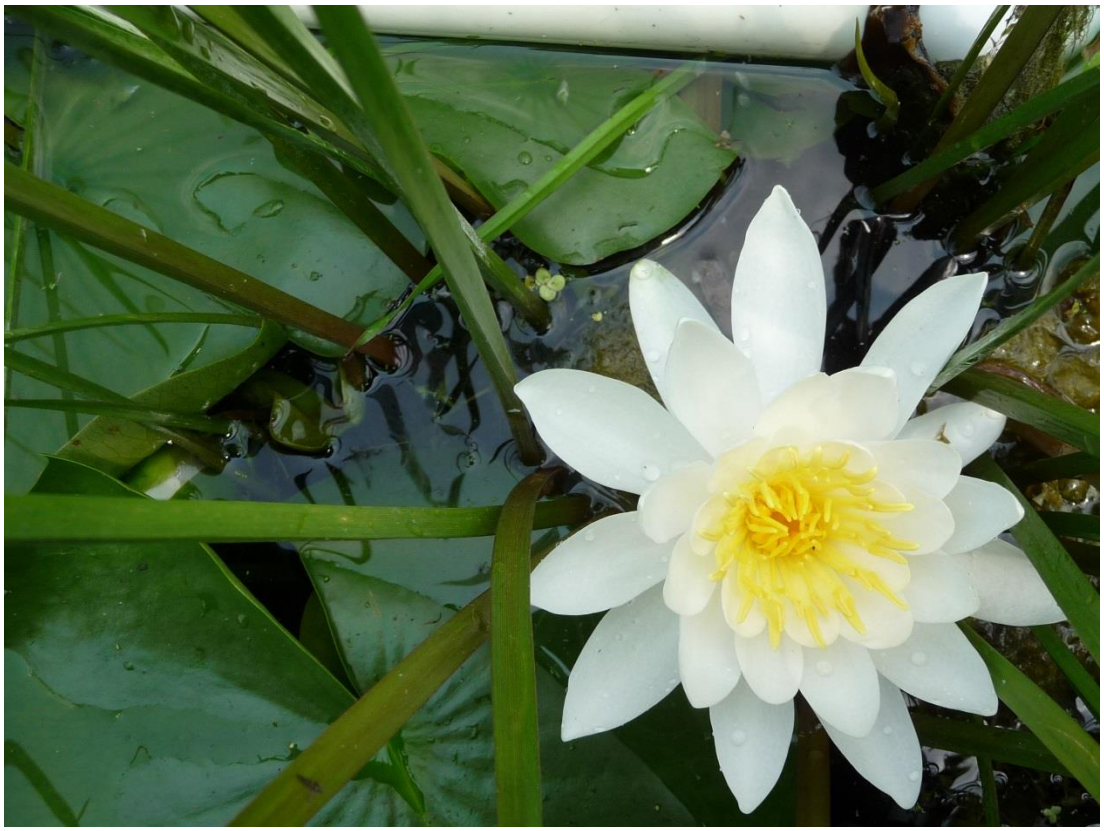
Adaptive Management of Flowering Rush Using the Contact Herbicide Diquat in Detroit Lakes, Minnesota 2016 – Final Report



A report to the Pelican River Watershed District

Gray Turnage[1], Brent Alcott[2], and Tera Guetter[2]

[1]Geosystems Research Institute, Mississippi State University, Mississippi State, MS 39762-9627

[2] Pelican River Watershed District, Detroit Lakes, MN 56501

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Executive Summary

Conclusions

- Based on field evaluations, 2016 sites receiving two submersed treatments with the contact herbicide diquat have had a continued decrease in rhizome bud density of flowering rush.
- Sites receiving one diquat treatment did not see an increase in rhizome bud density during the growing season.
- Applications of diquat have significantly reduced the nuisance problem and the potential for plants to regrow and spread.
- Diquat treatments do not appear to have a significant effect on species diversity, though some individual species in some plots may have been adversely affected.

Recommendations

- Field evaluations and monitoring of diquat or other herbicides should be continued to determine if reduction in belowground biomass and rhizome bud density is repeatable.
- We recommend that other herbicide active ingredients and use patterns be evaluated under controlled conditions to determine if there are alternatives to diquat treatments, which may be field demonstrated in the future.
- We recommend continued monitoring of all littoral areas for the presence of flowering rush and other AIS.

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Introduction

Flowering rush (*Butomus umbellatus* L.) is an emergent invasive plant that has invaded the Detroit Lakes area, specifically, Detroit Lake (Big Detroit, Little Detroit, and Curfman Lakes), Lake Sallie, Lake Melissa and Mill Pond (Becker County) since the 1960s. It is native to Europe and Asia and first entered the United States in 1928. Flowering rush has continued to be a problem in the Detroit Lakes system for the past three decades. However, applications of the contact herbicide diquat over the last six years have helped to control the spread and density of the plant.

Although flowering rush has been in North America for over forty years, very little information is known about its biology, ecology, and management. Bellaud (2009) reports that it was first observed in North America in St. Lawrence River (Quebec) in 1897. Flowering rush is currently found in all of the southern Canadian provinces, and all of the states bordering Canada and the Great Lakes (NRCS 2013).

The US Army Engineer Research and Development Center (USAERDC) studied the available aquatic herbicides for control of submersed flowering rush plants from Minnesota and Idaho (Poovey et al. 2012). As part of their study, they determined that populations in both Idaho and Minnesota were triploid, as confirmed by ploidy and AFLP (Poovey et al. 2012). Their studies of Minnesota-derived plants used diquat, endothall and flumioxazin at relatively short exposure times. Flumioxazin did not reduce shoot biomass in either treatment. Diquat at the full label rate (0.37 ppm) and at 6 and 12 hours contact time significantly reduced shoot biomass relative to the reference. Endothall treatments at 1.5 and 3 ppm at both 12 and 24 hours exposure time also reduced shoot biomass. No treatments reduced belowground biomass. In contrast, their studies with Idaho-derived plants found flumioxazin at 400ppb and 24 hours exposure time controlled shoot biomass, and endothall at 3 ppm and 24-hour exposure time controlled both aboveground and belowground biomass (Poovey et al. 2012). They also note that repeated treatments with contact herbicides, or integration with systemic herbicides, would be needed to achieve long-term control. Skogerboe (unpub. data) analyzed in lake treatments of endothall in the Detroit Lakes and determined that the adequate concentration exposure times could not be reached to control flowering rush. However, data collected on diquat treatments in the Detroit Lakes in 2012 and 2013 showed significant reduction in above and belowground biomass as well as rhizome bud density (Figure 1; Madsen et al. 2013, 2014). The 2012 diquat protocol was repeated in 2013 and 2014 on flowering rush beds in the Detroit Lakes.

In 2015 the protocol was amended such that sites with low density (<20% prevalence) of flowering rush received only one or no (<5% prevalence) diquat treatments instead of two while sites with high densities (>20% prevalence) of flowering rush still received two diquat treatments. The success of this protocol in 2015 (Turnage et al. 2016) led to its continuance in 2016.

The process of geographic range expansion is characterized by three phases once an invasive species reaches new habitat: the lag phase, exponential growth phase, and carrying capacity phase (Figure 2). The lag phase is seen when invasive species first reach a site; typically invasive plants in this phase are found in very low densities and do not appear to pose a threat as they are not expanding rapidly. The exponential growth phase is seen when plants are actively spreading across a site often doubling in abundance from one year to the next; at this point, the species becomes much more noticeable due to its larger geographic range. The carrying capacity phase is achieved when the invasive species has colonized as much available habitat as possible; often this is characterized by large monotypic stands of the invasive where a diverse assemblage of native species had been present historically.

The purpose of amending the 2014 protocol was to decrease resources needed on sites with low flowering rush prevalence so that they could be allocated elsewhere to sites with high prevalence of flowering rush. Sites treated once with diquat were treated in July to apply herbicide to the maximum amount of sprouted rhizome buds. Sites receiving two treatments were treated in June and July as in years past. The ultimate goal is conversion of all flowering rush sites to low or no prevalence sites (sites characteristic of the lag phase of the invasion process) in the Detroit Lakes system so that a minimum amount of resources is needed to control the species.

Materials and Methods

Treatments were made to manage flowering rush populations at designated treatment areas (Tables 1-2; Figures 3-4) of submersed or mostly submersed plants with the contact herbicide diquat using drop hoses from a boat, in 4 feet and less of water. From two feet to four feet deep, a rate of two gallons per surface acre were used, and in water depths from shoreline to two feet deep, a rate of one gallon per surface acre was applied; as per the US EPA label. The target water column concentration was 0.37 ppm of diquat. Treatments occurred in Big and Little Detroit (Figure 3), Curfman Bay (Figure 3), Sallie (Figure 4), and Melissa Lakes (Tables 1-2; Figure 4). Diquat formulation used was at 2 lbs. per gallon diquat cation formulation (Tribune, Syngenta Crop Protection, LLC, Greensboro, NC).

Assessment

We assessed the response of flowering rush to herbicide applications using biomass estimates. We assessed the impact of submersed applications on aquatic plant communities using a point intercept method. The initial point intercept survey in June was used to assign the number of diquat applications to each treatment site. Sites with greater than 20% presence of flowering rush still received two diquat applications, sites with prevalence between 5% and 20% received one diquat application, and sites with less than 5% prevalence received no herbicide treatment (Table 1).

Biomass estimates. Assessment of both submersed and emergent treatments in this system were done by sampling plant tissues (biomass) collected with a 6” diameter biomass coring device to

collect both shoots and rhizomes (Figure 5; Madsen et al. 2007) in nine plots (Table 2): three reference, three receiving one diquat treatment, and three receiving two diquat treatments. Forty cores per plot were collected before each proposed treatment, at the end of the 2016 growing season in September, and again at the beginning of the 2017 growing season (Table 2). Biomass samples were taken at predetermined points randomly selected from the point intercept survey points of those plots. After washing to remove sediment, biomass specimens were held on ice and shipped overnight to Mississippi State University. Specimens were separated into aboveground and belowground biomass. Rhizome buds (Figure 1) were counted, but not separated from the remainder of belowground biomass. Plants were dried for 72 hours at 70C or greater in a forced air over and then dried biomass was weighed. Biomass samples were taken at predetermined points randomly selected from the point intercept survey points (below) of those plots.

Statistical analysis of mean rhizome bud count was performed using an analysis of variance (ANOVA) procedure for within growing season analyses. Any differences in means were further separated using a Fishers Least Significant Difference test. For between year analyses, a Paired T-test was used. Statistical analysis was done using Statistix 9.0 at the p=0.05 level of significance (Analytical Software, Tallahassee, FL).

Point Intercept. To assess the community impact of submersed diquat treatments, point intercept sampling (Madsen 1999) was done on all treated plots and reference plots (Table 2). The grid interval was no less than 25 m. There were not an equal number of points per plot. Statistical analysis was performed using a Chi-Square test, testing for a statistically significant change in frequency between the three sampling dates. Analysis was done using Statistix 9.0 (Analytical Software, Tallahassee, FL).

Results and Discussion

Biomass. The measurement of abundance, such as biomass, is the best method to evaluate the effectiveness of control (Madsen 1993; Madsen and Bloomfield 1993; Madsen and Wersal 2017). Since the aboveground biomass often causes the nuisance problem, reduction in biomass may measure the reduction in nuisance potential. While reduction of the nuisance potential is important to resource user perception, it is also important to contribute to the long-term management of the invasive plant species. For flowering rush, the best indicator of reduction in long-term growth potential is rhizome bud number (or density). Rhizome bud density is important since buds appear to be the perennating and regrowth propagule (Marko et al. 2012; Madsen et al. 2012). Rhizomes are the main location to store carbohydrates, essential for overwintering and for regrowth from management. Rhizome buds are the individual growing points from which new ramets or leaves regrow. Reductions in these tissues should result in long-term control.

Rhizome bud density was significantly reduced ($p<0.0001$) in 2013, 2014, 2015 and again in 2016 in sites receiving two diquat applications (Figures 6 and 7). As in 2015, those sites receiving one diquat application did not have an increase in rhizome bud density in 2016 or at the beginning of the 2017 growing season (Figure 6). This suggests that sites with low flowering rush density can be effectively controlled with just one diquat application per growing season.

Biomass plots examined for bud density over time illustrate a general trend for reference site bud density to increase during the growing season, and treatment plot density to decline (Figure 7). Bud densities in reference plots were not lower than previous years (Figure 7). However, bud densities in diquat treated plots have significantly decreased from peak densities observed in 2013 (Figure 7).

Point Intercept. While decreasing the nuisance growth and reducing the long-term potential to spread and regrow is important for managing invasive plants, this benefit must be weighed against possible damage to the native plant community. A point intercept study was performed to evaluate the impact on native plant species and the overall community. This sampling did not detect a decrease in the abundance of native plants, but rather if plants survived and continued at the same frequency.

Flowering rush frequency was significantly lower in all plots by the final assessment in June 2017 (Tables 3-5; Figure 8). At this time it is unknown why flowering rush declined in reference plots; however it is possible that the species had started to senescence by the September 2016 sampling. In many individual plots, the frequency of flowering rush was dramatically reduced (Tables 7-35). For instance, frequency of flowering rush in plot C-DIQ-3 was 63.6% in June, 3% after one treatment in July, and 0% after two treatments in September 2016 (Table 23). In general, diquat treatments resulted in reduced nuisance potential from flowering rush growth.

Average species richness (no. per point) in reference plots did not decrease over the 2016 growing season and remained at similar levels in 2017 (Figure 9). Average species richness in diquat treated plots decreased in all diquat treated plots (Figure 9); this represents a decline of 0.54 species per point in sites receiving one diquat treatment and 1.39 species per point sites receiving two diquat treatments. This decline in species richness is expected in treatment plots as flowering rush was being reduced in these plots due to diquat treatments. Interestingly, sites receiving one diquat application had a reduction in mean species richness in 2016 but not in 2015 (Turnage et al. 2016). This suggests that one diquat application per year may be sufficient to reduce flowering rush biomass long term. As in 2014, we assessed plant frequency for all diquat treated (Table 3 and 4) and untreated (Table 5) plots, determining which species had a significant change over time. Of the 34 species found in previous years, 30 were found in the 2016 survey sites and 28 were found in the 2017 survey sites. There were 18 species that had no change from 2016 to 2017 regardless of site location or time, four of which were not found (*Heteranthera dubia* – water stargrass, *Juncus pelocarpus* – brownfruit rush, *Typha angustifolia* – narrrowleaf cattail, and *Wolffia* sp. - watermeal) in either survey (Table 6). There were two species

(*Stuckenia pectinata* – sago pondweed and *Utricularia macrorhiza* – common bladderwort) that increased in all sites (Table 6). There was one species (*Potamogeton foliosus* – leafy pondweed) that decreased in all plots (Table 6) however, this decline was likely due to the plant not yet sprouting during the 2017 survey rather than herbicide damage. The remaining species showed various types of change between survey efforts (Table 6), indicating small to moderate change in frequency with treatments.

Given that there are 29 individual plots (only nine were used for biomass analysis), an analysis of each plot will not be discussed.

Diquat treatments do not appear to have a significant effect on species diversity, though some individual species in some plots may have been adversely affected.

Project Overview of Biomass Sites

In total, there were nine sites at which biomass was collected at the end of this project: three reference sites, three sites receiving two diquat treatments per growing season, and three sites receiving one diquat treatment per growing season. As reduction of rhizome buds was the primary goal of this work, rhizome bud density was analyzed at each biomass site from year to year using a paired t-test or similar non-parametric test.

Reference Sites

Bud density at two of the reference sites (DREF and CREF) declined for unknown reasons over the course of this project. Bud density at the last reference site (SREF) increased during this project.

DREF: This site was first utilized as a reference site in 2012. Prior to this, it had received herbicide treatments. In 2014, rhizome buds at this site decreased by 82% of the 2012 density (Table 36). By 2017, rhizome bud density was at 28% of 2012 values (Table 36). At this time, it is not known why bud density at this site declined. It may be possible that native plants have increased in density such that they are shading out flowering rush (Table 21).

CREF: This site was first utilized as a reference site in 2013. Prior to this, it had been a treatment site. In 2014, rhizome buds at this site decreased by 81% of the 2012 density (Table 36). By 2017, rhizome bud density was at 1% of 2013 values (Table 36). Similar to DREF, it is unknown why the bud density at this site declined as it received no herbicide treatments from 2013 to 2017.

SREF: This site was first utilized as a reference site in 2012. This is the only reference site that received no herbicide treatments over the course of this project. In 2013, rhizome buds at this site increased by 488% of the 2012 density (Table 36). Rhizome bud density fluctuated over the course of this project but by 2017, rhizome bud density was at 274% of 2012 value (Table 36).

Two Diquat Application Sites

Rhizome bud density declined by greater than 98% at all sites receiving two applications of diquat by 2017. This suggests that two applications of diquat had the desired effect of reducing rhizome buds at sites with heavy infestations of flowering rush.

CDIQ3: This site was first utilized as a treatment site in 2013. This site received two applications of diquat per growing season. By 2014, bud density had been reduced by 93% (Table 36). By 2017, rhizome buds were no longer detected at this site (Table 36).

DDIQ1: This site was first utilized as a treatment site in 2012. This site received two applications of diquat per growing season. Bud density did not decline in 2013 however in 2014, bud density had been reduced by 90% (Table 36). By 2017, rhizome buds were at 2% of the 2012 value (Table 36).

DDIQ11: This site was first utilized as a treatment site in 2013. This site received two applications of diquat per growing season. By 2014, bud density had been reduced by 98% (Table 36). By 2017, rhizome buds were not detectable at this site (Table 36).

One Diquat Application Sites

Rhizome bud density did not increase at sites receiving one application of diquat. This suggests that one application of diquat had the desired effect of keeping flowering rush presence suppressed at sites that already have low flowering rush presence.

DDIQ2: This site was first utilized as a treatment site in 2012 but bud density data was not collected until the 2015 growing season. This site received two applications of diquat per growing season until 2015 at which time it only received one application of diquat per growing season until the end of the project in 2017. In 2015, rhizome buds were undetected (Table 36). By 2017, rhizome buds were still not detected at this site however bud density was so low at this site in all three years that a statistical analysis could not be conducted (Table 36).

DDIQ4: This site was first utilized as a treatment site in 2012 but bud density data was not collected until the 2015 growing season. This site received two applications of diquat per growing season until 2015 at which time it only received one application of diquat per growing season until the end of the project in 2017. In 2015, rhizome buds were detected but by the 2016 growing season bud density had been reduced by 100% of the 2015 value (Table 36). Rhizome buds were undetected in 2017 but this did not represent a statistical decrease from the 2015 density value, thus bud density remained constant until the end of the project (Table 36).

DDIQ8: This site was first utilized as a treatment site in 2012 but bud density data was not collected until the 2013 growing season. This site received two applications of diquat per growing season until 2015 at which time it only received one application of diquat per growing season until the end of the project in 2017. In 2014, rhizome buds were not detected but by 2015,

bud density was at 77% of the 2013 value (Table 36). In 2015, this site started receiving one application of diquat per growing season. Similar to DDIQ4, rhizome buds were undetected in 2017 but this did not represent a statistical decrease from the 2015 density value, thus bud density remained constant until the end of the project (Table 36).

Conclusions and Recommendations

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- Based on field evaluations, 2016 sites receiving two submersed treatments with the contact herbicide diquat have had a continued decrease in rhizome bud density of flowering rush.
- Sites receiving one diquat treatment did not see an increase in rhizome bud density during the growing season.
- Applications of diquat have significantly reduced the nuisance problem and the potential for plants to regrow and spread.
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Recommendations

- Field evaluations and monitoring of diquat or other herbicides should be continued to determine if reduction in belowground biomass and rhizome bud density is repeatable.
- We recommend that other herbicide active ingredients and use patterns be evaluated under controlled conditions to determine if there are alternatives to diquat treatments, which may be field demonstrated in the future.
- We recommend continued monitoring of all littoral areas for the presence of flowering rush and other AIS.

Acknowledgements

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TABLES AND FIGURES

Table 1. Treatment and reference plot names for the Detroit Lakes basins in 2016 with the 2015 plot designation, plot area, and number of diquat treatments per plot. In '# of Diquat Treatments' those numbers that are underlined are sites used for biomass analysis.

Lake	2017 Plot Designation	2016 Plot Designation	Area (acres)	# of Diquat Treatments
Curfman	CL_Diq-1	CL_Diq-1	1.4	2
Curfman	CL_REF-1	CL_REF-1	2.2	Reference
Curfman	CF_Diq-3	CF_Diq-3	13.3	2
Little Detroit	DL_Diq-1	DL_Diq-1	4.0	2
Little Detroit	DL_Diq-2	DL_Diq-2	5.6	1
Little Detroit	DL_Diq-3	DL_Diq-3	9.5	2
Big Detroit	DL_Diq-4	DL_Diq-4	6.9	1
Big Detroit	DL_Diq-5	DL_Diq-5	11.0	2
Big Detroit	DL_Diq-6	DL_Diq-6	19.3	1
Big Detroit	DL_Diq-7	DL_Diq-7	5.4	1
Big Detroit	DL_Diq-8	DL_Diq-8	83.4	1
Big Detroit	DL_Diq-9	DL_Diq-9	4.2	1
Big Detroit	DL_Diq-10	DL_Diq-10	8.3	2
Big Detroit	DL_Diq-11	DL_Diq-11	14.7	2
Big Detroit	DL_Diq-12	DL_Diq-12	13.7	2
Big Detroit	DL_Diq-13	DL_Diq-13	3.5	2
Big Detroit	DL_Diq-14	DL_Diq-14	1.2	2
Big Detroit	DL_REF-1	DL_REF-1	6.4	Reference
Melissa	LM_Diq-1	LM_Diq-1	7.4	1
Melissa	LM_Diq-2	LM_Diq-2	3.4	2
Melissa	LM_Diq-3	LM_Diq-3	4.1	1
Melissa	LM_Diq-4	LM_Diq-4a	7.9	1
Melissa	LM_Diq-6	LM_Diq-4b	2.1	2
Melissa	LM_Diq-5	LM_Diq-5	20.1	0
Melissa	LM_Diq-7	LM_Diq-6	11.6	2
Sallie	LS_REF-1	LS_REF-1	21.0	Reference
Sallie	LS_Diq-1	LS_Diq-1	16.5	2
Sallie	LS_Diq-2	LS_Diq-2	0.8	1
Sallie	LS_Diq-3	LS_Diq-3	7.7	2
TOTAL			373.2	

Table 2. Nine sites, which had 40 biomass samples per site collected in June, July, and September of 2016 as well as June of 2017.

Lake	2016 Plot Designation	2015 Plot Designation	Area (acres)	Notes
Curfman	CL_REF-1	CL_REF-1	2.20	Reference
Big Detroit	DL_REF-1	DL_REF-1	6.41	Reference
Sallie	LS_REF-1	LS_REF-1	21.01	Reference
Little Detroit	DL_Diq-2	DL_Diq-2	3.37	One Treatment
Big Detroit	DL_Diq-4	DL_Diq-4	6.92	One Treatment
Big Detroit	DL_Diq-8	DL_Diq-8	83.40	One Treatment
Little Detroit	DL_Diq-1	DL_Diq-1	4.00	Two Treatment
Curfman	CL_Diq-3	CL_Diq-3	13.27	Two Treatment
Big Detroit	DL_Diq-11	DL_Diq-11	14.73	Two Treatment

Table 3. Frequency of occurrence for species in all plots receiving one diquat treatment in the Detroit Lakes system from 2015 to 2017. P-value is based on a Chi-square test, comparing 2015 and 2017 values for each species. A p-value of "M" indicates insufficient presence while p-values in bold type indicate a statistically significant difference at the 0.05 level of significance. N = 184, 213, 262; respectively.

Common	Scientific	CODE	2015	2016	2017	P-value
Water marigold	*Bidens beckii*	BBEC	0	0	0	M
Flowering rush	*Butomus umbellatus*	BUMB	29	42	33	0.4044
Coontail	*Ceratophyllum demersum*	CDEM	12	3	39	**0.0064**
Chara	*Chara*	CHARA	158	188	211	0.1621
Water moss	*Drepanocladus*	DREP	26	38	23	0.0905
Elodea	*Elodea canadensis*	ECAN	3	6	11	0.1698
Water stargrass	*Heteranthera dubia*	HDUB	0	0	0	M
Brownfruit rush	*Juncus pelocarpus*	JPEL	0	0	0	M
Common duckweed	*Lemna minor*	LMIN	0	0	0	M
Star duckweed	*Lemna trisulca*	LTRI	44	11	3	**<0.0001**
Northern watermilfoil	*Myriophyllum sibiricum*	MSIB	11	29	32	**0.0336**
Bushy naiad	*Najas flexilis*	NFLEX	0	0	0	M
Nitella	*Nitella*	NITEL	0	3	0	M
White waterlily	*Nymphaea odorata*	NODOR	0	2	1	1.0000
Yellow pondlily	*Nuphar lutea*	NVARI	2	2	2	1.0000
Curlyleaf pondweed	*Potamogeton crispus*	PCRI	26	47	31	0.5648
Leafy pondweed	*Potamogeton foliosus*	PFOL	45	12	9	**<0.0001**
Variable pondweed	*Potamogeton gramineus*	PGRAM	2	0	43	**<0.0001**
Illinois pondweed	*Potamogeton illinoensis*	PILL	52	48	27	**<0.0001**
Floating pondweed	*Potamogeton nataus*	PNAT	0	1	0	M
Whitestem pondweed	*Potamogeton praelongus*	PPRA	5	2	7	1.0000
Richardson's pondweed	*Potamogeton richardsonii*	PRICH	32	53	52	0.5406
Robbin's pondweed	*Potamogeton robbbinsii*	PROBB	2	0	0	0.1697
Flatstem pondweed	*Potamogeton zosteriformis*	PZOS	36	21	32	**0.0442**
Widgeongrass	*Ruppia cirrhosa*	RCIRR	0	0	0	M
White water buttercup	*Ranunculus longirostris*	RLON	1	0	0	0.4126
Hardstem bulrush	*Schoenoplectus acutus*	SACU	0	12	14	**0.0012**
Arumleaf arrowhead	*Sagittaria cuneata*	SCUN	0	0	0	M
Sago pondweed	*Stuckenia pectinata*	SPEC	0	56	39	**<0.0001**
Narrowleaf cattail	*Typha angustifolia*	TANG	0	0	0	M
Broadleaf cattail	*Typha latifolia*	TLAT	0	0	0	M
Common bladderwort	*Utricularia macrorhiza*	UMAC	1	5	12	**0.0184**
Watercelery	*Vallisneria americana*	VAME	52	73	54	0.0707
Watermeal	*Wolffia*	WOOLF	0	0	0	M
Total species richness		SPP	19	21	20	
Native species richness		NATSPP	17	19	18	

Table 4. Frequency of occurrence for species in all plots receiving two diquat treatments in the Detroit Lakes system from 2015 to 2017. P-value is based on a Chi-square test, comparing 2015 and 2017 values for each species. A p-value of "M" indicates insufficient presence while p-values in bold type indicate a statistically significant difference at the 0.05 level of significance. N = 311, 376, 327; respectively.

Common	Scientific	CODE	2015	2016	2017	P-value
Water marigold	*Bidens beckii*	BBEC	0	0	0	M
Flowering rush	*Butomus umbellatus*	BUMB	142	164	98	**<0.0001**
Coontail	*Ceratophyllum demersum*	CDEM	9	26	16	0.1933
Chara	*Chara*	CHARA	295	300	236	**<0.0001**
Water moss	*Drepanocladus*	DREP	54	23	16	**<0.0001**
Elodea	*Elodea canadensis*	ECAN	1	19	3	0.3405
Water stargrass	*Heteranthera dubia*	HDUB	0	0	0	M
Brownfruit rush	*Juncus pelocarpus*	JPEL	0	0	0	M
Common duckweed	*Lemna minor*	LMIN	0	4	0	M
Star duckweed	*Lemna trisulca*	LTRI	14	44	17	0.6823
Northern watermilfoil	*Myriophyllum sibiricum*	MSIB	44	105	22	**0.0021**
Bushy naiad	*Najas flexilis*	NFLEX	0	0	0	M
Nitella	*Nitella*	NITEL	0	0	1	0.3291
White waterlily	*Nymphaea odorata*	NODOR	5	4	5	0.9363
Yellow pondlily	*Nuphar lutea*	NVARI	41	27	24	**0.0147**
Curlyleaf pondweed	*Potamogeton crispus*	PCRI	56	98	77	0.0850
Leafy pondweed	*Potamogeton foliosus*	PFOL	106	5	7	**<0.0001**
Variable pondweed	*Potamogeton gramineus*	PGRAM	1	0	21	**<0.0001**
Illinois pondweed	*Potamogeton illinoensis*	PILL	72	92	42	**0.0007**
Floating pondweed	*Potamogeton nataus*	PNAT	0	0	1	0.3291
Whitestem pondweed	*Potamogeton praelongus*	PPRA	4	31	34	**<0.0001**
Richardson's pondweed	*Potamogeton richardsonii*	PRICH	106	135	104	0.5403
Robbin's pondweed	*Potamogeton robbbinsii*	PROBB	1	0	0	0.3408
Flatstem pondweed	*Potamogeton zosteriformis*	PZOS	71	91	58	0.1094
Widgeongrass	*Ruppia cirrhosa*	RCIRR	1	0	0	0.3408
White water buttercup	*Ranunculus longirostris*	RLON	2	6	1	0.5336
Hardstem bulrush	*Schoenoplectus acutus*	SACU	18	11	11	0.1418
Arumleaf arrowhead	*Sagittaria cuneata*	SCUN	0	0	0	M
Sago pondweed	*Stuckenia pectinata*	SPEC	0	127	59	**<0.0001**
Narrowleaf cattail	*Typha angustifolia*	TANG	6	0	6	0.9301
Broadleaf cattail	*Typha latifolia*	TLAT	0	4	0	M
Common bladderwort	*Utricularia macrorhiza*	UMAC	0	14	11	**0.0011**
Watercelery	*Vallisneria americana*	VAME	99	176	98	0.6106
Watermeal	*Wolffia*	WOOLF	0	0	0	M
Total species richness		SPP	22	22	24	
Native species richness		NATSPP	20	20	22	

Table 5. Frequency of occurrence for species in all untreated reference plots in the Detroit Lakes system from 2015 to 2017. P-value is based on a Chi-square test, comparing 2015 and 2017 values for each species. A p-value of "M" indicates insufficient presence while p-values in bold type indicate a statistically significant difference at the 0.05 level of significance. N = 71, 69, 69; respectively.

Common	Scientific	CODE	2015	2016	2017	P-value
Water marigold	*Bidens beckii*	BBEC	0	0	0	M
Flowering rush	*Butomus umbellatus*	BUMB	36	47	44	0.1280
Coontail	*Ceratophyllum demersum*	CDEM	10	26	14	0.3750
Chara	*Chara*	CHARA	37	43	18	**0.0019**
Water moss	*Drepanocladus*	DREP	4	7	1	0.3662
Elodea	*Elodea canadensis*	ECAN	9	10	9	1.0000
Water stargrass	*Heteranthera dubia*	HDUB	0	0	0	M
Brownfruit rush	*Juncus pelocarpus*	JPEL	0	0	0	M
Common duckweed	*Lemna minor*	LMIN	0	0	0	M
Star duckweed	*Lemna trisulca*	LTRI	32	32	37	0.3980
Northern watermilfoil	*Myriophyllum sibiricum*	MSIB	17	23	23	0.2630
Bushy naiad	*Najas flexilis*	NFLEX	0	0	0	M
Nitella	*Nitella*	NITEL	0	3	0	M
White waterlily	*Nymphaea odorata*	NODOR	8	9	9	0.8002
Yellow pondlily	*Nuphar lutea*	NVARI	20	17	12	0.1600
Curlyleaf pondweed	*Potamogeton crispus*	PCRI	22	25	15	0.2524
Leafy pondweed	*Potamogeton foliosus*	PFOL	17	0	4	**0.0037**
Variable pondweed	*Potamogeton gramineus*	PGRAM	0	0	0	M
Illinois pondweed	*Potamogeton illinoensis*	PILL	16	9	7	0.0672
Floating pondweed	*Potamogeton natans*	PNAT	0	0	0	M
Whitestem pondweed	*Potamogeton praelongus*	PPRA	1	15	14	**0.0002**
Richardson's pondweed	*Potamogeton richardsonii*	PRICH	10	13	15	0.2744
Robbin's pondweed	*Potamogeton robbbinsii*	PROBB	1	0	1	1.000
Flatstem pondweed	*Potamogeton zosteriformis*	PZOS	30	17	24	0.3896
Widgeongrass	*Ruppia cirrhosa*	RCIRR	0	0	0	M
White water buttercup	*Ranunculus longirostris*	RLON	12	6	3	**0.0263**
Hardstem bulrush	*Schoenoplectus acutus*	SACU	12	18	17	0.3005
Arumleaf arrowhead	*Sagittaria cuneata*	SCUN	0	0	0	M
Sago pondweed	*Stuckenia pectinata*	SPEC	0	16	14	**<0.0001**
Narrowleaf cattail	*Typha angustifolia*	TANG	3	0	3	1.0000
Broadleaf cattail	*Typha latifolia*	TLAT	0	5	0	M
Common bladderwort	*Utricularia macrorhiza*	UMAC	0	24	25	**<0.0001**
Watercelery	*Vallisneria americana*	VAME	14	20	16	0.8374
Watermeal	*Wolffia*	WOOLF	0	0	0	M
Total species richness		SPP	20	21	22	
Native species richness		NATSPP	18	19	20	

Table 6. Dynamics of species in diquat-treated and untreated reference plots in the Detroit Lake system from 2016 to 2017; where a "+" indicates species that statistically increased, a "0" indicates species with no significant change, and a "-" indicates species with a significant decrease in frequency at points.

Common	Scientific	CODE	1 Diquat	2 Diquat	Reference
Water marigold	*Bidens beckii*	BBEC	0	0	0
Flowering rush	*Butomus umbellatus*	BUMB	0	-	0
Coontail	*Ceratophyllum demersum*	CDEM	+	0	0
Chara	*Chara*	CHARA	0	-	-
Water moss	*Drepanocladus*	DREP	0	-	0
Elodea	*Elodea canadensis*	ECAN	0	0	0
Water stargrass	*Heteranthera dubia*	HDUB	0	0	0
Brownfruit rush	*Juncus pelocarpus*	JPEL	0	0	0
Common duckweed	*Lemna minor*	LMIN	0	0	0
Star duckweed	*Lemna trisulca*	LTRI	-	0	0
Northern watermilfoil	*Myriophyllum sibiricum*	MSIB	+	-	0
Bushy naiad	*Najas flexilis*	NFLEX	0	0	0
Nitella	*Nitella*	NITEL	0	0	0
White waterlily	*Nymphaea odorata*	NODOR	0	0	0
Yellow pondlily	*Nuphar lutea*	NVARI	0	-	0
Curlyleaf pondweed	*Potamogeton crispus*	PCRI	0	0	0
Leafy pondweed	*Potamogeton foliosus*	PFOL	-	-	-
Variable pondweed	*Potamogeton gramineus*	PGRAM	+	+	0
Illinois pondweed	*Potamogeton illinoensis*	PILL	-	-	0
Floating pondweed	*Potamogeton natans*	PNAT	0	0	0
Whitestem pondweed	*Potamogeton praelongus*	PPRA	0	+	+
Richardson's pondweed	*Potamogeton richardsonii*	PRICH	0	0	0
Robbin's pondweed	*Potamogeton robbbinsii*	PROBB	0	0	0
Flatstem pondweed	*Potamogeton zosteriformis*	PZOS	-	0	0
Widgeongrass	*Ruppia cirrhosa*	RCIRR	0	0	0
White water buttercup	*Ranunculus longirostris*	RLON	0	0	-
Hardstem bulrush	*Schoenoplectus acutus*	SACU	+	0	0
Arumleaf arrowhead	*Sagittaria cuneata*	SCUN	0	0	0
Sago pondweed	*Stuckenia pectinata*	SPEC	+	+	+
Narrowleaf cattail	*Typha angustifolia*	TANG	0	0	0
Broadleaf cattail	*Typha latifolia*	TLAT	0	0	0
Common bladderwort	*Utricularia macrorhiza*	UMAC	+	+	+
Watercelery	*Vallisneria americana*	VAME	0	0	0
Watermeal	*Wolffia*	WOOLF	0	0	0
	Increases		6	4	3
	No change		24	23	28
	Decreases		4	6	3

Table 7. Species prevalence at survey points in site DL-DIQ-1 from 2015 to 2017.

SITE	DL-DIQ-1		
YEAR	2015	2016	2017
POINTS	20	20	20
Bidens beckii	0	0	0
Butomus umbellatus	13	13	5
Ceratophyllum demersum	0	0	3
Chara	20	20	20
Drepanocladus	0	1	7
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	2	0
Myriophyllum sibiricum	0	7	1
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	6	4	3
Potamogeton crispus	0	10	5
Potamogeton foliosus	11	0	2
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	5	7	7
Potamogeton natans	0	0	0
Potamogeton praelongus	2	2	4
Potamogeton richardsonii	13	14	12
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	4	0	1
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	10	8	8
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	12	0
Typha angustifolia	0	0	1
Typha latifolia	0	0	0
Utricularia macrorhiza	0	1	0
Vallisneria americana	17	8	2
Wolffia	0	0	0

Table 8. Species prevalence at survey points in site DL-DIQ-2 from 2015 to 2017.

SITE	DL-DIQ-2		
YEAR	2015	2016	2017
POINTS	23	24	24
Bidens beckii	0	0	0
Butomus umbellatus	3	8	2
Ceratophyllum demersum	0	0	8
Chara	23	22	20
Drepanocladus	0	0	4
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	3	0
Myriophyllum sibiricum	0	8	0
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	1	0	0
Potamogeton crispus	0	1	0
Potamogeton foliosus	10	0	4
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	9	6	4
Potamogeton natans	0	0	0
Potamogeton praelongus	3	4	3
Potamogeton richardsonii	11	8	2
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	5	6	2
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	10	1
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	4	5	2
Wolffia	0	0	0

Table 9. Species prevalence at survey points in site DL-DIQ-3 from 2015 to 2017.

SITE	DL-DIQ-3		
YEAR	2015	2016	2017
POINTS	25	25	25
Bidens beckii	0	0	0
Butomus umbellatus	12	13	6
Ceratophyllum demersum	0	0	3
Chara	20	25	25
Drepanocladus	0	0	0
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	1	0
Myriophyllum sibiricum	4	1	0
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	2	9	6
Potamogeton foliosus	12	0	2
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	4	6	2
Potamogeton natans	0	0	0
Potamogeton praelongus	1	0	1
Potamogeton richardsonii	10	8	5
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	7	1	0
Ruppia cirrhosa	1	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	1	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	11	0
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	11	14	5
Wolffia	0	0	0

Table 10. Species prevalence at survey points in site DL-DIQ-4 from 2015 to 2017.

SITE	DL-DIQ-4		
YEAR	2015	2016	2017
POINTS	30	31	31
Bidens beckii	0	0	0
Butomus umbellatus	5	8	3
Ceratophyllum demersum	0	0	1
Chara	29	30	23
Drepanocladus	4	0	0
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	22	0	0
Myriophyllum sibiricum	1	6	0
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	0	6	1
Potamogeton foliosus	1	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	6	12	6
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	0	1	1
Potamogeton robbinsii	1	0	0
Potamogeton zosteriformis	3	4	1
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	8	4
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	6	10	4
Wolffia	0	0	0

Table 11. Species prevalence at survey points in site DL-DIQ-5 from 2015 to 2017.

SITE	DL-DIQ-5		
YEAR	2015	2016	2017
POINTS	20	20	20
Bidens beckii	0	0	0
Butomus umbellatus	9	1	11
Ceratophyllum demersum	0	0	0
Chara	19	20	13
Drepanocladus	5	9	0
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	0	0
Myriophyllum sibiricum	0	0	0
Najas flexilis	0	1	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	1	0	2
Potamogeton foliosus	3	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	0	0	7
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	1
Potamogeton richardsonii	1	0	8
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	0	0	0
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	0	0
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	1	11	8
Wolffia	0	0	0

Table 12. Species prevalence at survey points in site DL-DIQ-6 from 2015 to 2017.

SITE	DL-DIQ-6		
YEAR	2015	2016	2017
POINTS	34	34	34
Bidens beckii	0	0	0
Butomus umbellatus	8	3	3
Ceratophyllum demersum	0	0	3
Chara	34	31	31
Drepanocladus	12	15	4
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	1	0
Myriophyllum sibiricum	2	0	0
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	3	2	2
Potamogeton crispus	5	10	12
Potamogeton foliosus	21	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	0	0	2
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	6	3	9
Potamogeton robbinsii	1	0	0
Potamogeton zosteriformis	0	1	7
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	12	10
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	10	5	7
Wolffia	0	0	0

Table 13. Species prevalence at survey points in site DL-DIQ-7 from 2015 to 2017.

SITE	DL-DIQ-7		
YEAR	2015	2016	2017
POINTS	25	25	25
Bidens beckii	0	0	0
Butomus umbellatus	5	4	1
Ceratophyllum demersum	3	1	0
Chara	7	6	1
Drepanocladus	14	6	6
Elodea canadensis	0	0	1
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	2	3	0
Myriophyllum sibiricum	2	3	0
Najas flexilis	0	0	0
Nitella	0	2	0
Nymphaea odorata	0	0	0
Nuphar lutea	1	0	0
Potamogeton crispus	8	0	1
Potamogeton foliosus	3	0	0
Potamogeton gramineus	1	0	0
Potamogeton illinoensis	2	0	0
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	5	0	0
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	10	2	0
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	1	0
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	11	13	8
Wolffia	0	0	0

Table 14. Species prevalence at survey points in site DL-DIQ-8 from 2015 to 2017.

SITE	DL-DIQ-8		
YEAR	2015	2016	2017
POINTS	43	44	44
Bidens beckii	0	0	0
Butomus umbellatus	6	11	8
Ceratophyllum demersum	0	0	20
Chara	42	44	44
Drepanocladus	0	13	8
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	1	0
Myriophyllum sibiricum	1	5	1
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	2	26	9
Potamogeton foliosus	27	1	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	3	0	4
Potamogeton natans	0	0	0
Potamogeton praelongus	1	2	3
Potamogeton richardsonii	3	8	9
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	1	0	3
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	26	14
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	23	13	4
Wolffia	0	0	0

Table 15. Species prevalence at survey points in site DL-DIQ-9 from 2015 to 2017.

SITE	DL-DIQ-9		
YEAR	2015	2016	2017
POINTS	19	20	20
Bidens beckii	0	0	0
Butomus umbellatus	6	2	2
Ceratophyllum demersum	0	0	2
Chara	19	20	18
Drepanocladus	1	3	1
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	3	0
Myriophyllum sibiricum	1	2	1
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	0	1	1
Potamogeton foliosus	2	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	7	7	1
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	8	4	0
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	5	1	1
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	3	0
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	3	0
Vallisneria americana	9	8	1
Wolffia	0	0	0

Table 16. Species prevalence at survey points in site DL-DIQ-10 from 2015 to 2017.

SITE	DL-DIQ-10		
YEAR	2015	2016	2017
POINTS	25	26	26
Bidens beckii	0	0	0
Butomus umbellatus	4	8	6
Ceratophyllum demersum	9	9	0
Chara	9	2	0
Drepanocladus	8	5	0
Elodea canadensis	2	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	20	18	7
Myriophyllum sibiricum	1	3	0
Najas flexilis	0	0	0
Nitella	0	0	1
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	15	8	3
Potamogeton foliosus	1	0	1
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	10	0	1
Potamogeton natans	0	0	0
Potamogeton praelongus	1	3	3
Potamogeton richardsonii	1	1	1
Potamogeton robbinsii	1	0	0
Potamogeton zosteriformis	9	5	1
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	1	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	0	0
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	9	0
Vallisneria americana	6	2	8
Wolffia	0	0	0

Table 17. Species prevalence at survey points in site DL-DIQ-11 from 2015 to 2017.

SITE	DL-DIQ-11		
YEAR	2015	2016	2017
POINTS	23	23	23
Bidens beckii	0	0	0
Butomus umbellatus	16	8	6
Ceratophyllum demersum	0	0	0
Chara	22	22	23
Drepanocladus	12	10	8
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	1	0
Myriophyllum sibiricum	1	1	2
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	7	4	4
Potamogeton crispus	5	6	6
Potamogeton foliosus	7	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	1	0	0
Potamogeton natans	0	0	0
Potamogeton praelongus	0	1	2
Potamogeton richardsonii	3	1	0
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	1	0	0
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	13	8
Typha angustifolia	1	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	7	6	10
Wolffia	0	0	0

Table 18. Species prevalence at survey points in site DL-DIQ-12 from 2015 to 2017.

SITE	DL-DIQ-12		
YEAR	2015	2016	2017
POINTS	-	25	25
Bidens beckii	-	0	0
Butomus umbellatus	-	14	4
Ceratophyllum demersum	-	0	2
Chara	-	25	25
Drepanocladus	-	0	0
Elodea canadensis	-	4	0
Heteranthera dubia	-	0	0
Juncus pelocarpus	-	0	0
Lemna minor	-	0	0
Lemna trisulca	-	0	0
Myriophyllum sibiricum	-	18	0
Najas flexilis	-	0	0
Nitella	-	0	0
Nymphaea odorata	-	0	0
Nuphar lutea	-	0	0
Potamogeton crispus	-	11	3
Potamogeton foliosus	-	0	0
Potamogeton gramineus	-	0	0
Potamogeton illinoensis	-	12	4
Potamogeton natans	-	0	0
Potamogeton praelongus	-	0	0
Potamogeton richardsonii	-	24	11
Potamogeton robbinsii	-	0	0
Potamogeton zosteriformis	-	20	1
Ruppia cirrhosa	-	0	0
Ranunculus longirostris	-	0	0
Schoenoplectus acutus	-	0	0
Sagittaria cuneata	-	0	0
Stuckenia pectinata	-	23	17
Typha angustifolia	-	0	0
Typha latifolia	-	0	0
Utricularia macrorhiza	-	0	0
Vallisneria americana	-	25	1
Wolffia	-	0	0

Table 19. Species prevalence at survey points in site DL-DIQ-13 from 2015 to 2017.

SITE	DL-DIQ-13		
YEAR	2015	2016	2017
POINTS	-	12	12
Bidens beckii	-	0	0
Butomus umbellatus	-	0	2
Ceratophyllum demersum	-	0	0
Chara	-	12	0
Drepanocladus	-	1	0
Elodea canadensis	-	0	0
Heteranthera dubia	-	0	0
Juncus pelocarpus	-	0	0
Lemna minor	-	0	0
Lemna trisulca	-	7	0
Myriophyllum sibiricum	-	0	0
Najas flexilis	-	4	0
Nitella	-	0	0
Nymphaea odorata	-	0	0
Nuphar lutea	-	0	0
Potamogeton crispus	-	0	0
Potamogeton foliosus	-	0	0
Potamogeton gramineus	-	0	0
Potamogeton illinoensis	-	0	1
Potamogeton natans	-	0	0
Potamogeton praelongus	-	0	0
Potamogeton richardsonii	-	0	0
Potamogeton robbinsii	-	0	0
Potamogeton zosteriformis	-	0	0
Ruppia cirrhosa	-	0	0
Ranunculus longirostris	-	0	0
Schoenoplectus acutus	-	0	0
Sagittaria cuneata	-	0	0
Stuckenia pectinata	-	0	0
Typha angustifolia	-	0	0
Typha latifolia	-	0	0
Utricularia macrorhiza	-	0	0
Vallisneria americana	-	4	0
Wolffia	-	0	0

Table 20. Species prevalence at survey points in site DL-DIQ-14 from 2015 to 2017.

SITE	DL-DIQ-14		
YEAR	2015	2016	2017
POINTS	-	5	5
Bidens beckii	-	0	0
Butomus umbellatus	-	0	3
Ceratophyllum demersum	-	0	0
Chara	-	5	2
Drepanocladus	-	2	0
Elodea canadensis	-	0	0
Heteranthera dubia	-	0	0
Juncus pelocarpus	-	0	0
Lemna minor	-	0	0
Lemna trisulca	-	1	0
Myriophyllum sibiricum	-	0	0
Najas flexilis	-	0	0
Nitella	-	0	0
Nymphaea odorata	-	0	0
Nuphar lutea	-	0	0
Potamogeton crispus	-	0	0
Potamogeton foliosus	-	0	0
Potamogeton gramineus	-	0	0
Potamogeton illinoensis	-	2	0
Potamogeton natans	-	0	0
Potamogeton praelongus	-	0	0
Potamogeton richardsonii	-	0	0
Potamogeton robbinsii	-	0	0
Potamogeton zosteriformis	-	0	0
Ruppia cirrhosa	-	0	0
Ranunculus longirostris	-	0	0
Schoenoplectus acutus	-	0	0
Sagittaria cuneata	-	0	0
Stuckenia pectinata	-	1	0
Typha angustifolia	-	0	0
Typha latifolia	-	0	0
Utricularia macrorhiza	-	0	0
Vallisneria americana	-	1	1
Wolffia	-	0	0

Table 21. Species prevalence at survey points in site DL-REF-1 from 2015 to 2017.

SITE	DL-REF-1		
YEAR	2015	2016	2017
POINTS	21	21	21
Bidens beckii	0	0	0
Butomus umbellatus	2	7	6
Ceratophyllum demersum	3	11	6
Chara	4	2	3
Drepanocladus	3	1	1
Elodea canadensis	0	1	1
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	20	12	14
Myriophyllum sibiricum	5	7	7
Najas flexilis	0	0	0
Nitella	0	3	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	16	12	4
Potamogeton foliosus	0	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	8	2	2
Potamogeton natans	0	0	0
Potamogeton praelongus	1	10	12
Potamogeton richardsonii	5	2	2
Potamogeton robbinsii	1	0	0
Potamogeton zosteriformis	15	4	3
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	4	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	0	0
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	5	0
Vallisneria americana	3	4	2
Wolffia	0	0	0

Table 22. Species prevalence at survey points in site C-DIQ-1 from 2015 to 2017.

SITE	C-DIQ-1		
YEAR	2015	2016	2017
POINTS	9	9	9
Bidens beckii	0	0	0
Butomus umbellatus	6	8	5
Ceratophyllum demersum	2	2	3
Chara	7	9	9
Drepanocladus	0	0	0
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	6	3	5
Myriophyllum sibiricum	4	6	3
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	8	8	7
Potamogeton crispus	3	1	0
Potamogeton foliosus	5	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	2	0	0
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	1
Potamogeton richardsonii	4	3	1
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	4	0	5
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	3	2
Typha angustifolia	3	0	0
Typha latifolia	0	4	3
Utricularia macrorhiza	0	0	3
Vallisneria americana	0	7	6
Wolffia	0	0	0

Table 23. Species prevalence at survey points in site C-DIQ-3 from 2015 to 2017.

SITE	C-DIQ-3		
YEAR	2015	2016	2017
POINTS	32	33	33
Bidens beckii	0	0	0
Butomus umbellatus	20	21	15
Ceratophyllum demersum	3	5	2
Chara	29	33	33
Drepanocladus	0	0	0
Elodea canadensis	1	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	6	3	4
Myriophyllum sibiricum	11	8	1
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	15	9	10
Potamogeton crispus	9	14	17
Potamogeton foliosus	23	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	8	1	0
Potamogeton natans	4	0	0
Potamogeton praelongus	0	4	5
Potamogeton richardsonii	4	10	4
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	6	0	8
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	1	0	0
Schoenoplectus acutus	4	3	3
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	20	19
Typha angustifolia	2	0	2
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	3
Vallisneria americana	2	12	10
Wolffia	0	0	0

Table 24. Species prevalence at survey points in site C-REF-1 from 2015 to 2017.

SITE	C-REF-1		
YEAR	2015	2016	2017
POINTS	14	14	14
Bidens beckii	0	0	0
Butomus umbellatus	6	12	9
Ceratophyllum demersum	0	0	1
Chara	12	13	14
Drepanocladus	0	0	0
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	1	1	2
Myriophyllum sibiricum	0	6	6
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	1	0
Nuphar lutea	5	6	4
Potamogeton crispus	3	3	3
Potamogeton foliosus	7	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	1	1	0
Potamogeton natans	0	0	0
Potamogeton praelongus	0	1	1
Potamogeton richardsonii	2	4	5
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	3	0	9
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	2	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	10	9
Typha angustifolia	3	0	3
Typha latifolia	0	5	0
Utricularia macrorhiza	0	0	2
Vallisneria americana	1	7	5
Wolffia	0	0	0

Table 25. Species prevalence at survey points in site S-DIQ-1 from 2015 to 2017.

SITE	S-DIQ-1		
YEAR	2015	2016	2017
POINTS	41	42	42
Bidens beckii	0	0	0
Butomus umbellatus	23	15	14
Ceratophyllum demersum	0	2	3
Chara	27	27	26
Drepanocladus	0	1	1
Elodea canadensis	0	0	3
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	7	1
Myriophyllum sibiricum	2	6	2
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	4	4	4
Nuphar lutea	1	2	0
Potamogeton crispus	2	13	12
Potamogeton foliosus	4	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	6	7	11
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	15	26	26
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	8	7	8
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	3	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	5	0
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	2	3
Vallisneria americana	11	32	33
Wolffia	0	0	0

Table 26. Species prevalence at survey points in site S-DIQ-2 from 2015 to 2017.

SITE	S-DIQ-2		
YEAR	2015	2016	2017
POINTS	5	5	4
Bidens beckii	0	0	0
Butomus umbellatus	2	1	2
Ceratophyllum demersum	0	0	0
Chara	4	5	2
Drepanocladus	0	0	0
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	0	0
Myriophyllum sibiricum	0	2	0
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	2	1	0
Potamogeton foliosus	0	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	2	0	3
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	0	5	3
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	1	1	1
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	1	0
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	2	5	4
Wolffia	0	0	0

Table 27. Species prevalence at survey points in site S-DIQ-3 from 2015 to 2017.

SITE	S-DIQ-3		
YEAR	2015	2016	2017
POINTS	25	25	25
Bidens beckii	0	0	0
Butomus umbellatus	7	9	4
Ceratophyllum demersum	0	1	0
Chara	21	25	17
Drepanocladus	0	0	0
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	0	0
Myriophyllum sibiricum	1	14	0
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	10	7	14
Potamogeton foliosus	4	0	0
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	6	1	3
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	12	11	9
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	6	0	5
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	8	3
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	1	1
Vallisneria americana	11	20	5
Wolffia	0	0	0

Table 28. Species prevalence at survey points in site S-REF-1 from 2015 to 2017.

SITE	S-REF-1		
YEAR	2015	2016	2017
POINTS	35	34	34
Bidens beckii	0	0	
Butomus umbellatus	28	28	29
Ceratophyllum demersum	6	15	7
Chara	20	8	1
Drepanocladus	1	6	0
Elodea canadensis	9	9	8
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	10	19	21
Myriophyllum sibiricum	12	10	10
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	8	8	9
Nuphar lutea	15	11	8
Potamogeton crispus	3	10	8
Potamogeton foliosus	10	0	4
Potamogeton gramineus	0	0	0
Potamogeton illinoensis	7	6	5
Potamogeton natans	0	0	0
Potamogeton praelongus	0	4	1
Potamogeton richardsonii	3	7	8
Potamogeton robbinsii	0	0	1
Potamogeton zosteriformis	11	13	12
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	8	6	3
Schoenoplectus acutus	12	16	17
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	6	5
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	19	22
Vallisneria americana	10	9	9
Wolffia	0	0	0

Table 29. Species prevalence at survey points in site M-DIQ-1 from 2015 to 2017.

SITE	M-DIQ-1		
YEAR	2015	2016	2017
POINTS	19	20	20
Bidens beckii	0	0	0
Butomus umbellatus	4	3	2
Ceratophyllum demersum	0	0	0
Chara	18	19	18
Drepanocladus	0	0	0
Elodea canadensis	0	0	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	0	0
Myriophyllum sibiricum	1	1	5
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	0	1	2
Potamogeton foliosus	2	0	0
Potamogeton gramineus	0	0	7
Potamogeton illinoensis	8	4	1
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	6	6	6
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	4	1	5
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	2	0
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	0
Vallisneria americana	1	5	1
Wolffia	0	0	0

Table 30. Species prevalence at survey points in site M-DIQ-2 from 2015 to 2017.

SITE	M-DIQ-2		
YEAR	2015	2016	2017
POINTS	19	20	20
Bidens beckii	0	0	0
Butomus umbellatus	2	7	5
Ceratophyllum demersum	0	0	0
Chara	19	20	20
Drepanocladus	0	0	0
Elodea canadensis	1	1	0
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	0	0
Myriophyllum sibiricum	5	10	9
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	1	8	4
Potamogeton foliosus	1	0	0
Potamogeton gramineus	1	0	9
Potamogeton illinoensis	14	12	3
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	6	6	4
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	4	15	10
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	1	1
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	1	1	0
Vallisneria americana	1	14	3
Wolffia	0	0	0

Table 31. Species prevalence at survey points in site M-DIQ-3 from 2015 to 2017.

SITE	M-DIQ-3		
YEAR	2015	2016	2017
POINTS	31	32	32
Bidens beckii	0	0	0
Butomus umbellatus	1	8	1
Ceratophyllum demersum	0	1	4
Chara	25	30	30
Drepanocladus	0	0	0
Elodea canadensis	1	6	7
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	1	0	3
Myriophyllum sibiricum	9	14	17
Najas flexilis	0	0	0
Nitella	0	1	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	1	5	3
Potamogeton foliosus	5	11	3
Potamogeton gramineus	0	0	22
Potamogeton illinoensis	21	18	5
Potamogeton natans	3	1	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	8	8	13
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	9	10	9
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	12	12	14
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	6	9
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	2	9
Vallisneria americana	2	7	13
Wolffia	0	0	0

Table 32. Species prevalence at survey points in site M-DIQ-4a from 2015 to 2017.

SITE	M-DIQ-4a		
YEAR	2015	2016	2017
POINTS	27	27	27
Bidens beckii	0	0	0
Butomus umbellatus	7	6	9
Ceratophyllum demersum	1	0	1
Chara	25	27	23
Drepanocladus	9	1	0
Elodea canadensis	0	0	3
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	2	0
Myriophyllum sibiricum	2	4	8
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	1	1	1
Nuphar lutea	0	0	0
Potamogeton crispus	4	2	2
Potamogeton foliosus	0	0	2
Potamogeton gramineus	0	0	14
Potamogeton illinoensis	4	16	0
Potamogeton natans	0	0	0
Potamogeton praelongus	1	0	1
Potamogeton richardsonii	9	14	9
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	8	4	3
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	1	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	0	1
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	1
Vallisneria americana	2	15	10
Wolffia	0	0	0

Table 33. Species prevalence at survey points in site M-DIQ-4b from 2015 to 2017.

SITE	M-DIQ-4b		
YEAR	2015	2016	2017
POINTS	-	6	6
Bidens beckii	-	0	0
Butomus umbellatus	-	4	1
Ceratophyllum demersum	-	0	0
Chara	-	6	4
Drepanocladus	-	0	0
Elodea canadensis	-	0	0
Heteranthera dubia	-	0	0
Juncus pelocarpus	-	0	0
Lemna minor	-	0	0
Lemna trisulca	-	0	0
Myriophyllum sibiricum	-	1	1
Najas flexilis	-	0	0
Nitella	-	0	0
Nymphaea odorata	-	1	1
Nuphar lutea	-	0	0
Potamogeton crispus	-	1	3
Potamogeton foliosus	-	0	0
Potamogeton gramineus	-	0	3
Potamogeton illinoensis	-	3	1
Potamogeton natans	-	0	0
Potamogeton praelongus	-	0	0
Potamogeton richardsonii	-	5	6
Potamogeton robbinsii	-	0	0
Potamogeton zosteriformis	-	1	1
Ruppia cirrhosa	-	0	0
Ranunculus longirostris	-	0	1
Schoenoplectus acutus	-	0	0
Sagittaria cuneata	-	0	0
Stuckenia pectinata	-	5	2
Typha angustifolia	-	0	0
Typha latifolia	-	0	0
Utricularia macrorhiza	-	0	1
Vallisneria americana	-	1	1
Wolffia	-	0	0

Table 34. Species prevalence at survey points in site M-DIQ-5 from 2015 to 2017.

SITE	M-DIQ-5		
YEAR	2015	2016	2017
POINTS	31	31	31
Bidens beckii	0	0	0
Butomus umbellatus	8	1	9
Ceratophyllum demersum	0	0	2
Chara	30	31	31
Drepanocladus	1	0	0
Elodea canadensis	0	0	6
Heteranthera dubia	0	0	0
Juncus pelocarpus	0	0	0
Lemna minor	0	0	0
Lemna trisulca	0	0	0
Myriophyllum sibiricum	14	4	16
Najas flexilis	0	0	0
Nitella	0	0	0
Nymphaea odorata	0	0	0
Nuphar lutea	0	0	0
Potamogeton crispus	5	4	9
Potamogeton foliosus	11	1	2
Potamogeton gramineus	0	0	23
Potamogeton illinoensis	25	22	2
Potamogeton natans	0	0	0
Potamogeton praelongus	0	0	0
Potamogeton richardsonii	16	11	11
Potamogeton robbinsii	0	0	0
Potamogeton zosteriformis	11	1	4
Ruppia cirrhosa	0	0	0
Ranunculus longirostris	0	0	0
Schoenoplectus acutus	0	0	0
Sagittaria cuneata	0	0	0
Stuckenia pectinata	0	5	3
Typha angustifolia	0	0	0
Typha latifolia	0	0	0
Utricularia macrorhiza	0	0	9
Vallisneria americana	5	9	3
Wolffia	0	0	0

Table 35. Species prevalence at survey points in site M-DIQ-6 from 2015 to 2017.

SITE	M-DIQ-6		
YEAR	2015	2016	2017
POINTS	-	36	36
Bidens beckii	-	0	0
Butomus umbellatus	-	16	11
Ceratophyllum demersum	-	7	0
Chara	-	15	19
Drepanocladus	-	0	0
Elodea canadensis	-	14	0
Heteranthera dubia	-	0	0
Juncus pelocarpus	-	0	0
Lemna minor	-	1	0
Lemna trisulca	-	5	0
Myriophyllum sibiricum	-	16	3
Najas flexilis	-	0	0
Nitella	-	0	0
Nymphaea odorata	-	0	0
Nuphar lutea	-	0	0
Potamogeton crispus	-	3	1
Potamogeton foliosus	-	5	2
Potamogeton gramineus	-	0	9
Potamogeton illinoensis	-	19	2
Potamogeton natans	-	0	1
Potamogeton praelongus	-	17	17
Potamogeton richardsonii	-	15	18
Potamogeton robbinsii	-	0	0
Potamogeton zosteriformis	-	28	18
Ruppia cirrhosa	-	0	0
Ranunculus longirostris	-	6	0
Schoenoplectus acutus	-	0	0
Sagittaria cuneata	-	0	0
Stuckenia pectinata	-	5	3
Typha angustifolia	-	0	0
Typha latifolia	-	0	0
Utricularia macrorhiza	-	0	0
Vallisneria americana	-	9	5
Wolffia	-	0	0

Table 36. Rhizome bud density for each site per year. Numbers in year columns are # of rhizome buds per m^2. In the %-Diff columns, a negative number denotes a decrease in bud density and a positive number denotes an increase in bud density. In %-Diff columns, those values with an '*' are significant changes from the bud density in the first year of collection for that site; for site DDIQ8, bud densities in 2014 and 2015 were compared against 2013, while densities in 2016 and 2017 were compared against 2015. In the TRT column, REF is reference sites, TWO denotes sites that received two diquat applications per growing season, and ONE denotes those sites that received one diquat application per year; Site DDIQ8 received two diquat applications in 2013 and 2014 and one diquat application in 2015 and 2016. 'NA' denotes a %-difference that was unable to be calculated. All statistics conducted at the p=0.05 level of significance.

SITE	TRT	2012	2013	%-Diff	2014	%-Diff	2015	%-Diff	2016	%-Diff	2017	%-Diff
DREF	REF	250	194	-22.40	43.86	-82.46*	0	-100*	35.63	-85.75*	69.90	-72.04*
CREF	REF		369		69.44	-81.18*	35.63	-90.34*	35.63	-90.34*	4.11	-98.89*
SREF	REF	52	306	488.46*	228.42	339.27*	353.59	579.98*	105.53	102.94	194.61	274.25*
CDIQ3	TWO		442		29.24	-93.39*	47.97	-89.15*	35.63	-91.94*	0	-100*
DDIQ1	TWO	220	242	10.10	21.93	-90.02*	6.85	-96.88*	68.53	-68.82*	4.11	-98.13*
DDIQ11	TWO		108		1.83	-98.31*	16.45	-84.77	26.04	-75.89*	0	-100*
DDIQ2	ONE						0		10.96	NA	0	NA
DDIQ4	ONE						20.56		0	-100	0	-100
DDIQ8	TWO-ONE		132		0	-100*	30.15	-77.16*	1.37	-95.45	0	-100

Figure 1. Rhizome of flowering rush (*Butomus umbellatus*) with two rhizome buds visible. This is the major propagule or growing point of the triploid biotype.

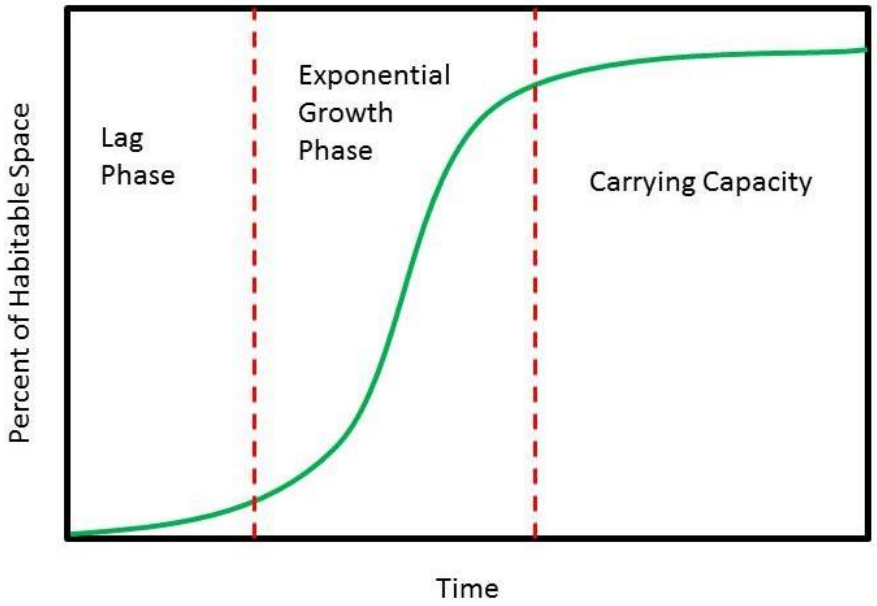

Figure 2. Figure showing the different phases of spread after a site has been invaded.

Figure 3. Sites receiving one diquat treatment, two diquat treatments, and reference plots in Detroit Lake, MN, in 2016.

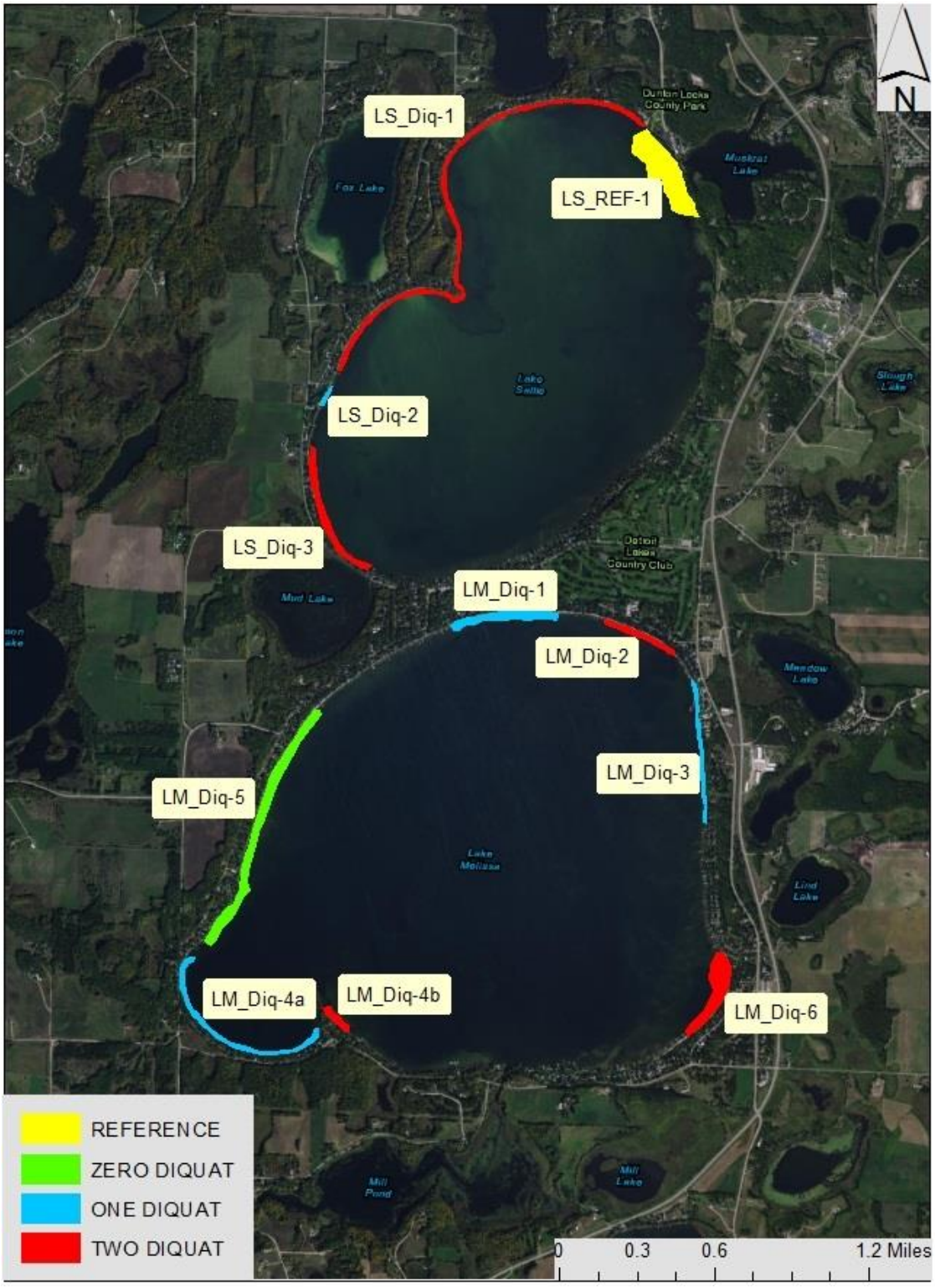

Figure 4. Sites receiving zero diquat treatments, one diquat treatment, two diquat treatments, and reference plots in Lakes Sallie and Melissa, MN, in 2014.

Figure 5. The 6” diameter-coring device used to collect aboveground and belowground biomass of flowering rush in the Detroit Lakes.

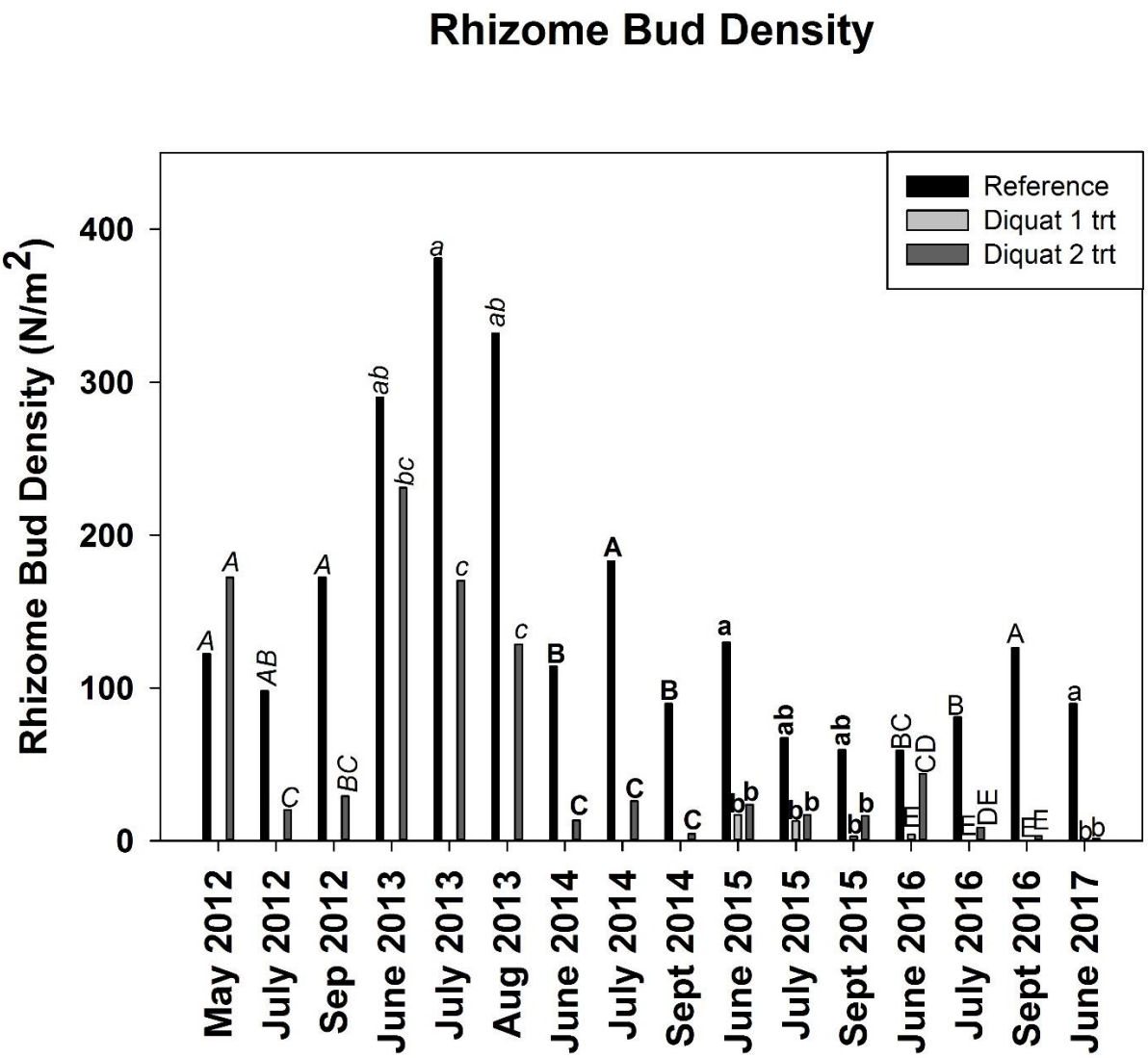

Figure 6. Rhizome bud density (N/m^2) for May, July, and September of 2012; June, July and August of 2013; June, July, and September 2014; and June, July, and September of 2015 of reference (untreated) and diquat-treated plots in the Detroit Lake Systems. Diquat 1 trt bars represent those sites that received one diquat treatment (2015 and 2016 only) while those designated Diquat 2 trt received two herbicide treatments. Bars sharing the same letter within a year are not significantly different from one another. Means comparison by homogenous groups, $p \leq 0.05$, comparing means of treatments and months within a year. Therefore, comparisons for 2012 are capital italics, for 2013 are lower case italics, for 2014 are upper case bold type, for 2015 are lower case normal type, for 2016 are uppercase normal type, and 2017 are lowercase normal type. Plots varied between the five years.

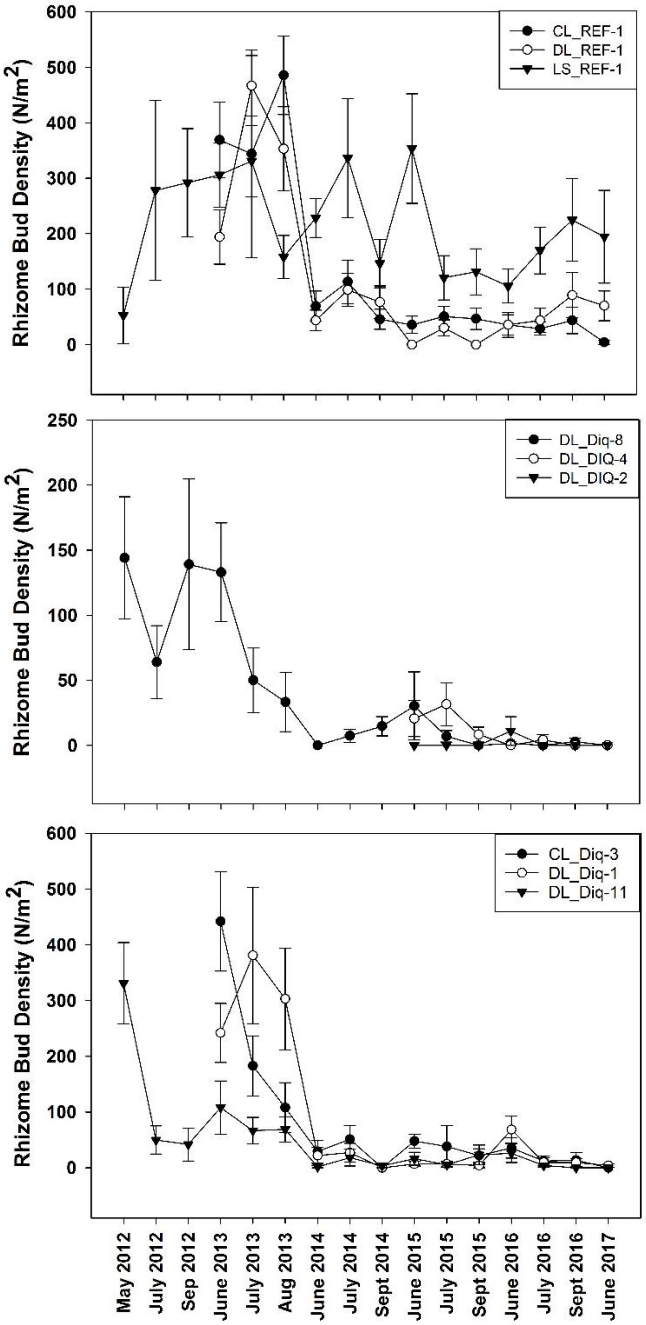

Figure 7. Rhizome bud density (N/m^2) for reference sites (top), sites receiving one diquat treatment (middle), and sites receiving two treatments (bottom) in the Detroit Lakes system from 2012 through 2016. Points are the means for 20 samples in 2012 and 2013, 30 samples in 2014, and 40 samples in 2015, 2016, and 2017 per plot per time interval. Error bars represent one standard error of the mean.

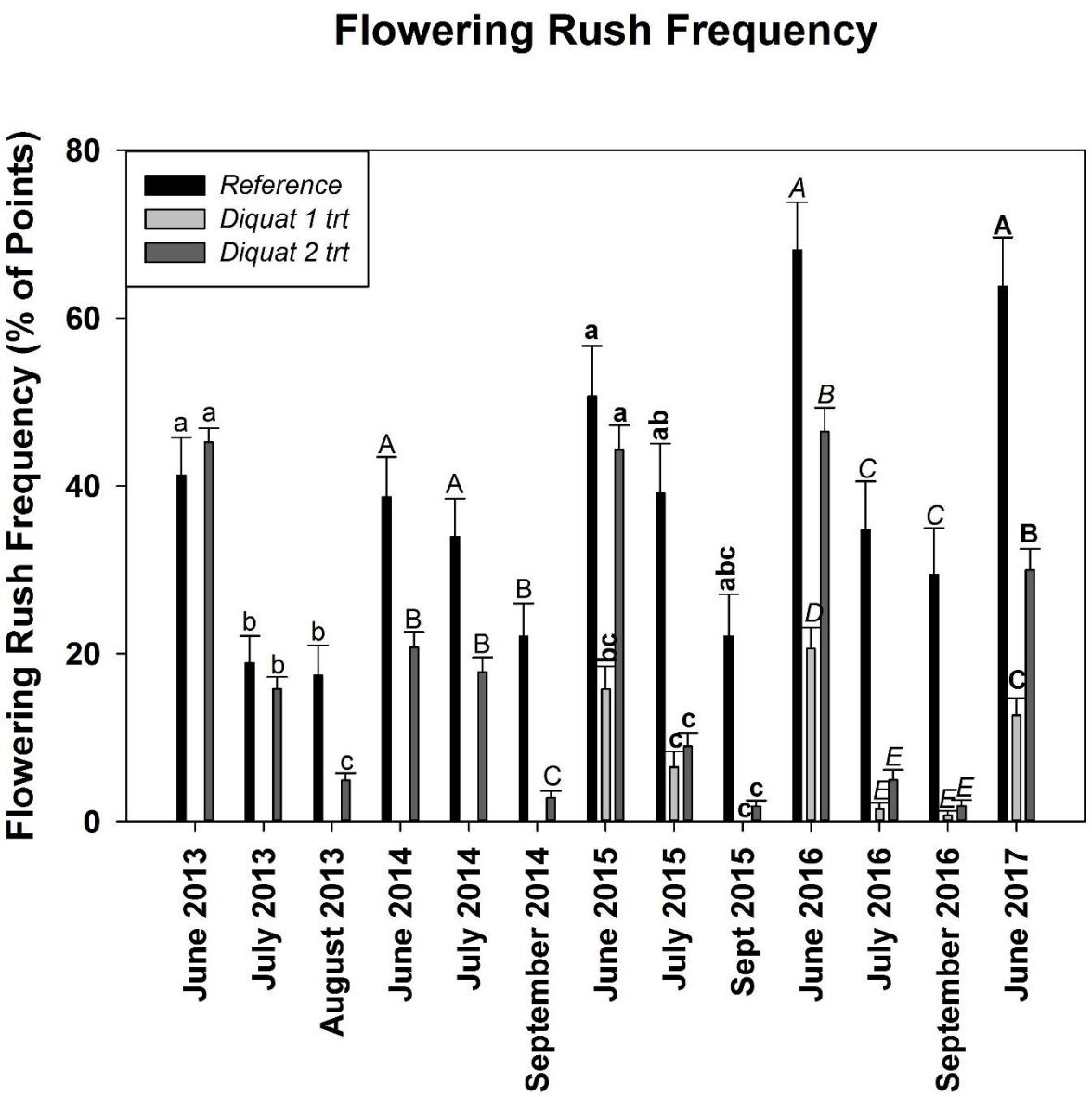

Figure 8. Percent frequency of flowering rush in June, July, and August of 2013 and June, July, and September of 2014, 2015, and 2016 in plots on Detroit Lakes system, MN. Lower case letters are for 2013 data, upper case are for 2014, lower case bold type are for 2015 data, uppercase italics are for 2016 data, and uppercase bold type is 2017 data. Bars sharing the same letter within years are not significantly different from one another. Error bars represent one standard error of the mean.

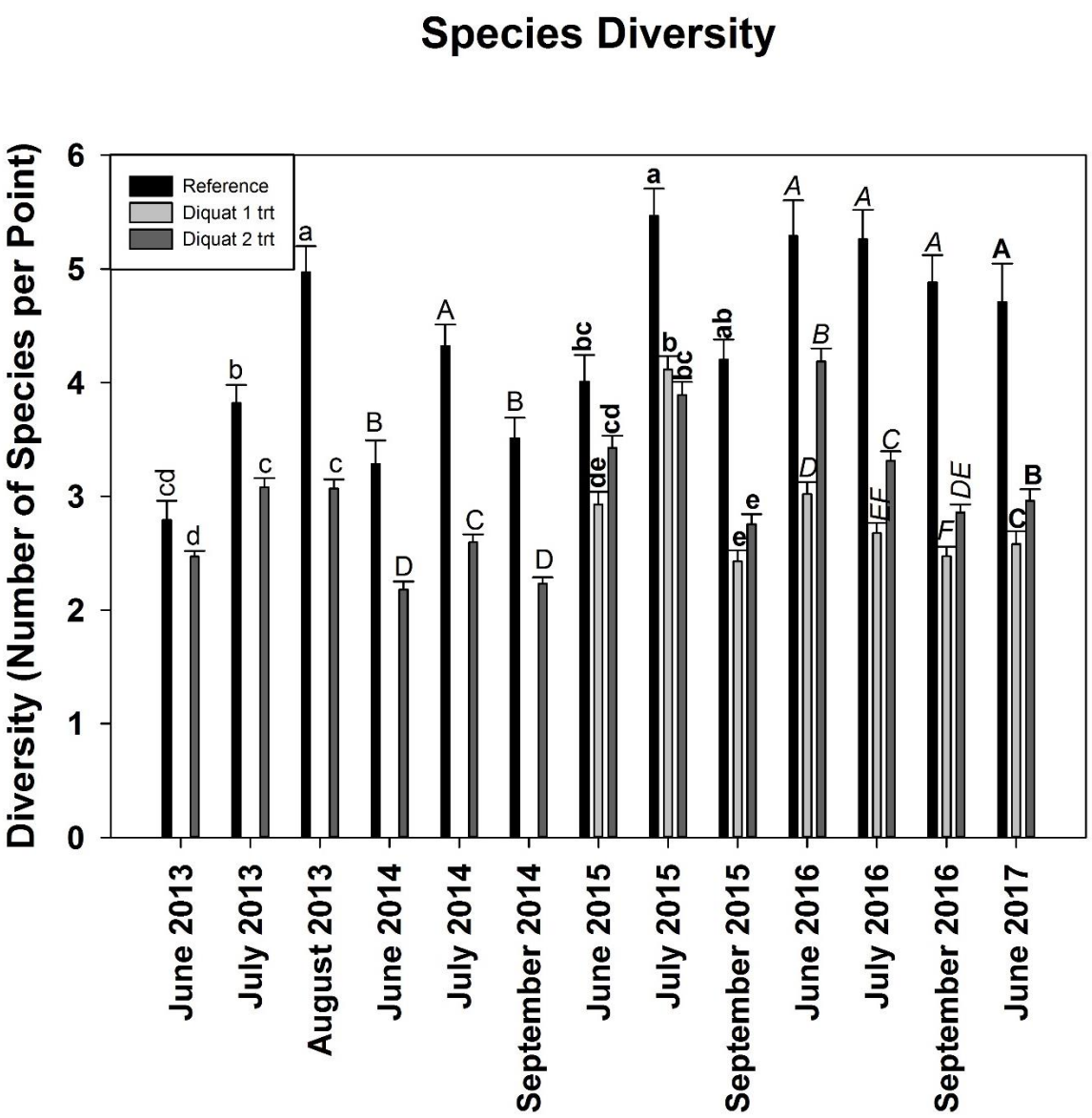

Figure 9. Species diversity (as average number of species per point) in reference and diquat-treated plots in the Detroit Lakes system in 2013, 2014, 2015, and 2016. Lower case letters are for 2013 data, upper case are for 2014 data, lower case bold type are for 2015, uppercase italics are for 2016 data, and uppercase bold type is 2017 data. Bars sharing a letter within a year are not significantly different from one another. Error bars represent one standard error of the mean.