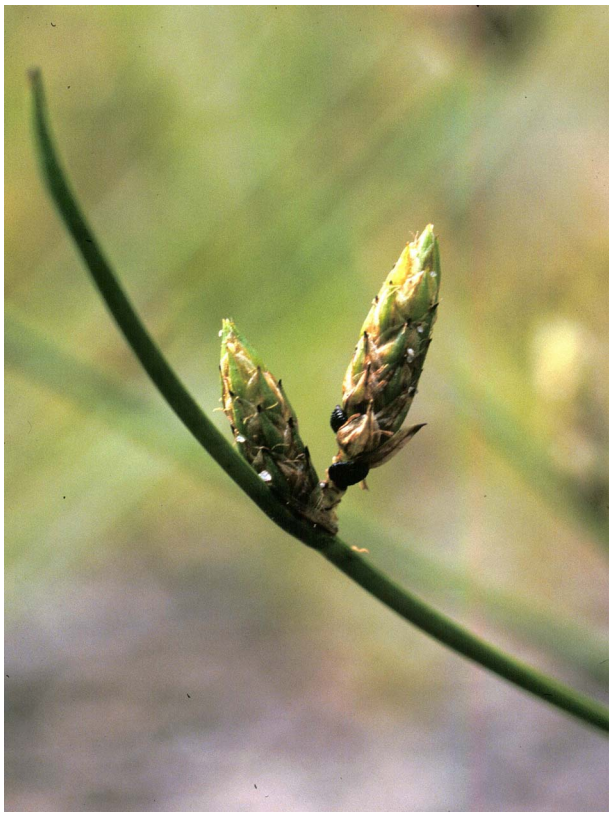
Hall's Bulrush Habitat Characterization and Monitoring Project 2003 Report



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MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

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Introduction

Michigan Natural Features Inventory (MNFI) initiated population and vegetation monitoring of an exemplary occurrence of Hall's bulrush (*Shoenoplectus hallii* (A. Gray) S.G. Smith) in a coastal plain marsh within Allegan State Game Area, in 1999. This widespread but extremely rare annual sedge is ranked as globally imperiled (G2) by NatureServe and it is anticipated that it will be recommended for candidate status (C1), leading ultimately to designation as a threatened (LT) species under the Federal Endangered Species Act (ESA). The Michigan study was initiated to help fill data gaps on the habitat and ecological requirements of Hall's bulrush and to develop and test a long-term monitoring protocol. The results of this study will help ensure that appropriate protection and management measures will be taken to conserve this species.

The methods and results of the first three years of monitoring are presented in our 1999-2002 report (Penskar & Higman 2003). The same monitoring protocol was conducted in 2003 and will be continued through 2006, resulting in detailed population and habitat data over a seven-year period. In addition, in 2003, four other known Michigan occurrences of the bulrush were re-visited to assess their status and *de novo* surveys were conducted in Allegan County to look for additional occurrences of this species. *De novo* surveys will be conducted in Muskegon and Van Buren counties in 2004 and 2005. This report presents the results of the monitoring and of the status and *de novo* surveys conducted in 2003. More comprehensive site comparisons will be made in 2006 during the final year of the study.

Study Site

The monitoring protocol was conducted in Section 7 Marsh, located within the Allegan State Game Area (SGA), a 50,000 acre (20,234 ha) public tract located in western Allegan County in southwest Lower Michigan (Figure 1). The site is one of two documented occurrences of Hall's bulrush in the SGA and is located in the northeastern region of the tract where a large population was first identified in 1989. The population occurs within a high quality occurrence of coastal plain marsh, a globally imperiled (G2) natural community (Kost 2000). The marsh occurs in a shallow, isolated depression within an extensive sand plain dominated by closed canopy oak-pine forest. Largely dominated by graminoids (grasses, sedges, and rushes), as is typical of coastal plain marshes, this site is one of several such exemplary occurrences in the SGA and one of approximately 40 in southwest Michigan.

Status surveys were conducted at three of four additional sites where Hall's bulrush has been previously documented in Michigan, including Carr Lake and Pine Island Lake-North in Muskegon County, and 36th Avenue Marsh in Allegan County. The fourth site, Pine Island Lake Marsh, in Muskegon County, was not surveyed in 2003 because we were unable to obtain permission to access the site during the survey window. Additional surveys were conducted at 19 other sites, one in Muskegon County and the remainder in Allegan County. The known Hall's bulrush sites and other surveyed sites are shown in Figures 2 and 3.

Methods

Population and Vegetation Monitoring

Population and vegetation monitoring were conducted according to the protocol first established in 1999, whereby 100 random quadrats were sampled within a 50m x 50m permanent macroplot (Penskar and Higman 2003). Percent cover of all vascular plant species, bare soil, and litter detected in each quadrat were recorded. Because of the timing

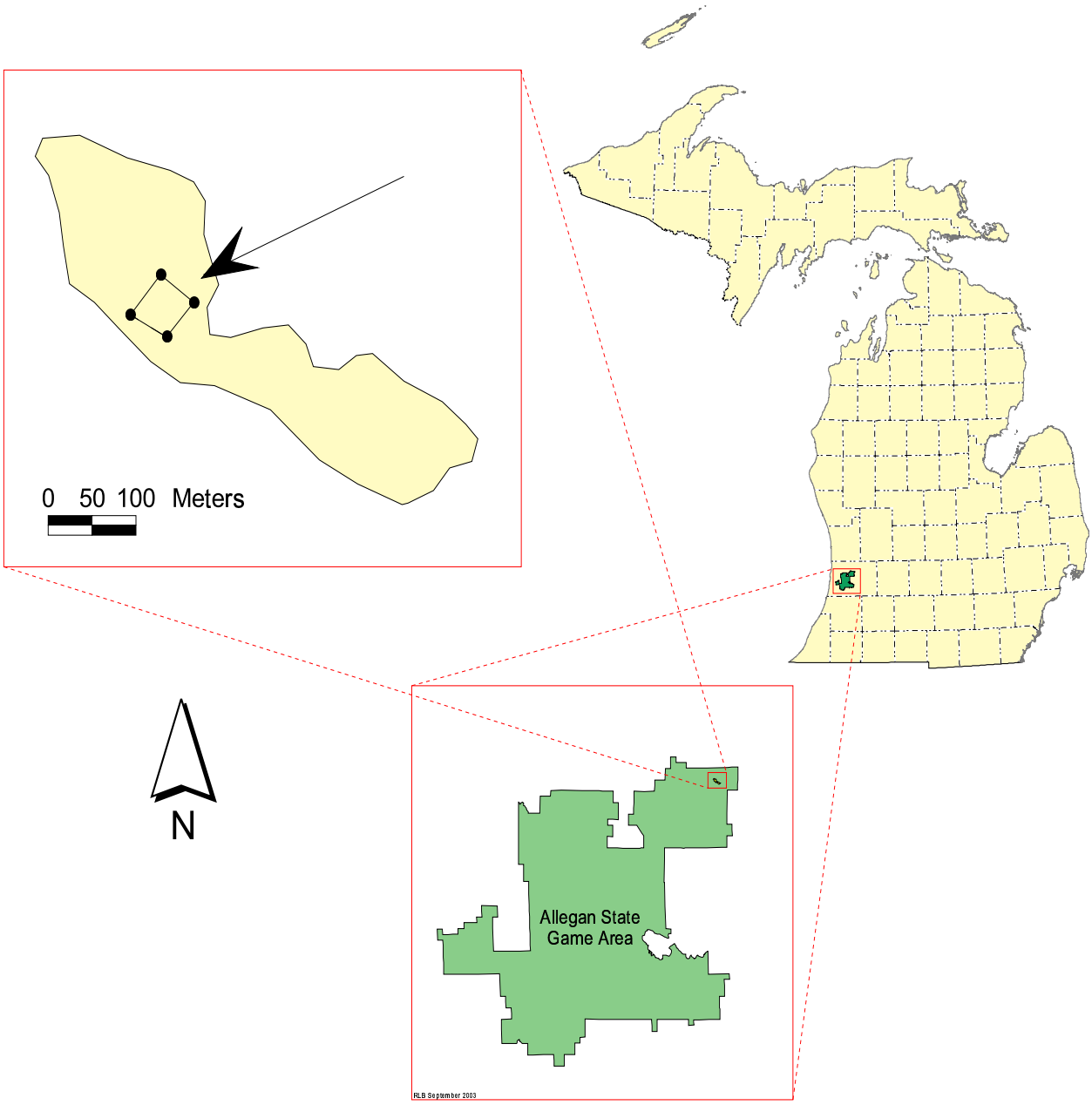

Figure 1. The study site in the Allegan State Game Area in southwest Lower Michigan. The arrow in the upper box points to the Hall's bulrush monitoring macroplot within a coastal plain marsh community.

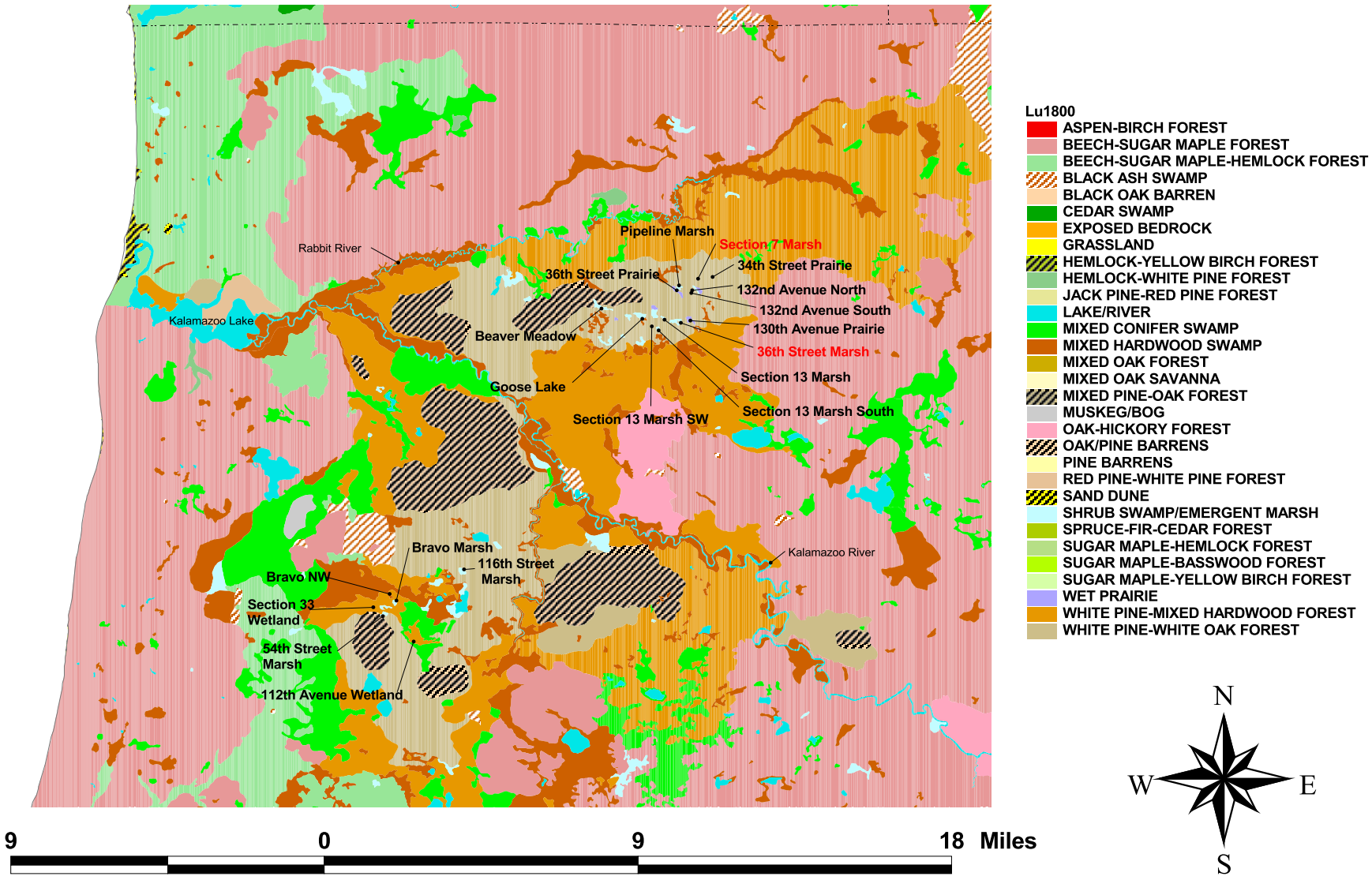

Figure 2. Sites surveyed for Hall's bulrush in Allegan county during 2003. Red font type indicates sites where the bulrush has previously been documented. Background shows vegetation cover, circa 1800, as indicated by legend.

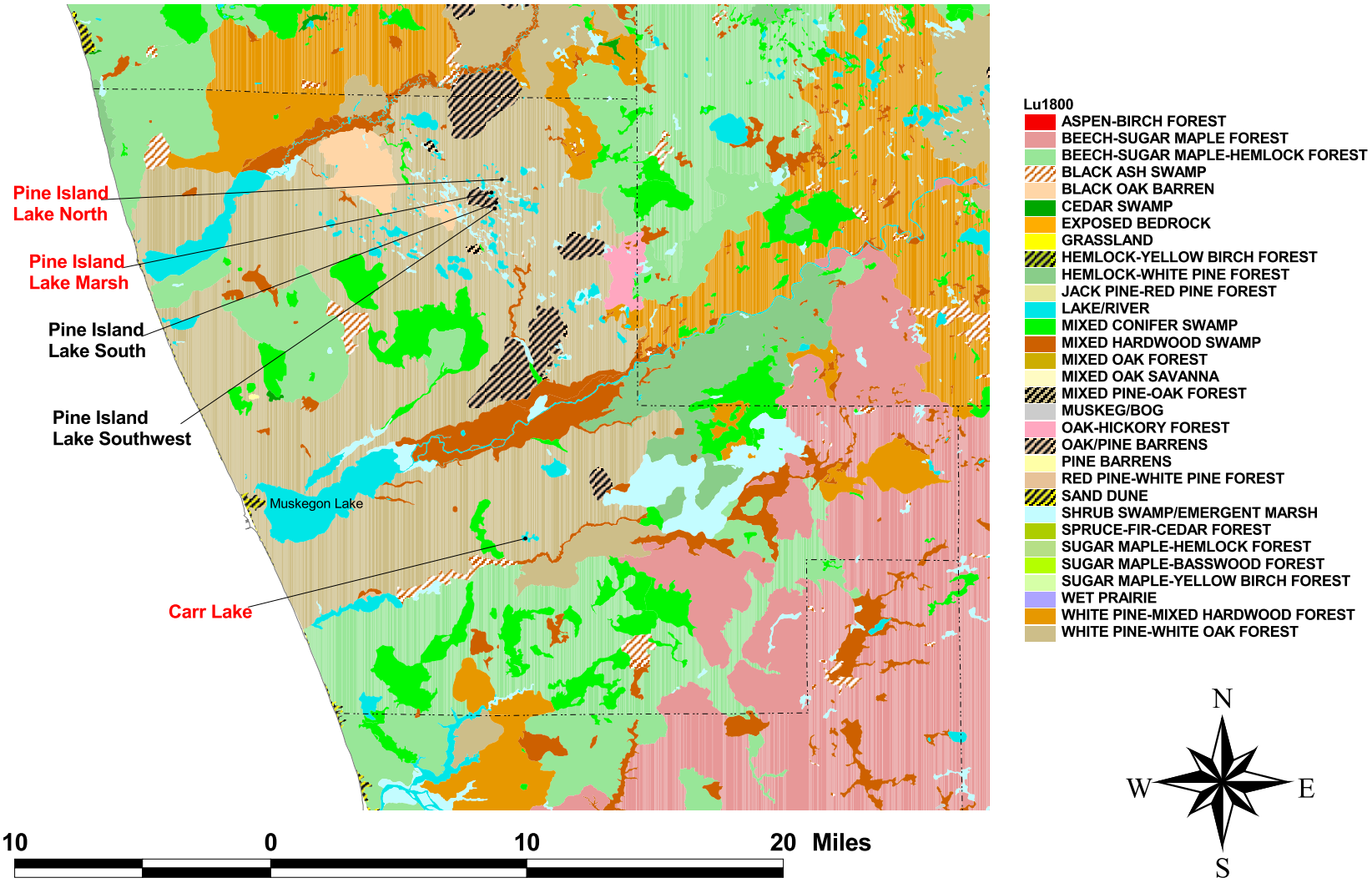

Figure 3. Sites surveyed for Hall's bulrush in Muskegon County during 2003. Red font type indicates sites where the bulrush has been previously documented. Background shows vegetation cover, circa 1800, as indicated by legend.

of the initiation of the study and with the inclusion of one spring sampling, there have been six sampling periods to date: fall 1999, spring 2000, fall 2000, fall 2001, fall 2002, and fall 2003.

Floristic Characterization

The entire site was meander-surveyed and any vascular species not observed in previous years of the study were added to the compiled inventory list. The site native floristic quality index (FQI), mean coefficient of conservatism (COC,) and average wetland coefficient were re-calculated (Herman et al. 2000) and compared to year 2002 calculations.

Well Monitoring

Four new groundwater wells were constructed using 2" diameter PVC piping cut to 2 m lengths with ¼" holes, drilled in four rows approximately 1" apart throughout their length. A ¼" hole was drilled in a standard PVC cap and secured to the bottom of each pipe. The wells were wrapped in landscaping cloth and secured with several nylon cable ties along the length of the pipe, serving to keep sediments out. The wells were installed along a north-south transect through the mid-point of the macroplot at 16.7 m intervals from baseline to baseline. A soil auger was used to core a hole for each well such that the top of the well would just reach the soil surface. Once the wells were in place, the cut ends of the landscaping cloth were wrapped over the open top and secured with a removable cap. Excess space surrounding the wells was re-filled with soil and the tops of the wells were buried in order to make detection of the wells by others difficult. Depth to water table was measured using a stiff measuring tape inserted to the bottom of the wells in May, June, July, August, and September.

Soil Characterization

Soils at the monitoring site were characterized previously and are described in detail in the 1999-2002 report (Penskar & Higman 2003). Soil texture and pH of Section 7 Marsh were compared with those at three other sites where Hall's bulrush has previously been documented, as described below in the Status Surveys section.

Seed Bank Characterization

Four additional seed samples were taken from quadrats where the highest and lowest cover of Hall's bulrush was recorded during the fall 2002 monitoring, the only year the bulrush has germinated and emerged during this study. These samples were taken to assess if there was a marked difference in seed density between high and low cover quadrats or at different soil depths. The results of this sub-sample, although small, may help direct future seed sampling efforts. At each of the four locations, 1 m quadrats were placed at the approximate coordinates where they had been sampled in 2002 and soil cores were taken from the center of each quadrat using a bulb planter. Each sample was sliced horizontally through the mid-point, and then upper and lower portions of each soil core were placed in separate plastic bags. The samples were sieved and Hall's bulrush seeds were separated out and tallied for each sample. Separate counts were made for the upper (~ 5 cm) and lower (~5 cm) portions of each soil core.

Photo Monitoring

Photo monitoring was conducted as a means of quantitatively comparing the annual changes within the study site. Photos were taken from each of the four corners of the permanent macroplot, looking inward on the plot, and compared to previous years.

Status Surveys

All records pertaining to the four other known occurrences of Hall's bulrush in Michigan were reviewed in order to pin-point where they were previously documented as specifically as possible. Surveys were conducted on August 26-27, 2003, by meandering each site looking for emerged Hall's bulrush plants. Although each site was meander surveyed, intensive searches were concentrated in the specific locations where the plant had been previously recorded. Soil samples were inspected periodically to assess presence or absence of achenes. In addition, four random soil samples were gathered with a bulb planter, placed in plastic bags, and taken back to the office. These samples were air dried and closely inspected for seeds by processing through standard brass soil sieves with mesh sizes of 1.4 mm, 1.0 mm, and 0.7 mm. Each site was described and representative photos were taken. The soil of each of these sites was characterized by determining the specific soil series and other detailed features via the published soil survey for Allegan County (USDA 1983). Soils were also inspected *in situ* by taking a representative soil auger where Hall's bulrush had been previously recorded at each site. The pH of the various soil layers for each site was determined with a Cornell field test kit.

De novo Surveys

Aerial photos for Allegan County were reviewed in conjunction with USGS topographic maps to locate other potential sites for Hall's bulrush. Potential sites were identified using the search image of previously documented sites – grass and rush-dominated, shallow depressions with gently sloping sides, occurring on outwash and sandy lake plains. Sites were meander-surveyed in a similar fashion to the previously documented Hall's sites, and periodic soil samples were examined on-site for seeds during August 25-29 and October 6-10. Several well known coastal plain marshes in the vicinity of the *de novo* surveys sites where Hall's bulrush had not yet been previously detected, were also surveyed. Surveys were justified at these sites because surveys conducted in previous years may not have targeted Hall's bulrush specifically. Also, as is corroborated by our three years of monitoring data, the emergence of Hall's bulrush is very sporadic and previous surveys at these well known sites may not have been conducted during a year of emergence, making detection very difficult.

Results and Discussion

Population and Vegetation Monitoring

Aerial stems of Hall's bulrush were not observed during any site visit in 2003. Vegetation cover data from August 27, showed similar results to previous years with the same suite of species dominating the sample plots (Table 1). Species were considered dominant if they had an average coverage of more than 1% in at least one year and appeared within the macroplot during the 2003 and all four previous monitoring seasons. In order of average coverage in 2003, these include cord grass (*Spartina pectinata)*, hyssop hedge-nettle (*Stachys hyssopifolia)*, switch grass (*Panicum virgatum)*, panic grass (*Panicum spretum)*,

Table 1. Average percent cover and frequency of species identified in sampling quadrats from 1999-2003. Italicized species are dominants that have appeared in the macroplot during all five sampling years and had coverage of more than 1% in at least one year. Bolded species indicate rare Michigan taxa occurring in the monitoring macroplot.

	1999		*2000*		*2001-2pring*		*2001-fall*		*2002*		*2003*	
Species	**Freq**	**Avg. Cov.**	**Freq.**	**Avg. Cov.**	**Freq.**	**Avg. Cov.**	**Freq.**	**Avg. Cov.**	**Freq.**	**Avg. Cov.**	**Freq**	**Avg. Cov.**
Spartina pectinata	82	25.25	78	16.87	80	8.70	83	6.80	77	21.41	84	11.25
Stachys hyssopifolia	61	2.75	48	2.82	58	6.26	61	6.34	59	17.02	68	8.06
Panicum virgatum	85	6.80	80	3.91	74	1.87	78	1.27	87	5.93	95	6.23
Panicum spretum	71	26.1	65	36.72	53	13.6	8	0.13	54	2.10	58	5.63
Aster dumosus	21	0.73	19	1.81	11	0.36	17	0.66	21	4.94	21	2.82
Polygonum amphibium	16	0.35	13	0.14	11	0.16	9	0.12	22	1.50	11	.16
Carex brevior	21	1.11	24	0.05	30	0.92	20	0.50	26	0.68	8	.11
Agrostis hyemale	-	-	-	-	2	0.02	1	0.01	-	-	1	.01
Andropogon scoparius	2	0.03	-	-	1	0.02	2	0.03	-	-	-	-
Antennaria howellii	-	-	-	-	-	-	2	0.02	-	-	2	.02
Apocynum cannabinum	9	0.09	3	0.03	9	0.13	-	-	8	0.09	2	.02
Aster/Solidago sp.	3	0.03	-	-	-	-	-	-	-	-	-	-
Bulbostylis capillaris	-	-	-	-	-	-	-	-	18	0.18	-	-
Conyza canadensis	-	-	9	0.14	15	0.15	2	0.02	-	-	8	.08
Cyperus filiculmis	-	-	2	0.02	-	-	1	0.01	-	-	-	-
Echinodorus parvulus									1	0.01	-	-
Eleocharis engelmannii	-	-	-	-	-	-	-	-	5	0.40	-	-
Eleocharis tricostata	-	-	-	-	-	-	-	-	14	0.84	4	.23
Euphorbia maculata	-	-	-	-	-	-	-	-	-	-	1	.01
Fimbristylis autumnalis	-	-	-	-	-	-	-	-	1	0.01	-	-
Gnaphalium obtusifolia	-	-	-	-	-	-	-	-	-	-	2	.02
Hypericum canadense	-	-	-	-	-	-	-	-	2	0.02	-	-
Juncus tenuis	3	0.03	1	0.01	-	-	-	-	-	-	-	-
Krigia virginica	-	-	-	-	4	0.07	1	0.01	-	-	-	-
Lechea villosa	-	-	1	0.01	3	0.06	1	0.01	-	-	-	-
Linaria canadensis	-	-	-	-	30	3.57	-	-	-	-	-	-
Lobelia spicata	-	-	1	0.01	-	-	-	-	-	-	-	-
Lycopus americanus	-	-	1	0.01	-	-	-	-	-	-	-	-
Lycopus uniflorus	-	-	-	-	-	-	-	-	-	-	1	.01
Mollugo verticillata	-	-	-	-	-	-	-	-	9	0.14	-	-
Oenothera biennis	-	-	-	-	-	-	2	0.02	-	-	1	.03
Penstemon hirsutus	-	-	-	-	-	-	1	0.15	-	-	-	-
Polygala polygama	9	0.12	4	0.04	5	0.08	11	0.11	-	-	2	.02
Polygonella articulata	-	-	4	0.01	-	-	1	0.01	-	-	3	.04
Potentilla norvegica	-	-	-	-	-	-	-	-	-	-	2	.02
Rotala ramosior	-	-	-	-	-	-	-	-	64	2.93	-	-
Scirpus hallii	-	-	-	-	-	-	-	-	47	5.28	-	-
Sonchus sp.	-	-	-	-	-	-	1	0.01	-	-	-	-
Specularia perfoliata	-	-	-	-	4	0.04	-	-	-	-	-	-
Spiraea alba	1	0.01	-	-	-	-	-	-	-	-	-	-
Vernonia missurica	-	-	1	0.02	-	-	-	-	-	-	-	-

bushy aster (*Aster dumosus)*, water smartweed (*Polygonum amphibium),* and sedge (*Carex brevior)*. Average percent cover declined from 2002 for cord grass and hyssop hedge-nettle, bushy aster, water smart-weed, and *Carex brevior*, while it increased for panic grass, and switch grass. Cordgrass, hyssop hedge-nettle, and switch grass remain consistent dominants showing the highest average coverages over all six sampling periods. *Panicum spretum* has been among the top four dominants in four sampling periods and attained the highest average cover of all species during any single year, with an unusual spike in 2000. As in previous years, several additional species were occasionally detected in the quadrats with consistently lower cover values including Indian hemp (*Apocynum cannabinum*), rough cinquefoil (*Potentilla norvegica*), three-ribbed spike-rush (*Eleocharis tricostata*), ticklegrass (*Agrostis hyemale*), racemed milkwort (*Polygala polygama*), small pussytoes (*Antennaria howellii*), horseweed (*Conyza canadensis*), cudweed (*Gnaphalium obtusifolium*), northern bugleweed (*Lycopus uniflorus*), common evening-primrose (*Oenothera biennis*), jointweed (*Polygonella articulata*), and nodding spurge (*Euphorbia maculata*).

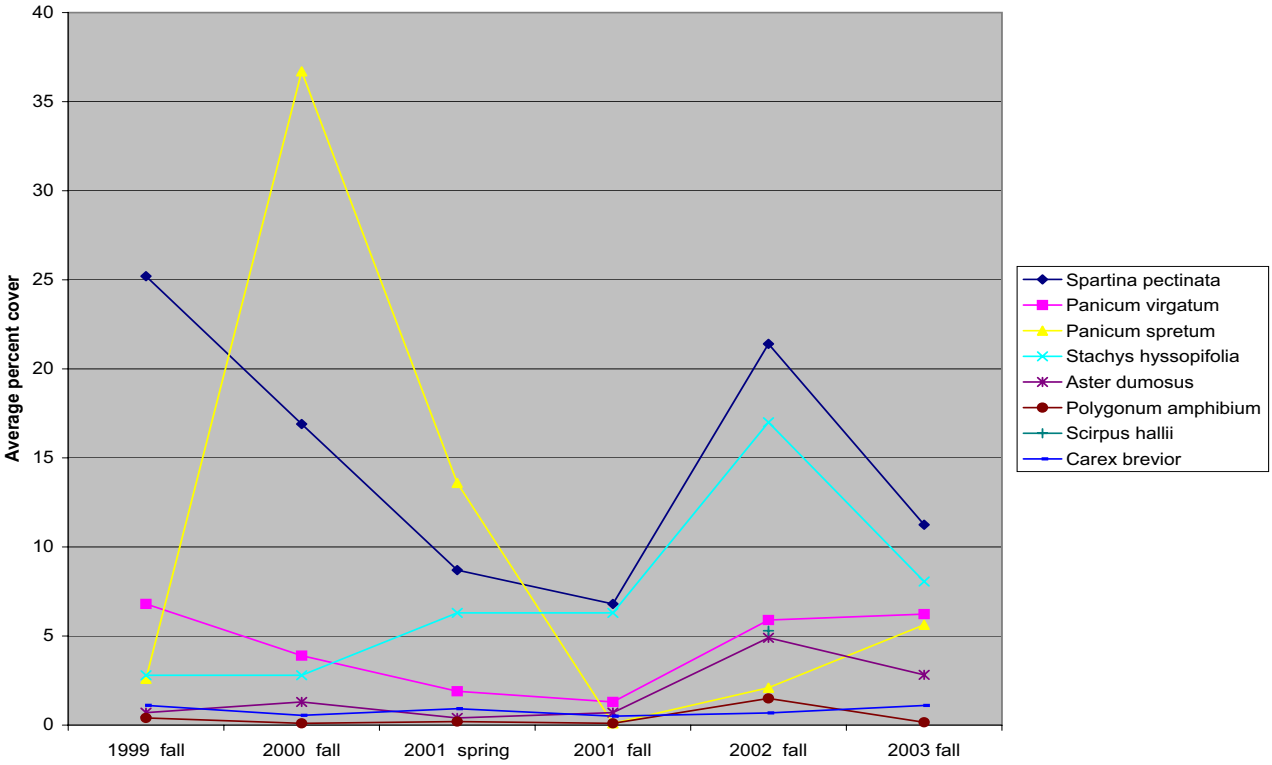

Figure 4. Average percent cover values of dominant vascular plant species in monitoring macroplot from 1999-2003, showing a single point for Hall's bulrush based on the sole year of emergence in 2002.

The emergence and detection in the sampling quadrats of state threatened three-ribbed spike-rush, albeit in very small numbers, is of note. This rare coastal plain disjunct species was detected previously only in 2002 when *Scirpus hallii* also emerged. Since the spike-rush emerged in 2003 while Hall's bulrush did not, it appears that the conditions required for germination of these two coastal plain disjunct species are not strictly identical. Alternatively, it is possible that the germination of small numbers of the spike-rush could

represent individuals lying in the extreme tails of the average germination curve, i.e., a rare few individuals that were able to emerge in less than optimal conditions. However, evidence provided by the last five year's of emergence and monitoring data combined, indicate that three-ribbed spike-rush has never been abundant at the site, while Hall's bulrush persists in huge abundance and under appropriate conditions also emerges in abundance (Table 2). Average cover when the bulrush emerged in 2002 was 5.3% for all plots combined and cover in individual sample quadrats reached as high as 85%. If the conditions for germination for the two species were identical, the chances of detecting the Hall's bulrush during monitoring would be considerably higher than that for the spike-rush. Thus, our data support the hypothesis that germination of Hall's bulrush is governed by a narrower range of conditions than for three-ribbed spike-rush.

We will continue to monitor vegetation cover over the next three years and at the conclusion of the study will have eight years of data from which to make further comparisons and potential statistical correlations.

Table 2. Frequency and average cover of rare coastal plain disjunct species at Section 7 Marsh during 2002 and 2003.

		2002		2003	
state status	species	frequency	% cover	frequency	% cover
E	*Scirpus hallii*	47	5.28		
T	*Eleocharis tricostata*	14	0.84	4	0.23
SC	*Eleocharis engelmannii*	5	0.40		
E	*Echinodorus parvulus*	1	0.01		
SC	*Rotala ramosior*	64	2.93		

Floristic Characterization

Ten new species were added to the inventory list including blue-joint (*Calamagrostis canadensis*), cudweed (*Gnaphalium obtusifolium*), swamp dewberry (*Rubus hispidus*), Canada goldenrod (*Solidago canadensis*), steeplebush (*Spiraea tomentosum*), wood sage (*Teucrium canadense*), blueberry (*Vaccinium angustifolium*), lance-leaved violet (*Viola lanceolata*), bracken fern (*Pteridium aquilinum*), and flowering dogwood (*Cornus florida*). This brings the total number of vascular plant species observed at the site to 107, comprised of 101 native and six non-native species (Table 3). Using the Michigan Floristic Quality Assessment System (Herman et al. 2001), the new site native FQI was 48.4 with a native mean COC of 4.8. These values reflect an increase from 2002 (46 and 4.6 respectively) further demonstrating the high quality and diversity of the site. The average wetland coefficient with the additional species included was FAC- indicating drier conditions in 2003. This is corroborated by our well monitoring data discussed below.

Well Monitoring

During the October visit, the northern-most well was found to be missing its cap, while the other three wells remained untouched. The one well that had been tampered with was the one most likely to be discovered by others, occurring in a two-track with very sparse cover at the north baseline of the macroplot. Thus, since the other three remained undetected, the camouflaging of the wells appears to be a fairly effective strategy to impede the vandalization

Table 3. Compiled vascular plant species list for the study site, over five seasons of vegetation monitoring and meander searches.

SCIENTIFIC NAME	WETNESS	PHYSIOGNOMY	COMMON NAME
Agrostis hyemalis	FAC-	Nt P-Grass	TICKLEGRASS
Ambrosia artemisiifolia	FACU	Nt A-Forb	COMMON RAGWEED
Andropogon gerardii	FAC-	Nt P-Grass	BIG BLUESTEM
Andropogon scoparius	FACU	Nt P-Grass	LITTLE BLUESTEM GRASS
Antennaria howellii	UPL	Nt P-Forb	SMALL PUSSYTOES
Apocynum cannabinum	FAC	Nt P-Forb	INDIAN HEMP
ARABIDOPSIS THALIANA	UPL	Ad A-Forb	MOUSE EAR CRESS
Arabis glabra	UPL	Nt B-Forb	TOWER MUSTARD
Artemisia campestris	FAC	Nt B-Forb	WORMWOOD
Asclepias amplexicaulis	UPL	Nt P-Forb	CLASPING MILKWEED
Aster dumosus	FAC+	Nt P-Forb	BUSHY ASTER
Bulbostylis capillaris	FACU+	Nt A-Sedge	SEDGE
Calamagrostis canadensis	OBL	Nt P-Grass	BLUE JOINT GRASS
Carex brevior	FAC	Nt P-Sedge	SEDGE
Carex muhlenbergii	UPL	Nt P-Sedge	SEDGE
Carex pellita	OBL	Nt P-Sedge	SEDGE
Carex pensylvanica	UPL	Nt P-Sedge	SEDGE
Carex rugosperma	UPL	Nt P-Sedge	SEDGE
CIRSIUM VULGARE	FACU-	Ad B-Forb	BULL THISTLE
Conyza canadensis	FAC-	Nt A-Forb	HORSEWEED
Coreopsis lanceolata	FACU	Nt P-Forb	SAND COREOPSIS
Cornus florida	FACU-	Nt Tree	FLOWERING DOGWOOD
Cyperus filiculmis	FACU-	Nt P-Sedge	SLENDER SAND SEDGE
Danthonia spicata	UPL	Nt P-Grass	POVERTY GRASS; OATGRASS
DIANTHUS ARMERIA	UPL	Ad A-Forb	DEPTFORD PINK
Echinodorus tenellus	OBL	Nt P-Forb	DWARF BURHEAD
Eleocharis engelmannii	FACW	Nt A-Sedge	ENGELMANN'S SPIKE RUSH
Eleocharis tricostata	OBL	Nt P-Sedge	THREE RIBBED SPIKE RUSH
Eragrostis spectabilis	UPL	Nt P-Grass	PURPLE LOVE GRASS
Euphorbia corollata	UPL	Nt P-Forb	FLOWERING SPURGE
Euphorbia maculata	FACU-	Nt A-Forb	NODDING SPURGE
Euthamia graminifolia	FACW-	Nt P-Forb	GRASS LEAVED GOLDENROD
Euthamia remota	FACW	Nt P-Forb	LAKES FLAT TOPPED GOLDENROD
Fimbristylis autumnalis	FACW+	Nt A-Sedge	AUTUMN SEDGE
Fragaria vesca	FACU-	Nt P-Forb	WOODLAND STRAWBERRY
Gnaphalium obtusifolium	UPL	Nt A-Forb	OLD FIELD BALSAM
Helianthus divaricatus	UPL	Nt P-Forb	WOODLAND SUNFLOWER
Hypericum canadense	FACW	Nt A-Forb	CANADIAN ST. JOHN'S WORT
Hypericum kalmianum	FACW-	Nt Shrub	KALM'S ST. JOHN'S WORT
Juncus greenei	FAC	Nt P-Forb	GREENE'S RUSH
Juncus tenuis	FAC	Nt P-Forb	PATH RUSH
Koeleria macrantha	UPL	Nt P-Grass	JUNE GRASS
Krigia virginica	UPL	Nt A-Forb	DWARF DANDELION
Lechea villosa	UPL	Nt P-Forb	HAIRY PINWEED
Lespedeza capitata	FACU	Nt P-Forb	ROUND HEADED BUSH CLOVER
Liatris aspera	UPL	Nt P-Forb	ROUGH BLAZING STAR
Liatris cylindracea	UPL	Nt P-Forb	CYLINDRICAL BLAZING STAR
Linaria canadensis	UPL	Nt A-Forb	BLUE TOADFLAX
Linum sulcatum	UPL	Nt P-Forb	GROOVED YELLOW FLAX
Lithospermum canescens	UPL	Nt P-Forb	HOARY PUCCOON
Lobelia spicata	FAC	Nt P-Forb	PALE SPIKED LOBELIA
Lupinus perennis	UPL	Nt P-Forb	WILD LUPINE
Lycopus americanus	OBL	Nt P-Forb	COMMON WATER HOREHOUND
Lythrum alatum	OBL	Nt P-Forb	WINGED LOOSESTRIFE
MOLLUGO VERTICILLATA	FAC	Ad A-Forb	CARPET WEED

Table 3 continued.

Monarda punctata	UPL	Nt P-Forb	HORSEMINT
Nyssa sylvatica	FACW+	Nt Tree	BLACK GUM
Oenothera biennis	FACU	Nt B-Forb	COMMON EVENING PRIMROSE
Oxalis stricta	FACU	Nt P-Forb	COMMON YELLOW WOOD SORREL
Panicum praecocius	UPL	Nt P-Grass	PANIC GRASS
Panicum spretum	OBL	Nt P-Grass	PANIC GRASS
Panicum virgatum	FAC+	Nt P-Grass	SWITCH GRASS
Penstemon hirsutus	UPL	Nt P-Forb	HAIRY BEARD TONGUE
Pinus banksiana	FACU	Nt Tree	JACK PINE
Pinus strobus	FACU	Nt Tree	WHITE PINE
POA COMPRESSA	FACU+	Ad P-Grass	CANADA BLUEGRASS
Polygala polygama	FACU-	Nt B-Forb	RACEMED MILKWORT
Polygonella articulata	UPL	Nt A-Forb	JOINTWEED
Polygonum amphibium	OBL	Nt P-Forb	WATER SMARTWEED
Populus deltoides	FAC+	Nt Tree	COTTONWOOD
Potentilla simplex	FACU-	Nt P-Forb	OLD FIELD CINQUEFOIL
Prunus serotina	FACU	Nt Tree	WILD BLACK CHERRY
Pteridium aquilinum	FACU	Nt Fern	BRACKEN FERN
Quercus alba	FACU	Nt Tree	WHITE OAK
Quercus velutina	UPL	Nt Tree	BLACK OAK
ROSA MULTIFLORA	FACU	Ad Shrub	MULTIFLORA ROSE
Rotala ramosior	OBL	Nt A-Forb	TOOTH CUP
Rubus flagellaris	FACU-	Nt Shrub	NORTHERN DEWBERRY
Rubus hispidus	FACW	Nt Shrub	SWAMP DEWBERRY
Rudbeckia hirta	FACU	Nt P-Forb	BLACK EYED SUSAN
Salix humilis	FACU	Nt Shrub	PRAIRIE WILLOW
Salix petiolaris	FACW+	Nt Shrub	SLENDER WILLOW
Sassafras albidum	FACU	Nt Tree	SASSAFRAS
Schoenoplectus hallii	OBL	Nt A-Sedge	HALL'S BULRUSH
Sisyrinchium montanum	FAC+	Nt P-Forb	MOUNTAIN BLUE EYED GRASS
Solidago canadensis	FACU	Nt P-Forb	CANADA GOLDENROD
Solidago hispida	UPL	Nt P-Forb	WHITE GOLDENROD
Solidago juncea	UPL	Nt P-Forb	EARLY GOLDENROD
Solidago nemoralis	UPL	Nt P-Forb	OLD FIELD GOLDENROD
Sorghastrum nutans	FACU+	Nt P-Grass	INDIAN GRASS
Spartina pectinata	FACW+	Nt P-Grass	CORDGRASS
Specularia perfoliata	FAC	Nt A-Forb	VENUS'S LOOKING GLASS
Spiraea alba	FACW+	Nt Shrub	MEADOWSWEET
Spiraea tomentosa	FACW	Nt Shrub	STEEPLEBUSH
Stachys hyssopifolia	FACW+	Nt P-Forb	HYSSOP HEDGE NETTLE
Teucrium canadense	FACW-	Nt P-Forb	WOOD SAGE
Toxicodendron radicans	FAC+	Nt W-Vine	POISON IVY
Tradescantia ohiensis	FACU+	Nt P-Forb	COMMON SPIDERWORT
Ulmus americana	FACW-	Nt Tree	AMERICAN ELM
Vaccinium angustifolium	FACU	Nt Shrub	BLUEBERRY
Verbena hastata	FACW+	Nt P-Forb	BLUE VERVAIN
Vernonia missurica	FAC+	Nt P-Forb	MISSOURI IRONWEED
Veronica peregrina	FACW+	Nt A-Forb	PURSLANE SPEEDWELL or NECKWEED
Viola lanceolata	OBL	Nt P-Forb	LANCE LEAVED VIOLET
Viola pedata	UPL	Nt P-Forb	BIRDFOOT VIOLET
Viola sagittata	FACW-	Nt P-Forb	ARROW LEAVED VIOLET
Vitis riparia	FACW-	Nt W-Vine	RIVERBANK GRAPE

that had occurred in previous years. The agent(s) and motivation for vandalizing remains unclear, however the Allegan State Game Area Wildlife Biologist suggested that is was likely related to hunters that traditionally use this area. We recapped the one well and plan to continue our camouflaging efforts.

The wells were just barely moist at 2 meters on May 29 and completely dry when sampled in June July, August, September, and October. The lack of emergence of Hall's bulrush this year supports the recently published conclusions drawn from over ten years of seed germination experiments using seeds from several Missouri bulrush populations (Baskin et al. 2003). In this study, Hall's bulrush germinated consistently and only if seeds were buried in non-flooded soil during winter temperatures and subsequently flooded and exposed to light and ethylene under growing season temperatures. In natural populations, flooding of soil in the presence of organic matter results in the production of ethylene. Germination would be expected if the aforementioned flooding conditions were met and the seeds were near the soil surface where they would be exposed to light. Although we do not have detailed water level data, our data do suggest that there was no significant flooding of seeds in the spring of 2003.

Soil Characterization

Although Hall's bulrush was not found at the three other known sites surveyed in 2003, representative soil samples were taken in the vicinity of the original observation of the species based upon field notes. Table 4 compares soil texture and pH at four depths, for each site sampled. Sapric peat was present only in the upper layers of the Carr Lake sample, while all other site samples at all depths, including Section 7 Marsh, were comprised of fine sand. pH values ranged from 5.0 to 7.0. It is difficult to infer much from these data, since Hall's was directly observed only at Section 7 Marsh during this study and we could not be certain of the exact conditions where it was previously observed at the other sites. Further comparisons will be made if the bulrush is found at any of the other sites in subsequent years of the study. General soil associations and characterizations are included for each site in the Status Survey Section below.

Table 4. Field characterization of soil profiles at four Hall's bulrush sites, taken during 2003.

Soil layer depth	Section 7 Marsh		Section 36 Marsh		Carr Lakes		Pine Island Lake North	
	Texture	pH	Texture	pH	Texture	pH	Texture	pH
0-17 cm	fine sand	5.0	fine sand	5.5	sapric peat	6.5	fine sand	5.5
17-31 cm	fine sand	5.5	fine sand	5.5	sapric peat	7.0	fine sand	6.5
45-62 cm	fine sand	6.0	fine sand	6.0	fine sand	7.0	fine sand	6.5
62-190 cm	fine sand	6.5	fine sand	7.0	fine sand	6.5	fine sand	6.5

Seed Bank Characterization

Table 5 shows the number of seeds counted in the upper 5 cm and lower 5 cm of each of the four soil samples. The dramatically higher numbers of seeds in samples A and B correspond to the much higher cover percentages of Hall's bulrush (85%, 60%) recorded in 2002 compared to those where samples C and D were taken (1%, 0%). Although we have no way of telling how many of the seeds in the samples were produced during 2002 versus how many were present in the seed bank from previous years, it is likely that at least some portion of the difference in number of seeds is due to year 2002 seed production. Most of the seeds produced would have fallen in the vicinity of the parent plants.

It also seems likely that areas with high coverage of the bulrush in 2002 would have had similarly high coverage in previous years of emergence, thus contributing to the seed bank over the years. Other factors include the potential movement of seeds by animals or water, the latter affected by the amount and timing of precipitation and other climatic factors such as wind. If movement by water is a significant factor, e.g. during spring flooding, the type and amount of nearby vegetative cover could present varying barriers to movement of seed, resulting in concentrations of seeds in regions that have fewer plant competitors. We have not observed movement of seeds by animals; however predation appears to be occurring, as evidenced by the observation of

Table 5. Number of seeds in upper and lower portions of four soil samples collected from Section 7 Marsh in 2003. Percent cover of Hall's bulrush where samples were taken, is shown in parentheses.

	Sample			
	A (85%)	B (60%)	C (1%)	D (0%)
Soil layer depth				
1-5 cm	285	325	88	44
6-10 cm	130	160	32	27
Total Seeds	415	485	120	71

many empty seed coats with small holes in them, which we observed during seed tallying.

All four samples show a higher percentage of seeds in the upper 5 cm of soil, which is not surprising since seeds land on the soil surface when shed, requiring some kind of mechanical action or transport agent to move them deeper. Percolation into deeper layers of soil is likely facilitated by weather events such as rain or the freezing and shifting of soil, or possibly transport by various soil organisms or other animals. Since the seeds require light to germinate (Baskin & Baskin 2003), seeds nearest the soil surface are more likely to have the opportunity to successfully emerge. It is possible that the requisite spring flooding serves the dual purpose of producing ethylene and churning up seeds from soil depths bringing them closer to the sunlight.

We will continue processing the remaining soil samples taken in 1999 to better characterize the seed bank and will map seed densities to see of a similar or other discernable pattern emerges in relation to percent cover of Hall's bulrush, associated species, or soil depth.

Photo Monitoring

The chronological series of photos of the northwest corner of the macroplot from 1999-2002 is appended with the 2003 shot, for comparison (Figure 5-10). Coincident with a drier year, the 2003 photo point pictures show vegetation cover similar to those of years 1999-2001, but not as lush as in 2002 when Hall's bulrush emerged.

Below: Figures 5-10. Chronological series of photos from northwest corner of monitoring macroplot taken over five growth seasons (1999-2003).

Figure 5. Northwest plot corner, 10/14/1999.

Figure 6. Northwest plot corner, 09/15/2000.

Figure 7. Northwest plot corner, 06/19/2001.

Figure 8. Northwest plot corner, 11/14/2001.

Figure 9. Northwest plot corner, 09/15/2002, displaying marked increase in growth and dominance of vegetation during a year in which Hall's bulrush and several rare coastal plain disjuncts emerged.

Figure 10. Northwest plot corner, 8/27/03

Status Surveys

Surveys were conducted at three of the four additional sites where Hall's bulrush has previously been observed in Michigan; Pine Island Lake-North, Carr Lake, and 36th Street Marsh (Figure 2, 3). Surveys were not conducted at the fourth known Hall's bulrush site, Pine Island Lake Marsh, because we were unable to coordinate with the landowner during the survey window. The bulrush was not observed either above ground or in the seed bank at any of the surveyed sites. Although the lack of detection of the bulrush at these sites gives rise to some concern, the cryptic nature of this species, coupled with its known sporadic emergence, renders detection exceedingly difficult, particularly if it is present only in the seed bank during the survey period. Also, unlike the large, exemplary population at Section 7 Marsh, Hall's bulrush was only observed at these other sites in low numbers, making detection even more difficult. These sites will be re-visited in subsequent years of the study and an attempt will be made to contact the botanists who originally documented each of these occurrences to see if they can either accompany us on surveys or provide more detailed survey guidance. We will also attempt to coordinate with the landowners of the Pine Island Lake Marsh site and the western lakes of the Carr Lake site in 2004. General descriptions and soil characterizations of the surveyed sites are provided below. If Hall's bulrush is observed at any of these sites or others during subsequent years of this monitoring effort, we will attempt more detailed comparisons within and among sites.

Carr Lake

This B-ranked Coastal Plain Marsh occurs in a large depression within a landscape of oak forest with scattered dry prairie openings. The marsh itself is comprised of five shallow bowls known locally as "Five Lakes". They are groundwater seepage lakes with no water inflow or outflow, and display dramatic seasonal fluctuations, typically with standing water in the spring reduced to scattered wet spots by late summer. The soil, however, is usually saturated most of the growing season. The northern-most depression has been dramatically altered by dredging, while the others retain more of their natural character, particularly the eastern-most depression. *Scirpus hallii* was previously reported in an upland area between the two southern-most depressions. We concentrated our survey effort in these areas as well as the large eastern unit, where coastal plain marsh habitat was abundant and apparently little disturbed. We were unable to get permission to survey the western depressions, but will attempt to do so in 2004

Excellent coastal plain marsh habitat was found in the eastern unit, with a mosaic of repeating plant assemblages including patches dominated by tall beak rush (*Rhynchospora macrostyacha*), hard-stem bulrush (*Schoenoplectus acutus*), autumn sedge (*Fimbristylis autumnalis)* and bald rush (*Psilocarya scirpoides*), patches dominated by blue-joint (*Calamagrostis canadensis*), twig-rush (*Cladium mariscoides*), and lakes flat topped goldenrod (*Euthamia remota*), and the wettest patches dominated by hardstem bulrush, tall beakrush (*Rhynchospora macrostachya*), sweet scented water-lily,(*Nymphaea odorata*), yellow pond-lily (*Nuphar variegatum*), and pipewort (*Eriocaulon septangulare*). Although many coastal plain disjunct species were observed in abundance, Hall's bulrush was not detected.

With its steep sloped edges, the small middle depression is unsuitable for coastal plain marsh habitat. It was vegetated by common wetland sedges and grasses with clusters of reed grass (*Phalaris arundinacea*) dominating locally. The fifth depression immediately south of the eastern-most depression was highly disturbed, with evidence of considerable ORV traffic. Hall's bulrush was not observed here either.

Soils are mapped within a Rubicon-Croswell-Deer Park association, which is

characterized as nearly level to steep, well drained and moderately well drained, sandy soils on outwash plains (USDA 1983). Specifically the soils within the depression are classified as Houghton peat and muck and Roscommon and Au Gres sands. The wetland transitions to Croswell and Au Gres sands on 0-6% slopes along the upland edge.

Pine Island Lake-North

This wetland lies within a shallow, square shaped depression with linear extensions from each of the four sides. It is one of many depressions and kettle holes within a fairly intact upland matrix of oak-pine forest occurring on a sandy glacial outwash plain. Small remnant patches of former oak barrens and dry sand prairie that were present historically are also found in this region. Much of the area encompassing these features has been designated as a USFS Research Natural Area.

Surveys were concentrated in the northern arm where Hall's bulrush had been previously been found in 1988: "less than 100 shoots in an approximate 10 yard^2 area along the broad sand shore of an emergent marsh" (MNFI 2003a). It was associated with autumn sedge (*Fimbristylis autumnalis*), brook nut sedge (*Cyperus rivularis*), lance-leaved violet (*Viola lanceolata*), Canadian St. John's-wort (*Hypericum canadensis*), hyssop hedge nettle (*Stachys hyssopifolia*), and state special concern tooth-cup (*Rotala ramosier*). In August 2003, the heart of the wetland was dominated by Canada blue-joint (*Calamagrostis canadensis*), an emergent marsh species, however, there was no standing water. Patches of wet meadow were interspersed, particularly where soils were exposed by deep ORV ruts crossing through the middle of the wetland. The broad sandy edge where Hall's bulrush was previously observed persists and grades into oak-pine forest in the upland. Although the bulrush was not observed, all of the previous associates were detected except tooth-cup. We also documented a new occurrence of state threatened, black-fruited spike rush (*Eleocharis melanocarpa)* in this ecotonal region, where it was quite common.

Soils are mapped within a Rubicon-Croswell-Deer Park association, which is characterized as nearly level to steep, well drained and moderately well drained, sandy soils on outwash plains (USDA 1968. The soils within the depression are specifically typed as Houghton peat and muck grading to Au Gres-Saugatuck sands with 0-6% slopes, surrounded by Grayling-Rubicon sands with 25-45% slopes.

Pine Island Lake Marsh

We did not survey this site in 2003 (see above) and therefore do not have current descriptive data. Based upon the original survey data from 1986, Hall's bulrush was documented on a two-track road long the shore of the southwest arm of Pine Island Lake. Surveyors described the lake as a "shallow, sandy, seepage lake with a zone of a coastal plain marsh zone at the SW edge" (MNFI 2003b). No abundance or associated species data were provided. Soils are mapped within a Rubicon-Croswell-Deer Park association, which is characterized as nearly level to steep, well drained and moderately well drained, sandy soils on outwash plains. Specifically, the soils are typed as Roscommon and AuGres sands grading to Grayling-Rubicon sands with 12-25% slopes.

36th Avenue Lake Marsh

A well surveyed site, Section 36th Street Marsh lies in a broad depression within an extensive sand plain dominated by closed canopy oak-pine forest and adjacent to a low dune. It is a high quality A-ranked coastal plain marsh with zones of open water, beds of floating aquatic plants, and grass and rush dominated moist meadow. The extent of each

zone varies with yearly and seasonal water levels. A small area of wet-mesic prairie occurs at the northeast corner. The site has a diverse flora including 15 rare coastal plain disjunct species, three of which are state endangered: Appalachian quillwort (*Isoetes engelmannii*), dwarf burhead (*Echnidorus tenellus*), and Hall's bulrush (*Scirpus hallii*). The historical disturbance of the site by ORV's seems to have abated, however, a former two-track road that runs across the northern edge of the site is now used as a horse trail. This poses a distinct threat to the marsh, acting as a vector for the spread of invasive species both by the trail itself and by seeds that may be carried in horse dung. Compaction of the soil due to trail use is also associated with hydrologic alterations, which may also impact the marsh.

Based upon the specific knowledge of one the report authors, who had observed it when Hall's bulrush was first documented at this site, we were able to target our surveys very specifically. It was noted in 1989 along the sandy wetland edge just below the horse trail towards the eastern edge of the marsh as "very local and inconspicuous" growing with prairie cord grass (*Spartina pectinata*), Canada rush (*Juncus canadensis*), autumn sedge (*Fimbristylis autmunalis*), three-ribbed spike-rush (*Eleocharis tricostata*), Englemann's rush (*E. engelmannii*), black-fruited spike-rush (*E. melanocarpa*) and beak-rush (*Rhynchospora capitellata*) (MNFI 2003c). It has not been reported in subsequent years and we did not detect it in 2003, despite careful searching.

Soils are mapped within the Oakville Association characterized by nearly level to steep, moderately well drained and well drained sandy soils on outwash plains, lakeplains, dunes, moraines, and beach ridges (USDA 1983). Specifically the soils are classified as Newton mucky fine sand.

De Novo Surveys

Surveys were conducted at 18 Allegan County sites and one Muskegon County site in addition to the three previously known Hall's bulrush sites during the course of the 2003 field season (Figures 2, 3). Hall's bulrush was not observed at any of these locations, however 13 new occurrences of several coastal plain disjunct species were newly documented (Table 6). These include five occurrences of black-fruited spike-rush (*Eleocharis melanocarpa*), four occurrences of meadow beauty (*Rhexia mariana*), and one occurrence each of three-ribbed spike-rush (*Eleocharis trichocarpa*), Virginia meadow beauty (*Rhexia virginica*), and tall beak-rush (*Rhynchospora macrostachya*). These new occurrences were transcribed and mapped in the statewide, GIS-based natural heritage database, Biotics. Data were updated for previously known occurrences of other rare species, where significant changes were evident.

Summary and Future Work

Overall vegetation of Section 7 marsh was similar to previous years of the study, with a comparable list of total species and the same suite of dominants detected in the sample quadrats. Average percent cover of four of the six dominants declined from year 2002, the sole year of emergence of Hall's bulrush during the study, while two of the dominants increased. This year's well data indicate that the marsh did not flood during the growing season, likely accounting, at least in part, for the decline in coverage of the majority of dominants. The lack of emergence of Hall's bulrush corroborates the recent findings that among other factors, spring flooding is essential to germination of this species (Baskin & Baskin 2003). We will continue to monitor the vegetation over the next three years and assess potential correlations at the conclusion of the study.

The emergence of another rare coastal plain disjunct species, three-ribbed spike-rush, was detected this year in four sample quadrats with

Table 6. *De novo* and previously known sites surveyed for Hall's bulrush in Allegan and Muskegon counties in 2003.

Site Name	County	New occurrences of state listed rare plant species	Updates on known occurrences/Comments
112th Ave wetland	Allegan	no new rarities found	
116th Street Marsh	Allegan	no new rarities found	updated: *Eleocharis microcarpa* *Rhynchospora macrostachya* *Potamogeton bicupulatus*
130th Avenue Prairie	Allegan	*Pycnanthemum verticillatum*	
132nd Avenue North	Allegan	*Eleocharis melanocarpa* *Eleocharis tricostata* *Rhexia mariana* *Rhexia virginica*	
132nd Avenue South	Allegan	no new rarities found	
34th Street Prairie	Allegan	no new rarities found	site inaccessible – converted to a golf course
36th Avenue Prairie	Allegan	no new rarities found	
36th Street Marsh	Allegan	no new rarities found	*Schoenoplectus hallii* previously found here; not observed in 2003 updated: *Eleocharis trichcarpa* *Eleocharis melanocarpa* *Rhexia mariana* *Rhexia virginica* *Sisyrinchium atlanticum*
54th Street Marsh	Allegan	no new rarities found	updated: *Eleocharis melanocarpa,* *Rhexia mariana*
Beaver Meadow	Allegan	no new rarities found	
Section 33 Wetland	Allegan	no new rarities found	
Bravo Marsh	Allegan	no new rarities found	entry prohibited
Bravo NW	Allegan	no new rarities found	
Carr Lake	Muskegon	no new rarities found	*Schoenoplectus hallii* previously found here; not observed in 2003; updated: *Eleocharis melanocarpa* *Psilocarya scirpoides*
Goose Lake	Allegan	no new rarities found	updated: *Rhynchospora nitens** *Scleria triglomerata*
Pine Island Lake South	Muskegon	no new rarities found	
Pine Island Lake Southwest	Mukegon	*Eleocharis melanocarpa* *Rhynchospora macrostachya*	
Pine Island Lake North		*Eleocharis melanocarpa*	*Schoenoplectus hallii* previously found here; not observed in 2003
Pipeline marsh	Allegan	*no new rarities found*	
Section 7 Marsh	Allegan	*no new rarities found*	*Eleocharis tricostata* detected in monitoring plots, but *S. hallii* not observed
Section 13 Marsh	Allegan	*Eleocharis melanocarpa* *Rhexia mariana*	
Section 13 Southwest	Allegan	*Eleocharis melanocarpa* *Rhexia mariana*	
Section 13 South	Allegan	*Rhexia mariana*	

*only recently documented in Michigan; not yet on the State list of threatened and endangered species.

an average cover of 0.23. Since Hall's bulrush is present in much higher numbers at the site, yet was not detected above ground in any of the 100 sample quadrats, these data indicate that the germination requirements of the two species are not strictly identical. Our data suggest that emergence of Hall's bulrush requires a stricter adherence to specific germination requirements. We will continue the monitoring protocol in 2004 through 2006 and attempt to track precipitation events and water levels more frequently to further evaluate the role of water levels in the germination of Hall's bulrush in this exemplary natural population.

Based upon the seed samples taken over the four years of study thus far and qualitative observations during monitoring, the seed bank is abundant, appears healthy, and includes apparently fresh seed produced by plants that emerged in 2002. Seeds were dramatically more abundant in two samples taken where percent cover of Hall's bulrush was high (85%, 60%) than in two samples taken where percent cover was low (1%, 0%) in 2002. In all four samples, seeds were more abundant in the upper 5 cm of soil than the lower 5 cm of soil. These results would be expected for a species where the parent plant sheds its seeds directly onto the soil surface. We will continue tallying the 100 seed samples collected in 1999 over the next three years to better characterize the seed bank and create a general map of seed densities. We will compare the number of seeds for each samples to percent coverage values of associated vegetation to see if any patterns emerge. If time permits, we will also attempt to assess seed viability at different soil depths.

Hall's bulrush was not detected as emerged plants or in the seed bank at three of the four other sites where it has been previously observed in Michigan. We will assess these sites again in subsequent years of the study and attempt to coordinate with the landowners to access the fourth site and additional portions of the Carr Lakes site. More detailed comparisons of landscape setting, soils, and associated vegetation between these known sites will be made at the conclusion of the study.

The bulrush was not detected at nineteen additional sites surveyed in 2003, although one or more other rare coastal plain disjunct species were observed at many of these sites. These included a combined total of 13 new occurrences of black-fruited spike-rush, meadow beauty, Virginia meadow beauty, three-ribbed spike-rush, and tall beak-rush. These were transcribed and mapped as new occurrences in the MNFI statewide natural heritage database, Biotics. Additional *de novo* surveys will be focused in Muskegon County in 2004 and Van Buren County in 2005. If Hall's bulrush is detected at any of these sites, we will conduct a more thorough comparative assessment of soils, associated vegetation, and population data.

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Correspondingly, we would again like to express our appreciation to John Lerg, Maria Albright, and Sara Shafer of the MDNR Wildlife Division, who have had or currently have managerial responsibilities for the Allegan State Game Area, where our study site is located. These folks all champion the protection of natural features under their stewardship from seemingly continual threats, and have supported this study and numerous others like it, over the years.

We thank Paul McKenzie, USFWS botanist from Missouri and author of the 1998 Hall's bulrush Status Assessment, and Tony Reznicek, widely respected University of Michigan sedge and monocot expert, who provided critical ecological and taxonomic guidance for study of this species in Michigan and continue to supply valuable advice and support for our work.

We were elated to be able to compare our seed emergence data to the recently published findings of Carol Baskin, Jerry Baskin, Edward Chester, and Marian Smith, who, through extraordinary dedication, patience and perseverance, at long last cracked the code for the germination of Hall's bulrush. Their work, with personal guidance from Carol, has and will continue to bring focus to our investigation of the seed bank of our sporadically emerging focal species. This is a real bonus, considering the inevitable importance of the distinctly recognizable seed bank to our ability to study the species.

In addition to the significant assistance of Jennifer Olson, MNFI environmental review specialist and zoologist, over the first three years of study, this year we enlisted the aid of botanist/ecologist Ryan O'Connor, who joined MNFI in 2001. Ryan helped with the installation of new wells, meander-surveys of the site, and numerous site checks to inspect for the emergence of Hall's bulrush. We thank Jennifer and Ryan for their generous assistance.

Finally, as always, we thank Becca Boehm, Kraig Korroch, Michael Fashoway, and Ed Schools for providing their impeccable and patient expertise in all things technological, as we assembled the report.

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