

Clark Lake, Door County Wisconsin Bulrush Mapping and Density January 2007



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Introduction:

Large beds of bulrush (*Schoenoplectus acutus*) are absent or receding in Clark Lake, Door County WI. This phenomenon is occurring in a number of Wisconsin lakes and is an environmental concern because of potential impacts to the fishery and shifts in the aquatic ecosystem. This study assessed the prevalence of bulrush in Clark Lake both quantitatively and qualitatively.

Purpose:

The purpose of this study was to determine the density and areal extent of bulrush (*Schoenoplectus acutus*) beds in Clark Lake. The data may serve as a baseline which can be used to determine the extent of future changes in density and area of bulrush beds. The methods used to determine bulrush density are intended to be easily transferable to Lake Association volunteers to be performed in future years.

Methods:

Density

Density measurements of selected beds were performed on September 8, 16, and 17, 2006. Five bulrush beds, Areas 1-5 (Figure 8, 9, 11, 13 and 15) were selectively chosen and measured. Targeted beds were representative of different densities within the lake.

Three transects were established for each site by selecting a benchmark from which the 150+ foot tape measure was extended out into the lake along compass bearings and held in place by a solid fiberglass pole. A Garmin GPS MAP 76S was used to record the spatial location of each benchmark chosen to start transects. Compass bearings were taken using a Suunto MC-1D Compass (Figure 1). Compass bearings one and three were chosen to quantify transects consistent with the overall density of the

bulrush stand. Compass bearing two was determined by halving the difference between bearings one and three resulting in a 'middle' bearing.

An important note is that a 4 degree west declination setting was used in this study (2006). Each year the declination changes and it should be looked up (Table 1) at the following web address and changed accordingly in future years: (www.ngdc.noaa.gov/seg/geomag/jsp/struts/calcDeclination).

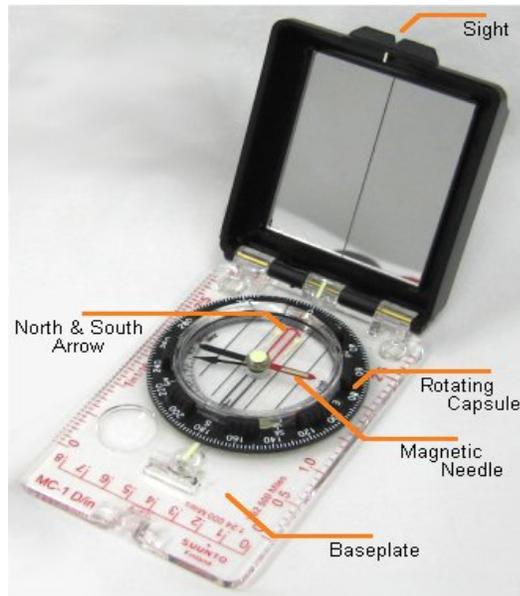


Figure 1. Suunto MC-1D Compass used in field study.

Table 1. Declination table for Clark Lake—source: NOAA.

Declination for Clark Lake, Door County, WI		
Latitude / Longitude	44.94° N	87.20° W
Year	Declination	
2007	4° 20' W	
2008	4° 24' W	
2009	4° 28' W	
* Every year declination is changing by 0° 4' W / year		

Density counts were taken within a quadrat at 10 foot increments along each transect. A 9 square foot (3' x 3') quadrat made of 1" PVC pipe was used to establish a consistent area to enumerate the emergent bulrush stems along transects. Density counts began with the 10 foot increment nearest to shore

(Figure 2). The shoreward side of the quadrat was flush with every 10 foot measurement; the quadrat itself was centered on the tape measure, lying directly over the top forming two halves of the quadrat (Figure 3). Only emergent bulrush stems with the base of the stem directly below and within the quadrat were enumerated. For each 10 foot increment the total number of stems was recorded in the appropriate transect and distance cell on the data sheet (Appendix A).

All quadrats were counted by wading along the transect line. Counting along the transect was terminated when water became too deep (generally about 4-5 feet), the bottom became too soft for wading, when the end of the tape was reached (160') or when there were no further visible stems along the transect.

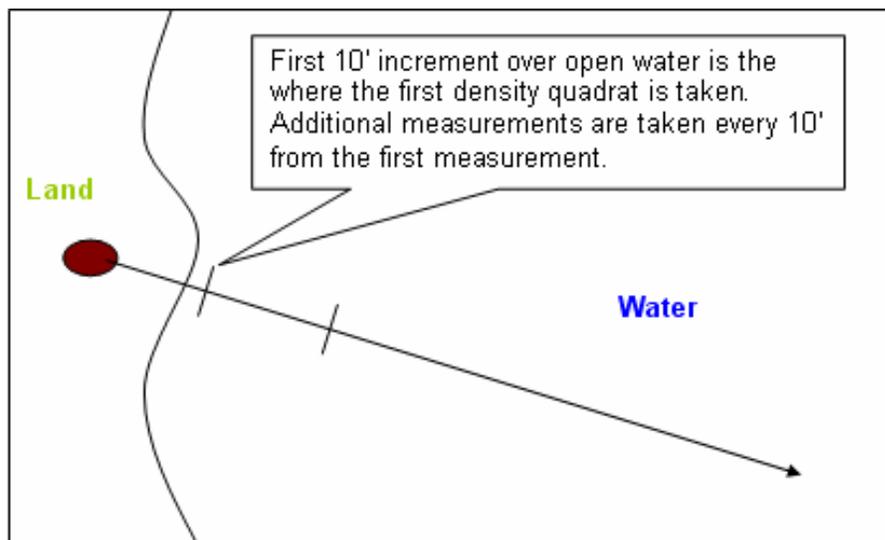


Figure 2. Schematic of density transects.

Quadrat is centered with shoreward edge on the 10' increment from starting point/benchmark



Figure 3. Quadrat centered over the transect line to enumerate emergent stems.

Mapping

Initial mapping began on September 7th and was completed on September 16th, 2006. Depending on the depth of the beds small boats and kayaks combined with wading were used as methods of tracing the bulrush beds.

Results:

Density

Bulrush densities ranged from an average of 3.1 to 10.2 emergent stems per quadrat for combined transects 1-3 at each site (Figure 4). The bulrush density for each transect within each area is found in Figure 5.

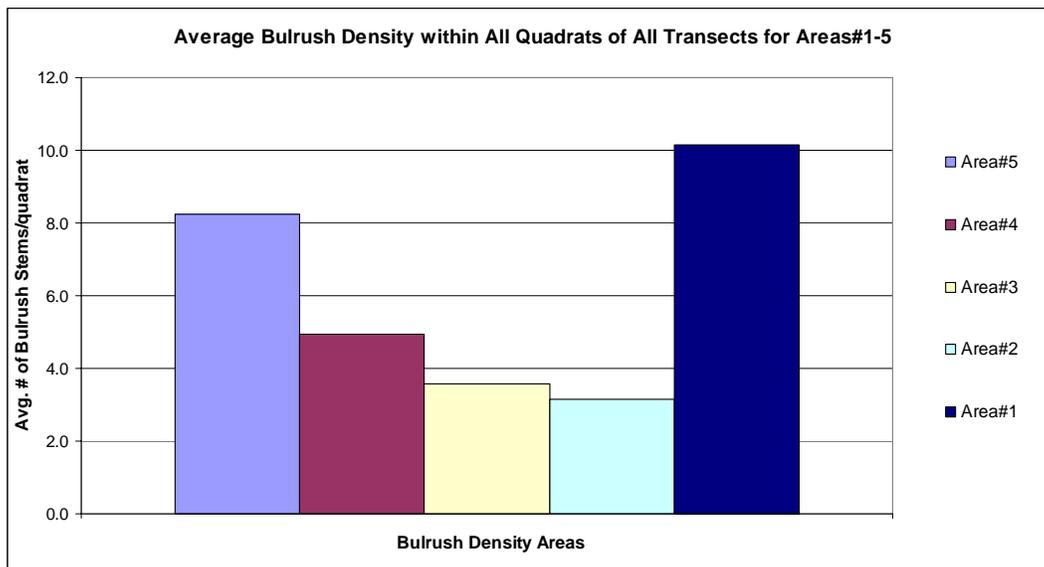


Figure 4. Average bulrush density within all quadrats of all transects for Areas#1-5.

Some transects only contained 9 quadrats with useful data; therefore, a more standardized comparison using only the first 9 quadrats within each transect was used at each location. Bulrush densities ranged from an average of 1.4 to 13.4 emergent stems per quadrat for combined transects 1-3 (Figure 6). Additionally, the bulrush density for each individual transect within each area is found in Figure 7.

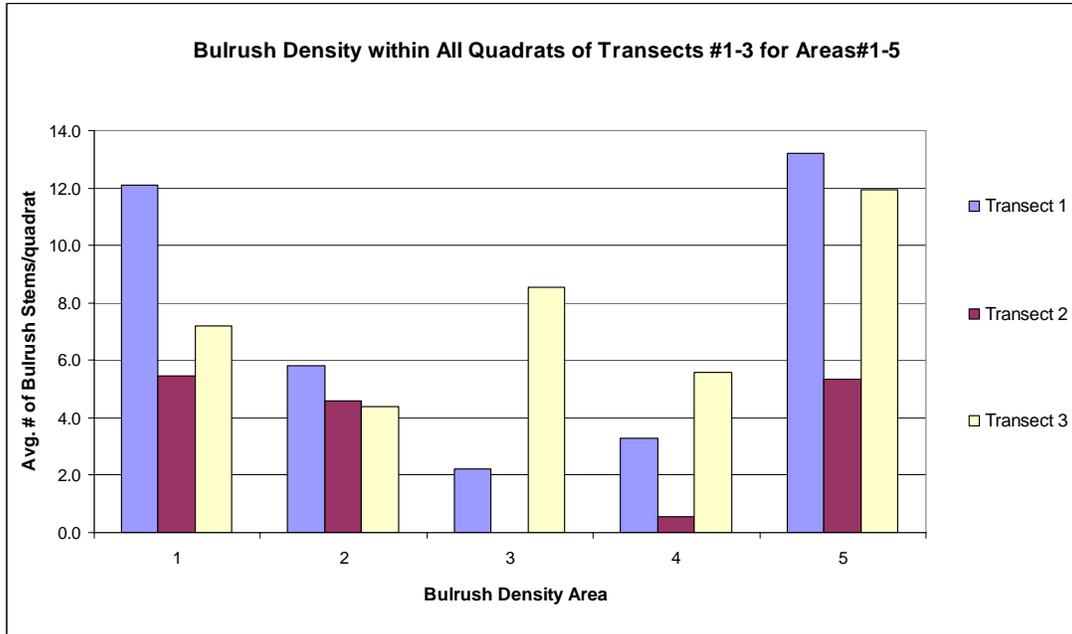


Figure 5. Average bulrush density within all quadrats for transects #1-3 for Areas#1-5.

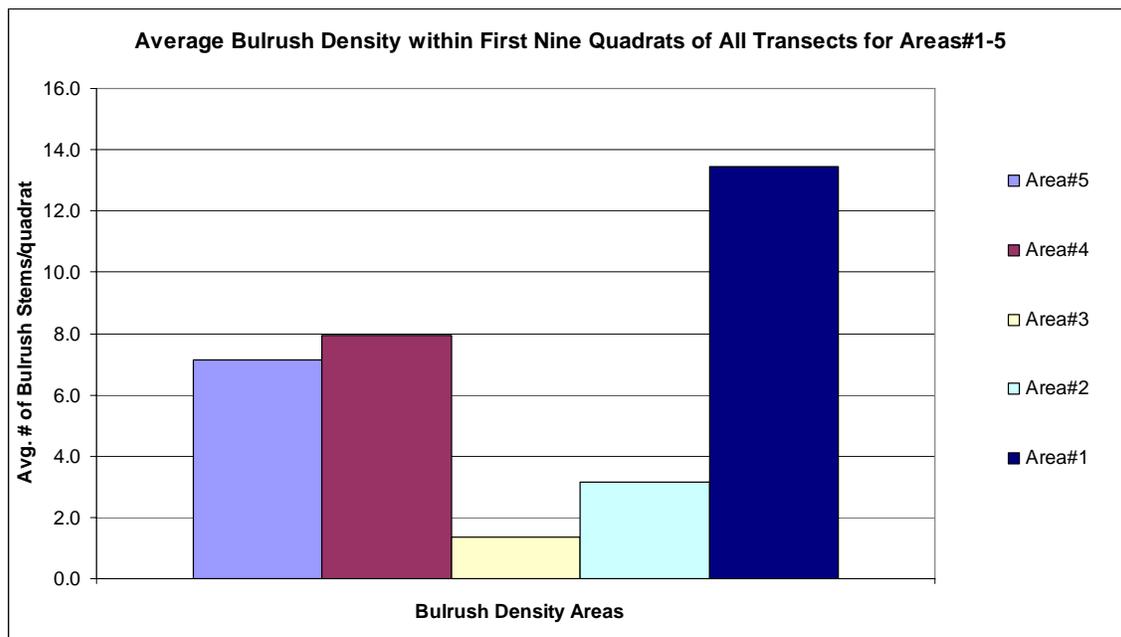


Figure 6. Average bulrush density within first nine quadrats of all transects for Areas#1-5.

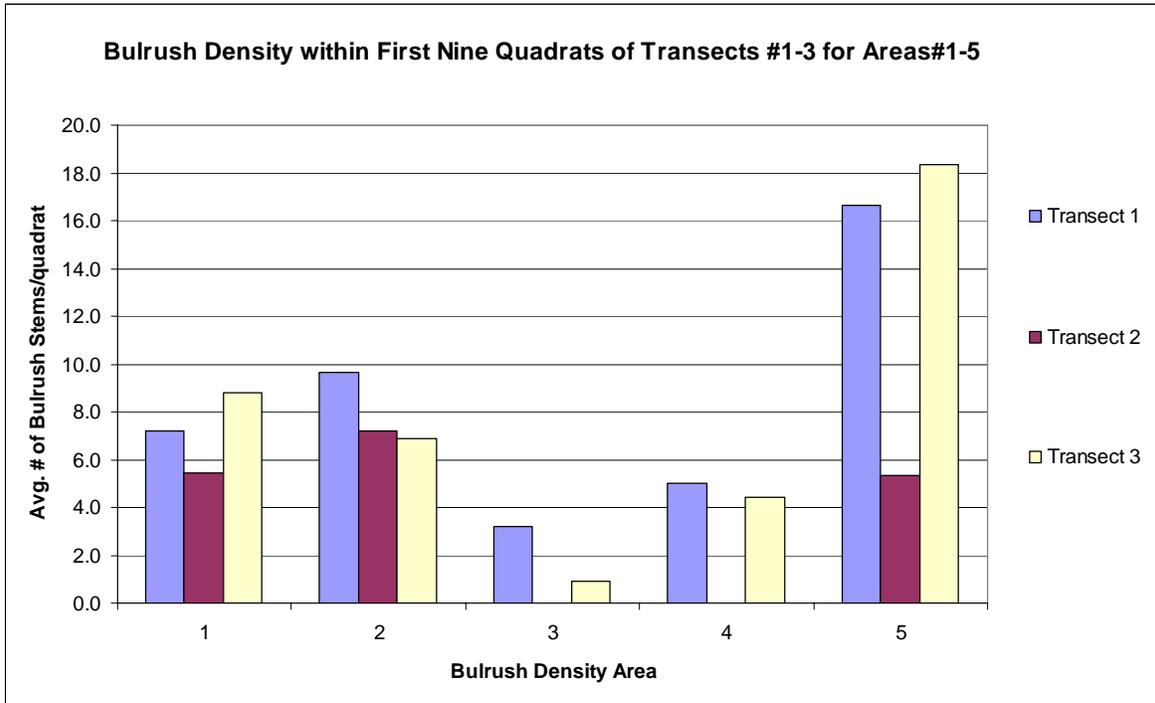


Figure 7. Average bulrush density within first nine quadrats for transects #1-3 for Areas#1-5.

The raw data for each of bulrush density Areas 1-5 are located in Tables 2-6, respectively. Additionally, the data is summarized in Appendix A. Aerial photos highlighting the bearings and lengths of transects for Areas 1-5 are found in Figures 8, 9, 11, 13 and 15 respectively.

Table 2. Bulrush density data for Area#1.

Location of Area#1: (44.9410° N and 87.2129° W)

The benchmark/starting point of each transect is a white cedar tree (found below) which is approximately 20 feet south of a waterfront deck and 5 feet from the water. Area#1 lies within bulrush bed “br01”—See Figure 8.

Transect	1	2	3
Bearing	130°	62°	354°
Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat		
0	Bank	Bank	Bank
10	14	27	Bank
20	1	6	56
30	22	2	67
40	33	9	0
50	48	0	0
60	9	0	4
70	8	0	1
80	0	0	13
90	10	0	24
100	5	4 (end, too soft to wade)	0
110	2		0
120	11		2
130	4		0
140	0		0
150	18 (end, too soft to wade)		0
160			0



Looking South

Benchmark

About 30' East from benchmark

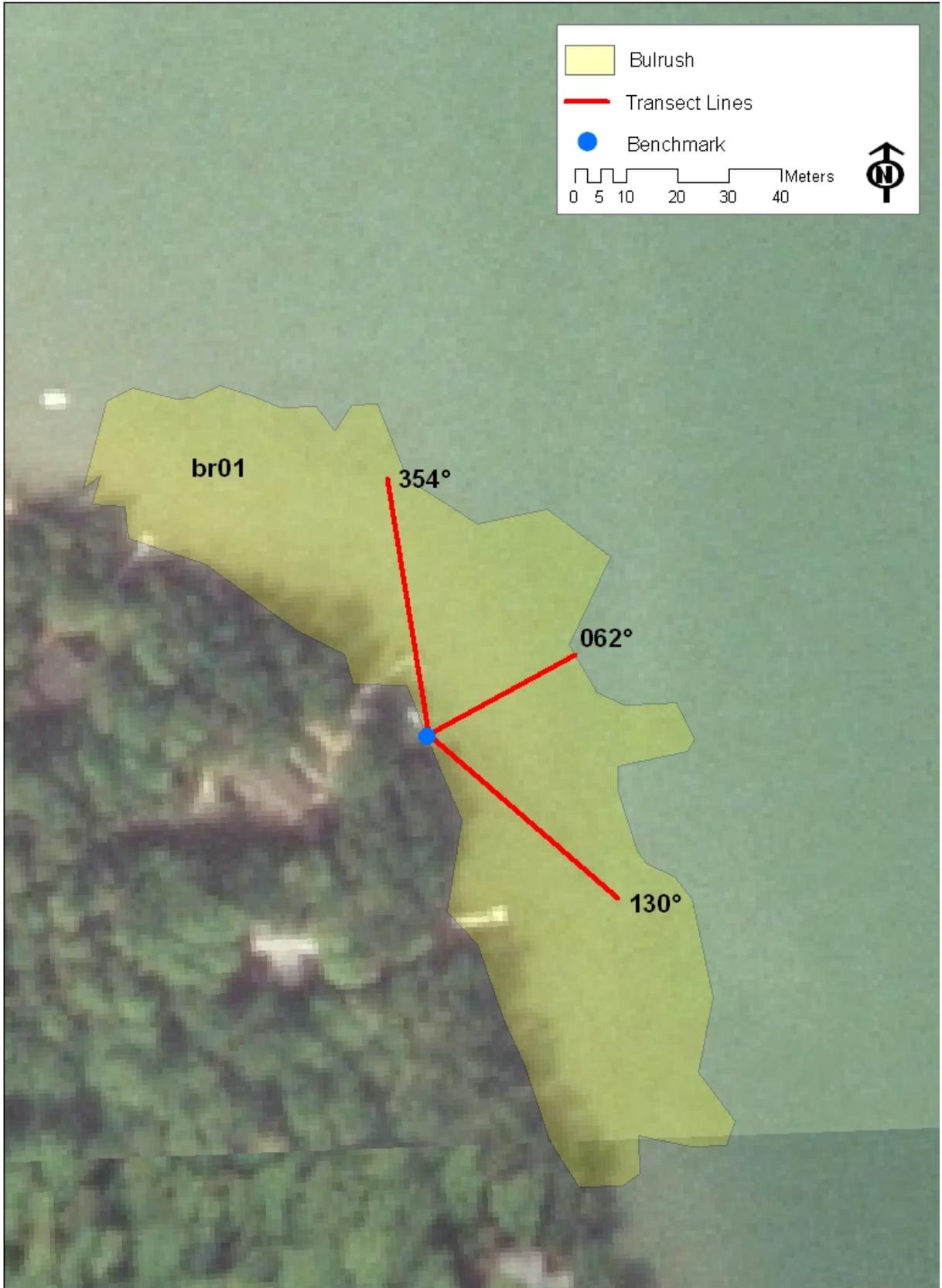


Figure 8. Aerial photo highlighting bulrush Area#1.

Table 3. Bulrush density data for Area#2.

Location of Area#2: (44.9269° N and 87.2120° W)

The benchmark is a medium sized white cedar tree as indicated below found along the southern portion of the east shore just south of a red house's waterfront. Area#2 lies within bulrush bed "br07"—See Figure 9.

Transect	1	2	3
Bearing	020°	085°	150°
Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat		
0	Bank	Bank	Bank
10	Bank	Bank	Bank
20	0	0	0
30	0	0	5
40	0	0	8
50	0	0	3
60	0	0	12
70	2	0	0
80	10	0	4
90	33	0	3
100	0	0	0
110	0	0	5
120	0	0	5
130	0	0	33
140	0	4	0 ***
150	0	4	0
160	1	0	0

***Note: Bulrush ends at 133' on Transect #3.



Benchmark—White Cedar tree



Transect #1 (020°)

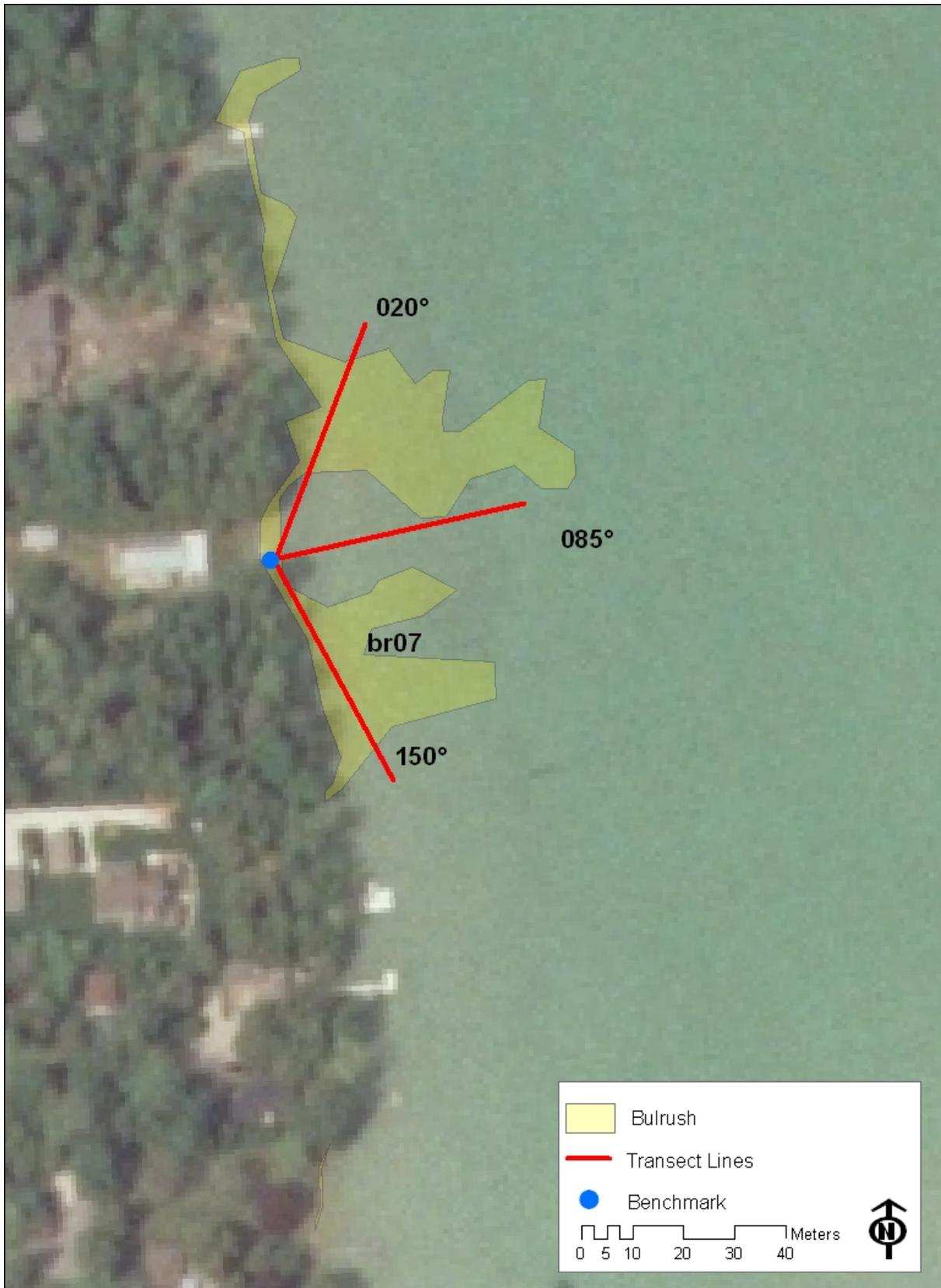


Figure 9. Aerial photo highlighting bulrush Area#2.

Table 4. Bulrush density data for Area#3.

Location of Area#3: (44.932590° N and 87.190728° W)

The benchmark is a large to medium sized white cedar tree on the southeast shore of the lake (Figure 10), just east of the Whitefish Dunes State Park access to the lake. Area#3 lies within bulrush bed “br23”—See Figure 11.

Transect	1	2	3
Bearing	030°	335°	280°
Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat		
0	Bank	Bank	Bank
10	Bank	Bank	Bank
20	Bank	Bank	Bank
30	*	*	*
40	*	*	*
50	*	*	*
60	*	0	*
70	11	0	0
80	7	0	0
90	9	0	0
100	0	0	0
110	2	0	0
120	0	0	8
130	0	0	103
140	0	0	0
150	0	0	0
160	0	0	0

* Represents over 100 Sedge stems per quadrat



Direction of Transect #3



Bulrush near end of Transect #3



Near shore along Transect #1



Whitefish Dunes State Park access to Lake is located here.

Looking West from benchmark



Benchmark—White Cedar Tree



Looking East from benchmark

Figure 10. Photo documentation of benchmark for Area#3.

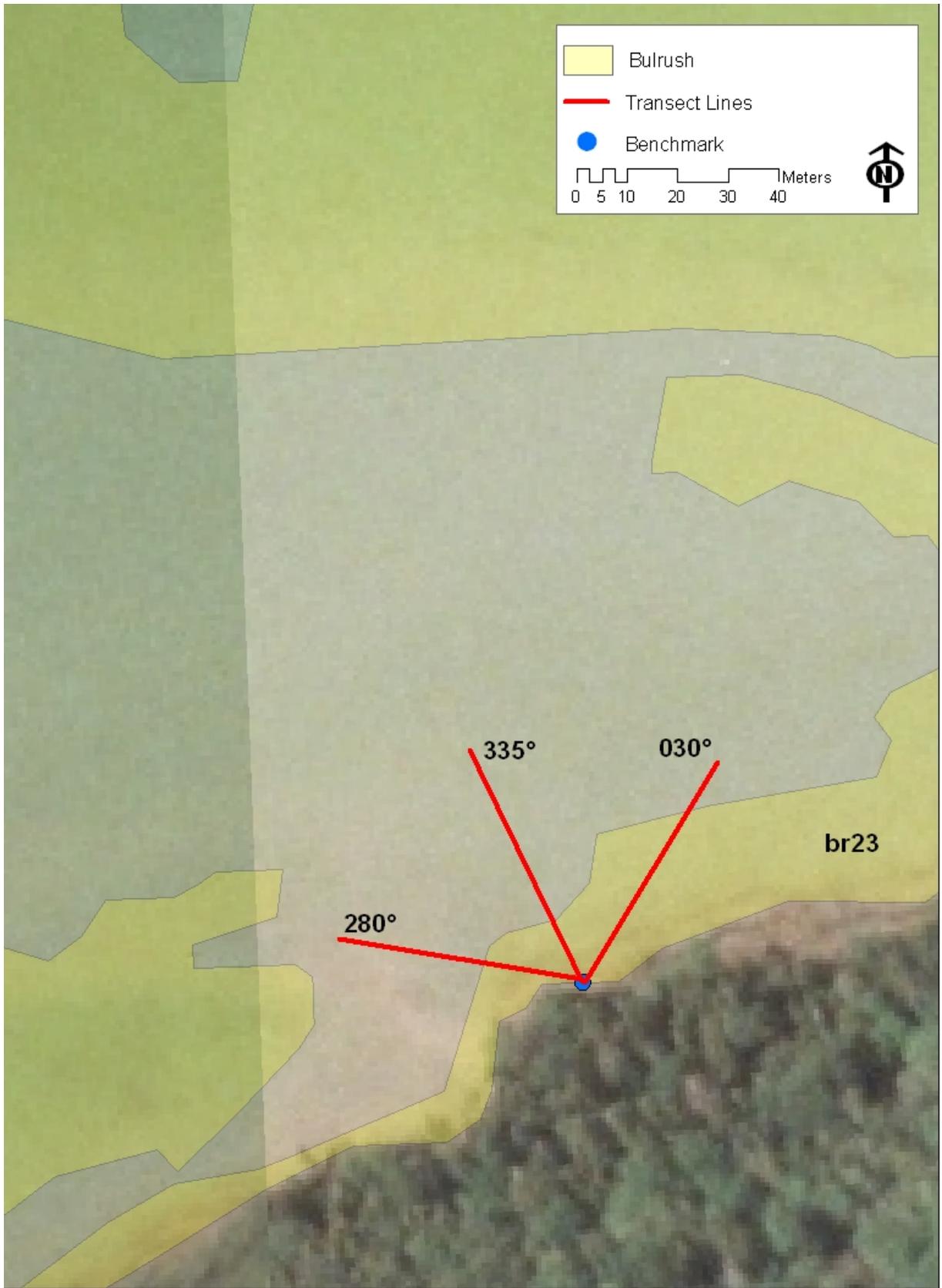


Figure 11. Aerial photo highlighting bulrush Area#3.

Table 5. Bulrush density data for Area#4.

Location of Area#4: (44.938839° N and 87.198023° W)

The benchmark is an aspen tree overhanging the water with an attached duck house (Figure 12), just west of Tom Cassidy’s house located on the northeast shore of the lake at 5522 Clark Lake Dr Sturgeon Bay, WI 54235. Area#4 lies within bulrush bed “br42”—See Figure 13.

Transect	1	2	3
Bearing	100°	150°	200°
Linear Length (feet)	Emergent bulrush stems within 3’ x 3’ quadrat		
0	27	27	22
10	10	27	23
20	26	2	10
30	17	0	3
40	4	0	0
50	0	0	0
60	0	0	4
70	0	9	0
80	3	0	0
90	0	0	0
100	0 **	1	0
110	0	0	0
120	0	0	4
130	0	0	0
140	0	1	0
150	0	2	0

**Note: Transect #1 the bulrush bed ends after 90 feet.



Benchmark--Aspen



Looking West from benchmark



Looking at the benchmark



Looking towards Tom Cassidy's house



Transect #1 (100°)



Transect #2 (150°)



Transect #3 (200°)

Figure 12. Photo documentation of benchmark for Area#4.

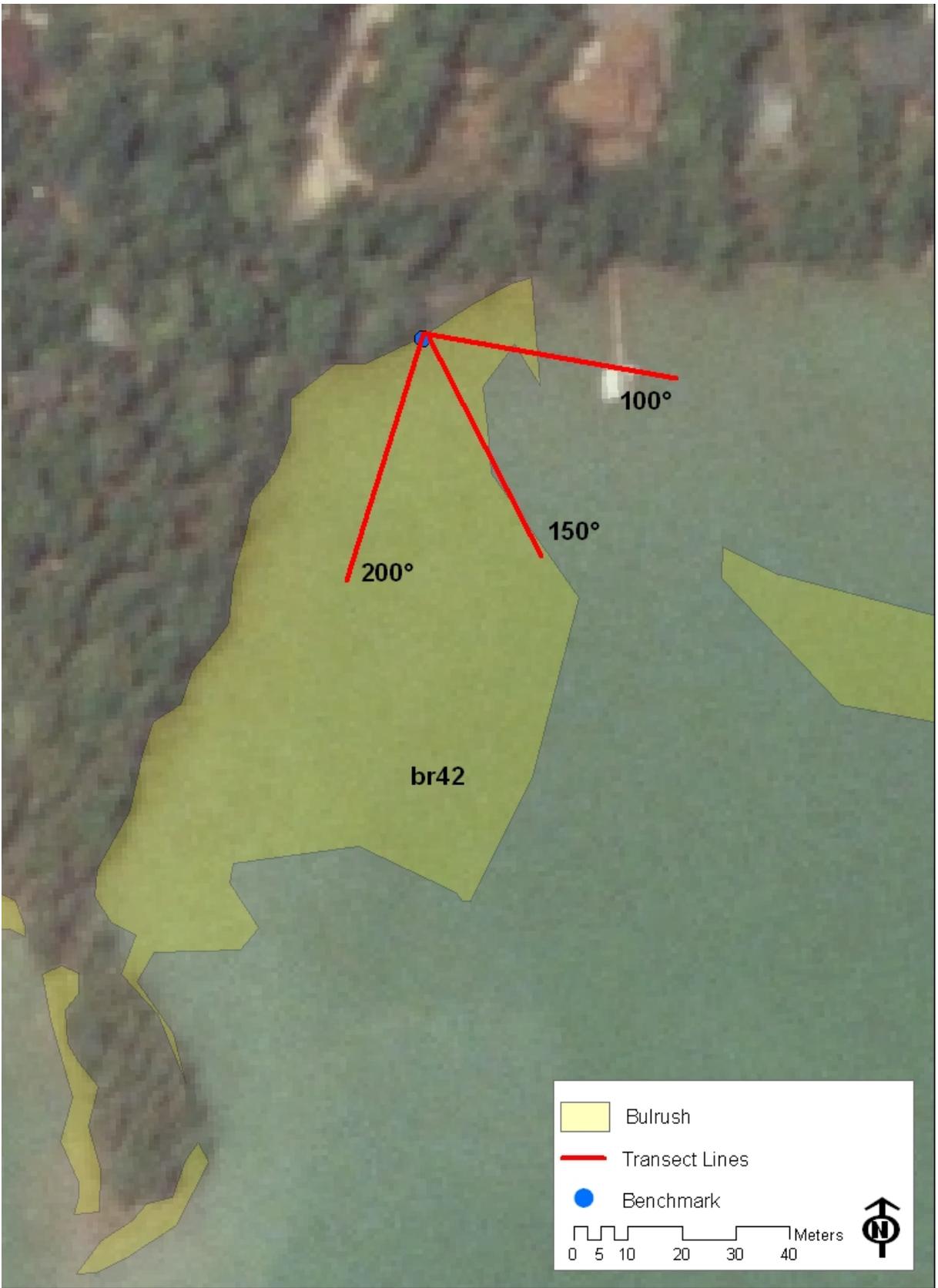


Figure 13. Aerial photo highlighting bulrush Area#4.

Table 6. Bulrush density data for Area#5.

Location of Area#5: (44.948261° N and 87.215239° W)

The benchmark is a metal pole (Figure 14) under the northeast corner of Ridges Sanctuary lookout platform (southern of the two present in 2006) on the northwest lake shore. Area#5 lies within bulrush bed “br72”—See Figure 15.

Transect	1	2	3
Bearing	184°	122°	60°
Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat		
0	Bank	Bank	Bank
10	Bank	3	Bank
20	0	29	29
30	2	3	10
40	29	5	29
50	17	9	7
60	1	0	4
70	1	0	0
80	0	0	0
90	3	0	0
100	7	0	0
110	5	End (too soft to wade)	0
120	47		0
130	21		0



Looking along Transect #1(184°)



Looking at Benchmark from Transect #1

Benchmark

Figure 14. Photo documentation of benchmark for Area#5.

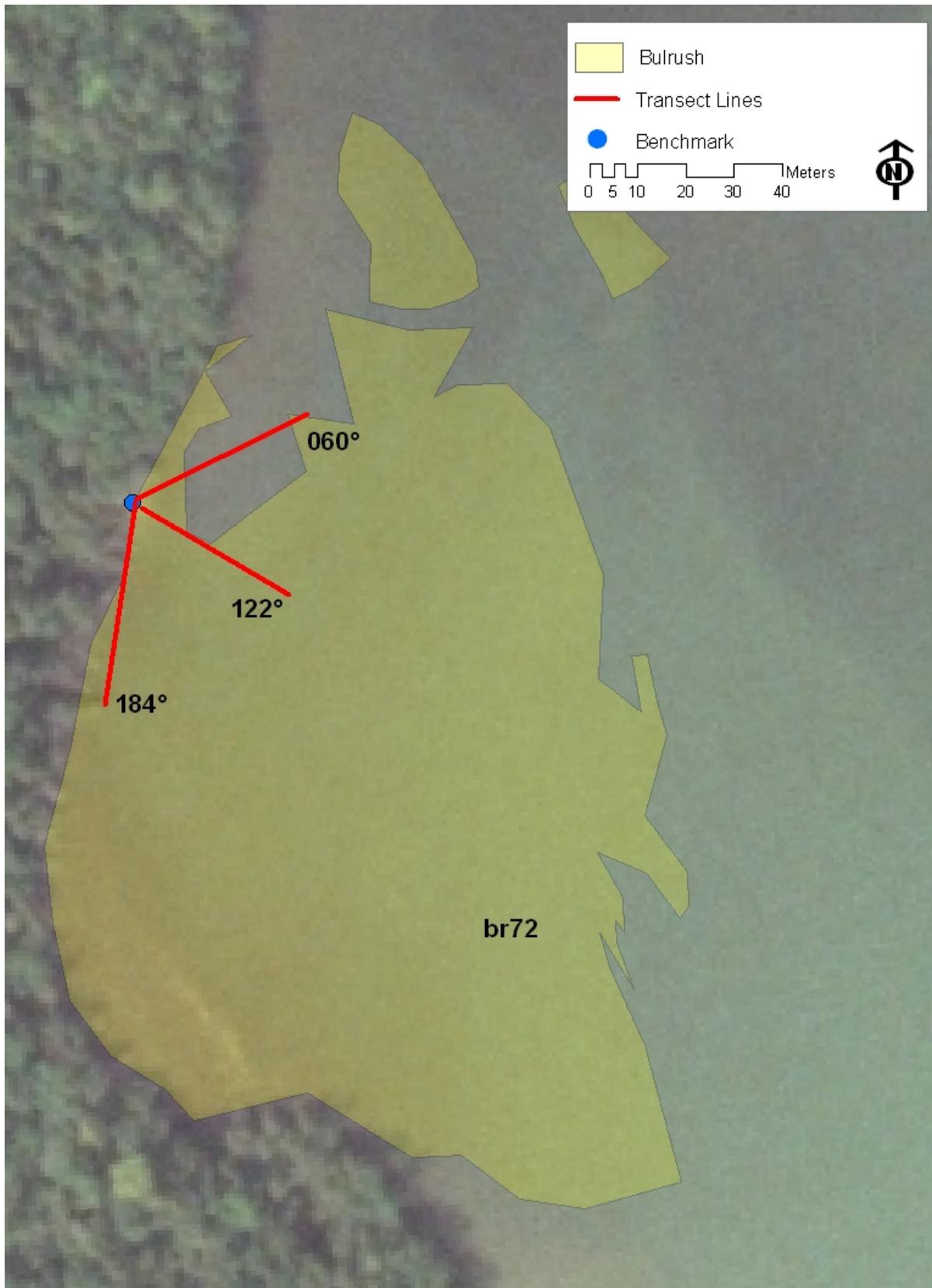


Figure 15. Aerial photo highlighting bulrush Area #5.

Mapping

Mapping of the bulrush revealed 76 separate beds of bulrush located within Clark Lake covering approximately 10.5% of the lake. All of the beds are represented in one of three sections of Clark Lake (See Figures 16-18). Detailed descriptions of each bed are found in Appendix B. Additionally, individual areas for each bulrush bed are given in Appendix C.

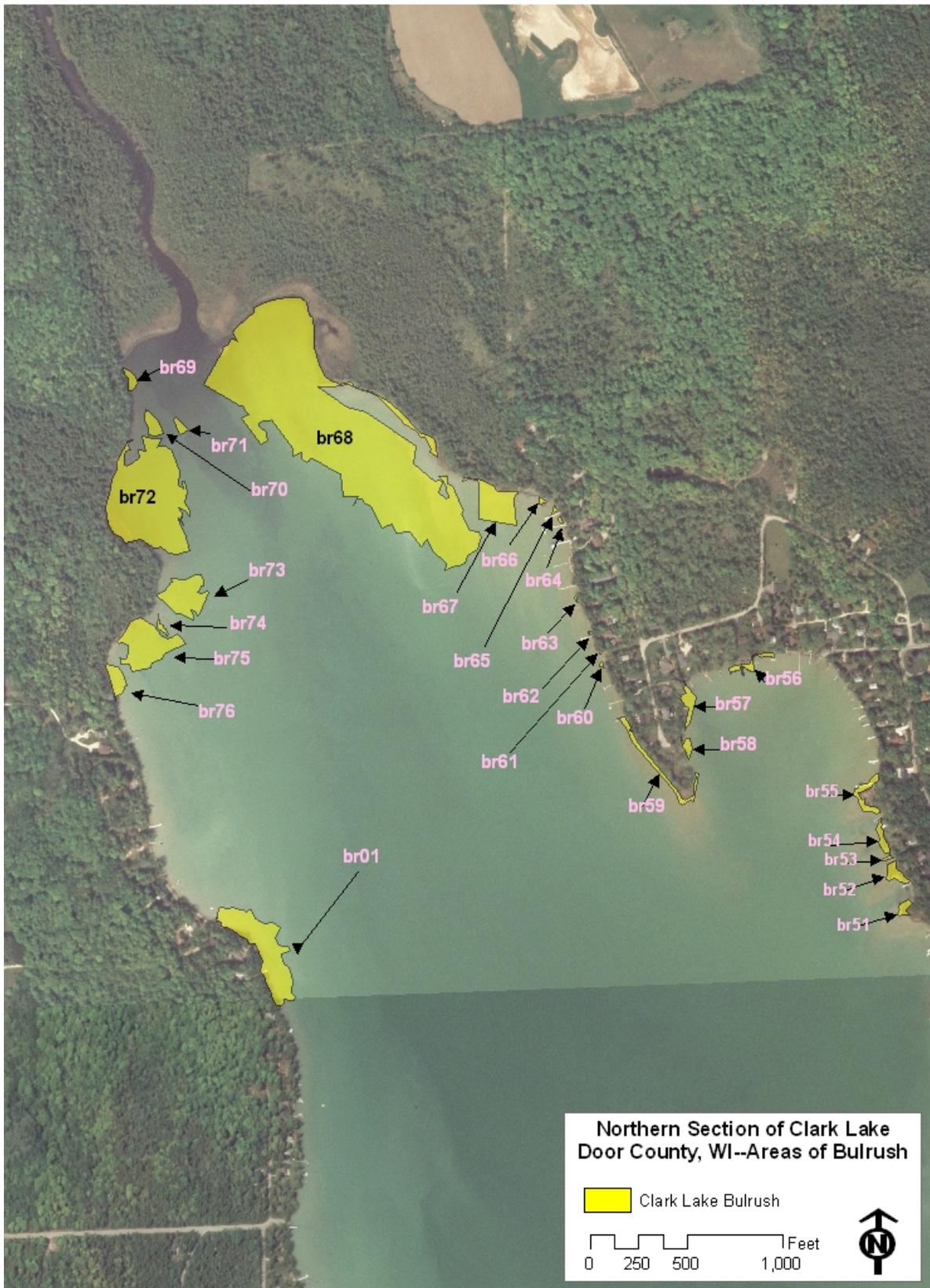


Figure 16. Aerial photo--northern area of Clark Lake's bulrush beds (br51 – br01).

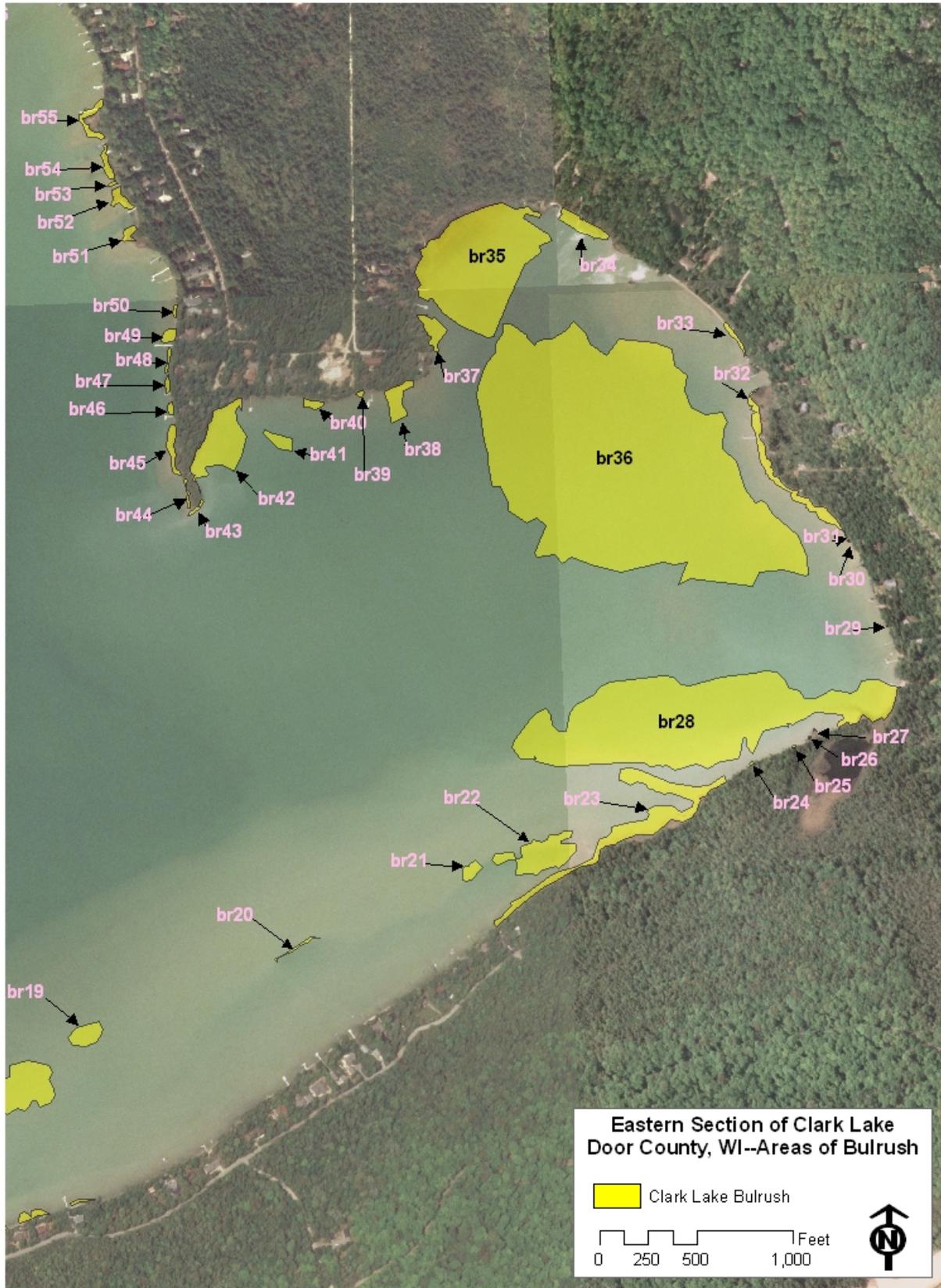


Figure 17. Aerial photo--eastern area of Clark Lake's bulrush beds (br19 – br55).



Figure 18. Aerial photo--southwestern area of Clark Lake's bulrush (br02–br18).

Discussion:

This enumeration of bulrush should be repeated by volunteers (lake association) on an annual basis in the future. It is recommended that a calm day be chosen for the work, otherwise error is introduced by the tape measure movement from the wind. The enumeration of stems should also be performed in the late summer or early fall so that all new stems are emergent. A compass with adjustable declination should be used while taking the bearings for transects. Additional data sheets are found in Appendix D for use in future bulrush density surveys.

A summary of the density data for Areas 1-5 is found in Appendix A. An example includes the number of stems per quadrat for only the first nine over water. This was done because some transects only contained useful data for the first nine quadrats. Furthermore, it should be noted that within the data tables for each bulrush areas density, no assumptions should be drawn as to whether the bulrush extends beyond the last recorded value in the data, or stops. Conditions such as the bottom being too soft to stand on (ex. Areas 1 and 3) and water depth prevented quantification of bulrush along the entire 160 foot transect in certain areas.

Bulrush maps compiled were also used to identify sensitive areas around Clark Lake. In the future these data and mapping will be used for comparison purposes to assess whether the bulrush is expanding or declining in coverage within the lake. Bulrush mapping should be performed at 5 year intervals.

Conclusion:

This study established baseline data so that trends can be ascertained in the future concerning the density and areal coverage of bulrush within Clark Lake.

Appendix A—Clark Lake Bulrush Density Survey: Areas#1-5 data

	Area #5				Area #4				Area #3				Area #2				Area #1			
	Transect	1	2	3	Transect	1	2	3	Transect	1	2	3	Transect	1	2	3	Transect	1	2	3
	Bearing	184°	122°	60°	Bearing	100°	150°	200°	Bearing	030°	335°	280°	Bearing	020°	085°	150°	Bearing	130°	62°	354°
	Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat			Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat			Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat			Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat			Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat		
	0	Bank	Bank	Bank	0	27	27	22	0	Bank	Bank	Bank	0	Bank	Bank	Bank	0	Bank	Bank	Bank
	10	Bank	3	Bank	10	10	27	23	10	Bank	Bank	Bank	10	Bank	Bank	Bank	10	14	27	Bank
	20	0	29	29	20	26	2	10	20	Bank	Bank	Bank	20	0	0	0	20	1	6	56
	30	2	3	10	30	17	0	3	30	*	*	*	30	0	0	5	30	22	2	67
	40	29	5	29	40	4	0	0	40	*	*	*	40	0	0	8	40	33	9	0
	50	17	9	7	50	0	0	0	50	*	*	*	50	0	0	3	50	48	0	0
	60	1	0	4	60	0	0	4	60	*	0	*	60	0	0	12	60	9	0	4
	70	1	0	0	70	0	9	0	70	11	0	0	70	2	0	0	70	8	0	1
	80	0	0	0	80	3	0	0	80	7	0	0	80	10	0	4	80	0	0	13
	90	3	0	0	90	0	0	0	90	9	0	0	90	33	0	3	90	10	0	24
	100	7	0	0	100	0	1	0	100	0	0	0	100	0	0	0	100	5	4 (end, too soft to wade)	0
	110	5	end(too soft to wade)	0	110	0	0	0	110	2	0	0	110	0	0	5	110	2		0
	120	47		0	120	0	0	4	120	0	0	8	120	0	0	5	120	11		2
	130	21		0	130	0	0	0	130	0	0	103	130	0	0	33	130	4		0
					140	0	1	0	140	0	0	0	140	0	4	0	140	0		0
					150	0	2	0	150	0	0	0	150	0	4	0	150	18 end		0
					160	0		0	160	0	0	0	160	1	0	0	160			0
Quadrats over Water		11	9	11		15	15	15		13	13	13		14	14	14		14	9	14
Total # of emergent Bulrush Stems in quadrats		133	49	79		87	69	66		29	0	111		46	8	78		185	48	167
Stems / quadrat--transect		12.1	5.4	7.2		5.8	4.6	4.4		2.2	0.0	8.5		3.3	0.6	5.6		13.2	5.3	11.9
Avg. Stems / quadrat (All 3 transects)	8.2				4.9				3.6				3.1				10.2			
Stems within the first 9 quadrats over water		65	49	79		87	65	62		29	0	8		45	0	40		150	48	165
Stems / quadrat--transect		7.2	5.4	8.8		9.7	7.2	6.9		3.2	0.0	0.9		5.0	0.0	4.4		16.7	5.3	18.3
Avg. Stems / quadrat (All 3 transects)	7.1				7.9				1.4				3.1				13.4			
# of empty quadrats over water within transect		2	5	7		10	9	10		10	14	12		11	13	6		2	5	8
Total # of quadrats along cross section over water		12	10	12		16	16	16		14	14	14		15	15	15		15	10	15
% of empty quadrats within transect over water		17	50	58		63	56	63		71	100	86		73	87	40		13	50	53

Appendix B—Clark Lake Bulrush Mapping: Bulrush bed descriptions

<i>Site ID*</i>	<i>Relative Location</i>	<i>Additional Data</i>
br01	First bed north of west shore boat landing.	--Some dense inner bulrush with mainly sparser outside areas --About 120' max. perpendicular distance from shore.
br02	First bed south of west shore boat landing.	--About 75' of the shoreline, extending max. distance of 40' out from shore and is dense for the first 10', then sparse. --Max. bulrush depth of about 1.5' with no stems broken.
br03	Just as the Point south of boat landing starts wrapping west on the south side.	--About 60' long and 40' out --Some dense bulrush in the first 5' from shore, rest is rather sparse. --Max. depth of about 2' with no stems broken.
br04	About 50' south of "br03" separated by a pier	--About 20' long and 60' out --Medium to sparse density throughout --Max. depth of about 2'. *Southern 10' of bulrush appears to have been cut by the landowner this past year.
br05	About 200' south of "br04"	--About 125' long and 50' out --Dense near shore and sparse on outer 25-30' --Bulrush bed is inclusive of a pier --Max. depth of about 2' with no stems broken.
br06	About 250' South of "br05" with a 1' diameter White Birch tree on the north side of the pier.	--Shaped like an hour glass with a pier in the middle absent of bulrush. --Basically 2 smaller patches separated by the pier, but are very similar. --Extremely dense. Very, very thick. --Combined 120' long and 40' out. --Max. depth of 2.5' with a few stems (about 20) broken on the outer 1' perimeter.
br07	In very SW corner of the lake near outlet of lake	--About 600' long and up to 100' out: very sparse—hardly any seeds, looks to have been grazed upon. --Max. depth of about 3' with significant stems broken.
br08	About 200' south of "br07"	--About 40' long and 2-5' out. --Present onshore and extends out to 1' depth of water. --Not a very big patch. --Mainly three square sedge.
br09	In the outlet canal of the lake on the east side.	--Very dense pockets, but overall a small patch. --Three square sedges on inside of the bulrush (East—near steel bank). --Max. depth of about 1.5' with a few broken stems on the outer 6" perimeter.

* See Figures Figure 16, Figure 17, Figure 18 for the location of beds on Clark Lake.

br10	On little sand point just east of the first pier east of Outlet canal and next point west of "br11".	--40' long and 1-5' out...very small. --Sparse, including three square sedge. --Max. depth of about 1' with no broken stems.
br11	On first point west of public beach.	--About 70' of contour, max of 5' out --Appears to be younger, newer growth on the shore in damp shoreline areas. --Very dense on shore and into the little cattail marsh. --Mainly sedges on the inner part of west side with only
br12	First patch east of the Public Beach.	--About a 40' little finger, fairly dense, but very small. --Max. depth of about 2' with noticeable broken stems on outer 1' perimeter.
br13	About 100' east of "br12" on southern shore.	--Another finger, but bigger than "br12". --Medium density, about 125' long and 70' wide. --Max. depth of about 2' with significant broken stems present.
br14	About 150' east of "br13" on southern shore.	--More of a point combined with a shoreline piece. --Nice patch, very dense on the shore and fairly dense out on the point. --Max. depth of about 3' with significant broken stems, but primarily on the northern half of the bed.
br15	About 250' east of "br14" near a log home with a stone wall facing the lake and a stone chimney.	--Dense shoreline piece about 150' long and 50' out. --One pier in the East end of the section. --Max. depth of about 1.5' with a very small amount of broken stems.
br16	Just east of the log home and about 50' east of "br15".	--Fairly dense, about 150' long and 30-40' out. --Pier extends into the lake further than the bulrush. --Max. depth of about 1' with no broken stems.
br17	About 100' east of "br16" on southern shore.	--About 120' long and 10-20' out. --Fairly dense. --Max. depth of about 1' with some broken stems on the outer 1' perimeter. --Very distinct rhizome reproduction—"stringers". --Rip-rap shoreline.
br18	Western-most island of bulrush, and directly north of "br16".	--Medium density and about 250' diameter circular shaped bed. --Max. depth of about 3' with significant broken stems throughout the bed.
br19	Island about 250' northeast of "br18".	--Medium density and about 175' feet east to west by 100' feet north to south. --Max. depth of about 3' with significant broken stems throughout the bed.
br20	Island about ½ way in between "br19 and br 20".	--About 125' long by 15' wide --Max. depth of about 3' with a severe case of broken stems.
br21	Island in southeastern area of lake.	--Max. depth of about 3' with significant broken stems.
br22	About 75' to the east of "br21"	--Max. depth of about 2.5' with significant broken stems. --Dense stand.
br23	Includes the Whitefish Dunes State Park access beach and	--Contains both thick inner strip and sparser outer edges.

	follows the shoreline for a long ways, inside distinctive bulrush fingers off the eastern part of South shore. Western edge is about 150' east of Bob Stracka's house at 5381 S Lake Rd Sturgeon Bay, WI 54235.	
br24	On southern shore inside of large eastern-most finger—"br28"	--Medium density.
br25	On southern shore inside of large eastern-most finger—"br28"	--Slightly more dense than "br24".
br26	Slightly west of small sand point that is directly north of the connected pond to the southeastern most bay of the lake.	--Medium density.
br27	On little sand point directly north of the pond.	--5' out and 30' of shoreline --Very healthy!
br28	Eastern-most finger off south shoreline. Pond entrance is right where the bed adjoins the shoreline.	--Very thick on the Southern edge of the finger. --Much sparser on the northern edge of finger.
br29	Near large White Pine on the shoreline.	--Twenty feet of shoreline and 10' out --Very dense and looks healthy.
br30	In southeastern bay of lake.	--Sparse and younger looking.
br31	About 10' south of larger shoreline fringe bed "br32"	--Twenty feet of shoreline, 5' out. --Younger looking.
br32	North end is by house (log cabin) with large Willow tree right on the waters edge.	--Shoreline stretch primarily no further out than 10'. --Dense, but does not extend out deeper than 1' of water for most part.
br33	Eastern shore of southeastern bay	--Three sided sedge, no bulrush --Nice bed of rush
br34	Eastern shore of southeastern bay	--Bulrush healthy and in good shape --Strong clustering
br35	North bay of southeastern bay.	--Massive bulrush stand --Tall and healthy, lots of growth
br36	Large island of sparse bulrush in the southeastern bay.	--Lots of damage to the bulrush.
br37	About 100' south of "br35".	--Not very dense.
br38	Just around the point from "br37"	
br39	About 100' west of "br38"	--Small bulrush stand --About 400 sq. ft. area.
br40	Shoreline bed on east side of point dividing SE lobe of lake from rest. Southern edge starts about 200' north of tip of the point.	--Rip-rap shoreline. --minimal bulrush.
br41	Island, just east of "br42"	--Very sporadic
br42	Shoreline bed on east side of point dividing SE lobe of lake from rest.	--Bulrush looks very healthy near shore.
br43	On southern tip of point, near shore.	

br44	Just around south tip on west side.	--Bulrush very near shore and shallow.
br45	About 20' north of "br44"	--Thick bed near shore and healthy.
br46	About 50' north of "br45"	--Nice healthy bed, near shore.
br47	Eastern shore of north half of lake	--Nice healthy bed, near shore.
br48	Eastern shore of north half of lake	
br49	Eastern shore of north half of lake	
br50	Eastern shore of north half of lake	
br51	Eastern shore of north half of lake	--Mix of bulrush and three square sedges and other <i>Juncus</i> .
br52	Eastern shore of north half of lake	--Mixed bulrush, <i>Juncus</i> , three square sedges, cattails, and <i>Phragmites</i> . --Very thick bed.
br53	Eastern shore of north half of lake	--Longer sliver of very thick, healthy bulrushes.
br54	Eastern shore of north half of lake	--Mix of sedge, bulrush, cattail, and <i>Juncus</i> . --Minimal bulrush.
br55	Eastern shore of north half of lake	--Mix of bulrush, <i>Juncus</i> , sedge and cattail --A lot of healthy bulrush on the north side of the bed.
br56	North end of bay on eastern shore of north half of the lake.	--Dense stand and healthy looking. --Not more than 200' long.
br57	About 500 feet north of rocky point along eastern side of point.	
br58	Shoreline piece on rocky point near eastern boat landing.	--Isolated patch along shoreline with coarse woody debris near on shoreline.
br59	Shoreline piece on rocky point near eastern boat landing.	--Mainly a 5-10' fringe along the shoreline.
br60	Eastern shore of northern-most lobe of lake.	--About 15' long by 5' out.
br61	Eastern shore of northern-most lobe of lake.	--About 5' long by 2' out.
br62	Eastern shore of northern-most lobe of lake.	--About 15' long by 5' out. --Isolated and sparse.
br63	Eastern shore of northern-most lobe of lake.	--About 20' long by 5' out. --Sparse
br64	Eastern shore of northern-most lobe of lake.	--About 20' long by 10' out. --Very sparse and separated from "br65" by a dock.
br65	Eastern shore of northern-most lobe of lake.	--About 50' out into the lake by a 20' base forming a triangular shape pointing southwest.
br66	Eastern shore of northern-most lobe of lake.	--About 20' by 20' with moderate density. --Separated from "br67" by a beach that the bulrush is remotely present on, but looks to be highly favorable to reestablishment.
br67	Shoreline piece in north lobe of the lake, just to the east of large healthy bulrush stand.	--Dense and healthy looking

br68	Largest bed in north lobe of the lake starting just east of inlet of Logan Creek.	--Very dense, especially the northwest half of the bed. --Sparser on the southeast half.
br69	First bed west of inlet, butting up to the northern lookout platform of the Ridges land.	--About 80' long by 50' out --Very thick and healthy, lots of nutlets.
br70	Bulrush island in western part of North lobe of the lake.	--About 100' south to north by 40' wide, creating an oval shape. --Separated from "br72" by only a few feet.
br71	Isolated island in western part of North lobe of the lake.	--20' SW pointing NE by 10' wide
br72	Shoreline piece joining the Ridges Sanctuary southern lookout tower on western shore.	--Large bed and very dense.
br73	Island narrowly separated from shore east of rock bar point on western shore of north lobe of the lake.	--Spotty groups of dense bulrush.
br74	Island growing out of actual rock bar from the point.	--Some dense pieces, but mainly sparse groupings.
br75	Northwest lobe of lake on southern side of rock bar point.	--Big and dense with more sparse outer fringes. --Small 5-20 meter gap between "br74" because of rock bar point substrate --Little patch growing on the rocks of the point.
br76	Northwest lobe of lake just south of "br76".	--Moderately thick, Sparse on the north side --About 100' out from shore and 150' long *Property owner says the bulrush in this area has thickened in the past 10 years including the submergent macrophytes.

Appendix D—Clark Lake Bulrush Mapping: Additional data sheets

Area #1

(44.9410° N and 87.2129° W)

--Benchmark/starting point of each transect is white cedar tree (found below) which is approx. 20 feet south of waterfront deck and 5 feet from water

--Within bulrush bed “br01”—See Figure 8.

Area #1																							
Transect	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3
Bearing	130°	130°	130°	130°	130°	130°	130°	130°	62°	62°	62°	62°	62°	62°	62°	62°	354°	354°	354°	354°	354°	354°	354°
Year	2006								2006								2006						
Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat																						
0	Bank								Bank								Bank						
10	14								27								Bank						
20	1								6								56						
30	22								2								67						
40	33								9								0						
50	48								0								0						
60	9								0								4						
70	8								0								1						
80	0								0								13						
90	10								0								24						
100	5								4 ^								0						
110	2																0						
120	11																2						
130	4																0						
140	0																0						
150	18 ^																0						
160																	0						

^ end(too soft to wade)

Area #2

(44.9269° N and 87.2120° W)

--Benchmark is a medium sized white cedar tree as indicated below found along the southern portion of the east shore just south of a red house's waterfront.

--Within bulrush bed "br07"—See Figure 9.

Area #2																							
Transect	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3
Bearing	020°	020°	020°	020°	020°	020°	020°	020°	085°	085°	085°	085°	085°	085°	085°	085°	150°	150°	150°	150°	150°	150°	150°
Year	2006								2006								2006						
Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat																						
0	Bank								Bank								Bank						
10	Bank								Bank								Bank						
20	0								0								0						
30	0								0								5						
40	0								0								8						
50	0								0								3						
60	0								0								12						
70	2								0								0						
80	10								0								4						
90	33								0								3						
100	0								0								0						
110	0								0								5						
120	0								0								5						
130	0								0								33						
140	0								4								0 ***						
150	0								4								0						
160	1								0								0						

***Note: Bulrush ends at 133' on Transect 3.

Area #3

(44.932590° N and 87.190728° W)

--Benchmark is a large to medium sized white cedar tree on the southeast shore of the lake, just east of the Whitefish Dunes State Park access to the lake.

-- Within bulrush bed “br23”—See Figure 11.

Area #3																								
Transect	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	
Bearing	030°	030°	030°	030°	030°	030°	030°	030°	335°	335°	335°	335°	335°	335°	335°	335°	280°	280°	280°	280°	280°	280°	280°	
Year	2006								2006								2006							
Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat																							
0	Bank								Bank								Bank							
10	Bank								Bank								Bank							
20	Bank								Bank								Bank							
30	*								*								*							
40	*								*								*							
50	*								*								*							
60	*								0								*							
70	11								0								0							
80	7								0								0							
90	9								0								0							
100	0								0								0							
110	2								0								0							
120	0								0								8							
130	0								0								103							
140	0								0								0							
150	0								0								0							
160	0								0								0							

* Represents over 100 Sedge stems per quadrat

Area #4

(44.938839° N and 87.198023° W)

--Benchmark is an aspen tree overhanging the water with an attached duck house just west of Tom Cassidy's house located on the northeast shore of the lake at 5522 Clark Lake Dr Sturgeon Bay, WI 54235.

--Within bulrush bed "br42"—See Figure 13.

Area #4																							
Transect	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3
Bearing	100°	100°	100°	100°	100°	100°	100°	100°	150°	150°	150°	150°	150°	150°	150°	150°	200°	200°	200°	200°	200°	200°	200°
Year	2006								2006								2006						
Linear Len	Emergent bulrush stems within 3' x 3' quadrat																						
0	27								27								22						
10	10								27								23						
20	26								2								10						
30	17								0								3						
40	4								0								0						
50	0								0								0						
60	0								0								4						
70	0								9								0						
80	3								0								0						
90	0								0								0						
100	0 **								1								0						
110	0								0								0						
120	0								0								4						
130	0								0								0						
140	0								1								0						
150	0								2								0						
160																							

**Note: Transect 1 the bulrush bed ends after 90'.

Area #5

(44.948261° N and 87.215239° W)

--Benchmark is a metal pole under the northeast corner of Ridges Sanctuary lookout platform (southern of the two present in 2006) on northwest lake shore.

--Within bulrush bed “br72”—See Figure 15.

Area #5																							
Transect	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3
Bearing	184°	184°	184°	184°	184°	184°	184°	184°	122°	122°	122°	122°	122°	122°	122°	122°	60°	60°	60°	60°	60°	60°	60°
Year	2006								2006								2006						
Linear Length (feet)	Emergent bulrush stems within 3' x 3' quadrat																						
0	Bank								Bank								Bank						
10	Bank								3								Bank						
20	0								29								29						
30	2								3								10						
40	29								5								29						
50	17								9								7						
60	1								0								4						
70	1								0								0						
80	0								0								0						
90	3								0								0						
100	7								0								0						
110	5								^								0						
120	47																0						
130	21																0						

^ end(too soft to wade)

Appendix E—Overview of Density and Mapping Methods

Density

- 1) Obtain coordinates from Appendix D and enter into GPS unit as Areas 1-5.
- 2) Travel to Areas 1-5 and locate benchmark using the photographic aids found in Bulrush Mapping and Density Report.
- 3) Secure Tape measure (150+ ft) around benchmark and extend in direction of transect bearings found in Appendix D.
 - Make sure declination of compass is set correctly.
- 4) Secure tape measure in place using solid fiberglass pole in lake bottom.
- 5) Begin counting emergent bulrush stems with quadrat at 10 ft intervals along the tape measure (transect).
- 6) Record bulrush stem counts on data sheets provided in Appendix D.
- 7) Once finished with transect 1, complete remaining 2 transects.
- 8) Proceed to remaining bulrush areas.

Mapping

Using a GPS unit manually trace all bulrush beds within Clark Lake and save as separate 'tracks'.

- Make sure that GPS unit can be uploaded into a computer for GIS analysis.
- Overlay layers and determine extent loss or gain of bulrush beds.
- Evaluate health, density, and other information at each bed.