PATRICK LEAHY
Lake Champlain
Basin Program

TECHNICAL REPORT NO. 113

Riparian Buffer Establishment Using Various Management Techniques

October 2025

Prepared by: Stever Bartlett and Dr. Kris Stepenuck
University of Vermont

For:
The Lake Champlain Basin Program and NEIWPCC

This report was funded and prepared under the authority of the Lake Champlain Special Designation Act of 1990, P.L. 101-596 and subsequent reauthorization in 2002 as the Daniel Patrick Moynihan Lake Champlain Basin Program Act, H. R. 1070, through the US EPA. Publication of this report does not signify that the contents necessarily reflect the views of the states of New York and Vermont, the Lake Champlain Basin Program, the US EPA or the Great Lakes Fishery Commission.

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NEIWPCC Job Code: 0100-328-002

FINAL REPORT

NEIWPCC Job Code:	0100-328-002
Project Code:	L-2020-024
Contractor:	University of Vermont
Prepared By:	Stever Bartlett and Dr. Kris Stepenuck
Project Period:	4/17/2020-7/31/2023
Date Submitted:	July 6, 2023
Date Approved:	July 10, 2023

RIPARIAN BUFFER ESTABLISHMENT USING VARIOUS MANAGEMENT TECHNIQUES FINAL REPORT

CONTACT INFORMATION

University of Vermont

81 Carrigan Dr, Burlington VT 05405

802-868-1048

kstepenu@uvm.edu

This is a Lake Champlain Basin Program and NEIWPCC funded project.

This project was funded by an agreement awarded by the Great Lakes Fishery Commission to NEIWPCC in partnership with Lake Champlain Basin Program.

EXECUTIVE SUMMARY

In riparian areas of the northeastern United States, well-established reed canary grass (*Phalaris arundinacea*) stands are common and have proven to be a challenge for the success of tree plantings during riparian forest restoration projects. To address the opportunity for widespread forest restoration and the challenge of reed canary grass (RCG) infestations, the purpose of this experiment was to assess survival of native trees subject to glyphosate, till and mowing management techniques vs. herbicide-free till and mowing management techniques, and to compare RCG density between plots under caried treatments over time. To accomplish this, treatment plots of ten species of native tree stems were planted at eight sites and stem survival was assessed over two growing seasons. In addition, percent cover of RCG was recorded at each site. Chi Square, independent T-test and binary logistic regression statistics were used to assess tree stem survival and the relationship between tree stem survival and percent cover of RCG between treatment and control plots. The data suggest that preparing plots by tilling and the application of herbicide (glyphosate) combined with two mowing events in each of the two growing seasons did not result in higher tree stem survival rates than the treatment plots that were prepared by tilling only and were mowed four times in each of the two growing seasons. As was expected, plots treated with glyphosate, significantly reduced reed canary grass density in the first growing season. However, after the second growing season the percent cover of RCG in the mechanically treated and chemically treated plots was not statistically different. This suggests that the mechanical prescription was as effective at RCG suppression than the chemical, during the second year. Furthermore, the odds ratio produced by the binary logistic regression models in this study can be useful to practitioners and landowners when considering which methods of management to use in restoration projects.

As this project was undertaken, a variety of news stories were developed and published. These were picked up by local media in communities as well as UVM and were always published by Lake Champlain Sea Grant and the Watershed Forestry Partnership. In addition, the project was featured in a Restoration Roundup podcast of the Watershed Forestry Partnership, also funded by LCBP. A master’s thesis and scientific manuscript were developed, and a guidance document for individuals within the basin was prepared. This report is accompanied by photos and data collected during the project period from fall 2020 through fall 2022.

CONTENTS

1. PROJECT SYNOPSIS

In riparian areas of the northeastern United States, well-established reed canary grass (*Phalaris arundinacea*) stands are common and have proven to be a challenge for the success of tree plantings during riparian forest restoration projects. The impacts of reed canary grass (RCG) on the habitats it invades are numerous. Reed canary grass reduces biological diversity by homogenizing habitat structure, richness, and environmental variability. Its rapid growth rate and invasive nature limit tree regeneration in riparian forests by shading and crowding out seedlings. Riparian forests improve water quality, wildlife habitat, flood control, and provide a variety of other ecosystem services. As such, there is interest in restoring riparian areas that have been inundated by reed canary grass stands to forest.

A critical step to promoting and ensuring widespread adoption of riparian forest restoration efforts is to identify best practices for site preparation and maintenance at locations where RCG has become well-established. Due to its invasive nature, the time, labor and cost of managing plantings to encourage high percent survival have made restoration efforts challenging. To ease the restoration process, the herbicide glyphosate is commonly used to eliminate reed canary grass prior to tree planting. Recent research has suggested that glyphosate may have sublethal and chronic impacts on wildlife and people, with particular impact on birds.

To address the opportunity for widespread forest restoration and the challenge of reed canary grass infestations, the purpose of this experiment was to assess survival of native trees subject to glyphosate, till and mowing management techniques (treatment B) vs. herbicide-free till and mowing management techniques (treatment A), and to compare RCG density between treatment and control plots over time. To accomplish this, treatment A and treatment B plots of ten species of native tree stems were planted at eight sites and stem survival was assessed over two growing seasons. In addition, percent cover of RCG was recorded at each site. Chi Square, independent T-test and binary logistic regression statistics were used to assess tree stem survival and the relationship between tree stem survival and percent cover of RCG between treatment and control plots. It can be concluded that preparing plots by tilling and the application of herbicide (glyphosate) combined with two mowing events (treatment B) in each of the two growing seasons did not result in higher tree stem survival rates than the treatment A plots that were prepared by tilling only and were mowed four times in each of the two growing seasons. As was expected, treatment B plots (glyphosate use) significantly reduced reed canary grass density in the first growing season. However, after the second growing season the percent cover of RCG in the treatment A and treatment B plots was not statistically different. This suggests that the treatment A prescription was as effective at RCG suppression than the treatment B, during the second year. Furthermore, the odds ratio produced by the binary logistic regression models in this study can be useful to practitioners and landowners when considering which methods of management to use in restoration projects.

2. TASKS COMPLETED

Task 0. Order stems. We worked with the Intervale Nursery to order 1400 native tree and shrub bare root stems ranging from 2-4 feet in size, which were planted in spring 2021. All species were naturally occurring in clayplain forests. These included: red maple - *Acer rubrum*, silver maple – *Acer saccharinum*, swamp white oak - *Quercus bicolor*, bur oak - *Quercus macrocarpa*, American basswood - *Tilia Americana*, silky dogwood - *Cornus amomum*, red osier dogwood - *Cornus sericea*, nannyberry - *Viburnum lentago*, arrowwood - *Viburnum dentatum*, and grey dogwood - *Cornus racemose.*

Task 1. Develop QAPP. A quality assurance project plan was developed and approved for the research project. This was submitted along with this final report for complete record-keeping.

Task 2. Study site selection. We worked with VT Fish and Wildlife staff to identify the population of reed canary grass riparian stands in Vermont Fish and Wildlife Department Wildlife Management Areas within the Champlain Valley that were not subject to ice scour, that were designated as clayplain forest natural communities, and that allowed for tractor access for site preparation. From those, we randomly selected eight sites at which to implement this research. The wildlife management areas from north to south are: Little Otter Creek (locally known as Slang Creek) in Ferrisburgh, Lower Otter Creek in Vergennes, Dead Creek in Addison, Whitney/Hospital Creek in Addison, and Lemon Fair River in Cornwall. A suite of photos has been submitted along with this final report. Site descriptions are included in figures 1-3 and in tables 1 and 2 below.

Figure 1: Riparian restoration site locations. Locations of eight research sites in Central Vermont.

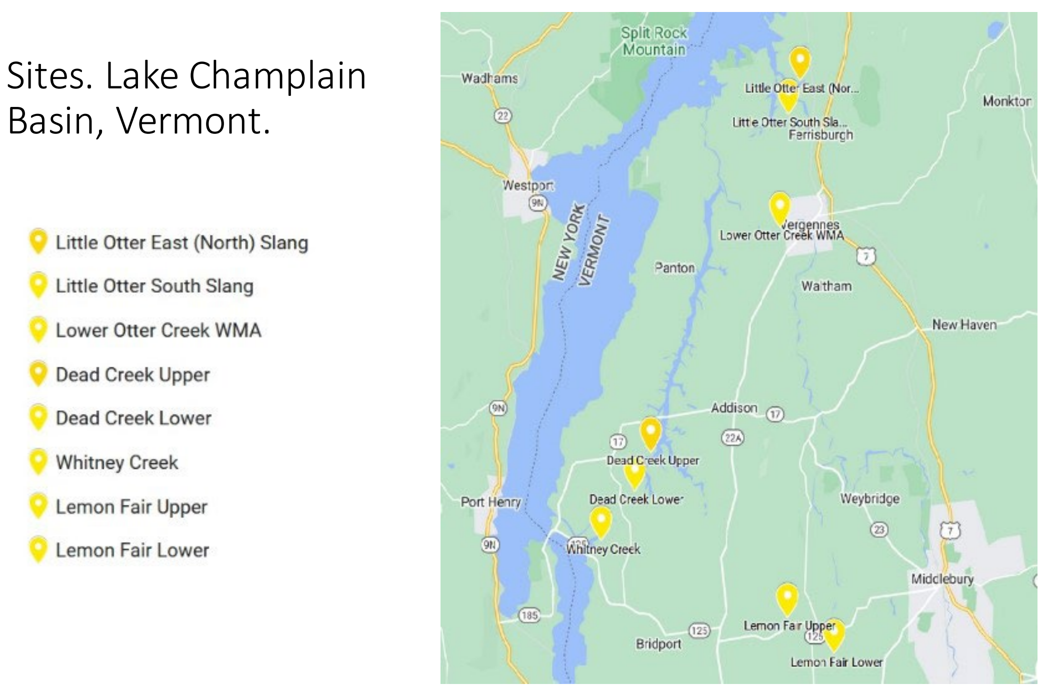


Table 1. Site locations. Site locations from north to south by town, wildlife management area, soil type and geographic coordinates.

Site and Site ID	Town, State	Wildlife Management Area	Soil Type	Geographic Coordinates
Slang Creek East (North) Site ID = SEN	Ferrisburgh, VT	Little Otter Creek WMA	Swanton Fine Sandy Loam and Covington/Panton silty clays	44.22857098228275, -73.25989956227517
Slang Creek South Site ID = SS	Ferrisburgh, VT	Little Otter Creek WMA	Covington/Panton silty clays	44.220443845457, -73.26746793531356
Lower Otter Creek Site ID = LOC	Vergennes, VT	Lower Otter Creek WMA	Vergennes clay	44.16577036817095, -73.27292136210052
Dead Creek Lower Site ID = DCL	Addison, VT	Dead Creek WMA	Covington/Panton silty clays	44.064542663743545, -73.36275510821979
Dead Creek Upper Site ID = DCU	Addison, VT	Dead Creek WMA	Covington/Panton silty clays	44.064077410423785, -73.36401977876764
Whitney Creek Site ID = WC	Addison, VT	Whitney/Hospital Creek WMA	Covington/Panton silty clays	44.031498748233005, -73.38896355778077
Lemon Fair Lower Site ID = LFL	Cornwall, VT	Lemon Fair WMA	Livingston clay, flooded	43.993030261471475, -73.24777324184952
Lemon Fair Upper Site ID = LFU	Cornwall, VT	Lemon Fair WMA	Vergennes clay	44.031498748233005, -73.38896355778077

Figure 2: Map of land use in the study area of the Lake Champlain Valley of Vermont. Land use associated within each of eight research sites. Map Credit Jordan Rosenthal.

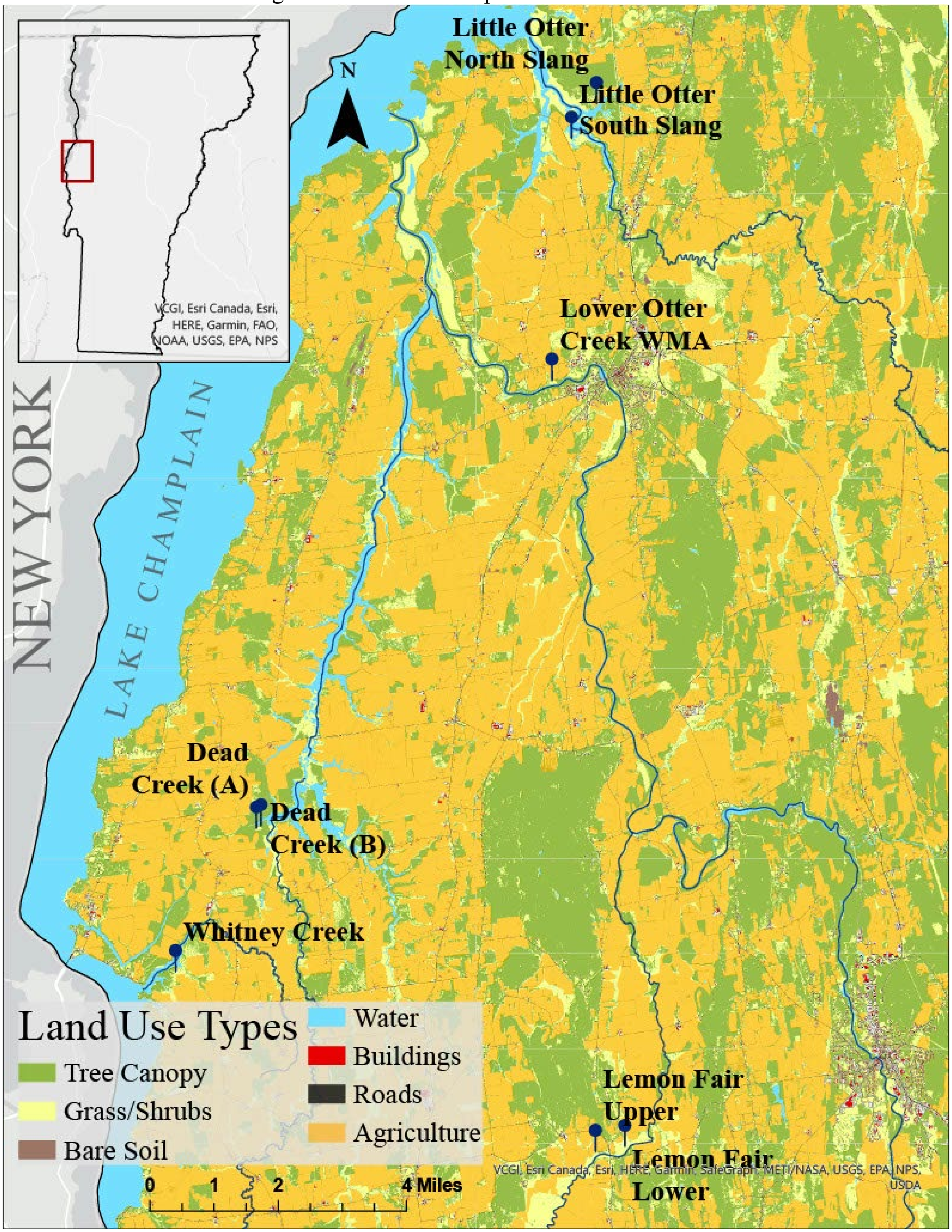


Figure 3: Map of soils. Soil type associated with each of eight research sites in the Lake Champlain Valley. Map credit Jordan Rosenthal.

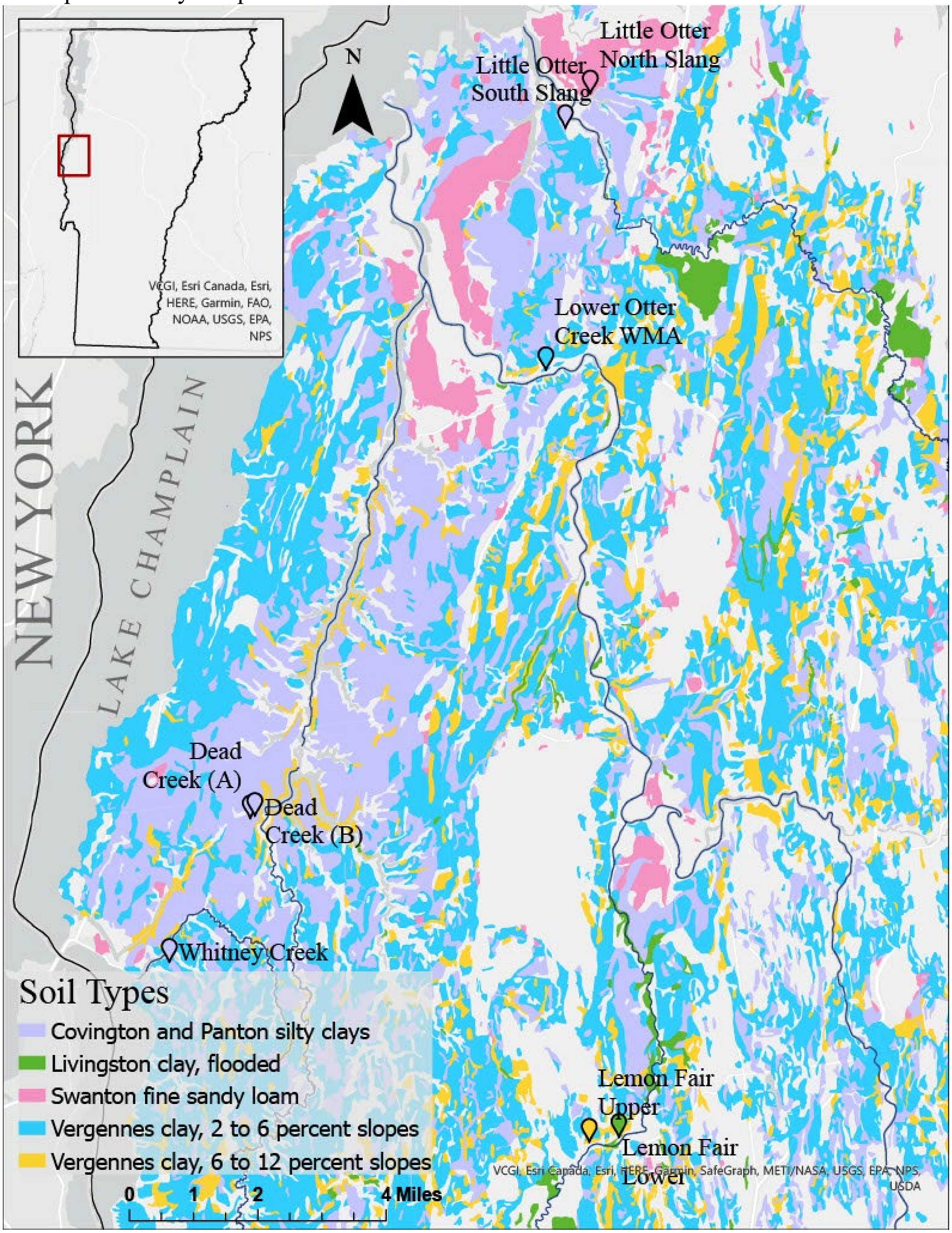


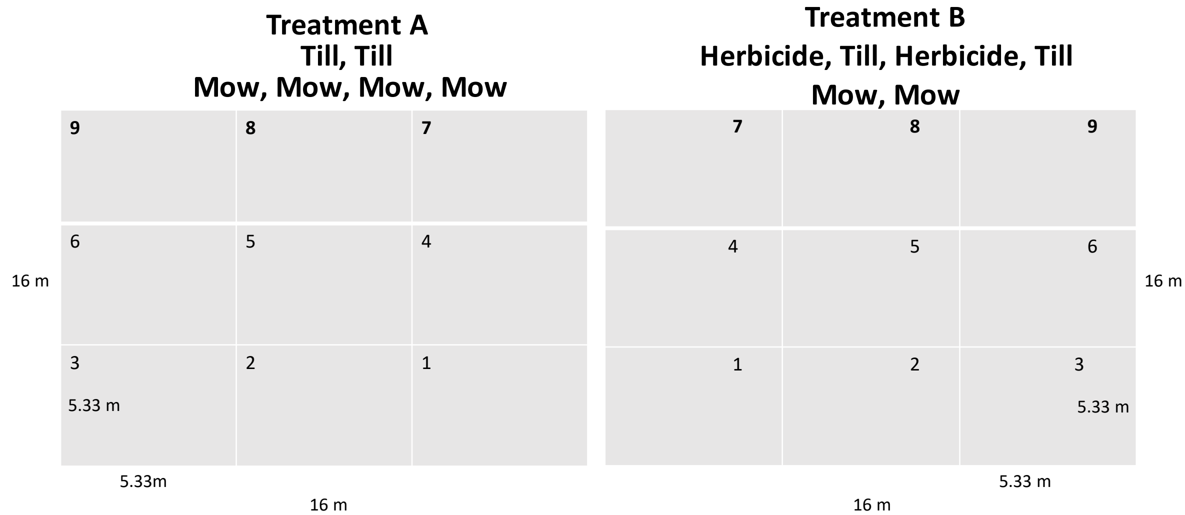
Table 2: Site location, elevation (m) and distance from water body (m). These were used to calculate slope (*m=rise/run*) of the study site from the highest to lowest point on the plot.

Site and Site ID	Elevation	Distance from water body
Slang Creek East (North) Site ID = SEN	32m	71m
Slang Creek South Site ID = SS	31m	15m
Lower Otter Creek Site ID = LOC	31m	170m
Dead Creek Lower Site ID = DCL	37m	205m
Dead Creek Upper Site ID = DCU	38m	208m
Whitney Creek Site ID = WC	32m	115m
Lemon Fair lower Site ID = LFL	43m	54m
Lemon Fair Upper Site ID = LFU	45m	71m

Task 3. Site preparation.

For each of the eight sites, a 0.05 ha plot was established and divided into two square 0.025 ha plots adjacent to each other. A square plot design was chosen to minimize edge influence of surrounding reed canary grass and minimize corrections that would be needed in the calculation of spatial statistics. Each .025 ha plot was divided into nine 5.33 x 5.33 m subplots for ease of counting live and dead stems, estimation of RCG percent cover, and to allow for analysis of variance (Figure 2.4).

Figure 2.4: Plot design and pre-planting preparation. Dimensions of treatment A, treatment B, and subplots, as well as tilling and herbicide prescription.



Two pre-planting treatments were made for each of the eight sites in September through October of 2020. Treatment A plots consisted of mowing (to remove standing RCG) and tilling twice separated by 16 days, and treatment B plots were mowed (to remove standing RCG) and herbicide was applied a week before each of the two tilling dates. In early September of 2020 the plots were mowed with emphasis on expelling cut grass beyond the edge of the plots to reduce thatch on the soil surface which inhibits herbicide infiltration and can clog the tiller tines when tilling. On September 22nd, 2021, a 2% active ingredient glyphosate solution (Rodeo®) was applied to treatment B plots using a 18.92 L (5 ga) backpack sprayer and 78.66 ml (2.66 oz) of 53.8% ai concentrate per 3.78 L (1 ga) of water as directed by label. Following label recommendations 75.70 L (20 ga) of glyphosate solution was applied across the eight treatment B plots for an application rate of 3.14 L (3.32 quarts) per .40 ha (1 ac). Helfire® brand herbicide adjuvant (active ingredients animated phosphoric, carboxylic acids, sulphurated amides) was added at a rate of 94.63 ml (3.2 oz) per 18.92 L (5 ga) as directed by label. Blue food coloring dye was used to allow visibility and ensure even application. Particular attention to droplet size was taken to reduce drift of herbicide. Tilling was conducted six days later on September 28th, to allow adequate time for stem and grass blade cellular damage as well as root absorption and based on the manufacturer recommendation for the herbicide. The treatment A and treatment B plots were tilled using a Kubota L039 tractor (39 HP) and a 3 pt. hitch, 66" tiller Landpride Model RTA1266. The desired till depth was 20 cm (8 inch) and due to the lack of precipitation, the soils were extremely hard, and a depth of 12.7 cm (5 in) was accomplished (note second tilling in October achieved the 20 cm (8-in) desired depth. Ten days later (October 7th), was the scheduled date for second herbicide application. Due to rain on that day, it was postponed and completed on October 9th. On October 14th the treatment A and treatment B plots were tilled again. Due to recent precipitation which provided softer soil, the desired depth of 20 cm was achieved.

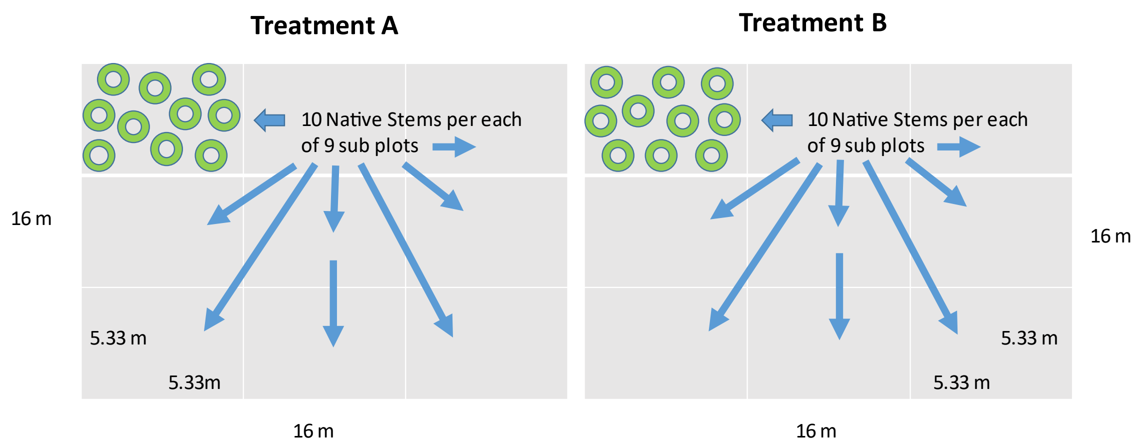
Task 4. Prepare to plant.

In April of 2021, the touching border between the treatment A and treatment B plots received a rubberized weed retention fabric installed as a 33 cm (12 in) vertical barrier to prevent grass and rhizome migration between the control and treatment plots. The treatment A and treatment B plots were each divided into nine square subplots of 5.33m x 5.33m and corners were indicated with steel marking flags. Hot pink flags were used to mark treatment B subplots while treatment A subplots were marked with blue flags.

Task 5. Plant and maintain plots.

From April 29 to April 30th, 2021, all sites except the two Lemon Fair sites were planted. The planted sites were wet with saturated soils or standing water, yet manageable for planting. The two Lemon Fair sites were under 15- 20 cm (6-8 in) of standing water and not conducive to planting during the April 29th to 31st planting period. On May 9th and 10^{th,} the Lemon Fair Upper and Lower sites were planted successfully. Bare root stems were purchased from Intervale Center Conservation Nursery in Burlington VT, USA. Stems were planted by hand 0.75m to one meter apart at a density of ten stems per subplot, which was 90 stems per .025 ha plot. A total of 180 stems were planted in each of the eight plots (Figure 2.5). That was a rate of 1440 stems per 0.40 ha (1 ac). Species were randomly planted and not placed in lines or rows. Each subplot received American basswood (*Tilia americana*), arrowood (*Viburnum dentatum),* burr oak (*Quercus macrocarpa*) grey dogwood (*Cornus racemosa*), nannyberry (*Viburnum lentago)* red maple (*Acer rubrum*) red osier dogwood (*Cornus sericea*), silky dogwood (*Cornus amomum*), silver maple (*Acer saccharum)* and swamp white oak (*Quercus bicolor*). Red osier dogwood (*Cornus sericea*) and silky dogwood (*Cornus amomum*) stems were 1.2 m to 1.5 m in height and the remaining eight species' stems were all between 0.60 m and 1.2 m in height. Each stem received a strip of surveyor tape tied on an upper sturdy part of the stem to help in locating trees during later site management and monitoring. This was important because it aided in visually locating stems as surrounding vegetation height increased over the summer. Biodegradable surveyor tape was used to prevent waste and potential for microplastics entering the environment if the tape fell off. The biodegradable tape degraded sooner than expected and each of the 1,140 trees was tagged again in May of 2022 with plastic surveyor tape to ensure stems could be visible for counting in the future months.

Figure 2.5: Planting design. Each subplot within the treatment A and treatment B plots was planted with the same ten native species. Spacing between stems was 0.75 - 1 m and stems were planted in random locations not in lines or rows.



Each site was visited four times in the growing season of 2021 and four times in the growing season of 2022. In the first week of June 2021, each site was visited and the vegetation growing on the treatment A and treatment B plot was cut to ground level using a battery powered 56-volt handheld Ego weed eater. Careful attention was made to not cut tree stems with the weed eater. In the first week of July 2021, only the treatment A plots were cut with the weed eater. In the first week of August 2021, both the treatment A and B plots' vegetation was cut again, and in the first week of September only the treatment A plot vegetation was cut. The same pattern was repeated for the growing season of 2022 (Table 2.3). The maintenance protocol for manual weed cutting of RCG was a recommendation of the steering committee to: 1) Allow seedlings to have access to sunlight and reduce competition; 2) Minimize ideal winter habitat for voles and other rodent predators in the vicinity of the stems; 3) Maintain RCG shorter than the planted tree stems to most easily observe and ultimately ensure stems were not accidentally destroyed during future maintenance; 4) To mimic the anticipated capacity of landowners/land managers to maintain a site with little external assistance.

Table 2.3: Maintenance protocol for 2021 and 2022. In 2021 and 2022, treatment A plots at each site were mowed each month between June and September. In 2021 and 2022, treatment B plots were mowed in June and August.

	June	**July**	**August**	**September**
Treatment A (herbicide-free)	Mow	Mow	Mow	Mow
Treatment B (glyphosate use)	Mow	None	Mow	None

Task 6. Conduct outreach. A variety of news articles and outreach was conducted through the project period. These are summarized in the table below.

Description of Outreach	Date	Location	Links
News article by Lisa Halvorsen, UVM Extension	11/10/2020	Sent to multiple media sources. Published by: UVM; Bennington Banner; Lake Champlain Sea Grant	https://www.uvm.edu/news/story/researcher-receives-grant-riparian-buffer-study https://www.benningtonbanner.com/riparian-research/image_221037fa-23c7-11eb-9581-03f44be001cc.html https://www.uvm.edu/seagrant/news/graduate-student-receives-grant-riparian-buffer-study
News article by Stever Bartlett	6/7/2021	LCSG	https://www.uvm.edu/seagrant/news/ongoing-riparian-buffer-study-plots-planted-native-tree-species
Podcast (and supporting news article)	10/26/2022	LCSG; Spotify and other podcast locations	https://www.uvm.edu/seagrant/news/graduate-students-study-restoration-wetland-ecosystems https://www.uvm.edu/seagrant/watershed-forestry-partnership/restoration-roundup-podcast/graduate-student-research-roundtable
Local and regional agencies and organizations were invited to Bartlett's thesis defense and spring 2023 Webinar.	12/8/2022 5/30/2023	Teams and in-person Webinar for Restoration practitioners, managers and landowners	NA https://www.uvm.edu/seagrant/programs/events/got-reed-canary-grass-got-trees-and-want-riparian-plantings-grow

Task 7. Submit reports. Quarterly project updates were prepared that summarized progress to date and challenges. These were submitted beginning for the fall 2020 quarter through to the fall 2022 quarter.

Task 8. Maintain plots and collect data. In the second year following planting (May-October 2022) we continued to conduct management techniques and collect data, measurements and photos. See Task 5 description. A split plot design was used to evaluate the effect of treatment methods on stem survival with primary predictors of percent cover of RCG, year, and site location. Soil nutrient and heavy metal concentrations were added to the model as well. In the summer of 2021, soil samples were collected and taken to the University of Vermont laboratory for nutrient and metal analysis. Samples were taken from the center of the subplot numbered “5”, for each treatment A plot and treatment B plot, at each of the eight sites. T-tests were run to determine “no difference” in soil type between A and B plots ($p < 0.05$). Phosphorus (P), organic soil matter and aluminum (Al) were compared for the T-tests. No significant differences were found when comparing these parameters across A and B plots across the eight study sites. Phosphorus ($p = 0.582$), soil organic matter ($p = 0.946$), or aluminum ($p = 0.795$).

In the 2021 growing season, each site was visited four times,in the first week of June, July, August, and September. Trees were counted and recorded on a data sheet as live or dead in each of nine subplots for the treatment A plot and treatment B plot for all of the eight sites. Out of the ten stems in each subplot, the stems that were deceased and could be identified by species were documented, and if mechanism of death was evident, that was also recorded. In addition to counting mortality of stems in each subplot, a visual estimation of percent coverage of RCG was recorded for each subplot. For each subplot in the A and B plots, a 1m x 1m quadrat was placed in the approximate center of the subplot and a visual estimate of the percent cover of reed canary grass in the quadrat was recorded. Then without removing the quadrat, a visual estimate of the percent cover of reed canary grass in the entire subplot was made and recorded. This assisted in estimating subplot RCG cover because subplots were not uniform in RCG cover and quadrates had higher or lower percent cover than the entire subplot. The quadrat served as a good visual aid for accuracy. Photo documentation of both plots was taken for each visit during the plot preparation period, the planting process, the 2021 growing season, and the 2022 growing season.

Task 9. Prepare scientific paper. A master’s thesis was prepared by Stever Bartlett and was modified and submitted to Restoration Ecology (June 2023) for consideration for publication in this peer-reviewed journal. A master’s committee was comprised of three faculty at the University of Vermont. This included Dr. Kristen Underwood (committee chair), Dr. Bill Keeton, and Dr. Kristine Stepenuck (academic advisor). Through their roles as committee members, they provided review and critique of the manuscript to ensure its strength and validity. The thesis included a literature review of known peer-reviewed works relevant to the study as well as a summary of ongoing similar work in the Lake Champlain basin and Vermont. Bartlett’s thesis was submitted along with this report as a deliverable. The manuscript that was submitted for publication consideration is also included as a deliverable.

Task 10. Prepare guidance and host training.

A guidance document and associated training was developed that operationalize techniques followed for site preparation and planting, and that shares challenges, recommendations, and results. Its purpose was both to allow landowners who may be considering riparian restoration to understand potential pros and cons of tree/shrub survival based on a traditional herbicide-based approach with minimal management following planting to a non-herbicide, but heavily labor-intensive approach to weed management to enhance survival of seedlings. The guidance document and training included reference to ongoing similar work in the Lake Champlain basin and Vermont.

Task 11. Prepare final report. This report serves as the project final report. Articles, photographs and maps are included here or have been submitted along with the report.

3. METHODOLOGY

Methods are described above in tasks 2 through 5 above.

4. QUALITY ASSURANCE TASKS COMPLETED

All planned quality control measures were taken and this project was in compliance with the planned QAPP. One request to modify the QAPP was requested and approved as related to the statistical program to use for analyses. SPSS was used in place of R.

5. DELIVERABLES COMPLETED

Deliverables included here or as attachments to be submitted with this final report include:

- Invoice listing tree and shrub species and quantities
- Approved QAPP
- Location information and photos of the 8 study sites
- Tiller rental and herbicide receipts
- Photos of tilled/herbicided sites
- Plot maps
- Tree receipt
- Volunteer planting schedule
- Equipment rental details
- Photos of plots and tree survival
- Data from plot assessments
- Press releases (see task 6 above)
- Quarterly reports (previously submitted)
- Scientific manuscript submitted for consideration for publication to X journal
- Stever Bartlett thesis

6. CONCLUSIONS

Based on the average percent survival of tree stems across all eight sites, there was no difference in survival in treatment A (site prepared by tilling and mowed four times per growing season) or treatment B (site prepared by tilling and herbicide and mowed two times per growing season) plots in year one. Overall survivorship in year one was similar to previous studies (Sweeney & Czapka, 2004; Hovick and Reinartz 2007) at 91.8 % treatment A and 91.5 % treatment B. Although survivorship in year two (81%) was 10% less than year one in the B plots (herbicide and till), it was still higher than a similar study by Hovick and Reinartz, (2007) that registered 50.5 % survival for their herbicide and plow plot after two years. This gives evidence that adding mowing to herbicide and till preparation methodology increases tree stem survival. Observational data and pictures recorded that two of the eight sites had much higher densities of RCG outside of the plots than the others. Those sites also showed less effective RCG control by either treatment A or B. Choosing restoration sites with initial lower RCG density and shorter stands of grass for restoration plantings is recommended and is a suggested area of future study.

Herbivory can be a significant cause of mortality in restoration projects. Few stems in this study indicated mortality from herbivory. No stems indicated girdling which is a common cause of mortality (Heroldova et al., 2012). By controlling the density of RCG it reduced the habitat (in the plots) that is conducive to mole, vole, and rodent species that girdle stems. Restoration practitioners currently use plastic tube stem shelters to prevent girdling and other herbivory (deer browse) (Sweeney & Czapka 2004). Tree shelters were not used in this study because of the associated micro plastic contamination that occurs as a result of such planting practices, and because using plastic shelter tubes is an environmental concern (Chau et al., 2021). Additionally, a comprehensive life cycle assessment study and multi factor overall analysis suggests planting seedlings without tree shelters is the environmentally preferable option (Chau et al., 2021).

Reed canary grass cover in this study presented some unexpected results from previous studies. First, the treatment A plots showed a 3.7 % decrease in percent cover from 2021 to 2022, when percent cover was expected to increase based on knowledge obtained about exponential RCG growth in year two after non herbicide management practices (Clark & Thomsen, 2020; Hovick & Reinartz 2007; Sweeney & Czapka 2004). Second, the increase in RCG cover in the B plots (herbicide), which was 9.5 % from year one to year two, was not expected because previous research (Hovick & Reinartz 2007; Sweeney & Czapka 2004) found herbicide and plow methods to be more effective at reducing RCG after two growing seasons. Third, as RCG cover in the treatment A plots was lower than in the treatment B plots after two years, our findings suggest that herbicide and tilling is not more effective than non-herbicide options. Although the reduction in RCG cover in the treatment A plots was unexpected, it could be explained by the repetitive weed eating in the design of this study. The four weed eating events in each growing season allowed for the establishment of a dense surface cover of the invasive species bird's-foot trefoil (*Lotus corniculatus*, also called bird's-foot Deer Vetch) at all sites but the Lemon Fair Upper and the Lemon Fair Lower. The encroachment of bird's-foot trefoil likely prevented the excessive establishment of RCG. This is similar to the role that cover crops provide for agricultural fields, suggesting that planting cover crops after tilling in the fall could provide dense ground cover to outcompete RCG to the point that mowing as a management tool might not be necessary. Future research on cover cropping and its effect on RCG is needed and could be a suitable non-chemical method to apply to restoration projects of large scale.

The time commitment involved in preparation, planting and site management, was large and obstacles such as weather, site access, site moisture and issues around weed cutting efficiency all contributed. This study indicated that weed cutting was a predictor of tree survival success and puts forward that future planting designs incorporate planning to allow for mowing on a larger scale using tractors or other haying equipment. A common problem for mowing is that the spacing in between tree stems needs to be significant in distance to allow for tractor passage. This reduces planting density. To accomplish desired planting density, the use of high horse-power, four wheel drive mini tractors (often used in vineyards and small mountain farms in Europe) for mowing would be a close substitute for handheld weed cultivation. This could result in the ability to achieve desired planting densities and still mow in between trees effectively and efficiently. Other possible solutions to the time and energy commitment of manually mowing RCG is to tap into citizen science and examine opportunities for volunteer groups to manually weed eat vegetation at planted restoration projects.

There were limitations to this study that future research could include. A true control was not used because research and knowledge is well documented that survival of tree stems planted in densely vegetated RCG stands with no mechanical or chemical manipulations is very low (Adams & Galatowitsch, 2006; Galatowitsch, 2000; Hovick & Reinartz, 2007). Additionally, the study could have been more robust by measuring RCG biomass and tree stem growth over the two growing seasons. Measuring survival success by species in each of the subplots would have provided some additional insight into the effect of treatment on tree species.

This study provides a picture of the survival of tree stems and growth patterns of RCG across multiple sites with different prescriptions for site preparation and site maintenance over two years. It can be concluded that preparing plots by tilling and the application of herbicide (glyphosate) combined with two mowing events in each of the two growing seasons (treatment B) did not result in higher tree stem survival rates than the treatment plots that were prepared by tilling only and were mowed four times in each of the two growing seasons (treatment A). This result suggests such methods may be a viable alternative to standard herbicide application methods for riparian restoration at sites with endangered or protected species, sensitive ecosystems, wetlands, herbicide prohibition, or that have landowners who prefer to use non-herbicide control methods. Additionally, dense ground cover of bird's-foot trefoil was established at six of the eight study sites, suggesting that this groundcover was able to outcompete RCG. It is possible that the site preparation, in conjunction with the quadruple weed cutting regime during the two growing seasons, weakened the RCG density to the point that bird's-foot trefoil became dominant,although it is expected that the RCG will encroach in the following years. Future research might be carried out to assess this relationship further. For instance, it would be valuable to assess if percent cover of bird's foot trefoil is inversely related to percent RCG cover and the length of time the species out competes RCG (without more mowing in future growing seasons). Given what was found regarding the role of site preparation, weed cutting and the resulting low-lying ground cover vegetation in this study, the possibility of preparing sites with tilling followed by planting a native ground cover and then planting stems in that seed bed would be useful to study. Such site preparation might reduce the time commitment to manually cut vegetation or mow, therefore providing a chemical free alternative to riparian restoration plantings.

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8. APPENDICES

Appendix 1: News Articles

Menu

Graduate Student Receives Grant for Riparian Buffer Study

By Lisa Halvorsen, UVM Extension
November 11, 2020

In the Champlain Valley, restoration of riparian forests, also known as forested floodplains, can be challenging, given the presence of heavy clay soils and stands of reed canary grass, an invasive species that can outcompete native tree species.

A new University of Vermont (UVM) research project will evaluate different management practices to assess survival of native plants when establishing riparian buffer corridors in river floodplains. The results will help landowners who are considering riparian restoration for flood control, wildlife habitat, or reduction of surface runoff to achieve greater success in establishing forested buffer plantings.

Graduate student Stever Bartlett will carry out the project in collaboration with Alison Adams, UVM Extension forestry coordinator, and Kate Forrer, UVM Extension community forestry specialist. Bartlett, a master's student in the UVM Rubenstein School of Environment and Natural Resources, is advised by Dr. Kris Stepenuck, Lake Champlain Sea Grant Extension leader.

Menu

Ongoing Riparian Buffer Study Plots Planted with Native Tree Species

By Stever Bartlett, Graduate Student
June 07, 2021

The clayplain forests of the Lake Champlain basin prior to European colonization were expansive in acreage and extensive in the ecological services they provided. Restoring functioning clayplain forests in and around current wetlands, shorelines, and river riparian areas is a long sought after goal. In an effort to reach that goal, continued research is happening in the Lake Champlain basin to determine best management practices for planting trees in riparian areas that are dominated by reed canary grass (*Phalaris arundinacea*).

As a University of Vermont (UVM) graduate student in the Rubenstein School of Environment and Natural Resources, I am continuing my research this summer which is funded by a Pollution Prevention and Habitat Conservation grant from the Lake Champlain Basin Program (https://www.lcbp.org/). It is the first applied research project of the new Watershed Forestry Partnership (https://www.uvm.edu/seagrant/outreach/watershed-forestry-partnership), a collaboration of UVM Extension (https://www.uvm.edu/extension), Lake Champlain Sea Grant (https://www.uvm.edu/seagrant) and various partnering organizations.

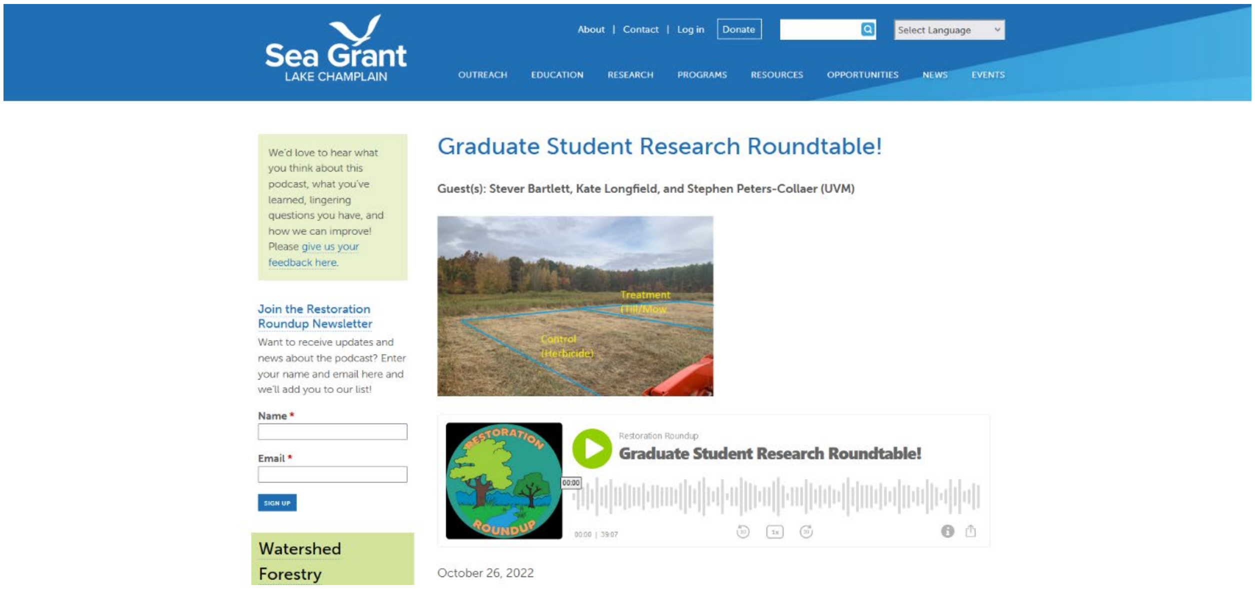
Menu

Graduate Students Study Restoration of Wetland Ecosystems

By Lake Champlain Sea Grant Staff
October 26, 2022

Three graduate students in the University of Vermont (UVM) Rubenstein School of Environment and Natural Resources are studying forest restoration in riparian, or wetland and stream, ecosystems. Master's student Stever Bartlett studies invasive reed canary grass management in restored riparian ecosystems, and Master's student Kate Longfield examines the role of government trust in farmers willingness to participate in government-run riparian restoration programs. Both work with Dr. Kris Stepenuck. PhD candidate Stephen Peters-Collaer works with Dr. Bill Keeton to investigate the value of downed wood in streams in storing carbon in old growth forest ecosystems.

Hear from each researcher in the newly released October episode of the Restoration Roundup podcast Graduate Student Research Roundtable (https://www.uvm.edu/seagrant/watershed-forestry-partnership/restoration-roundup-podcast/graduate-student-research-roundtable). Learn what brought each student to their respective research topics, what interesting preliminary results they are finding that can inform forest restoration practitioners, and what is next for their work.



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Watershed Forestry

Graduate Student Research Roundtable!

Guest(s): Stever Bartlett, Kate Longfield, and Stephen Peters-Collaer (UVM)

Treatment (Till/Mow)

Control (Herbicide)

RESTORATION ROUNDUP

Restoration Roundup

Graduate Student Research Roundtable!

00:00 | 39:07

October 26, 2022