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Observations of Hall's Bulrush (*Schoenoplectus hallii*) (Cyperaceae) in Mason County Illinois in 2009

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ABSTRACT

Historical locations of *Schoenoplectus hallii* in Mason County, Illinois were visited in 2009 and compared to trips made in previous years. Searches for the species were conducted at potential new sites with suitable habitat. Of the 24 sites visited, Hall's bulrush was documented at 10 sites. Population estimates ranged from a few juvenile plants to sites that contained tens and hundreds of thousands of individuals. Associated species were similar to those recorded in previous studies. Presence of Hall's bulrush in Mason County is dependent upon water levels on the nearby Illinois River and the rise of groundwater to the surface. During years when water levels on the Illinois River are above flood stage due to precipitation amounts in excess of monthly and annual averages, habitat may persist at some sites for 1-2 years following high total rainfall events. Sites at Sand Lake are somewhat anomalous in that ground water reserves in the area are so large that *S. hallii* may be present during years when precipitation and water levels on the Illinois River are at or well below monthly and yearly averages. During years when precipitation and water levels on the Illinois River exceed monthly and yearly averages, Hall's bulrush may be absent in the Sand Lake area due to flooded conditions. We recommend continued monitoring of Hall's bulrush sites in Mason County and other localities in Illinois using GPS equipment and advocate the development of a standardization protocol for obtaining population estimates of the species.

INTRODUCTION

Schoenoplectus hallii (A. Gray) S.G. Smith (Hall's bulrush) is a rare annual/short-lived perennial sedge that is a widely scattered obligate wetland species that currently occurs in a wide variety of habitats across nine states in the Midwest and central Plains (McKenzie et al. 2007). Due to its rarity, scattered distribution, and numerous threats, *S. hallii* is a species of conservation concern (Beatty et al. 2004) and has been considered as a possible candidate for listing under the Endangered Species Act (McKenzie et al. 2007). Detailed information on the species' status, historical and current distribution, life history requirements, threats to its habitat, status in each state where it occurs, suggested management actions, and research needs is provided in Beatty et al. (2004) and McKenzie et al. (2007). Hall's bulrush is associated with habitats that have fluctuating water

levels (Robertson et al. 1994, McClain et al. 1997, McKenzie 1998, Beatty et al. 2004, Smith and Houpis 2004, McKenzie et al. 2007). The species benefits from an extensive and persistent seed bank that likely contributes to its potential for population regeneration (Smith et al. 2006).

Although more sites have been documented for the species in Illinois than in any other state (McKenzie et al. 2007), it is listed as threatened by the Illinois Endangered Species Protection Board (2009). The largest number of populations of Hall's bulrush in Illinois occurs in Cass and Mason counties (Robertson et al. 1994). Numerous collections of *S. hallii* have been taken from these counties since 1957 and 1958 when R. Rexroat and G. Winterringer recorded the species southeast of Beardstown (Mohlenbrock 1976, Robertson et al. 1994). The species was noted in abundance at a site in western Cass County by J. Schwegman in 1975 (Schwegmann 1984) and P. Shildneck collected the species in Mason County in 1985 (Robertson et al. 1994). Following the large flood event in Illinois in 1993, K. Robertson, L. Phillippe and S. Gehlhausen discovered numerous populations of Hall's bulrush in Cass and Mason counties (Robertson et al. 1994). In 1994 and 1995, W. McClain, R. McClain and J. Ebinger conducted a survey of the flora of temporary sand ponds in Cass and Mason counties and commented on the occurrence of Hall's bulrush at selected sampling sites (McClain et al. 1997). Additionally, P. McKenzie, J. Schwegmann, J. Ebinger, W. McClain, and G. Bade noted large populations of the species in 1995 in Mason County at some of the same sites surveyed by McClain et al. (1997) (McKenzie 1998). M. Smith recorded observations on *S. hallii* in Mason County in 2000 while conducting a study on achene morphology for the species (Smith et al. 2006).

DESCRIPTION OF THE STUDY AREA

Mason County is situated within a region of Illinois characterized by extensive and deep sand deposits and large underground aquifers. It is bounded on the west by the Illinois River and on the south by the Sangamon River, both of which may have a major impact on the groundwater levels in the southwestern portion of the county. The geography, topography, climate, and relationship between the geology and the underlying water table of the region have been well summarized by Walker et al. (1965), Sanderson and Buck (1995), McClain et al. (1997), and Hlinka et al. (1999).

MATERIALS AND METHODS

On 23-24 September 2009, the authors visited 24 sites in Mason County where *S. hallii* had been previously reported or areas where wet, sandy soil suggested that habitat conditions were suitable for germination and growth. This followed the fourth highest year for precipitation in Illinois (Illinois State Climatologist Office 2010; http://www.isws.illinois.edu/atmos/statecli/).

The purposes of our visit were to: 1) provide additional observations on *S. hallii* populations in Mason County, 2) compare these findings with previous surveys, 3) collect fresh plant tissue for an ongoing genetic study on *S. hallii, S. saximontanus* (Fernald) J. Raynal and potential hybrids between the two taxa currently being conducted at Southern Illinois University in Edwardsville, 4) collect achenes, if available, for permanent cold storage, 5)

identify any potential new threats to the species, 6) outline recommendations for additional research, and 7) suggest management recommendations that may ensure the persistence of this species in Illinois.

Site information shown in Table 1 was compiled using the following method: Location of population sites recorded in 2009 using a GPS system, and those reported in Element Occurrence Records (EORs) maintained by the Illinois Natural History Survey (INHS), were marked on a map of Mason County using Google Earth version 5.1.3 (Google.com 2010) by entering longitude/latitude coordinates. When other sites (e.g., those reported in Robertson et al. 1994) were reported using directions based on locations along state or county roads, these sites were correlated to the 2009 data using the measuring tool in Google Earth.

To form a basis for comparison of our observations with historical records, we collected data from all available resources (publications and EORs) and recorded them in Table 1. Years for which data were available about *S. hallii* population sites and sizes were compared with respect to precipitation at the Havana, IL station (http://www.ncdc.noaa.gov/oa/ncdc.html) and flood stage data from the US Army Corps of Engineers gauge station at River Mile 119.6, which is 100ft downstream from the bridge at Highway 136 [(http://www2.mvr.usace.army.mil/WaterControl/stationinfo2.cfm?sid=HAVI2&fid=HAVI2&dt=S) (Fig. 1A & B)].

Plant tissue for genetic analyses was taken from 20 separate plants per site and placed in small collection bags with silica gel. Voucher specimens were collected by McKenzie and will be housed at the Missouri Botanical Garden (MO) (P.M.McKenzie #s **2416-2424**). GPS readings were taken at each collection site (NAD 83). A rough population estimate was taken at each locality and main plant associates recorded. Achenes were collected by T. Kelley on 7 October 2009 and donated to the Center for Plant Conservation at MOBOT, St. Louis, Missouri for permanent cold storage. Botanical nomenclature follows Yatskievych (1999) or Yatskievych & Turner (1990).

RESULTS AND DISCUSSION

Schoenoplectus hallii was observed at 10 sites in Mason County including localities where the species had been historically recorded [e.g., previous collections by Schwegman in 1974, (Schwegman 1984), McClain et al. in 1994 and 1995 (McClain et al. 1997), McKenzie et al. in 1995 (McKenzie 1998, McKenzie et al. 2007), Smith et al. in 2000 (Smith et al. 2006) and various others as reported in EORs 1, 3, 9, & 16-21; Table 1], but the species was conspicuously absent at others. We surveyed all 11 sites from which collections were made by Phillippe and Gehlhausen in 1993 (Robertson et al. 1994). Of these, only five had plants in 2009, and two of the sites reported to have *S. hallii* in 1994 and 1995 (McClain et al. 1997) had none in 2009. Populations at positive sites ranged from a few immature individuals to hundreds of thousands of mature plants that formed large colonies and covered several acres.

Plant associates recorded at *S. hallii* sites were similar to those recorded by Robertson et al. (1994) and McClain et al. (1997) and included *Alisma subcordatum* Raf., *Ammannia coccinea* Rottb., *Bacopa rotundifolia* (Michx.) Wettst., *Bidens cernua* L., *C. acuminatus*

Torr. & Hook., *C. erythrorhizos* Muhl., *C. esculentus* L., *Cyperus odoratus* L., *C. strigosus* L., *Eleocharis ovata* (Roth) Roem. & Schult., *Digitaria sanguinalis* (L.), Scop., *Echinochloa crusgalli* (L.) P. Beauv., *E. muricata* (P. Beauv.) Fernald, *Gnaphalium obtusifolium* L., *Heteranthera limosa* (Sw.) Willd., *Juncus brachycparus* Engelm., *Leersia oryzoides* (L.) Sw., *Lindernia dubia* (L.) Pennell, *Lipocarpha micrantha* (Vahl) G.C. Tucker, *Mollugo verticillata* L., *Panicum capillare* L., *P. dichotomiflorum* L., *Polygonum amphibium* L., *P. lapathifolium* L., *P. pensylvanicum* L., *Rotala ramosior* (L.), Koehne, *Rorippa* sp., *Schoenoplectus mucronatus* (L.) Palla, *S. tabernaemontani* (C.C. Gmel.) Palla, *Setaria faberi* R.A.W.. Herrm., *Typha latifolia* L., and *Xanthium strumarium* L.

As previously reported, large populations occurred in fields that had been planted in *Zea mays* L. or *Glycine max* (L.) Merr. the previous year. One population was discovered in a *Triticum aestivum* L. stubble field. Associates at this site were similar to those at other localities except for the presence of *Chenopodium album* L., *Conyza canadensis* (L.) Cronq., *Physalis* sp., and *Setaria viridis* (L.) P. Beauv. Site 5 (see Table 1), 2.3 miles north of Bath on the W side of IL78, had 12 plants of the federally listed *Boltonia decurrens* (Torr. & A. Gray) A.W. Wood as an associate.

Populations of *S. hallii* at collection sites varied in population size, density and maturity. Although most populations had an abundance of mature achenes, other sites had young plants that lacked flowers or had immature fruit (Table 1, site 24). Moisture at collection locations ranged from moist sand without visible standing water to sites where areas were completely flooded with as much as ~ 36 in of water (e.g., site 6, south of Havana at the NE corner of the intersection of IL97 and county road 1500N, in an area historically known as Negro Lake but now referred to as Sand Lake). Most Hall's bulrush plants at this site were under water, but there were a few fertile culms just above the surface (Figure 2). Phillippe & Gehlhausen (Robertson et al. 1994, p.13, collection # 22984) reported that plants were growing in water ~2ft deep at the same locality (i.e., site 6, EOR # 1, Table 1) in 1993.

Underground aquifers and ground water levels in western Mason County are influenced by precipitation and water stages on the nearby Illinois River (Visocky 1965, McClain et al. 1997, Hlinka et al. 1999; Fig. 1A-B). During years when precipitation is unusually high (i.e. roughly above once every 50-250 year recurrence events; Visocky 1965; Fig. 1A-B), groundwater flooding occurs where ground-water levels rise above the land surface and create surface water and overland flooding (McClain et al. 1997, Hlinka et al. 1999). This overland flooding creates numerous temporary ground-water lakes and sand ponds that can exceed 3,672 ha in areal coverage, as occurred in Mason County following the flood of 1993 (McClain et al. 1997). During years when water levels on the Illinois River are above flood stage due to precipitation amounts in excess of monthly and annual averages (Figure 1), excess water may persist at some sites for 1-2 years following high total rainfall events (Hlinka et al. 1999).

Our observations of populations of Hall's bulrush on 23-24 September 2009 were similar to those recorded by other researchers following years of above average precipitation. During years when overland flooding occurs in the sandy soil of the region, germination and growth conditions are ideal for *S. hallii* (Baskin et al. 2003) and the species can be found in the tens to hundreds of thousands of plants covering several acres (Robertson et

al. 1994, McKenzie 1998, McClain et al. 1997, McKenzie et al. 2007). This is particularly true for sites 3, 4 & 5 (Table 1) that are within 1.7, 2, & 0.5 mi, respectively, of the Illinois River. We estimated hundreds of thousands of *S. hallii* plants at each of these sites during our visit in 23-24 September 2009. During years of average to below average precipitation, water levels in underground aquifers do not reach the surface such that wet sand habitat is unavailable and *S. hallii* can be completely absent (sites 1, 10, 11, 17, 23 or corresponding EORs 16-19, 20, Table 1). Additionally, during drier years, most sites in the region are cultivated for various agricultural crops, which is not possible during overland flood events (Robertson et al. 1994, McKenzie 1998, McClain et al. 1997, Beatty et al. 2004, McKenzie et al. 2007).

Although there is a general correlation between precipitation and water levels on the nearby Illinois River with abundance of *S. hallii*, there are some anomalous observations where the possible explanations for the presence or absence of the species at a particular site are not as apparent. For example, sites 15 and 16 (Table 1) were flooded during our visit in 23-24 September 2009 and no Hall's bulrush plants were visible. There were, however, thousands of *S. hallii* plants at site 16 in 2000 when the species was absent from other localities (Table 1). This is likely due to the overflow of ground water levels on some portions of the Sand Lake area following the above average rainfall in 1998 (Fig. 1-B) was sufficiently large enough for limited habitat to persist into 2000.

In respect to precipitation and flooding, the reasons for the absence of Hall's bulrush at some sites (e.g., 10-13, 17, 19 & 23, Table 1) during our visit in 23-24 September 2009 are not readily apparent. Flood stages and precipitation were very similar in 1993 and 2009 (Fig. 1A & B), so we inferred that habitat availability for *S. hallii* had declined during the intervening 16 years. This was particularly noticeable at some of the historical shallow roadside ditch habitats. Some ditches along roadside sites that provided historical habitat for Hall's bulrush had been widened and increased in depth. This manipulation led to the noticeable incision and erosion of some ditches. Increased ditch maintenance in Mason County may have been a result of flood management recommendations following the catastrophic flood in the county in 1993. Hlinka et al. (1999) analyzed interactions between ground and surface water at Sand Lake in Mason County following the 1993 flood and noted that the elevation of "transportation roadways" had been increased to reduce impacts of future floods. Hlinka et al. (1999) also recommended that future potential impacts from flooding around Sand Lake could be lessened by taking steps to ensure that there were mechanisms (e.g., pumping, improved drainage) in place to facilitate the discharge of excessive surface water into the Illinois River. While the deepening and widening of ditches in Mason County to facilitate runoff during years of above-average precipitation has impacted roadside populations of *S. hallii*, it is not known what effect such drainage operations will have on the species in adjacent agricultural fields. Sanderson and Buck (1995) studied groundwater levels in the Havana Lowlands that include sites for *S. hallii* and determined that underground aquifers in the area were of such magnitude that increased groundwater withdrawls over a 30-year period were insufficient to significantly decrease the resource. Nonetheless, the area has been identified as a major locality for human population growth due to its large underground aquifer; its under-utilized coal, sand and gravel resources; and its proximity to major highways and larger cities (Walker et al. 1965). Additionally, Sanderson and Buck (1995) calculated

that agricultural irrigation in Mason and adjacent southern Tazewell counties had increased from about 130 acres in 1954 to an estimated 117,000 acres in 1989.

In our attempt to determine the commonality of some sites we visited in 23-24 September 2009 with historical collections and EORs listed in the INHS Database, we noticed that it was extremely difficult to compare collection sites due to: 1) incorrect label data with inaccurate county road numbers, 2) inconsistency in how sites within a certain radius of one another were lumped into a single locality, 3) EORs were lacking from some sites listed in Table 1 (e.g., sites 2, 4-5, 13-14, 18, 21-22) but which were far enough apart from other localities that they should have been listed separately, and 4) the use of different names for the same apparent locality. In the latter case, Negro Lake listed in Robertson et al. (1994: p.13, Phillippe & Gehlhausen collection # 22984) is now referred to as Sand Lake (see sites 6, 7, 15, and 16 in Table 1; these are listed as EOR number 1 in the INHS Database). Some of our collection sites did not equate well with established EORs because: 1) a few localities were close enough that they would likely be lumped into a single location in the INHS database, 2) as far as we could ascertain, they were new records for the species separate from previous collections, and 3) in some cases we made collections at sites that were within 0.2-0.7 mi. of one another to maximize sample size for our genetics study.

Despite the large numbers of plants of *S. hallii* observed at localities in Mason County in 2009, all sites we visited are on private property and subject to further agricultural, industrial or residential development. Consequently, we recommend that the following actions be undertaken: 1) continue monitoring of known sites, especially following years of above-average rainfall, 2) initiate a seed bank ecology study at selected sites similar to a study conducted by M. Smith in Missouri (Smith 2001, 2002, 2003), 3) evaluate the potential effects of ditch maintenance and roadway elevation on area drainage patterns, 4) further assess changes in area human demographics and projected increased demands on water withdrawal for irrigation, and anticipated expansion for agricultural, industrial, mineral, and residential development, and 5) evaluate the potential of site maintenance and management at selected sites through conservation agreements or easements.

Based on analysis of water levels on the Illinois River and precipitation data from 2009, we predict that *S. hallii* will be abundant at sites closest to the Illinois River in 2010 (e.g., sites 3, 4, 5 & 9), but will be absent at some localities around Sand Lake due to flooded conditions. We also predict that in future years when total precipitation levels are at or below monthly/yearly averages, water levels at the Sand Lake site (including most of Section 8, extreme SE ¼ of Section 7, NE ¼ of Section 18 and NW ¼ of Section 17 in Township 21N and R8W) may be low enough to provide habitat for Hall's bulrush, even when the species is absent at other sites where there is insufficient moisture for germination and growth.

Finally, we recommend that GPS equipment be used to pinpoint the location of known sites and to record any new sites discovered. If site boundary cannot be recorded using the GPS, due to either time constraints or the inaccessibility of the habitat, an estimate of the extent of the area covered by the population would be helpful in developing shape files for mapping. Additionally, we recommend a standardization protocol be established in estimating population levels of each site. Even such rough categories as 10s, 100s,

1000s, 10,000s or 100,000s would provide more meaningful information than simply recording the presence of the species.

ACKNOWLEDGEMENTS

We thank private land owners in Mason County for granting us permission to survey their property and Nancy Parker for her assistance with Figure 2.

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Table 1. *Schoenoplectus hallii* sites and population sizes in Mason County, IL surveyed in 2009, with reference to collections in 1993[a], and observations from 1985[d], 1994[d], 1995[b], 1998[d], 1999[d], 2000[c], 2001[d] & 2004[d]. NP = No plants, PP = plants present, FP = few plants, NR = Not reported (Robertson et al. 1994)

Site	Longitude	Latitude	2009	Coll #	1993	Coll #	[d]EOR	Observations
1	40 06 15	90 09 57	100s	2416	1000s	22977	19	1998 NP site dry[d], 2004 NP, site dry[d]
2	40 06 17	90 11 35	100s	2417	NR		--	
3	40 07 58	90 11 20	100,000s	2418	100s*	--	9	*Schwegman July 1993; 1998 NP site dry[d]
4	40 08 3.3	90 10 44	100,000s	2419	NR	--	--	1995 100,000s, McKenzie #1651[b]
5	40 13 19	90 07 13	100,000s	2420	NR	--	--	2009, 12 *Boltonia decurrens* plants
6	40 16 31	90 02 16	10,000s	2421	100s	22984	1	1985 PP[d],1999 PP[d], 2000 NP[c], 2001 FP[d] , partially flooded in 2009
7	40 16 31	90 02 23	1000s	2422	NR	--	1	2000 NP[c] , partially flooded in 2009
8	40 17 35	89 53 02	100,000s	2423	1000s	23357	18	
9	40 11 32	90 06 02	1000s	2424	1000s	22978	20	1994 1000s[d], 1995 1000s, McKenzie #1654[b], 1998 NP site dry[d]
10	40 12 55	89 45 27	NP	--	100s	23361	16	1998 NP site dry[d], 2004 NP site dry[d]
11	40 17 50	89 53 24	NP	--	1000s	23337 23365	18	2004 NP, site dry and mowed[d]
12	40 17 20	90 01 08	NP	--	many	23353	--	1995 100s, McKenzie #1661[b]
13	40 16 27	90 01 09	NP	--	NR	--	--	1995 1000s, McKenzie #1660[b]

Site	Longitude	Latitude	2009	Coll #	1993	Coll #	[d]EOR	Observations
14	40 16 49	90 00 0.4	NP	--	NR	--	--	1994-95 PP (McClain et al. 1997 site #3), 2000 NP site dry[c]
15	40 16 28	90 02 14	NP	--	NR	--	1	2000 NP[c], site flooded in 2009
16	40 16 28	90 02 21	NP	--	NR	--	1	1994-95 PP (McLain et al. 1997 site #2); 2000 1000s[c] , site flooded in 2009
17	40 15 10	90 01 15	NP	--	25	23366	21	1998 NP site dry[d], 2004 NP site dry[d]
18	40 06 19	90 11 36	NP	--	NR	--	--	
19	40 06 52	90 12 33	NP	--	33+	22945	3	1989 PP[d], *Schwegman 1995 1000s plants, 1998 NP site dry[d]
20	40 11 29	90 05 52	NP	--	NR	--	20	0.66 mi from site 9
21	40 07 58	90 09 21	NP	--	NR	--	--	
22	40 06 19	90 12 19	NP	--	NR	--	--	
23	40 17 44	89 51 34	NP	--	500	23334	17	1998 NP site dry[d], 2004 NP site dry and mowed[d]
24	40 17 30	89 53 07	few juvenile	--	NR	--	18	Plants young, no inflorescences (<.2 mi from Site 8 on other side of 2500E)

*Reported by Schwegman, but not collected

[a] Robertson et al. 1994; collection by Phillippe & Gehlhausen; specimen housed at University of Illinois at Urbana/Champaign (ILLS)

[b] McKenzie 1995; specimen housed at the Missouri Botanical Garden (MO)

[c] Smith et al. 2006

[d] Illinois Natural History Database EOR (Element of Occurrence Record)

Figure 1. Illinois River flood gauge data and annual precipitation recorded at Havana, IL, for selected years. (A.) Mean annual water level (feet) taken from the USACE gauge at Illinois River Mile 119.6. The horizontal dashed line indicates flood stage. (B.) Total average precipitation (inches) (bars with left angled lines), and the mean annual deviation from the 100 year average (solid bars).

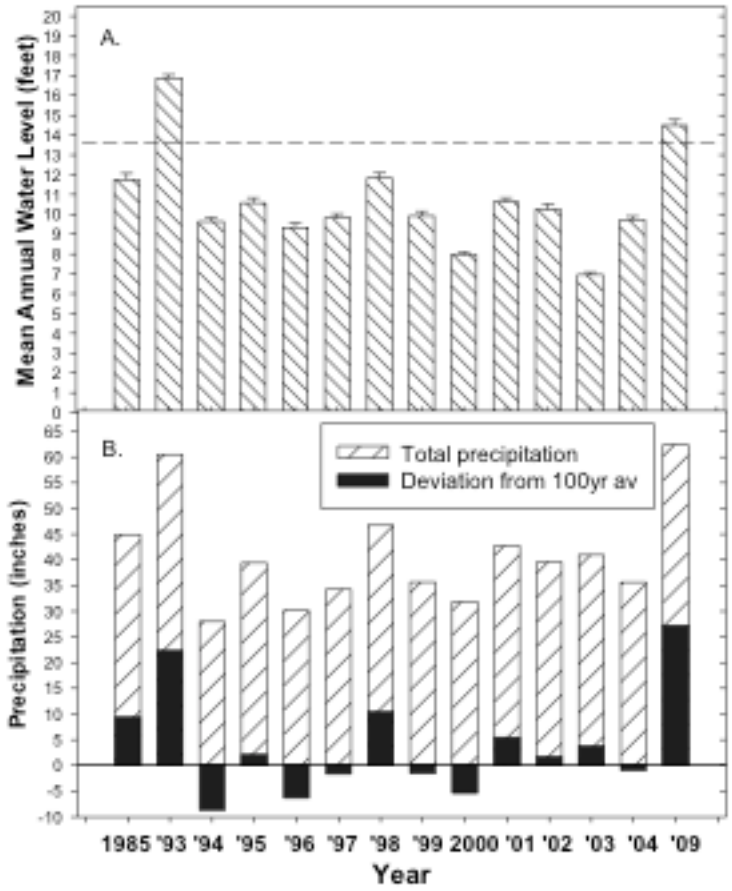

Figure 2. Inflorescences and achenes of *S. hallii* shown above water level at Site 6. Photo by Tim Kelley.