The Effects of the Contact Herbicide Diquat on Mixed Stands of Flowering Rush and Hardstem Bulrush in Lake Sallie, Minnesota 2015

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Introduction

The invasive aquatic plant flowering rush (*Butomus umbellatus*) is capable of utilizing habitat occupied by the native hardstem bulrush (*Shoenoplectus acutus*) in the Detroit Lakes system. Currently, the standing protocol for controlling flowering rush in infested areas is to inject two diquat herbicide treatments into the water column four weeks apart during the growing season.

Because bulrush is a desirable native species herbicide treatments haven't been administered in areas with bulrush due to the unknown effects of diquat on the species within these lakes. However, at least one site on from another study on Lake Melissa (LM-DIQ-3) does have bulrush reestablishing which suggests that the species is capable of withstanding the herbicide effects (Turnage and Madsen 2014). Three point intercept surveys were conducted in June, July, and September of 2013 and another three were conducted in June, July, and September of 2014 at this site. These surveys found bulrush at 37.5, 48.3, and 43.8% of survey points in June, July, and September (respectively) of 2013 (Madsen et al. 2014). The point intercept surveys found bulrush at 40, 42, and 43% of survey sites in June, July, and September (respectively) in 2014 (Turnage and Madsen 2014). While this data shows that bulrush can persist in treatment sites it does not definitively address the prevalence of bulrush within a site (sparse vs. dense stands) or health (high vs. low biomass) of the plant within treatment plots.

Here we conducted a study designed to determine if diquat treatments are detrimental to bulrush prevalence in sites infested with flowering rush.

Materials and Methods

Two five acre sites were established on Lake Sallie, MN: one is a treatment site and one is an untreated reference (Figure 1). The untreated reference falls completely within a larger reference site (LS-REF-1) that is being used for the previously mentioned study. The presence of hardstem bulrush and flowering rush has been documented at this reference site for the last four years (Turnage and Madsen 2014). Lake Sallie is immediately upstream of Lake Melissa on the Pelican River. Both the treatment and the reference site on Lake Sallie had bulrush and flowering rush present. Diquat was applied to the proposed treatment site using the 2014 treatment protocol: two applications of diquat herbicide at 0.37 ppm spaced four weeks apart during the growing season.

A grid of data collection points were placed in both the reference and the treatment plots (27 and 28 points respectively). At each point data was collected within a 0.1m^2 (13 inch on a side) area that was demarcated by a PVC frame (Figure 2). A Garmin 78 SC handheld GPS unit was used for navigation to survey points during each data collection effort. Data was collected in a non-destructive manner by Minnesota Department of Natural Resources and Pelican River Watershed District personnel and analyzed by the Geosystems Research Institute of Mississippi State University.

Stem (or leaf) count and maximum stem height from the bottom of the water were recorded for hardstem bulrush that fell within PVC frames at each survey point. Heights were measured to the nearest cm. Presence or absence of flowering rush and percent cover by flowering rush was also recorded within PVC frames at each point. Data was recorded prior to each herbicide treatment and again four weeks after the last treatment (three data collection efforts).

A paired T-test was used to compare means within each plot in the software package Statistix 9.0 (Analytical Software 2009). Data were only analyzed within plots as there were no replicates of each treatment with which to do a more rigorous statistical analysis (i.e. Analysis of Variance).

Results and Discussion

Reference Site

Data from points 20 through 27 in the reference site had to be dropped from the statistical analysis due to missing data at these sites in the first collection effort. No hardstem bulrush was present at these sites during the second collection effort but bulrush had established at one point by the third collection effort. Flowering rush was present at most of these sites during the second (six of the nine sites) and third (seven of the nine sites) collection efforts.

Bulrush stem count significantly increased ($p=0.0397$) after the second data collection effort but by the end of the study had started to senesce to levels that showed no significant difference ($p=0.0578$) from the first data collection effort (Table 1; Figure 3). Bulrush height above the sediment in the reference site did not statistically change over the course of the growing season ($p>0.05$; Table 1; Figure 4).

Surprisingly, the presence (frequency) of flowering rush declined between each collection effort ($p=0.0207$ and 0.0419 respectively) in the reference site (Table 1; Figure 5). Similarly, the percent cover of flowering rush in the reference site declined between collection efforts ($p=0.0193$ and 0.0208 respectively; Table 1; Figure 6). Flowering rush may undergo natural senescence earlier than some native species in the Pelican River Watershed, however this is unknown at this time due to a lack of studies examining flowering rush phenology in depth.

Treatment Site

Bulrush stem count significantly increased by 66% after two diquat treatments ($p=0.0290$; Table 1; Figure 3). Bulrush height above the sediment did not significantly change between sampling efforts ($p>0.05$; Table 1; Figure 4).

Flowering rush presence declined with each diquat treatment ($p=0.0310$ and 0.0001 respectively; Table 1) and was not detected at any of the survey points by the end of the study (Figure 5). The percent cover of flowering rush at survey points had significantly declined after two diquat applications ($p=0.0003$).

Some hardstem bulrush in this site did experience damage after an airboat was used for the second diquat application (Figure 7). It is believed that the exhaust from the fan of the airboat lifted diquat treated water into a mist that then drifted across some of the bulrush at this site. However areas showing damage did not impact the statistical analysis of this report as none of the survey points fell within the damaged areas. This damage should not affect bulrush presence at the site long term as the application occurred during the latter half of the growing season and the bulrush started to senesce soon after the last data collection effort.

Conclusions

Subsurface diquat applications do not appear to negatively affect hardstem bulrush while simultaneously reducing the presence of flowering rush within treatment sites.

Subsurface applications of diquat in mixed stands of bulrush and flowering rush appear to give selective control over flowering rush while simultaneously benefiting bulrush. This is most likely done by releasing bulrush from competition pressures associated with the growth rate and characteristics (density) of flowering rush.

It should be noted that diquat applications should not be made with an airboat as this has the potential to create a mist from treated water that can drift onto aerial portions of bulrush leaves thus damaging them.

References

Analytical Software. 2009. Statistix 9. User's Manual Analytical Software. Florida State University Tallahassee, Florida, USA.

Madsen, J.D., G. Turnage, and B. T. Sartain. 2014. Management of Flowering Rush Using the Contact Herbicide Diquat in Detroit Lakes, Minnesota 2013. Geosystems Research Institute Report 5063, Geosystems Research Institute, Mississippi State University, Mississippi State, MS. May 2014.

Turnage, G. and J. D. Madsen. 2014. Management of Flowering Rush Using the Contact Herbicide Diquat in Detroit Lakes, Minnesota 2014. Geosystems Research Institute Report 5065, Geosystems Research Institute, Mississippi State University, Mississippi State, MS. March 2015.

Tables and Figures

Table 1. Changes in plant characteristics at the reference and diquat treatment sites on Lake Sallie over the 2015 growing season. Percentages with an asterisk beside them represent statistically significant changes. P-values in bold type represent statistically significant changes.

Characteristic	Plot	Treatment One	Treatment Two	P-values (Treatment One)	P-values (Treatment Two)
Bulrush Stem Count	Reference	*130%	121%	**0.0397**	0.0578
	Treatment	-3%	*66%	0.8924	**0.0290**
Bulrush Height	Reference	59%	41%	0.0573	0.2967
	Treatment	2%	-2%	0.9292	0.8486
Flowering Rush Presence	Reference	*-29%	*-24%	**0.0207**	**0.0419**
	Treatment	*-50%	*-100%	**0.0310**	**0.0001**
Flowering Rush % Cover	Reference	*-33%	*-27%	**0.0193**	**0.0208**
	Treatment	-41%	*-100%	0.1027	**0.0003**

Figure 1. Map of Lake Sallie, MN showing the proposed treatment site and reference site locations for a proposed diquat treatment within bulrush stands.

Figure 2. Image of $0.1m^2$ sampling device and flowering rush.

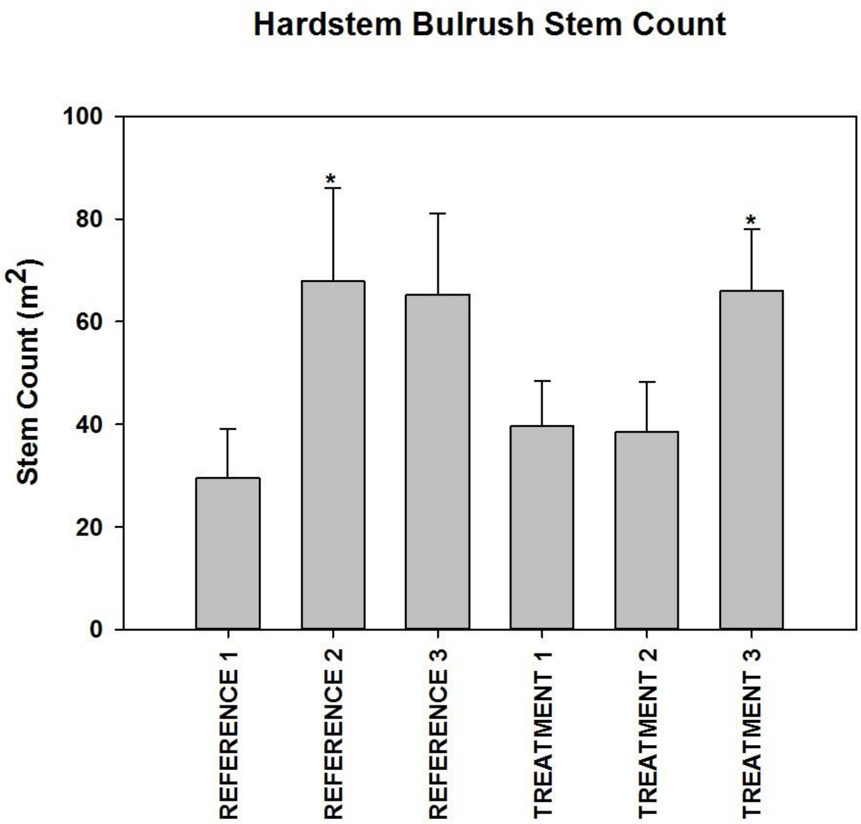

Figure 3. Hardstem bulrush stem (leaf) count in the reference and treatment sites on Lake Sallie. Numbers after site names represent data collection efforts. Reference and treatment site data were analyzed separately using paired t-tests. Bars with an asterisk above them are statistically different from the first data collection effort of a given site.

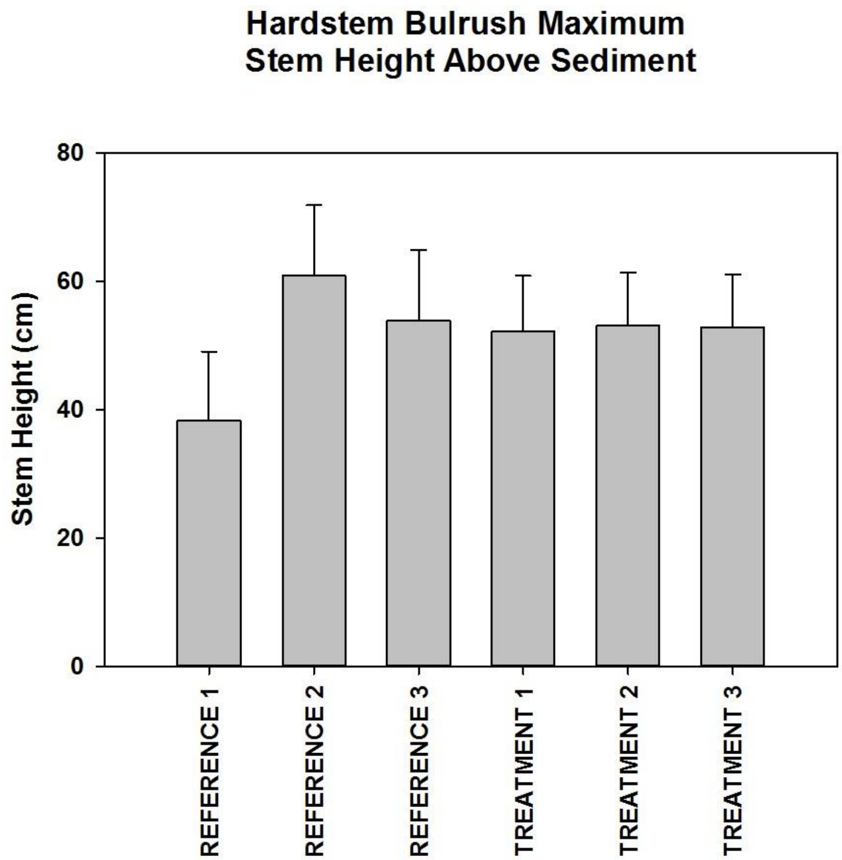

Figure 4. Hardstem bulrush stem height (cm) above sediment in the reference and treatment sites on Lake Sallie. Numbers after site names represent data collection efforts. Reference and treatment site data were analyzed separately using paired t-tests.

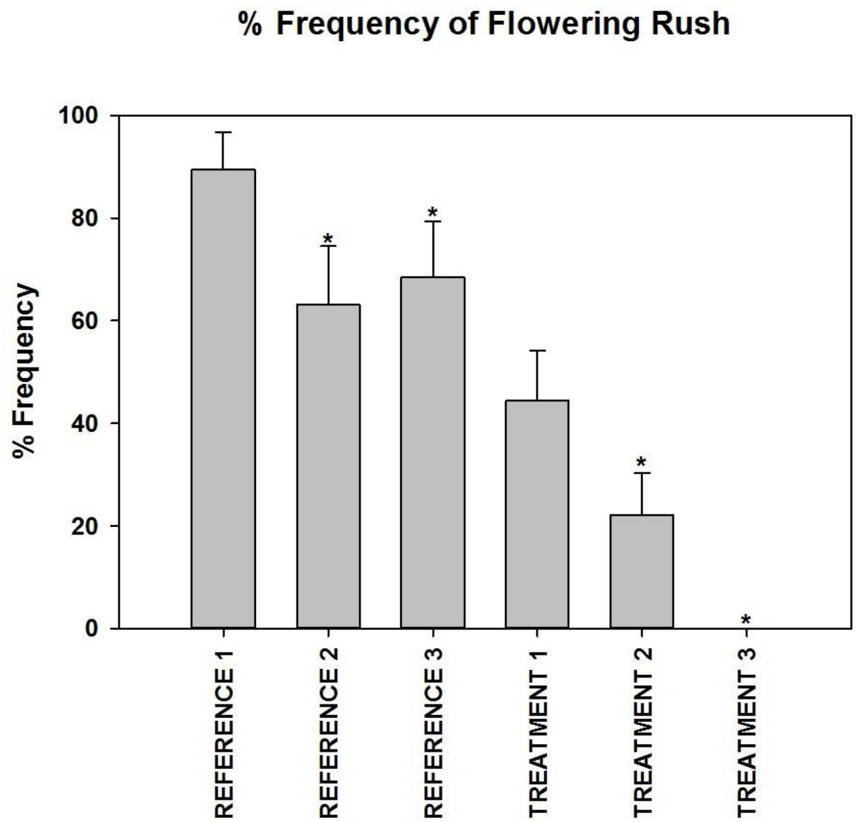

Figure 5. Percent flowering rush frequency in the reference and treatment sites on Lake Sallie. Numbers after site names represent data collection efforts. Reference and treatment site data were analyzed separately using paired t-tests. Bars with an asterisk above them are statistically different from the first data collection effort of a given site.

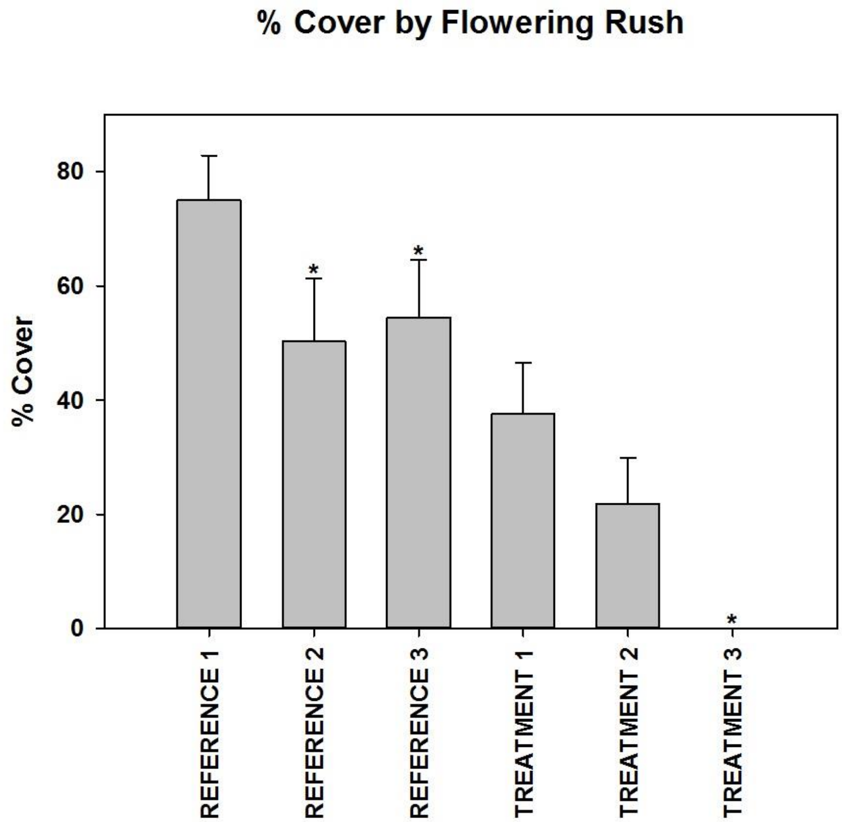

Figure 6. Percent flowering rush cover in the reference and treatment sites on Lake Sallie. Numbers after site names represent data collection efforts. Reference and treatment site data were analyzed separately using paired t-tests. Bars with an asterisk above them are statistically different from the first data collection effort of a given site.

Figure 7. Image of suspected damage (brown leaves on left side) to hardstem bulrush after the second diquat application.