FINAL REPORT

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CONTROL OF FLOWERING RUSH IN TOWN FARM BAY FINAL REPORT

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EXECUTIVE SUMMARY

We studied best management practices to control populations of flowering rush. Flowering rush (*Butomus umbellatus*) is an emerging threat to Lake Champlain wetlands and floodplain forests of Champlain direct drainage streams, both priority natural communities documented by Vermont FWD Natural Heritage Program. This grant was intended to better understand the extent of flowering rush in one area of Lake Champlain (Town Farm Bay, Charlotte, Vermont). We completed a survey and mapping of the area flowering rush, developed three treatment plots (control, pulling, and cutting), funded genetic testing of samples, funded a survey to improve field identification protocols, and helped determine if it is feasible to include management of flowering rush in our long-term stewardship of the area. The study occurred over the summers of 2020 and 2021. Results showed that flowering rush was widespread throughout the wetland area, and is likely spreading. The plants in this area are likely diploid (Gaskin et al. 2021), so seeds from flowers are likely viable and could be a source of spread.

Flowering rush is easily identified by the attractive pink blooms arranged in umbel form that appear throughout the growing season. However, we discovered that individual plants bloom at different points throughout the growing season, which could lead to an underestimate of the density. While the blooms are distinctive, the foliage is not. Flowering rush is very similar to American bur-reed (*Sparganium americanum*) and to a varying extent, other rushes.

Monitoring test plots over two growing seasons revealed some interesting dynamics:

1. Blooms take place periodically throughout the growing season. In our test plots, the highest density of blooms appeared during the months of July and August.
2. Pulling likely generated suppression of populations on a very localized basis.
3. Cutting limited growth of individual plants, but we could not determine the impact from 2020 to 2021.
4. This is a dynamic plant community. From 2020 to 2021 sweet flag (*Acorus sp.*) had the greatest impact on plant community composition, making a significant incursion, much greater than flowering rush.

Flowering rush has invaded ecosystems across the continent. Efforts have been undertaken to control this plant. A 2019 study (Turnage et al. 2019) indicates that control is possible. The study, and a discussion with one of the study's authors revealed the following:

A. Rush will respond to herbicide treatments. Diquat is the only formulation that has yielded documented results in field applications.

B. A degree of control can be achieved through repeated cutting. A protocol of 4 cuttings per season significantly reduced plant reserves and reproductive capacity.

C. Pulling is not a viable strategy, as it will likely result in the dispersal of rhizome fragments and rhizome buds, both displaying the propensity to produce new plants.

D. Documented studies involved dense stands (monocultures, or approaching monocultures) of flowering rush. We have not found documentation of control efforts where rush is a relatively modest component of a shallow emergent plant community, as we have in Thorp/Kimball wetlands.

Stewardship Conclusions - currently this plant is found at a ‘component’ level, <5% of shallow emergent plant community. Year to year survey and literature suggests that densities will increase. Control methods (mechanical, chemical) do not appear appropriate under this scenario. Detailed monitoring of infestation levels over a number of years (5 year minimum) would offer insight into the threat posed by flowering rush within this context - information that would likely add to the invasion ecology body of knowledge. Flowering rush can be monitored individually, but a detailed vegetation assessment for this plant community may be more revealing.

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1. PROJECT SYNOPSIS

We studied best management practices to control populations of flowering rush. Flowering rush (*Butomus umbellatus*) is an emerging threat to Lake Champlain wetlands and floodplain forests of Champlain direct drainage streams, both priority natural communities documented by Vermont FWD Natural Heritage Program. This grant was intended to better understand the extent of flowering rush in one area of Lake Champlain (Town Farm Bay, Charlotte, Vermont). Through this grant, we hoped to learn more about flowering rush, which appeared to have a growing presence in our priority wetlands (as identified in a 2018 site visit by Tina Heath, DEC Wetlands Scientist, and Meg Modley and Ellen Kujawa of the Aquatic Invasives group at LCBP). Our goals were to study the plant's distribution in this wetland and learn about when it flowers, learn if the population had viable seeds (e.g. to learn how this plant may spread through the wetland), clarify how to identify it (in relation to similar-looking species in the field, when not flowering), determine if non-chemical control methods (pulling, cutting) were viable to control the plant, and if it was feasible to include management of flowering rush in our long-term stewardship of the area. The study occurred over the summers of 2020 and 2021, and involved match time from four different local volunteers (for 24 hours total) in the survey and treatment work.

2. TASKS COMPLETED

We began this project by putting out an RFP and collecting bids (only one received, from Habitat Restoration Solutions, LLC), and contracting with HRS, then developing and receiving approval for a QAPP (Task 3). We then obtained approval from DEC Wetlands to conduct hand pulling in the wetland (Task 4). Next, we surveyed the area and established/flagged test plots (see Figure 1 below of surveyed area with polygon indicating the zone of highest rush density).

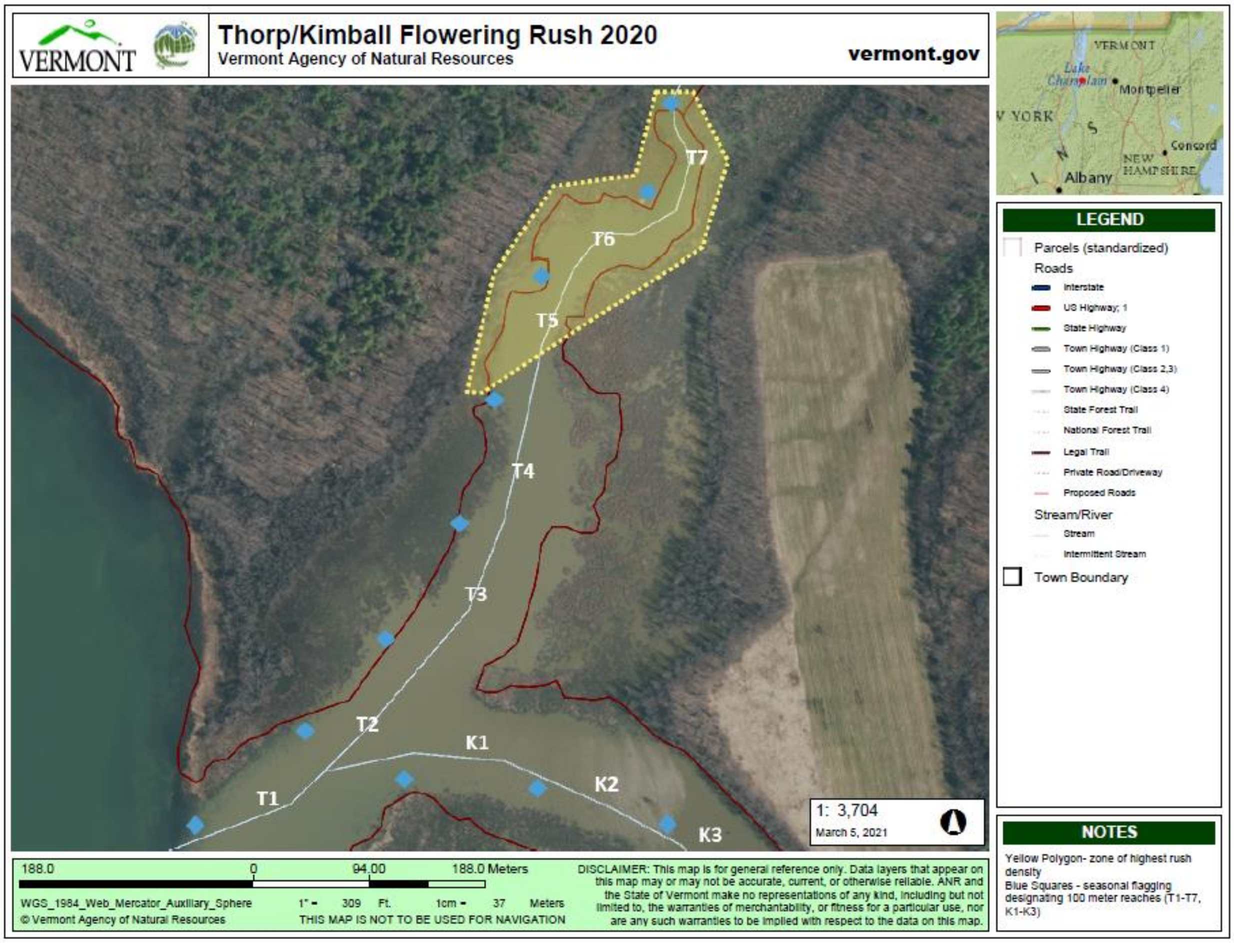

Figure 1. Survey area in Thorp and Kimball Brooks (blue squares indicating 100-meter reaches), and highest density of flowering rush (yellow polygon).

We made notes on shallow emergent plant community conditions as part of our survey. We collected samples for genetic analysis, and sent them to the lab for analysis. Finally, we collected data on plant response to pulling and cutting on our visits throughout the summer of 2020 (Task 5). We then continued field work in 2021 by attempting to measure plant response in year 2, and drafting a report indicating plant response in year 2, as well as field identification (Task 6). We completed a press release, Facebook and website posts (Task 7), and completed reporting (Task 8).

3. METHODOLOGY

For the portion of task 5 that included surveying the extent of flowering rush, the wetland complex was surveyed by canoe/kayak to determine extent of flowering rush. An initial survey was conducted on July 3, 2020, and additional surveys were conducted on July 20, August 22, and Sept 12, 2020. The area surveyed was the navigable sections of the wetland complex on that date. The area was divided into reaches approximately 100 meters in length. For each reach, absence/presence of Flowering rush was determined, and an approximation of rush coverage was made. Data were recorded on a field data sheet, and notes were made on the plant community conditions.

For the task 5 question regarding seasonal flowering, data were collected based on the detailed determination of presence of flowering with test plots. These test plots were established in a manner that allowed field workers to remove flowering plants without disturbing non-flowering and non-target plants. Plants that were flowering were removed (hand-pulled) were transported by canoe/kayak to floating scow/platform anchored in wetland; rhizomes, seeds, and flowers were be removed from plant body and left on the scow to desiccate, then removed at the end of the season to above the high-water line for disposal. Delineation of test plots that needed to persist into 2021 were marked with PVC tubing extending 1 meter into wetland bed.

For the task 5 question regarding response to cutting, five individual plants were marked and cut multiple times in 2020. Each time they were cut, re-growth was measured (linear height measurement, as measured from wetland bed). Plants were marked with PVC pipe driven into the wetland bed over the winter. The following July, the site was revisited to determine regrowth.

For the task 5 question regarding plant identification, we made qualitative observations to guide field differentiation between flowering rush and burr-reed outside of inflorescence.

For task 5 question regarding seed viability, we collected 10 plant samples as follows: 4 cm of a healthy, clean, leaf tip that has been wiped dry if wet, from one plant was placed in one silica bag. The silica will dry the plant tissue quickly, preserving the DNA and avoiding mold. This was repeated 10 times on one date during a field day (between 8 AM and 6 PM) (ten different plants, at least 5 meters apart from each other, both inside and outside the test plots), and the bags kept at ambient temperature, then shipped to USDA ARS NPARL as soon as all ten have been collected. Samples were labeled with date and location (latitude/longitude) of collection. Their genetic analysis protocol follows.

AFLPs

Genomic DNA will be extracted from approximately 20 mg of silica-dried leaf material using a modified CTAB method (Hillis et al. 1996). The AFLP method will follow Vos et al. (1995) with modifications as in Gaskin and Kazmer (2009). All 15 selective primer combinations of MseI + CAA, CAC, CAT, CTA, or CTA and EcoRI + AAG, ACC, or ACT are pre-screened for PCR product quality and number of variable loci using eight samples, and the two most polymorphic primer pairs were chosen (MseI + CAC/ EcoRI + ACT and MseI + CTA EcoRI + ACC). They omit AFLP data from any plants that did not produce a typical electropherogram pattern (i.e. noise > 20 relative fluorescence units (rfu) or failure to produce sufficient number of peaks). Final allele calls for loci are made manually with GeneMapper (ABI) at > 50 rfu; bin width of 1 base pair.

Similarity

Genetic similarity (Dice: 2a/(2a+b+c) where a=number of bands present in both samples, b and c=number of bands present in only one or the other sample, respectively) between genotypes will be calculated using the DIS/SIMILARITY module of NTSYS-pc v. 2.1 software (Rohlf 1992). To visually compare similarity of AFLP genotypes they will perform Principal Coordinates Analysis (PCoA) using Dice values and the DCENTER and EIGEN modules of NTSYS-pc. Number of genotypes (G) will be calculated manually in a spreadsheet of Dice similarity values. through genetic testing. Accuracy will be determined by USDA ARS NPARL testing lab.

4. QUALITY ASSURANCE TASKS COMPLETED

All quality control and invasive species spread prevention measures were taken. All GPS coordinates of 100 meter areas for sampling of flowering rush fell within 10 meters of the anticipated coordinate, meeting that accuracy goal. Although we missed one visit to the test plots (June 2021), we still made six of seven proposed visits (86% of visits, greater than our 80% quality assurance completeness goal).

5. DELIVERABLES COMPLETED

The RFP was issued on May 29, 2019, and the one bid was received. The contract with Habitat Restoration Solutions was approved June 11, 2019. The QAPP was approved June 23, 2020 (after a one year extension was granted in the fall of 2019). The letter from DEC was received in early July 2020. The report on genotype was received in September 2020. The map of test plots and distribution, and plant community report, was finalized in January 2021. After field work in summer of 2021, the final data sheet with results was completed in October 2021. A report indicating plant response to year 1 treatments and field identification was finished in December 2021. We had a difficult time monitoring cut plants from season to season, and drawing results from test plots, because there was so much variability year to year in both test and control plots, and it was difficult to determine if 2021 plant regrowth was from the same rhizome as the 2020 cut plants. Future work would likely need to be done in a lab situation, or be replicated many times over to adequately see changes. A press release, Facebook, website posts, and final reporting were completed in December 2021. Quarterly reports were submitted on time throughout the grant cycle.

6. CONCLUSIONS

Results showed that flowering rush was widespread throughout the wetland, and is likely spreading. The plants in this area are likely diploid (Gaskin et al. 2021), so seeds from flowers are likely viable and could be a source of spread. This study demonstrated the range of bloom periods for plants. The highest density of blooms appeared during the months of July and August, but were present in June and September as well. In surveying a wetland, we may be inclined to assess the density of flowering rush based on blooms alone. It is important to acknowledge that at any given point within the flowering season, only a fraction of the plants will be in bloom. There are a range of emergent plants displaying foliage similar to flowering rush (Figure 2). While individual plants can be identified (with some difficulty) based on foliage alone, it would be impracticable to do this on a landscape level. Field identification in the absence of flowers can be difficult, as a number of plants display similar growth pattern and leaf geometry (Figure 2). It is likely the case that new stands of suspected flowering rush will have to be observed over a period of time for positive identification.

The two other plant species we identified growing in close proximity to flowering rush are American bur-reed and grass-leafed arrowhead. Each has a distinctive bloom or fruit. In the absence of these the following may be helpful:

- We found the rush to be taller through the peak of the growing season
- Tips of rush leaves have a tendency to twist up to 90 degrees
- The base of the leaves above the root crown in the bur-reed and arrowhead grow in a rounded clump, similar to an onion. For the flowering rush, the base of the leaves grow in a 'stacked' pattern, which if cut would display a linear cross-section.

Figure 2. Bottom to top: flowering rush (*Butomus umbellatus*), American bur-reed (*Sparganium americanum*), grass-leaf arrowhead (*Sagittaria graminea*)

While pulling may have resulted in very localized reductions (within a 10'x30' test plot) we do not know how many plants were spawned in the process by releasing root buds and rhizome fragments in the water column. We could not validate the decline in local population, as both treatment and control plots recorded reductions from year 1 to year 2. We did observe a seasonal variation in densities of root buds on pulled plants (fewer present in June than later in the season). Pulling is not a viable strategy, as it will likely result in the dispersal of rhizome fragments and rhizome buds, both displaying the propensity to produce new plants. Repeated cutting appeared to result in a less robust plant, which suppressed flowering and seed production. This was supported by results in the Turnage et al. (2019) technical paper. We had a difficult time monitoring cut plants season to season. The Turnage study was conducted under laboratory conditions. One of the paper's authors, John D. Madsen, confirmed that repeated cuttings likely would not result in plant mortality. While the authors studied the effects of repeated cutting, the field practice they were considering was based on mechanical, non-selective cutting with a relatively large aquatic harvester. They did not envision hand cutting individual plants. Our results, combined with those of Turnage et al. (2019) may indicate that mechanical clipping multiple times over the season could decrease viability of individual plants, as well as decreased seed production. However, given the widespread and dispersed nature of flowering rush in our study wetland, it does not seem a viable option for volunteers for tackle. It may be a more viable option for small, new infestations that are limited in size.

Control methods (mechanical, chemical) do not appear appropriate under this scenario. Detailed monitoring of infestation levels over a number of years (5 year minimum) would offer insight into the threat posed by flowering rush within this context - information that would likely add to the invasion ecology body of knowledge. Flowering rush can be monitored individually, but a detailed vegetation survey for this plant community may be more revealing. It would be helpful to develop a better protocol for estimating flowering rush densities within the various wetland plant communities.

7. REFERENCES

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8. APPENDICES

Appended Documents:

Press release attached.

Photos:

Flowering rush flowers in the Thorp/Kimball wetland. Photo credit: Kate Kelly

Lewis Creek Association's Program Manager Kate Kelly pulls flowering rush from the Thorp/Kimball wetland. Photo credit: Robert Hyams.

Flowering rush in one of the high-density areas, flowering near native plants in the Thorp/Kimball wetland. Photo credit: Kate Kelly

Robert Hyams prepares to launch canoe loaded with hand-pulled flowering rush plants. Photo credit: Kate Kelly

Bottom to top: flowering rush (*Butomus umbellatus*), American bur-reed (*Sparganium americanum*), grass-leaf arrowhead (*Sagittaria graminea*). Photo credit: Robert Hyams

Electronic Data:

E-mailed to Project Officer.