown in this study.

Scirpus atrovirens spikelets are ovoid or narrowly ovoid. The spikelets are 5-10mm long. The scales are dark brown and persistent about 1.2-2.1 mm long. The achenes are mostly 1-1.3 mm long. Achenes are pale brown to almost white, elliptic or obovate in outline, plumply trigonous or plano-convex. The perianth bristles are persistent. The scales are dark brown with pale midribs, elliptic or broadly elliptic (Flora of North America 2002). The summit of the sheath is V-shaped (Lagrange et al 2011). The sheath of the Green bulrush has slightly raised cross connections between the veins (Mohlenbrock 1963).

Scirpus georgianus scales are reddish-brown or dark brown about 1-1.8 mm long. The spikelets are sessile, ovoid, and between 3-6 mm long. Achenes are pale brown to almost white, elliptic or obovate in outline, plumply trigonous or plano-convex. The achenes are 0.6-1.2 mm long. *Scirpus georgianus* is distinctive in having the perianth bristles absent (Flora of North America 2002). *Scirpus atrovirens* has been depicted as slightly more robust plant than *Scirpus georgianus* (Mohlenbrock 1963).

The Sorensen Index was used to measure the similarity in communities between *S. atrovirens* and *S. georgianus.* The Sorensen Index between the aggregate communities around each of the two species was 0.3. In the study done by Dalirsefat et al. (2009), the calculated Sorensen index from the study was 1.00 which showed that the similarity of habitats were highly related. The Sorensen Index of 0.3 from this study indicates that the plant community was significantly different between the two species. The floristic quality index is an indication of native vegetative quality of an area. An index of 1-19 indicates low vegetative quality. Wetlands

with a FQI of 20 or greater are considered high quality aquatic resources. The floristic quality index for the plant species found within 30 m of *S. atrovirens* was 25.1, which indicates that there were high quality aquatic resources. The floristic quality index for the plant species found within 30 m of *S. georgianus* was 18.8, which indicates that there was low vegetative quality.

The findings in this study added additional characteristics to be used to distinguish between *Scirpus atrovirens* and *Scirpus georgianus*. Using a 20 X hand lens, one could easily identify several morphological differences, which include spikelet length/width, culm width, and plant height (in addition to presence/absence of perianth bristles, which has traditionally been used). Furthermore, the ecological differences found between *S. atrovirens* and *S. georgianus* will assist in field identification. The ecological differences in the field could be assessed with the plants found within 30 m of *S. atrovirens* and *S. georgianus* mentioned in this study. Examining the plant species within 30 m of *S. atrovirens* and *S. georgianus* would help with identifying which species is present in that area. For example, referring to Figures 14 and 15, *Scirpus georgianus* typically occurs in locations with about 29% Poaceae and only 3% other Cyperaceae. Contrastingly, around *Scirpus atrovirens*, about 8% Poaceae and 24% Cyperaceae is the typical composition.

Future studies should examine additional characteristics, such as the leaf sheath, bract, involucral leaf, filament, and anther. These characteristics could be examined, because they are common among *Scirpus* and might show differences among length and width measurements. Studies in the future could also look at the Green bulrush and the Georgia bulrush in different states to compare if the differences between the species shown in this study.

Table 1. Timeline of species collection and data collection.

June 2012-October 2012	Collect *Scirpus atrovriens and Scirpus georgianus* at different counties in Illinois
November 2012-January 2013	Record morphological data on species collected from different counties in Illinois
January 2013-April 2013	Record morphological data on species collected from herbariums at Eastern Illinois, University of Illinois, and Morton Arboretum
June 2013-October 2013	Collect *Scirpus atrovriens and Scirpus georgianus* at different counties in Illinois
November 2013-January 2014	Record morphological data on species collected from different counties in Illinois
January 2014-March 2014	Record morphological data on species collected from herbariums at Eastern Illinois, University of Illinois, and Morton Arboretum

Table 2. Soil type and how many *Scirpus atrovirens* and *Scirpus georgianus* were found at each location. Soil types determined using online data provided by Natural Resources Conservation Service (2014).

County	**Location**	**Latitude**	**Longitude**	**USDA Soil**	**Number of *Scirpus atrovirens***	**Number of *Scirpus georgianus***
Alexander	edge of pond	37.0053	-89.1764	Camden silt loam		3
Bond	marshes	38.9989	-89.5736	Shoals Silt Loam	1	
Boone	streambank	42.3347	-88.8612	Hurst Silt Loam	1	
Carroll	edge of streams	42.0944	-90.1567	Sawmill Silty Clay Loam	1	
Champaign	lowland field	40.1164	-88.2433	Marseilles Silt Loam	2	
Clark	wet field	39.2992	-87.9925	Ozaukee Silt Loam	1	3
Clay	flatwoods	38.6689	-88.4856	Marseilles Silt Loam	2	
Clinton	open grassland	38.6056	-89.6820	Camden silt loam	1	3
Coles	open grassland	39.4961	-88.1761	Hurst Silt Loam	4	
Cook	floodplain forest	41.6028	-87.7439	Sawmill Silty Clay Loam	2	2
Crawford	prairie restoration	39.0053	-87.7391	Marseilles Silt Loam		3
Cumberland	wet field	39.3194	-88.4528	Hurst Silt Loam	1	2
Douglas	wet field	39.6847	-88.3064	Frankfort Silty Clay Loam	1	4
Edwards	marshes	38.3775	-88.0561	Marseilles Silt Loam	2	
Effingham	open grassland	39.1200	-88.5433	Camden silt loam	2	2
Jackson	open grassland	37.6175	-89.2089	Ozaukee Silt Loam	1	
Jasper	mesic woodland	39.0467	-88.3164	Camden silt loam		2
Lake	marshes	42.3636	-87.8447	Shoals Silt Loam	2	

LaSalle	streambank	41.3455	-88.8425	Ozaukee Silt Loam	1	
Lawrence	open grassland	38.7169	-87.8614	Camden silt loam	2	4
Livingston	flatwoods	41.0233	-88.3061	Marseilles Silt Loam	2	
Macoupin	floodplain forest	39.4464	-89.7809	Shoals Silt Loam	1	1
Marion	mesic upland	38.6269	-88.9456	Hurst Silt Loam		3
Mason	wet field	40.3000	-90.0609	Camden silt loam	1	1
McHenry	open grassland	42.1655	-88.2942	Hurst Silt Loam	2	
Moultrie	edge of deciduous forest	39.5994	-88.6078	Camden silt loam		1
Pope	open grassland	37.4989	-88.5878	Shoals Silt Loam	2	2
Richland	edge of pond	38.7308	-88.0853	Hurst Silt Loam		1
Rock Island	flatwoods	41.5094	-90.5787	Camden silt loam	2	
Saline	marshes	37.7383	-88.5406	Shoals Silt Loam	2	1
Schuyler	mesic upland	40.1211	-90.5631	Camden silt loam		2
Vermilion	wet field	40.1244	-87.6300	Hurst Silt Loam	2	2
Wabash	wet depression	38.4108	-87.7614	Ozaukee Silt Loam	1	
Washington	open grassland	38.5285	-89.1316	Camden silt loam	1	2
Will	open grassland	41.5894	-88.0578	Hurst Silt Loam	3	1
Williamson	edge of pond	37.7306	-88.9331	Shoals Silt Loam		2
Woodford	floodplain forest	40.7214	-89.2728	Camden silt loam	4	2
Union	mesic woodland	37.4603	-89.2470	Ozaukee Silt Loam		1

Table 3. Soil types from herbarium collections used in the current study. Specimens limited to those with precise label data (latitude and longitude, or Township-Range-Section) that could associated with mapped soil types, using online resource provided by Natural Resources Conservation Service (2014). (SG= *S. georgianus,* SA= *S. atrovirens*)

County	Collector-number	Herbarium	Latitude	Longitude	TRS	USDA Soil	Species
Alexander	Hill 31787	ILLS			T16S R2W S12	Darwin Silty Clay	SG
Alexander	Basinger 10745	ILLS			T16S R2W S16	Alvin Sandy Loam	SG
Clark	Tucker 11710	EIU	39.4323	-87.9042		Camden silt loam	SG
Clark	Tucker 11763	EIU			T10N R12W S2	Stoy Silt Loam	SG
Clark	Tucker 14175	EIU	39.2043	-87.9292		Shoals Silt Loam	SG
Clinton	Tucker 11765	EIU			T12N R13W S4	Stoy Silt Loam	SG
Clinton	Ebinger 28738	EIU			T1N R4W S28	Hurst Silt Loam	SG
Cook	Stoynoff 552	MOR			T41N R9E S/2 S19	Sawmill Silty Clay Loam	SA
Cook	Stoynoff 515	MOR			T51N R7E S/3 S17	Sawmill Silty Clay Loam	SA
Cook	Wilhelm 22798	MOR	41.5717	-87.8677		Frankfort Silty Clay Loam	SG
Cumberland	Tucker 15708	EIU	39.2227	-88.1854		Shoals Loam	SG
Cumberland	Ebinger 27340	EIU			T9N R7E S41	Shoals Loam	SG
DuPage	Sturner 481	MOR	41.8169	-88.0484		Ozaukee Silt Loam	SA
DuPage	Sturner 475	MOR			T54N R6E S/4 S18	Ozaukee Silt Loam	SA
DuPage	Sturner 439	MOR			T54N R8E S/3 S17	Ozaukee Silt Loam	SA
Edgar	Ebinger 13947	EIU			T17N R3E S3	Drummer Silt Clay Loam	SA
Edgar	Ebinger 13875	EIU			T11N R6E S4	Drummer Silt Clay Loam	SA
Edgar	Ebinger 8719	EIU			T16N R12W S32	Drummer Silty Clay Loam	SA

Jasper	Edgin 417	EIU			T6N R9E S27 NE/4	Darmstadt Silt Loam	SG
Jasper	Ebinger 27940	EIU			T8N R8E S31	Racoon Silt Loam	SG
Jasper	Kessler 238	EIU	38.9167	-88.2000		Racoon Silt Loam	SG
Jasper	Tucker 13633	EIU	38.9367	-88.1875		Racoon Silt Loam	SG
Jasper	Tucker 14561	EIU			T4S R10W S3	Hurst Silt Loam	SG
Jasper	Kessler 240	EIU			T2N R6W S18	Shoals Loam	SG
Jo Daviess	Ebinger 26662	EIU			T26N R2E S29	Sparta Loamy Sand	SA
Jo Daviess	Ebinger 8620	EIU			T17N R12W S33	Drummer Silty Clay Loam	SA
Jo Daviess	Ebinger 8812	EIU			T17N R14W S31	Drummer Silty Clay Loam	SA
Kendall	Schulenberg 73-819	MOR			T31N R13E S20	Drummer Silty Clay Loam	SA
Kendall	Schulenberg 76-813	MOR			T34N R6E S18	Drummer Silty Clay Loam	SA
Kendall	Schulenberg 75-851	MOR			T37N R7E S16	Drummer Silty Clay Loam	SA
LaSalle	Ebinger 13092	EIU			T33N R6E S31	Marseilles Silt Loam	SA
LaSalle	Ebinger 13554	EIU			T34N R4E S29	Marseilles Silt Loam	SA
Marion	Murphy 2927	ILLS	38.7013	-89.0975		Ava Silt Loam	SG
Marion	Murphy 2939	ILLS	38.6599	-89.1050		Cisne-Huey Silt Loam	SG
Marion	Murphy 2971	ILLS	38.5802	-89.1093		Silty Orthents	SG
Marion	Tucker 14130	EIU			T14S R3W S11	Shoals Loam	SG
Marshall	Murphy 5075	ILLS	40.9907	-89.4549		Marseilles Silt Loam	SA
Marshall	Ebinger 13502	EIU			T32N R2E S27	Marseilles Silt Loam	SA
Marshall	Murphy 5076	ILLS	40.9907	-89.4549		Marseilles Silt Loam	SA
Mercer	Phillippe 40839	ILLS	41.1003	-90.6071		Stronghurst Silt Loam	SA

Ogle	Phillippe 40701	ILLS	41.9948	-89.4703		Fayette Silt loam	SA
Richland	Hill 38917	ILLS	38.7145	-88.1135		Belknap Silt Loam	SG
Saline	Hill 30768	ILLS			T19N R14W S20	Holton Silt Loam	SA
Saline	Hill 38085	ILLS	38.8305	-88.4218		Holton Silt Loam	SG
Saline	Hill 32373	ILLS			T9s R6E S11 NW/4	Colp Silt Loam	SG
Schuyler	Rebman 2947	ILLS			T1N R2W S8	Cisne silt loam	SG
Shelby	Ebinger 24114	EIU			T12N R5E S7	Miami Loam	SA
St Clair	Hill 34325	ILLS			T28N R4W S29	Ipaya Silt Loam	SA
St. Clair	Hill 34336	ILLS	38.5458	-89.8400		Wakeland Silt Loam	SA
Union	Basinger 10761	ILLS			T13S R2W S13 NW/4	Menfro Silt Loam	SG
Vermilion	Phillippe 27576	ILLS	40.0708	-87.5750		Shaffton Loam	SG
Wabash	Ebinger 28784	EIU			T2S R13W S1	Alford Silt Loam	SG
Washington	Ebinger 27599	EIU			T1S R5W S22 NE/4	Hurst Silt Loam	SG
Washington	Ebinger 27601	EIU			T3S R7W S24 NE/5	Hurst Silt Loam	SG
Whiteside	Phillippe 29086	ILLS	41.9000	-90.0160		Ogle Silt Loam	SA
Will	Murphy 5240	ILLS	41.3165	-87.7993		Elliott Silty Clay Loam	SA
Will	Murphy 5248	ILLS			T40N R7E S22	Elliot Silty Clay Loam	SA
Williamson	Hill 34659	ILLS	37.8166	-88.9583		Bonnie Silt Loam	SG
Woodford	Marcum 5661	ILLS	40.6569	-89.1306		Huntsville Silt Loam	SA
Woodford	Murphy 2205	ILLS	40.7869	-89.3545		Ipava Silt Loam	SA

Table 4. Summary of occurrence of *Scirpus atrovirens* and *Scirpus georgianus* on various soil types.

Soil Type	*Scirpus atrovirens*	*Scirpus georgianus*
Loam	1	5
Clay Loam or Silty Clay Loam	15	4
Silt Loam (or Silty Orthents)	63	70
Sandy Loam or Loamy Sand	1	1

Table 5. Species associated with collections of *Scirpus atrovirens* and *S. georgianus*. Values for Coefficient of Conservatism **(CC)** and Wetness are those provided by Taft et al. (1997) for floristic analysis of Illinois plant communities.

Family	Scientific Name	Common Name	***CC***	***Wetness***	*S.atrovirens*	*S.georgianus*
Alismataceae	*Alisma subcordatum*	American water plantain	**2**	**-5**	x	
Amaranthaceae	*Amaranthus tuberculatus*	Tall waterhemp	**1**	**-5**	x	
Apiaceae	*Daucus carota*	Wild Carrot	**0**	**4**		x
Apocynaceae	*Asclepias incarnata*	Swamp Milkweed	**4**	**-5**	x	
Araceae	*Lemna minor*	Common duckweed	**3**	**-5**		x
Araceae	*Wolffia brasiliensis*	Brazilian watermeal	**6**	**-5**		x
Araliaceae	*Aralia racemosa*	American spikenard	**8**	**5**	x	
Asteraceae	*Achillea millefolium*	Common Yarrow	**0**	**3**		x
Asteraceae	*Erigeron philadelphicus*	Philadelphia fleabane	**3**	**-3**	x	
Asteraceae	*Eupatorium maculatum*	Spotted Joe-Pye Weed	**5**	**-5**	x	
Asteraceae	*Helenium autumnale*	Common Sneezeweed	**3**	**-4**	x	
Asteraceae	*Latris pycnostachya*	Prairie Blazing Star	**6**	**1**	x	
Asteraceae	*Oligoneuron riddellii*	Riddell's goldenrod	**7**	**-5**	x	
Asteraceae	*Solidago gigantea*	Giant goldenrod	**3**	**-3**	x	
Asteraceae	*Solidago graminifolia*	Grass-Leaved Goldenrod	**3**	**-2**		x
Asteraceae	*Solidago juncea*	Early Goldenrod	**4**	**5**		x
Asteraceae	*Solidago rugosa*	Wrinkleleaf Goldenrod	**8**	**-1**		x
Asteraceae	*Vernonia missurica*	Missouri ironweed	**5**	**-1**		x
Balsaminaceae	*Impatiens capensis*	Common Jewelweed	**2**	**-3**	x	

Ceratophyllaceae	*Ceratophyllum demersum*	Coontail	**3**	**-5**	x	
Cornaceae	*Cornus alternifolia*	Alternateleaf dogwood	**7**	**5**	x	
Cornaceae	*Cornus drummondii*	Roughleaf dogwood	**2**	**0**	x	
Cyperaceae	*Carex cristatella*	Crested Sedge	**3**	**-4**	x	
Cyperaceae	*Carex frankii*	Frank's sedge	**4**	**-5**	x	
Cyperaceae	*Carex granularis*	Limestone Meadow Sedge	**2**	**-4**	x	
Cyperaceae	*Carex hystericina*	Bottlebrush sedge	**6**	**-5**	x	
Cyperaceae	*Carex lacustris*	Hairy sedge	**6**	**-5**	x	
Cyperaceae	*Carex lupulina*	Hop sedge	**5**	**-5**	x	
Cyperaceae	*Carex lupulina*	Hop sedge	**5**	**-5**	x	x
Cyperaceae	*Carex stricta*	Upright Sedge	**5**	**-5**	x	
Cyperaceae	*Carex tribuloides*	Blunt Broom Sedge	**3**	**-4**	x	
Cyperaceae	*Carex vulpinoidea*	Fox Sedge	**3**	**-5**	x	
Cyperaceae	*Schoenoplectus tabernaemontani*	Softstem bulrush	**4**	**-5**	x	
Cyperaceae	*Scirpus cyperinus*	Woolgrass	**5**	**-5**	x	
Cyperaceae	*Scirpus fluviatilis*	River Bulrush	**3**	**-5**	x	
Cyperaceae	*Scirpus lineatus*	Drooping Bulrush	**3**	**-5**	x	
Cyperaceae	*Scirpus pendulus*	Rufous Bulrush	**3**	**-5**	x	
Equisetaceae	*Equisetum arvense*	Field Horsetail	**0**	**0**	x	
Fabaceae	*Cassia fasciculata*	Partridge Pea	**1**	**4**		x
Fabaceae	*Lathyrus palustris*	Marsh pea	**7**	**-5**	x	
Fagaceae	*Quercus bicolor*	Swamp White Oak	**7**	**-4**		x
Fagaceae	*Quercus macrocarpa*	Bur Oak	**5**	**1**		x
Hypericaceae	*Hypericum perforatum*	St John's wort	**0**	**-5**	x	
Juncaceae	*Juncus dudleyi*	Dudley's Rush	**4**	**0**	x	x
Juncaceae	*Juncus effusus*	Common rush	**4**	**-5**		x
Juncaceae	*Juncus nodatus*	Common rush	**6**	**-5**		x
Lamiaceae	*Lycopus americanus*	American Bugleweed	**3**	**-5**	x	

Lamiaceae	*Mentha arvensis*	Wild Mint	**4**	**-1**	x	
Lythraceae	*Lythrum alatum*	Winged Loosestrife	**5**	**-5**	x	
Molluginaceae	*Mollugo verticillata*	Carpetweed	**0**	**0**	x	
Oleaceae	*Fraxinus lanceolata*	Green ash	**2**	**-3**	x	
Oleaceae	*Fraxinus pennsylvanica*	Red ash	**5**	**-3**	x	
Onocleaceae	*Onoclea sensibilis*	Sensitive fern	**5**	**-3**	x	
Osmundaceae	*Osmunda regalis*	Royal fern	**8**	**-5**	x	
Penthoraceae	*Penthorum sedoides*	Ditch Stonecrop	**2**	**-5**		x
Poaceae	*Agrostis alba*	Redtop	**0**	**-3**	x	x
Poaceae	*Agrostis gigantea*	Redtop	**0**	**-3**	x	
Poaceae	*Calamagrostis canadensis*	Bluejoint	**3**	**-5**		x
Poaceae	*Dichanthelium clandestinum*	Deertongue	**4**	**-3**		x
Poaceae	*Elytrigia repens*	Couch grass	**0**	**3**	x	
Poaceae	*Glyceria striata*	Fowl Mannagrass	**4**	**-5**	x	x
Poaceae	*Hordeum jubatum*	Foxtail barley	**0**	**-1**		x
Poaceae	*Leersia oryzoides*	Rice Cutgrass	**3**	**-5**		x
Poaceae	*Panicum virgatum*	Switchgrass	**4**	**-1**		x
Poaceae	*Phalaris arundinacea*	Reed Canarygrass	**0**	**-4**	x	x
Poaceae	*Poa trivialis*	Rough bluegrass	**0**	**-3**	x	
Poaceae	*Spartina pectinata*	Prairie cordgrass	**4**	**-4**		x
Poaceae	*Sphenopholis intermedia*	Slender wedgescale	**5**	**0**		x
Polygalaceae	*Polygala sanguinea*	Purple Milkwort	**5**	**3**		x
Polygonaceae	*Polygonum persicaria*	Spotted ladysthumb	**0**	**-3**	x	
Polygonaceae	*Rumex crispus*	Yellow Dock	**0**	**-1**	x	
Primulaceae	*Lysimachia lanceolata*	Lanceleaf Loosestrife	**6**	**0**		x
Ranunculaceae	*Caltha palustris*	Yellow Marsh	**7**	**-5**	x	

		Marigold				
Ranunculaceae	*Clematis virginiana*	Love vine	**3**	**0**	x	
Rosaceae	*Fragaria virginiana*	Virginia Strawberry	**2**	**1**		x
Rosaceae	*Potentilla simplex*	Common Cinquefoil	**3**	**4**		x
Rubiaceae	*Cephalanthus occidentalis*	Common Buttonbush	**4**	**-5**		x
Rubiaceae	*Galium tinctorium*	Stiff marsh bedstraw	**6**	**-5**	x	
Salicaceae	*Populus deltoides*	Eastern cottonwood	**2**	**-1**	x	
Sparganiaceae	*Sparganium eurycarpum*	Broadfruit bur-reed	**5**	**-5**	x	
Thelypteridaceae	*Thelypteris palustris*	Marsh fern	**7**	**-4**	x	x
Tiliaceae	*Tilia americana*	American basswood	**5**	**3**	x	
Typhaceae	*Typha latifolia*	Common Cattail	**1**	**-5**	x	
Urticaceae	*Laportea canadensis*	Wood-nettle	**2**	**-3**	x	
Verbenaceae	*Verbena hastata*	Blue Vervain	**3**	**-4**	x	
Verbenaceae	*Verbena urticifolia*	White Vervain	**3**	**-1**	x	
Violaceae	*Viola fimbriatula*	Sand Violet	**6**	**-2**		x
Vitaceae	*Vitis riparia*	Frost grape	**2**	**-2**	x	
Vitaceae	*Vitis vulpina*	Fox Grape	**4**	**-2**		x

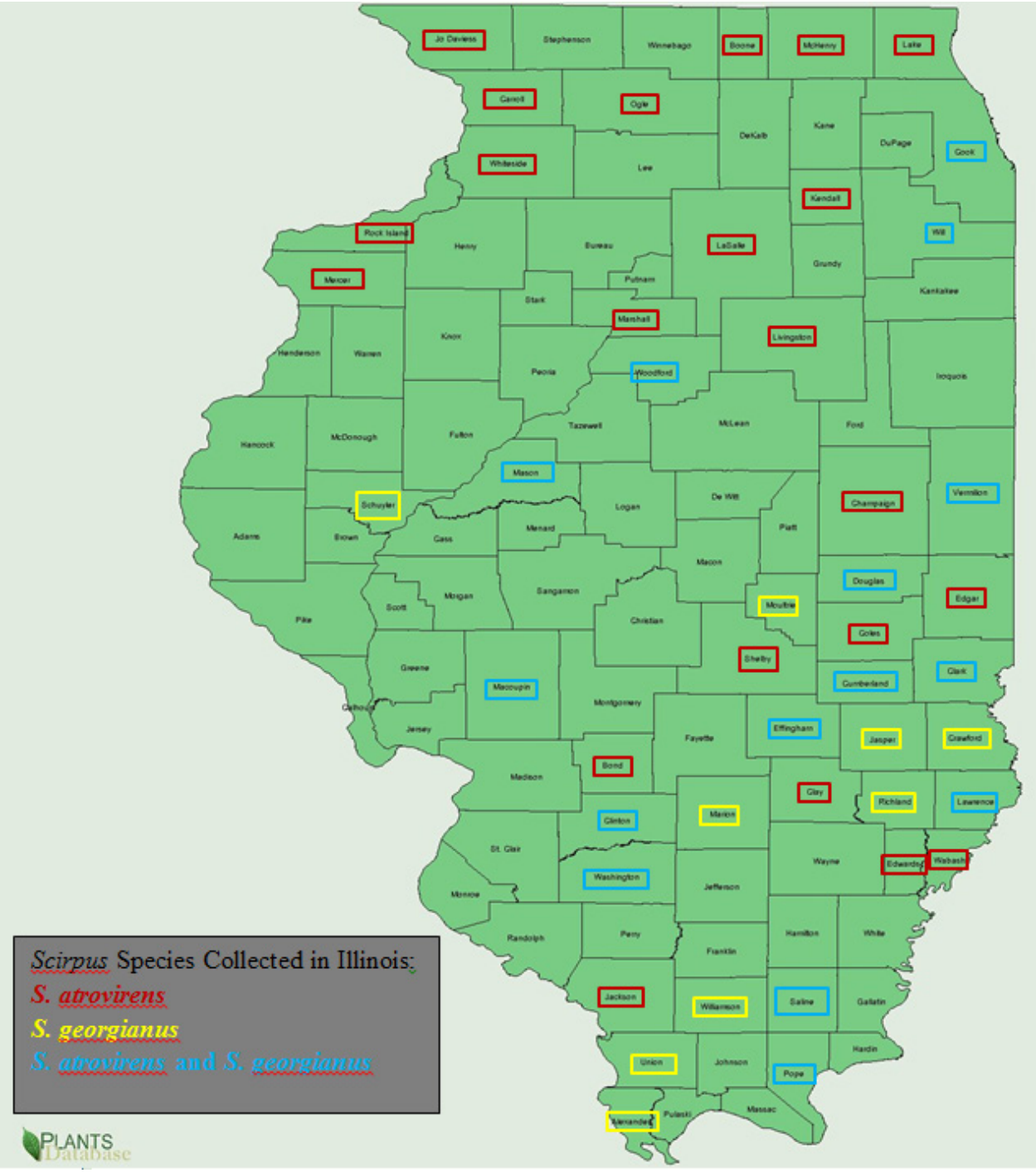

Figure 1. Counties where *Scirpus atrovirens* and *Scirpus georgianus* were collected. Taken from plants.usda.gov/

Figure 2. Image of a cluster of spikelets. Taken from gobotany.net.

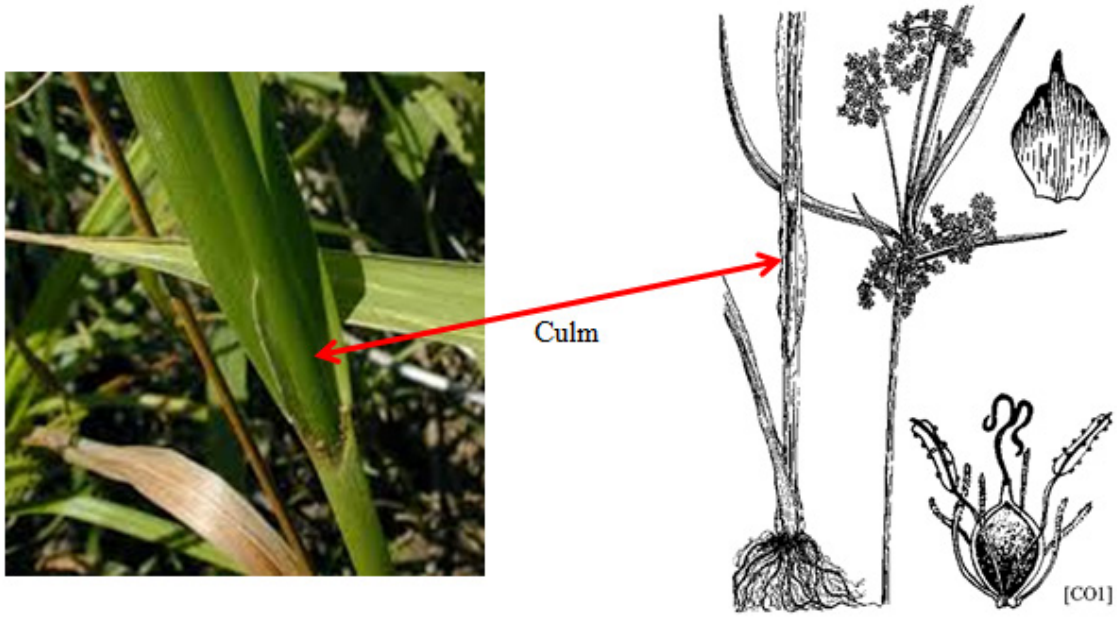

Figure 3. Image of a culm. Taken from Flora of North America.

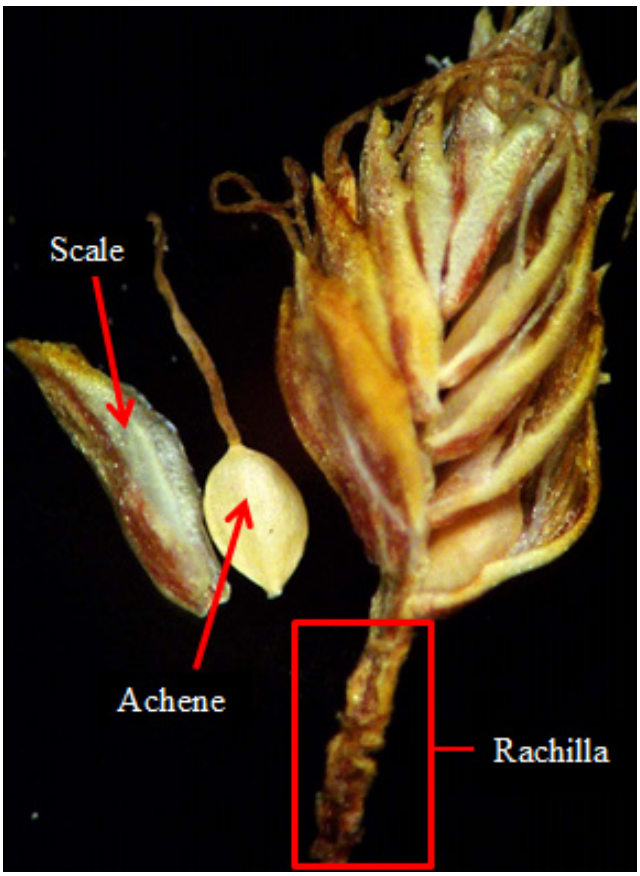

Figure 4. Image of the rachilla which encloses the scale and achene. Taken from Flora of North America.

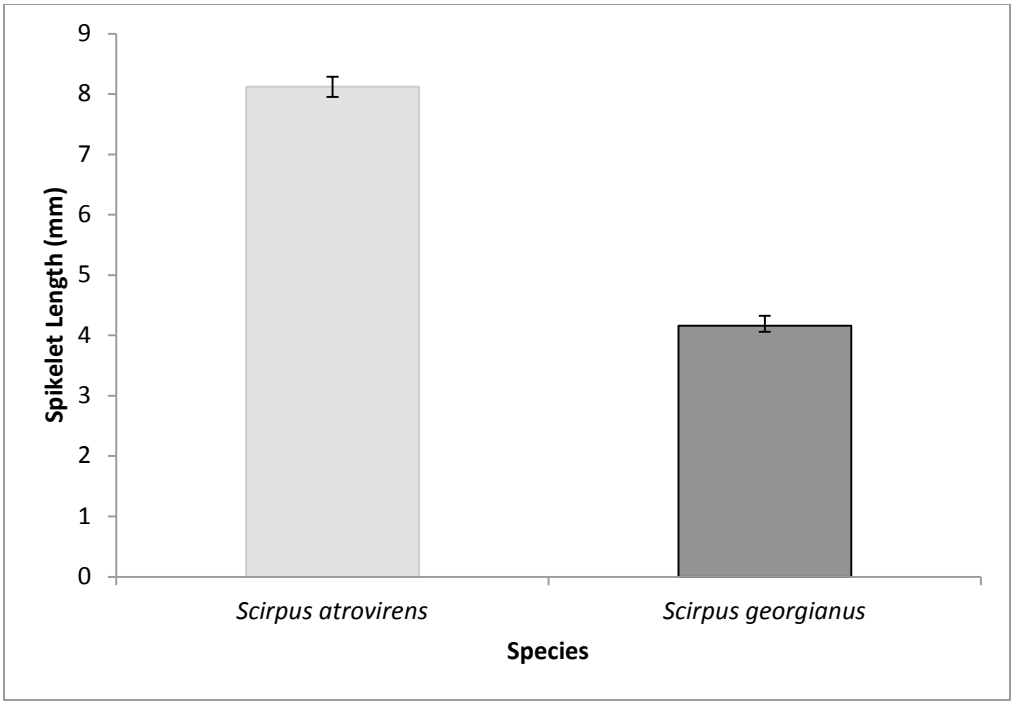

Figure 5. Spikelet length (mm) for *Scirpus atrovirens* (minimum length: 5 mm, maximum length: 10 mm) and *Scirpus georgianus* (minimum length: 3 mm, maximum length: 6 mm). Means ± standard errors. N=80, P<0.000.

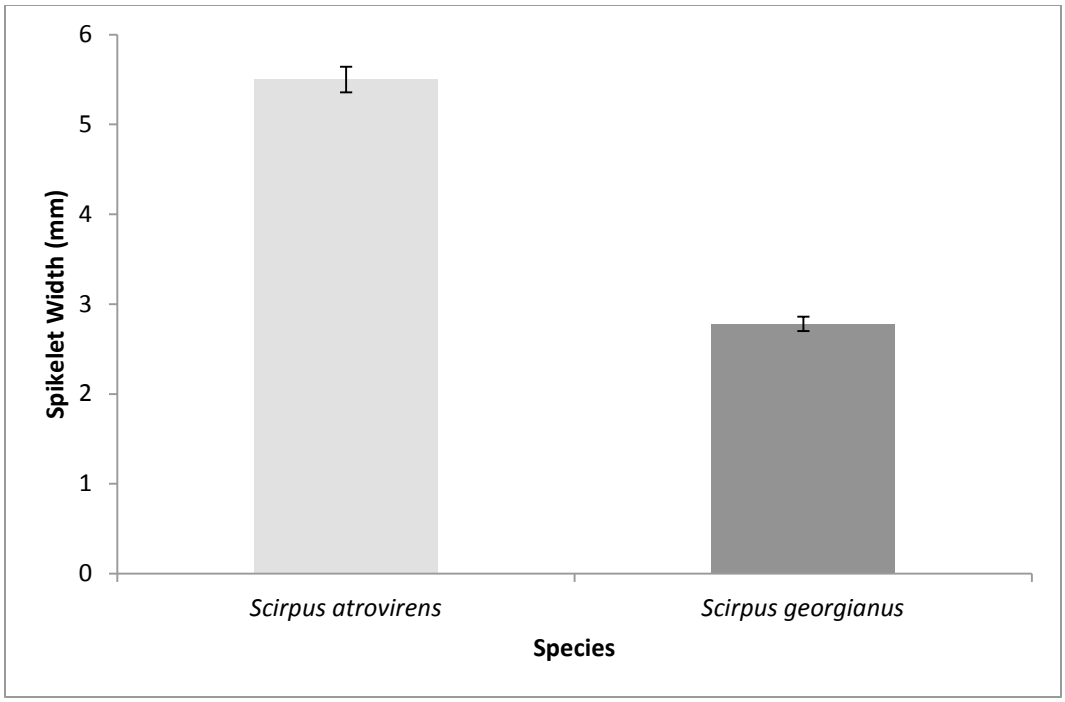

Figure 6. Spikelet width (mm) for *Scirpus atrovirens* (minimum width: 5 mm, maximum width: 8 mm) and *Scirpus georgianus* (minimum width: 2 mm, maximum width: 3 mm). Means ± standard errors. N=80, P<0.000.

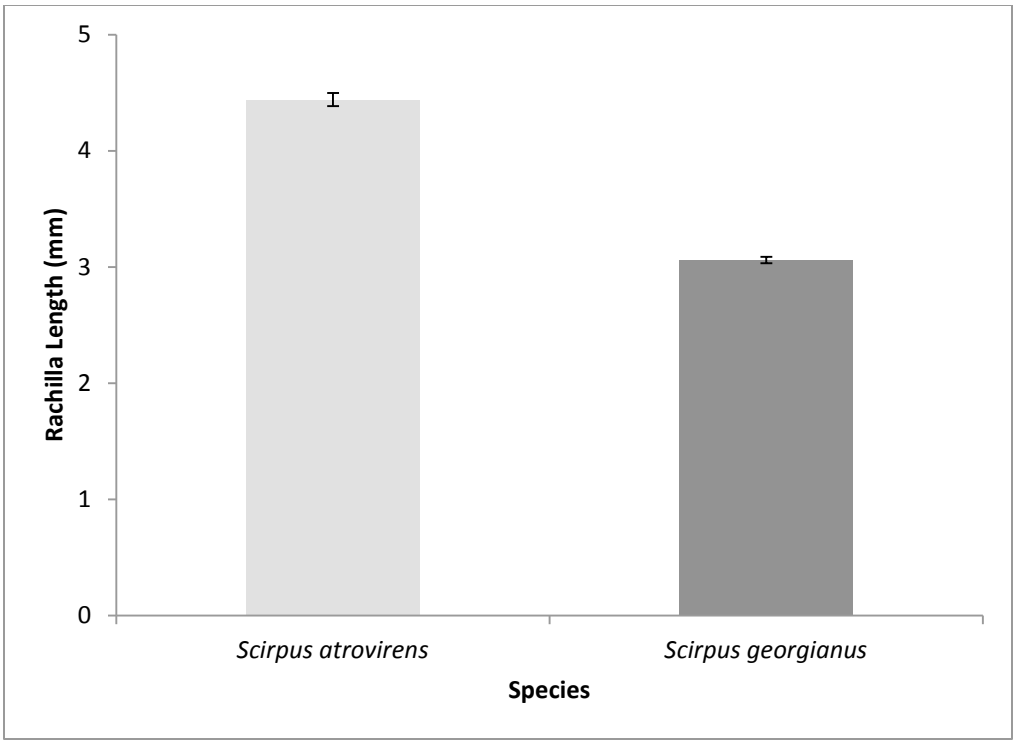

Figure 7. Rachilla length (mm) for *Scirpus atrovirens* (minimum length: 3 mm, maximum length: 5 mm) and *Scirpus georgianus* (minimum length: 2 mm, maximum length: 4 mm). Means ± standard errors. N=80, P<0.000.

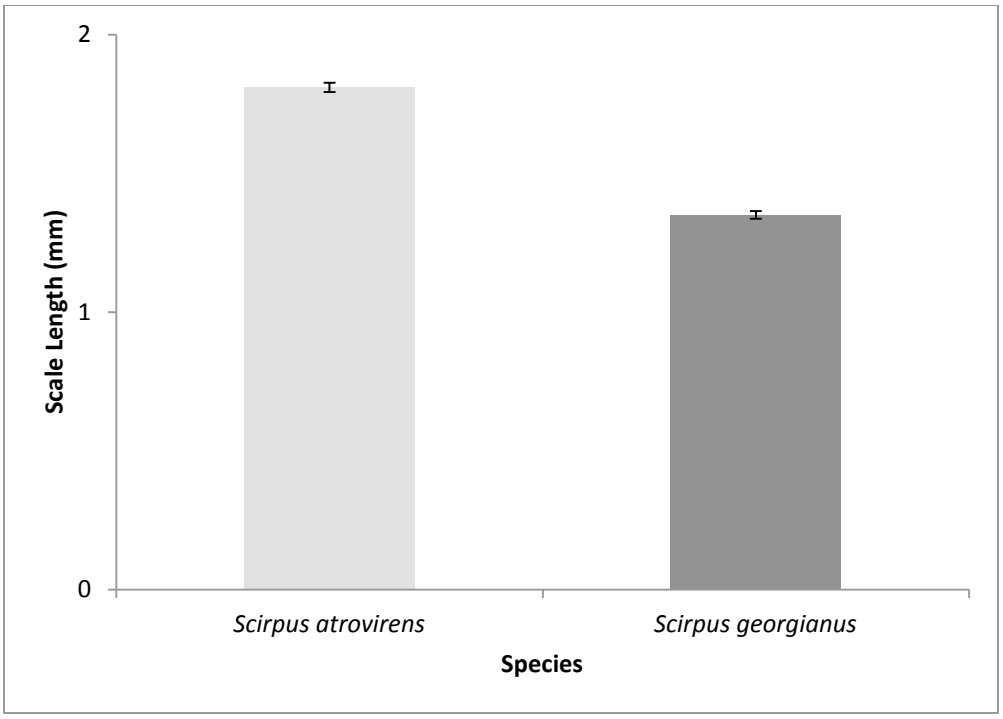

Figure 8. Scale length (mm) for *Scirpus atrovirens* (minimum length: 1.6 mm, maximum length: 2.1 mm) and *Scirpus georgianus* (minimum length: 1.2 mm, maximum length: 1.5 mm). Means ± standard errors. N=80, P<0.000.

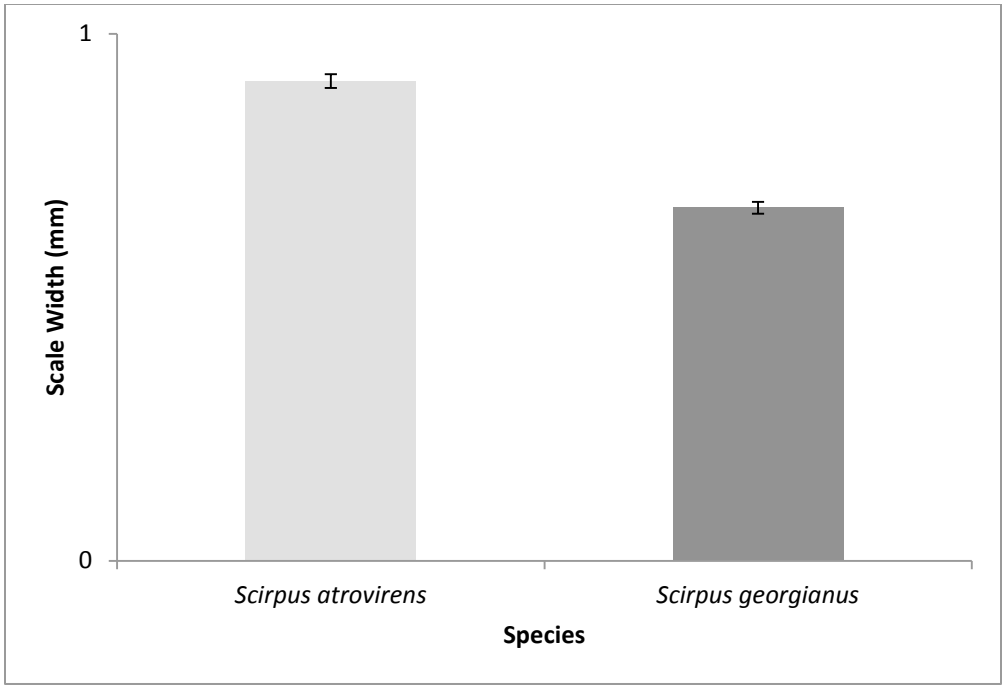

Figure 9. Scale width (mm) for *Scirpus atrovirens* (minimum width: 0.7 mm, maximum width: 1.1 mm) and *Scirpus georgianus* (minimum width: 0.4 mm, maximum width: 0.8 mm). Means ± standard errors. N=80, P<0.000.

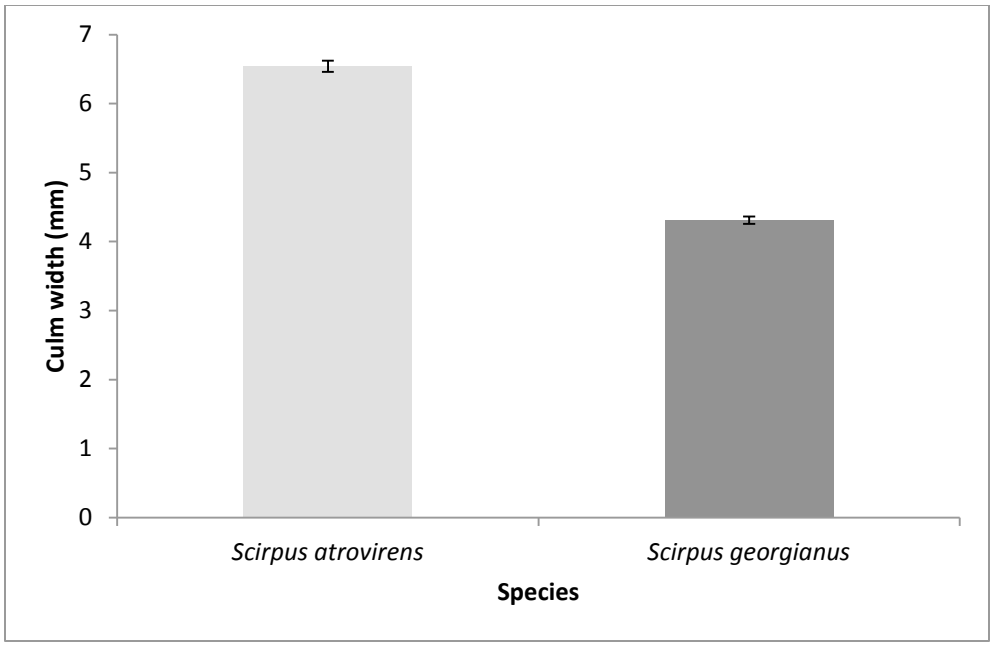

Figure 10. Culm width (mm) for *Scirpus atrovirens* (minimum width: 6 mm, maximum width: 8 mm) and *Scirpus georgianus* (minimum width: 4 mm, maximum width: 5 mm). Means ± standard errors. N=80, P<0.000.

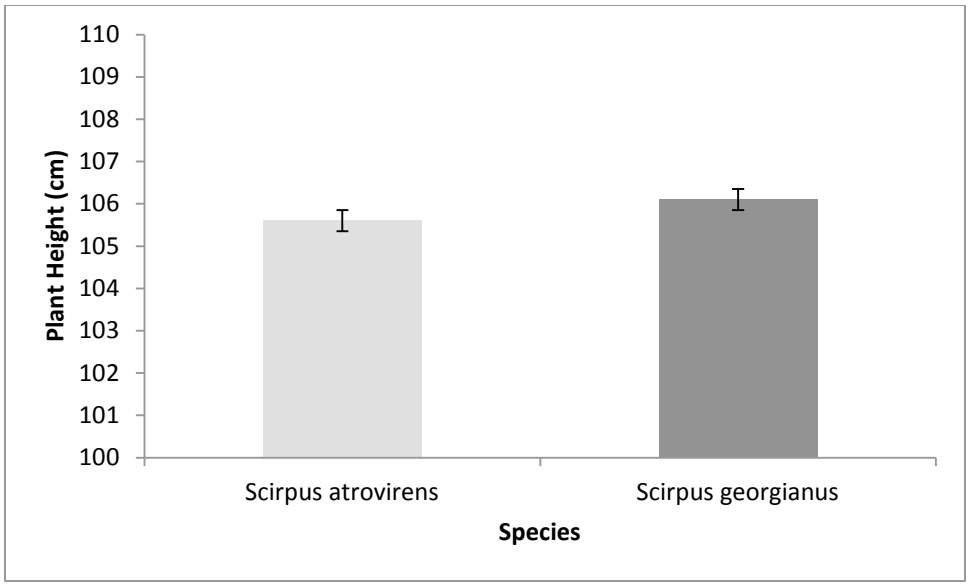

Figure 11. Plant height (cm) for *Scirpus atrovirens* (minimum height: 105 mm, maximum height: 110 mm) and *Scirpus georgianus* (minimum height: 104 mm, maximum height: 111 mm). Means ± standard errors. N=80, P=0.53.

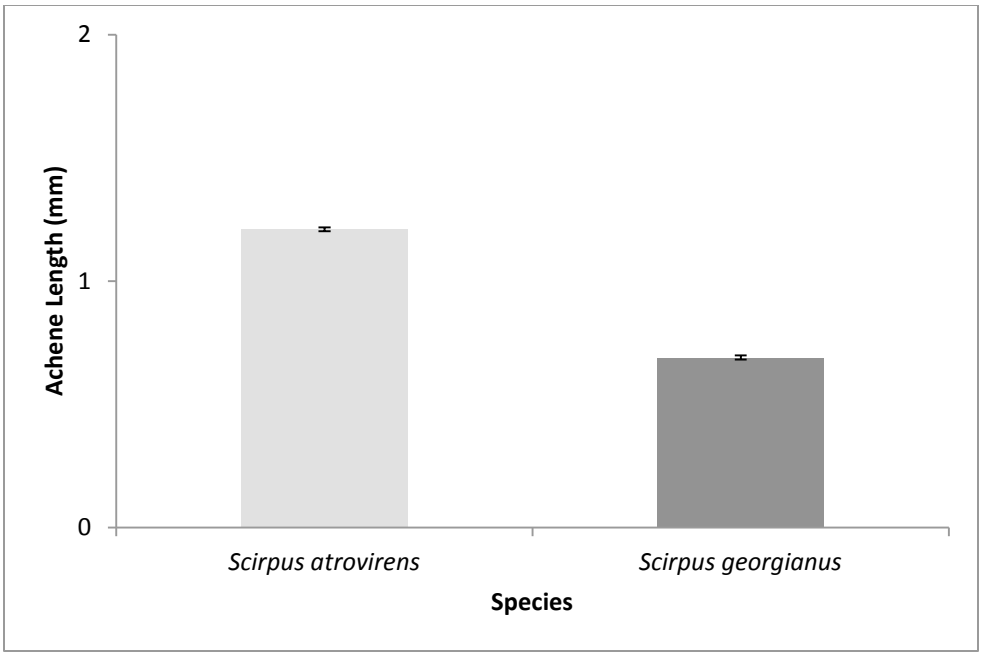

Figure 12. Achene length (mm) for *Scirpus atrovirens* (minimum length: 1.1 mm, maximum length: 1.3 mm) and *Scirpus georgianus* (minimum length: 0.6 mm, maximum length: 0.8 mm). Means ± standard errors. N=80, P<0.000.

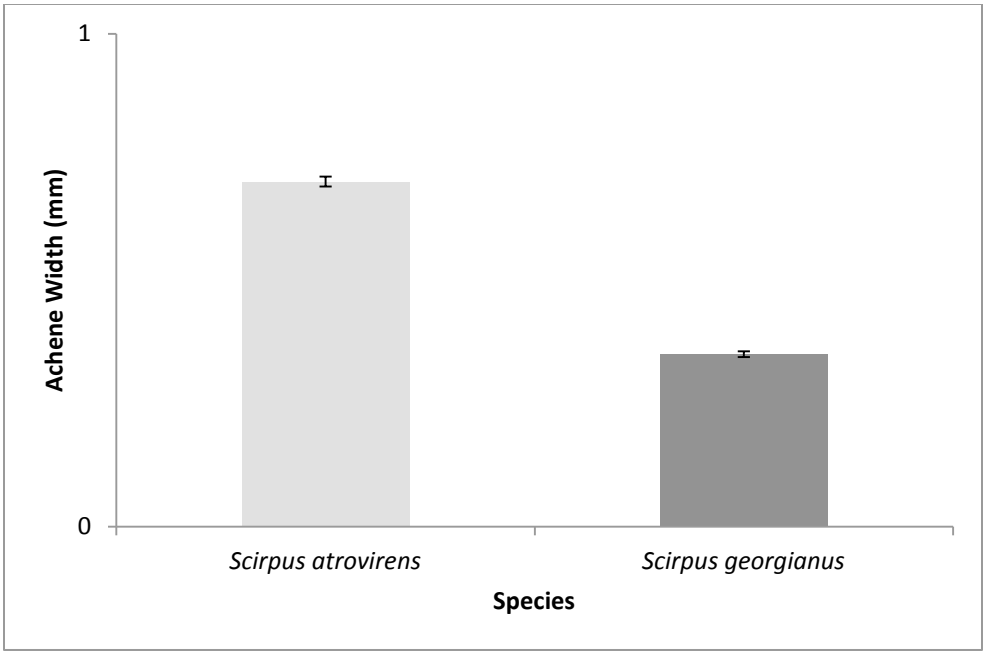

Figure 13. Achene width (mm) for *Scirpus atrovirens* (minimum width: 0.5 mm, maximum width: 0.8 mm) and *Scirpus georgianus* (minimum width: 0.3 mm, maximum width: 0.4 mm). Means ± standard errors. N=80, P<0.000.

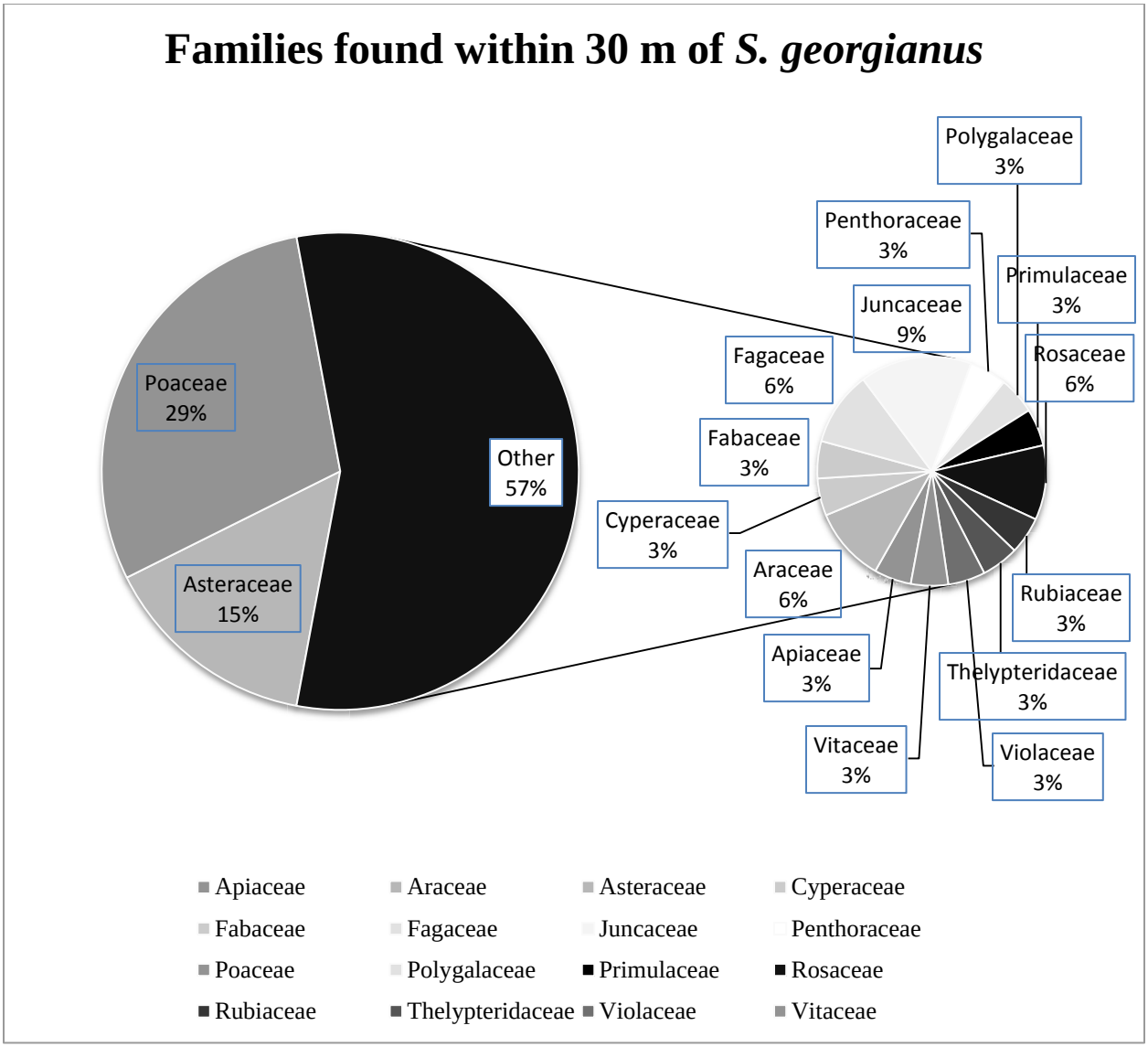

Figure 14. Pie chart showing the families found within 30 m of *S. georgianus.*

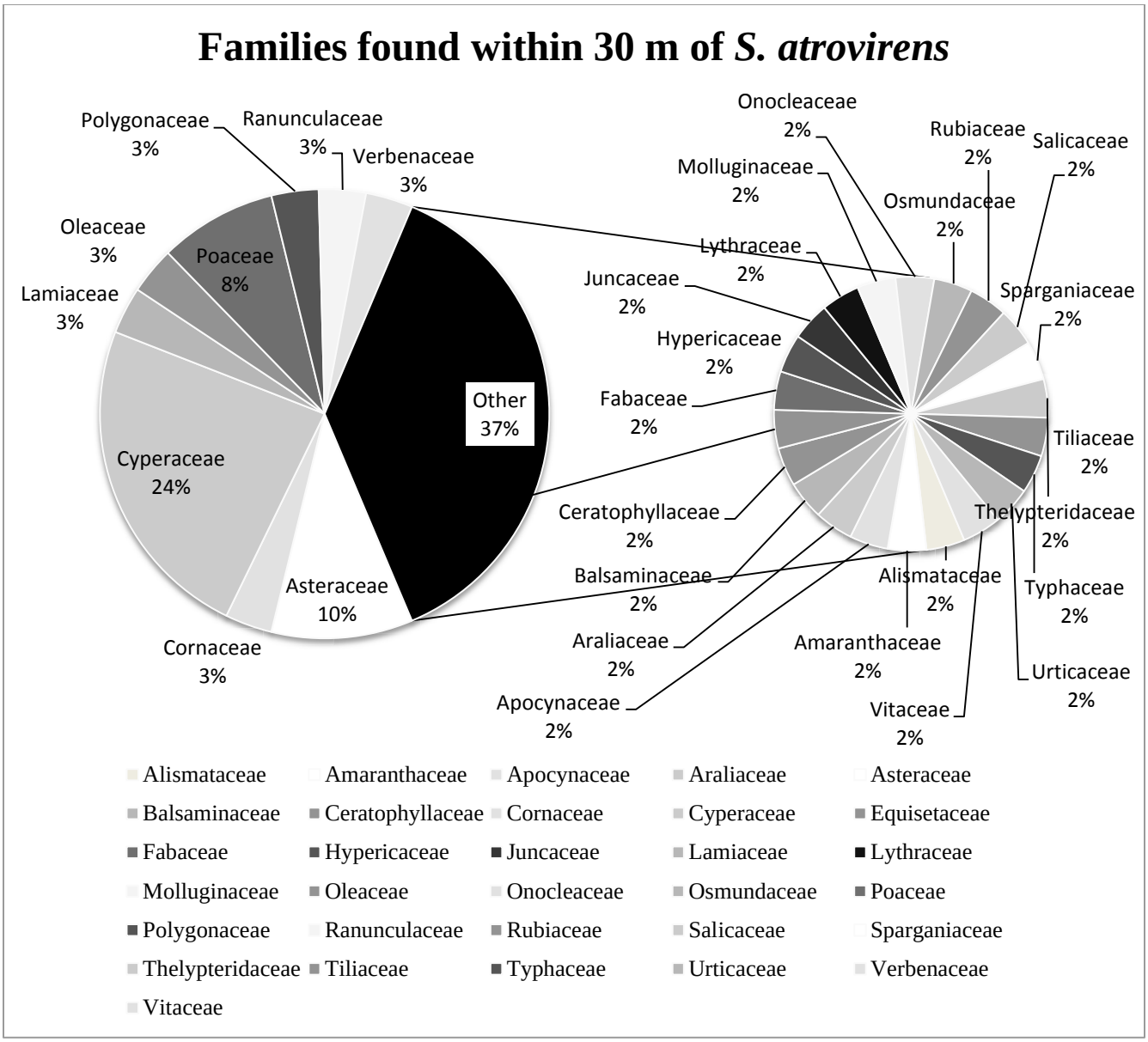

Figure 15. Pie chart showing the families found within 30 m of *S. atrovirens.*

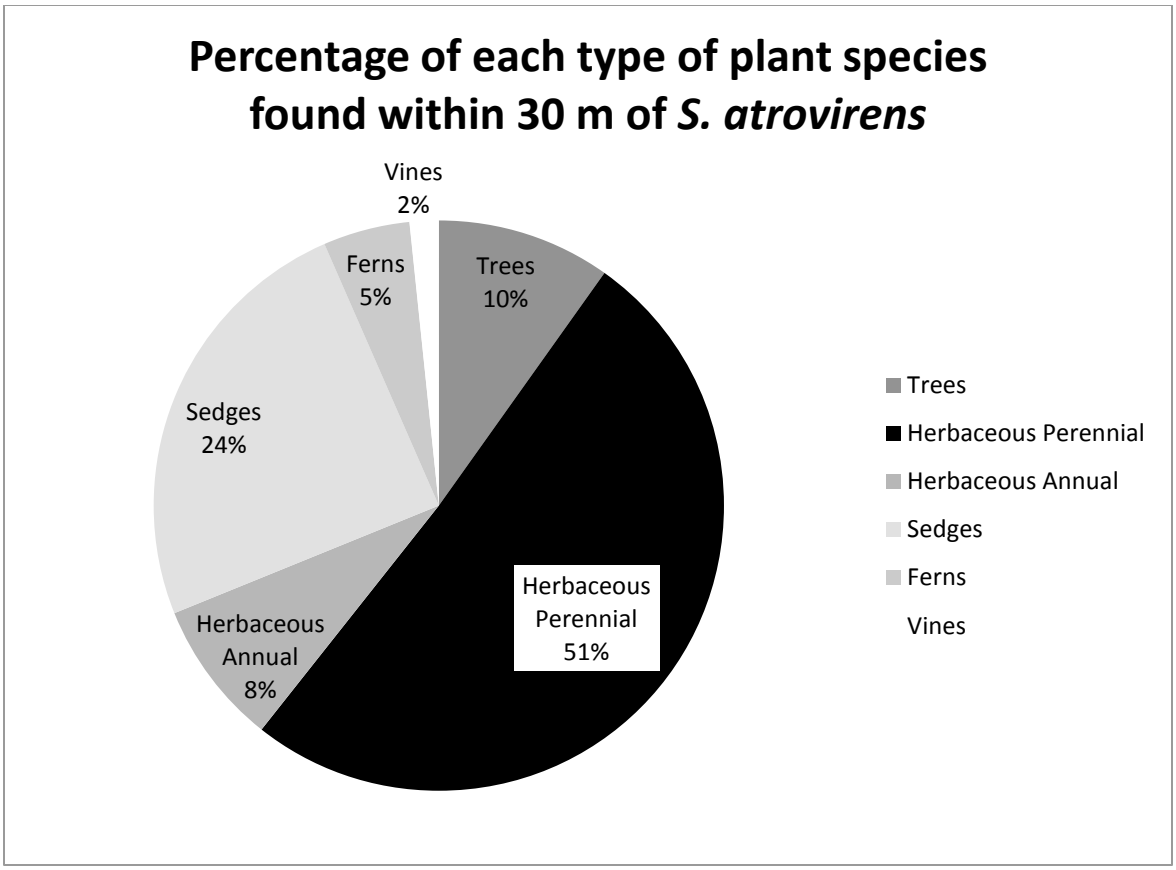

Figure 16. Pie chart showing the percentage of each type of plant species found within 30 m of *S. atrovirens*.

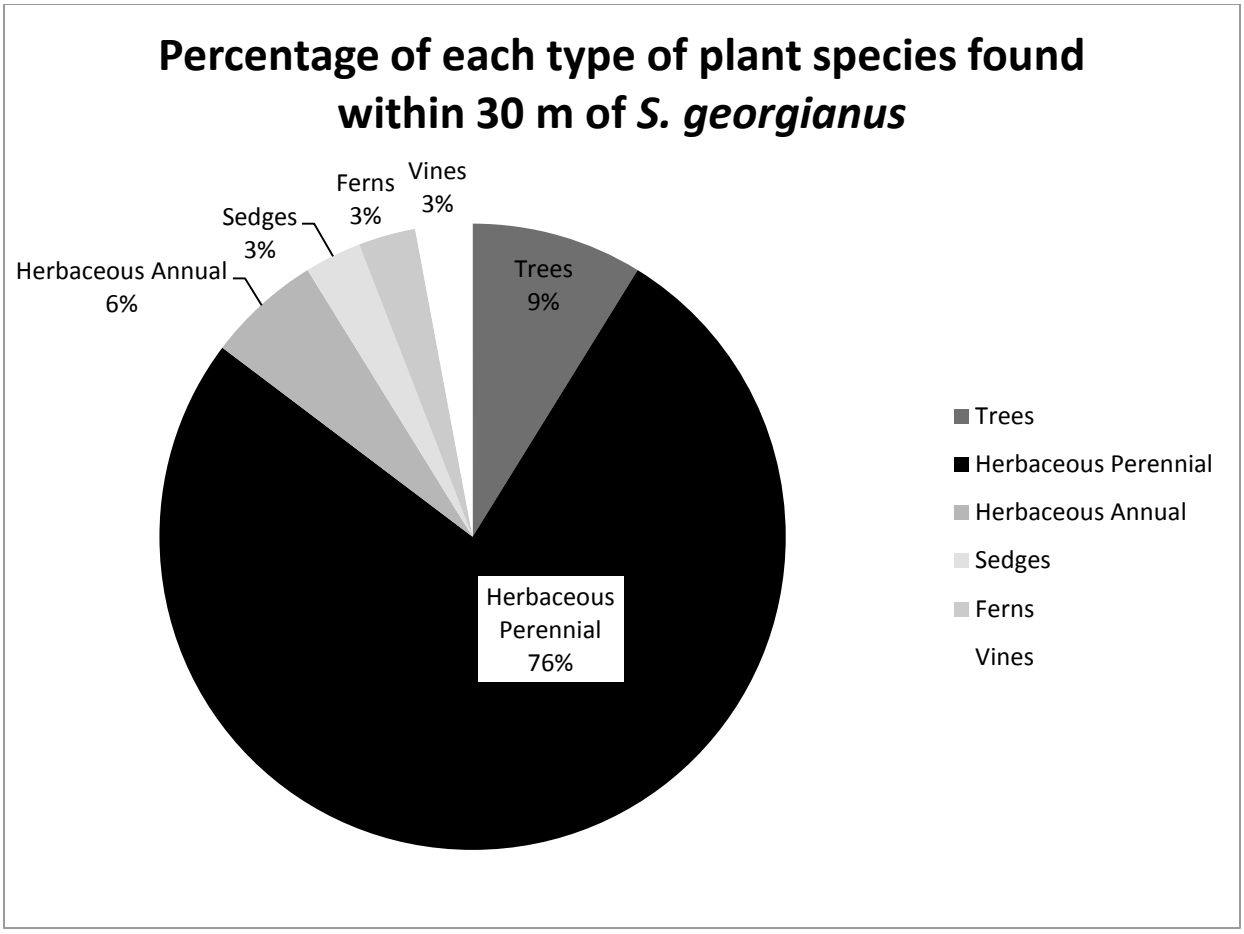

Figure 17. Pie chart showing the percentage of each type of plant species found within 30 m of *S. georgianus.*

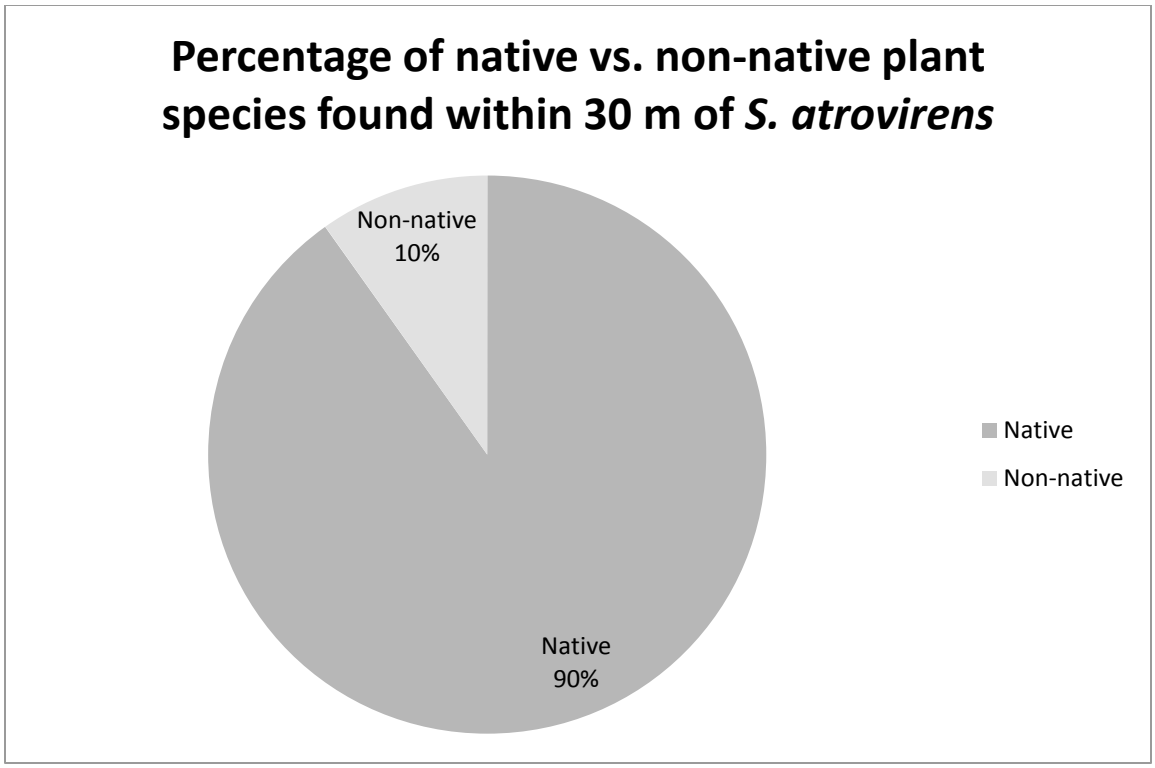

Figure 18. Pie chart showing the percentage of native vs. non-native plant species found within 30 m of *S. atrovirens.*

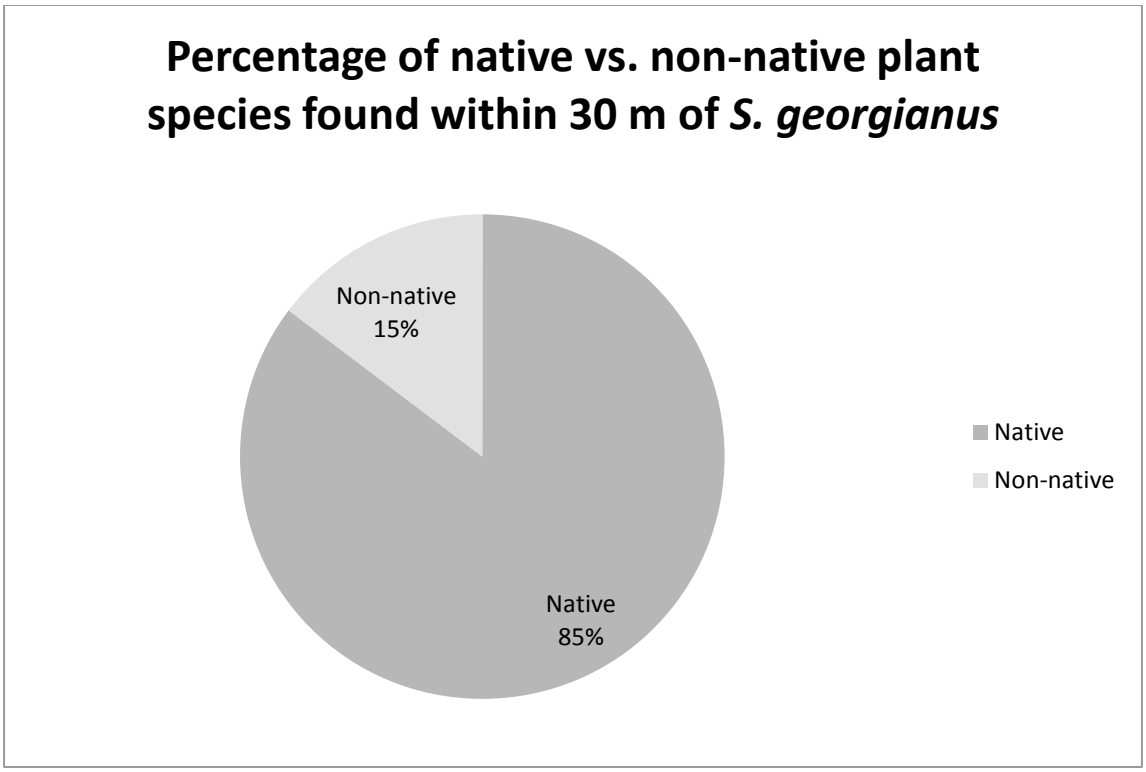

Figure 19. Pie chart showing the percentage of native vs. non-native plant species found within 30 m of *S. georgianus.*

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