Photo: K.M. Kettenring

Annual report to Delta Waterfowl

Treatments for effective restoration of *Phragmites*-dominated wetlands in the Great Salt Lake

Karin M. Kettenring, Christine B. Rohal, Chad Cranney, David England, and Eric L.G. Hazelton
Ecology Center and Department of Watershed Sciences
Utah State University

Cite as: Kettenring, K.M., C.B. Rohal, C. Cranney, D. England, and E.L.G. Hazelton. 2015. Treatments for effective restoration of *Phragmites*-dominated wetlands in the Great Salt Lake. Annual report to Delta Waterfowl. 17 pp.

Problem statement and report overview

Phragmites australis (common reed; hereafter *Phragmites*) is an invasive grass that has rapidly invaded wetlands across North America (Marks et al. 1994) and is widespread and dominant in wetlands and disturbed habitats in northern Utah (Kulmatiski et al. 2011, Kettenring et al. 2012a, Kettenring and Mock 2012). This plant is undesirable because it crowds out native vegetation and profoundly alters habitat quality for wildlife including waterfowl and other migratory birds by creating large monotypic stands (Marks et al. 1994). Great Salt Lake (GSL) wetlands are the most important wetland habitat for migratory birds in the region and are continentally significant (Evans and Martinson 2008). Unfortunately, tens of thousands of acres of diverse native wetland vegetation have been replaced by invasive *Phragmites*, reducing the availability and quality of habitat in GSL wetlands.

Given the extent of the *Phragmites* problem in Utah and elsewhere, managers are eager to understand what techniques are most effective for killing *Phragmites* while simultaneously fostering native plant recovery. A variety of strategies have been widely employed for *Phragmites* management including summer or fall herbicide application, mowing, burning, and flooding (Marks et al. 1994, Kettenring 2012, Hazelton et al. 2014). But, as is often the case with natural resource management, due to limited time and money, there has been little monitoring of success nor any systematic evaluation of management strategies across the varied environmental conditions where *Phragmites* is found, particularly in Utah. Given the interest in effective management strategies for *Phragmites*, there is a need to evaluate and monitor the success of different techniques. Another complicating factor in effective *Phragmites* management is that, contrary to popular belief, *Phragmites* spreads largely by seeds rather than rhizomes (Kettenring and Mock 2012). While a fall herbicide spray is widely used to manage *Phragmites*, this occurs <u>after</u> *Phragmites* has produced its seeds. Managers need additional tools to prevent seed production in conjunction with managing existing stands (e.g., mowing in conjunction with herbicide or using herbicide application earlier in the year). Finally, while the herbicide glyphosate has been widely used to manage *Phragmites*, another herbicide, imazapyr, has also been shown to be effective for managing *Phragmites* (Mozdzer et al. 2008, Hazelton et al. 2014). Further research is needed to compare the effectiveness of these herbicides, including the best time for application, for *Phragmites* management and native plant recovery. We have embarked on a five-year set of experiments where we are evaluating potential strategies for dealing with new infestations of *Phragmites* (small patch study) as well as large, dense monocultures of *Phragmites* (large stand study). Here we report on the effectiveness on the first three years of management treatments (2012-2014) and wetland recovery following the cessation of the management treats (2015).

Unfortunately, control of *Phragmites* may not be sufficient for fully restoring wetlands. As is the case with most invasive species control programs, active revegetation will likely be necessary to reestablish native plants (Kettenring and Reinhardt Adams 2011) and to restore vegetation that can resist future invasions (also called biotic resistance; *sensu* Levine et al. 2004). However, active revegetation is not pursued in most *Phragmites* control programs in Utah (Kettenring 2012) and across North America. In Utah, managers do not reintroduce native vegetation due to cost and time constraints, a lack of understanding of the importance of this step in the implementation of a successful *Phragmites* management plan, and a lack of knowledge about how to effectively reintroduce important habitat-forming species.

Some of the most important native plants in regional wetlands are perennial bulrushes, namely alkali bulrush (*Schoenoplectus maritimus*), hardstem bulrush (*S. acutus*), and threesquare bulrush (*S. americanus*). These species often occur in large, monotypic stands, provide important nesting and resting habitat for a variety of bird species, and serve as a food source for many birds either directly (seeds, rhizomes) or indirectly (by providing habitat for aquatic macroinvertebrates). To complement on-going *Phragmites* control efforts by managers, similarly large efforts of native plant revegetation are important. However, there is a dearth of knowledge of how to effectively restore these native species by seeds and rhizomes. There are many means by which to revegetate wetland plants such as broad-scale seeding at different densities, planting seedlings ("plugs") or rhizomes, and using "sod mats" (coconut fiber mats embedded with rhizomes. These techniques have not been widely evaluated in the context of reestablishing native vegetation following *Phragmites* removal. We are particularly interested in the trade-offs in cost of implementation of each technique over broad areas vs. which techniques most rapidly result in the establishment of dense, productive native vegetation. Dense, productive native vegetation will limit light resources that *Phragmites* seeds require to grow. Given that seeds are the main means by which *Phragmites* can invade new habitats (Kettenring and Mock 2012), limiting light and other resources for *Phragmites* seeds is critical for preventing its reinvasion into native vegetation. The most dense and productive native stands will be more resistant to *Phragmites* invasion. In addition, such productive vegetation will best support food webs that are the primary food resources for many migratory bird species. Here we report on the bulrush revegetation experiment that was initiated in summer 2015. The final data collection on this project occurred the last week of October and as such, results on the bulrush performance are not yet available. Therefore, we report detailed methods on the study to demonstrate progress on these objectives.

Broad goal of the project

To determine the best management strategies for controlling *Phragmites* and restoring native plant communities in Great Salt Lake wetlands.

Methods

Objective 1. To evaluate potential Phragmites control strategies in small patches and large stands for restoring wetlands in the GSL watershed.

The management studies are being conducted at two spatial scales – 0.25 acre treatment areas to evaluate strategies that may be effective for dealing with initial invasions of *Phragmites* and 3 acre treatment areas to evaluate strategies that may be more effective and logistically feasible for dealing with large, well-established stands of *Phragmites*.

Large stand study. We have four sites with extensive stands of *Phragmites* where we are conducting the management treatments: Ogden Bay Waterfowl Management Area (WMA), Farmington Bay WMA, sovereign lands west of Ogden Bay WMA, and sovereign lands northwest of Farmington Bay WMA. At each site, we applied one of five treatments to each 3 acre *Phragmites* stand (15 acres total per site). The five treatments we applied were: (1) summer glyphosate spray followed by winter mow, (2) summer imazapyr spray followed by winter mow, (3) fall glyphosate spray followed by winter mow, (4) fall imazapyr spray followed by winter mow, and (5) untreated area. Management techniques were applied each year 2012-2014. Monitoring is continuing through 2016 now that the management treatments have ended.

Small patch study. We have six sites (Inland Sea Shorebird Reserve, Ogden Bay WMA, Farmington Bay WMA, Bear River Migratory Bird Refuge, and two areas at TNC Shorelands Preserve) where we are evaluating *Phragmites* management treatments that might be effective for small *Phragmites* invasions. At each site, we applied one of six management treatments to a 0.25 acre *Phragmites* patch. The six treatments we applied at each site were: (1) summer mow, then cover with heavy duty black plastic; (2) summer mow followed by fall glyphosate spray; (3) summer glyphosate spray followed by winter mow; (4) fall glyphosate spray followed by winter mow; (5) summer imazapyr spray followed by winter mow; and (6) untreated area. Management techniques were applied each year 2012-2014. Monitoring is continuing through 2016 now that the management treatments have ended.

The *Phragmites* treatments for both studies were chosen based on our initial survey of GSL wetland managers (Kettenring et al. 2012b); extensive conversations with Randy Berger and other state, federal, and private managers; and our reading of the *Phragmites* management literature. We chose treatments that were logistically feasible for managers to apply, and chose a balance of treatments that represented commonly applied strategies as well as less common ones that hold great promise for GSL wetlands.

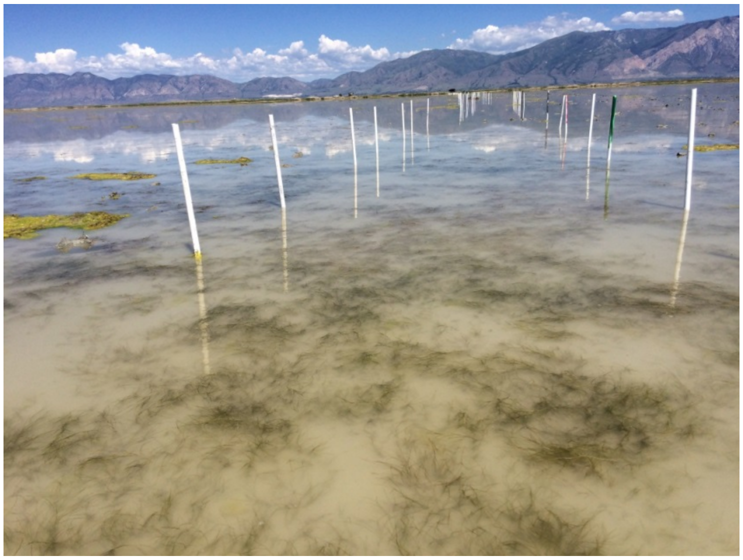
For both studies, treatment effectiveness is being assessed by looking at *Phragmites* and native plant cover. Vegetation is being monitored with on-the-ground surveys for both studies. In addition, we are characterizing sites with respect to nitrogen (ammonium, nitrate), phosphorous (phosphate), salinity (electrical conductivity), organic matter content, and soil moisture / flooding levels, all factors that could affect treatment success. Such data will be critical for making recommendations on which treatments to apply in which areas of the GSL. However, the soil analyses are not completed yet and as such, are not presented here.

Objective 2: to determine cost effective methods for reestablishing native, habitat-forming bulrushes (Schoenoplectus spp.) that are resistant to future Phragmites invasion.

This study focuses on three bulrush species: *Schoenoplectus americanus* (threesquare bulrush), *Schoenoplectus acutus* (hardstem bulrush), and *Schoenoplectus maritimus* (alkali bulrush).

<u>Experiment installation</u>

The U.S. Fish & Wildlife Service granted us permission to conduct this revegetation demonstration project in two of their management units (4B and 5B) at the Bear River Migratory Bird Refuge. In each management unit, we established 26 strips with five 4 m^2 plots per strip. Each strip contains a random subset of the different revegetation treatments: seeding with different densities and seed source population combinations, plantings of plug seedlings, plantings of rhizomes, or sod mats. Each revegetation treatment was replicated 5 times in each of the two wetland units.



Wetland Unit 5b (upper left) and 4b (left) at the Bear River Migratory Bird Refuge where the experiment was implemented. (upper right) Howard Browers, Wildlife Biologist at the Bear River Migratory Bird Refuge, during a scouting field trip to identify sites for the experiment installation.

<u>Acquisition and preparation of seed materials</u>

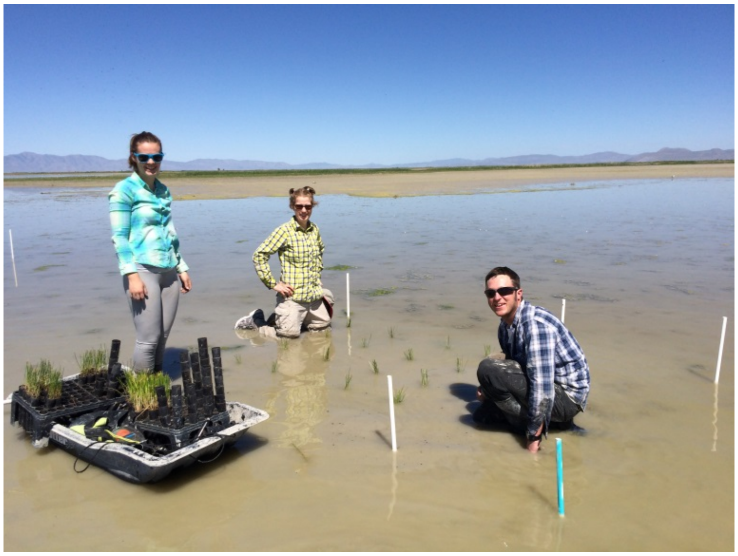
Seeds of the three bulrush species were collected in fall 2014 from seven sites in the Intermountain West (Bear River Migratory Bird Refuge, Bear Lake National Wildlife Refuge (NWR), Clear Lake Waterfowl Management Area (WMA), Fish Springs NWR, Farmington Bay WMA, Salt Creek WMA, and Sterling Wildlife Management Area). To break seed dormancy, the seeds were cold, moist stratified in a refrigerator for 3 months during spring 2015 by researchers at USU until sowing into the field plots in June 2015 (see below).

Example sites where seeds were collected for this bulrush revegetation study (left *S. maritimus*, right *S. acutus*).

Acquisition and preparation of plug materials

Seeds of the three bulrush species were collected in fall 2014 from seven sites in the Intermountain West (Bear River Migratory Bird Refuge, Bear Lake NWR, Clear Lake WMA, Fish Springs NWR, Farmington Bay WMA, Salt Creek WMA, and Sterling Wildlife Management Area). These seeds were then sent to North Fork Native Plants (Rexburg, Idaho) for them to cold stratify the seeds for 3 months and then produce the plugs in their greenhouse over winter/spring 2015.

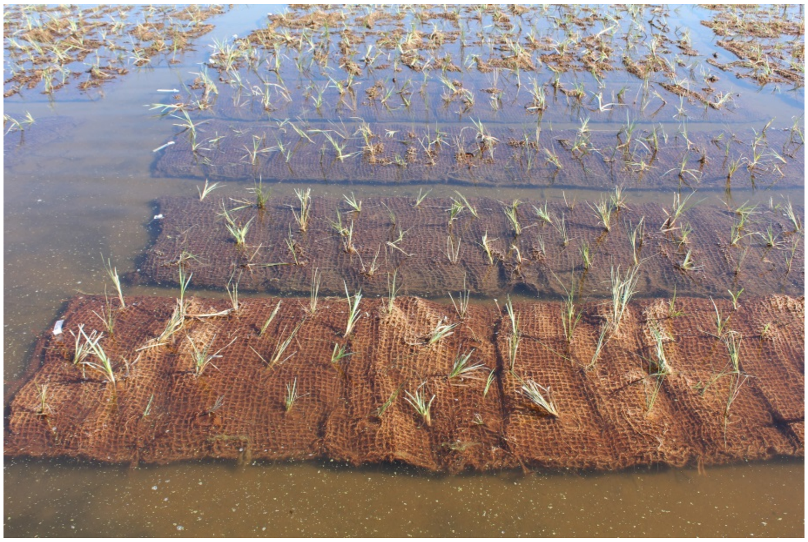
Example wetland plant plug from North Fork Native Plants.



David England, Rachel Hager, and Dr. Karin Kettenring planting plugs into the experimental plots at the Bear River Migratory Bird Refuge.

Acquisition and preparation of sod mats

Rhizomes of the three bulrush species were collected in spring 2014 from seven sites in the Intermountain West (Bear River Migratory Bird Refuge, Bear Lake NWR, Clear Lake WMA, Fish Springs NWR, Farmington Bay WMA, Salt Creek WMA, and Sterling Wildlife Management Area). The rhizomes were delivered to North Fork Native Plants (Rexburg, Idaho) in early summer 2014. The rhizomes were embedded in coconut fiber mats and maintained in their large propagation ponds to allow root/stem development over the 2014 growing season through spring 2015.



Example from North Fork Native Plants of a developing sod mat for wetland revegetation.

David England (far right) and two staff members from North Fork Native Plants planting Great Salt Lake-collected bulrush rhizomes into sod mats for this study.

Sod mats were transported to their respective plots in sleds, and here David England demonstrates how the sod mats were then placed in the plots by dragging them with hay hooks to the center 1m^2 of the 4m^2 plots (far left). David England demonstrates how the sod mats were held in place with wooden stakes (left).

<u>Acquisition and preparation of rhizome material</u>

In late spring 2015, rhizome material for *S. americanus* was collected from a large patch at Public Shooting Grounds WMA using a backhoe and transported to the Bear River Migratory Bird Refuge by Division of Wildlife Resources personnel under the supervision of Randy Berger and Arlo Wing. Rhizome material for *S. maritimus* and *S. acutus* were sourced directly from the Refuge property, harvested using a backhoe by Refuge staff, and then delivered to the wetland units manually via sleds.

Backhoe at Bear River Migratory Bird Refuge scooping *S. acutus* for later transplantation into the revegetation treatment plots.

<u>Monitoring plans</u>

The success of the revegetation treatments will be monitored every 3 weeks during the 2015 and 2016 growing seasons. We will assess cover of each bulrush in their respective $4m^2$ plots, bulrush stem density in four $0.9m^2$ subplots per $4m^2$ plots, and the amount of light reaching ground level (a factor important for limiting phragmites invasion). Also, water depth and salinity will be tracked along with the vegetation data collection.

Results

Objective 1. To evaluate potential Phragmites control strategies in small patches and large stands for restoring wetlands in the GSL watershed.

Large stand study. After four years of monitoring (and after three years of herbicide treatment), the cover of *Phragmites* is greatly reduced in the fall glyphosate and fall imazapyr spray plots (**Figure 1**). Surprisingly, the cover of *Phragmites* in the summer glyphosate and summer imazapyr spray plots increased dramatically since the 2014 monitoring and is equal or nearly equal to the cover in the untreated control plots (**Figure 1**).

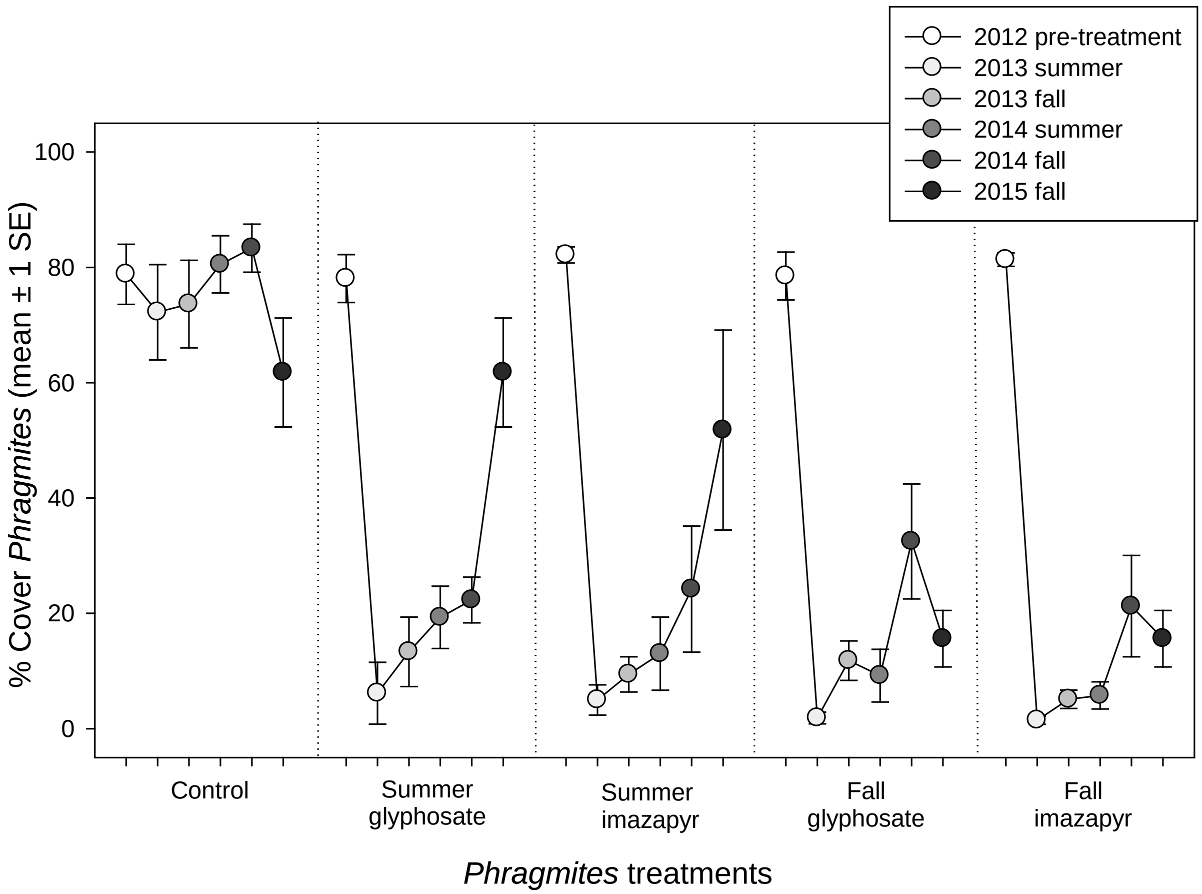


Figure 1. Effects of treatments on *Phragmites* percent cover.

Recovery of native plant species remains very minimal at all sites for all treatments, with only trace amounts of emergent species returning including *Schoenoplectus maritimus* (alkali bulrush), *Schoenoplectus americanus* (three-square bulrush), and *Schoenoplectus acutus* (hardstem bulrush (**Figure 2**). We believe one factor contributing to minimal native plant recovery was the large litter layer left after mowing. However, the cover of litter has dropped from 70% to <20% in all treatment plots (**Figure 3**) so we expect to see greater native plant recovery in 2016 now that litter will not block light reaching the seed bank. Also, the cover of open water has increased, again likely because litter and *Phragmites* cover has decreased (**Figure 4**), which may again favor native plant recovery in 2016.

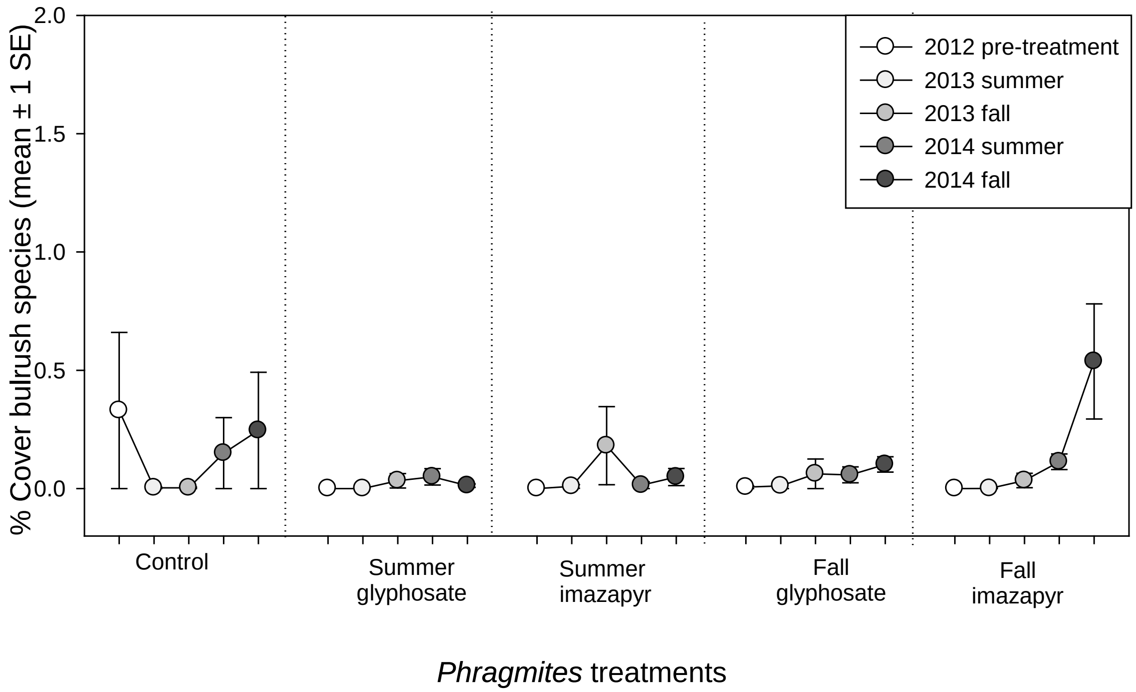


Figure 2. Effects of treatments on native bulrush percent cover.

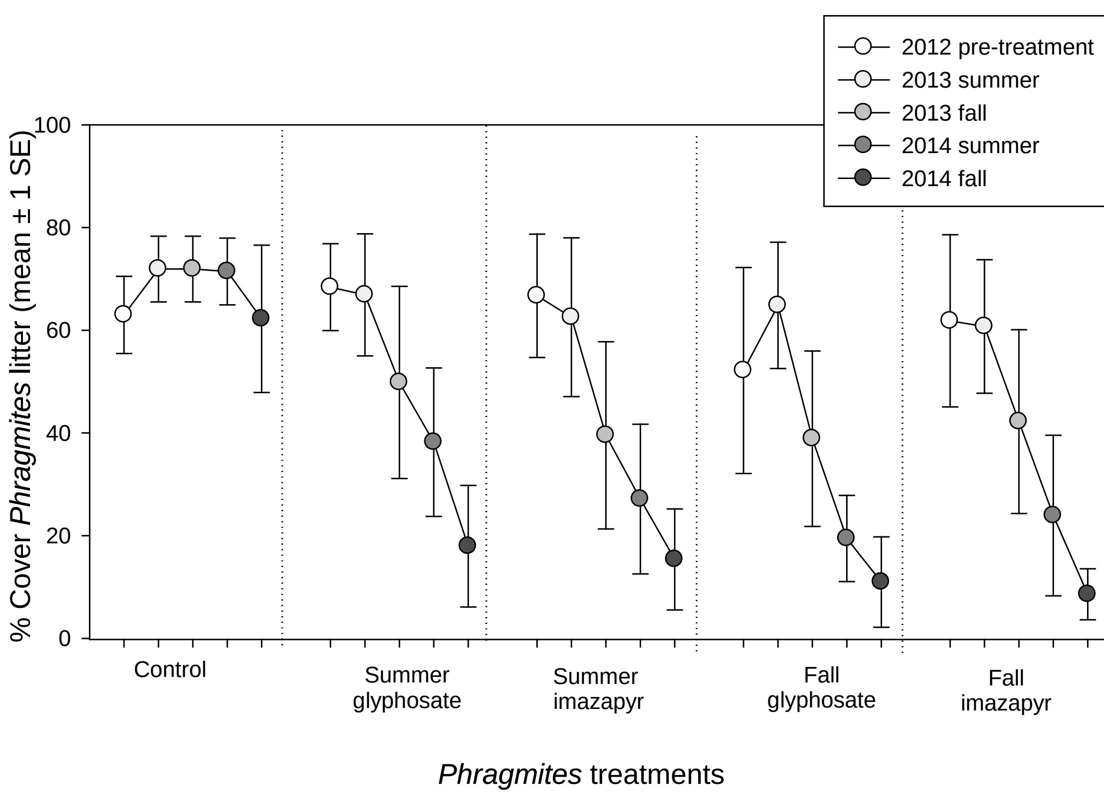


Figure 3. Cover of *Phragmites* litter pre-treatment (2012) and post-treatment (2013 and 2014).

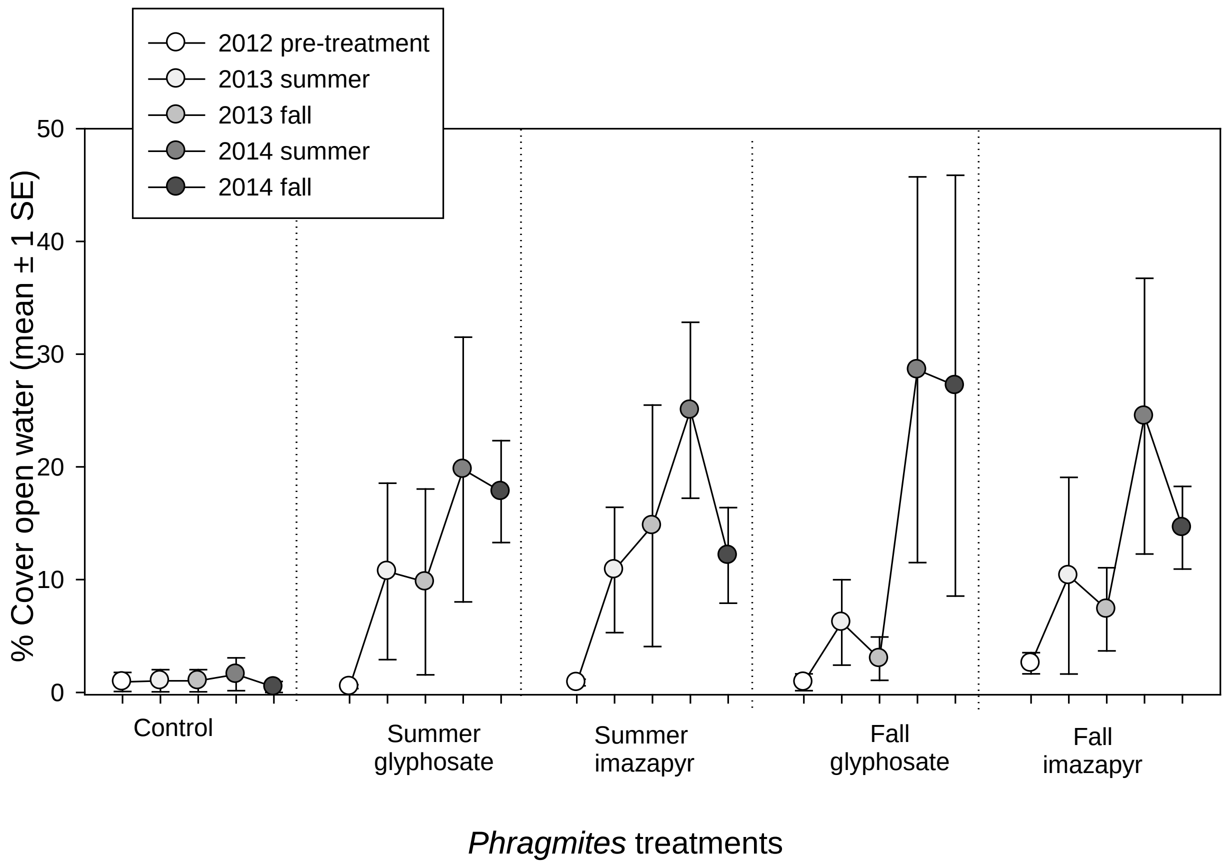


Figure 4. Cover of open water in each of the treatments for 2012 (pre-treatment) and post-treatment in 2013 and 2014.

Small patch study. All treatments, except the mow + black plastic, are effective at significantly reducing the cover of *Phragmites* (**Figure 5**). Similar to the results of the large stand study, *Phragmites* cover is lower in the two treatments with a fall herbicide spray while the *Phragmites* cover is rebounding in the summer imazapyr spray treatment.

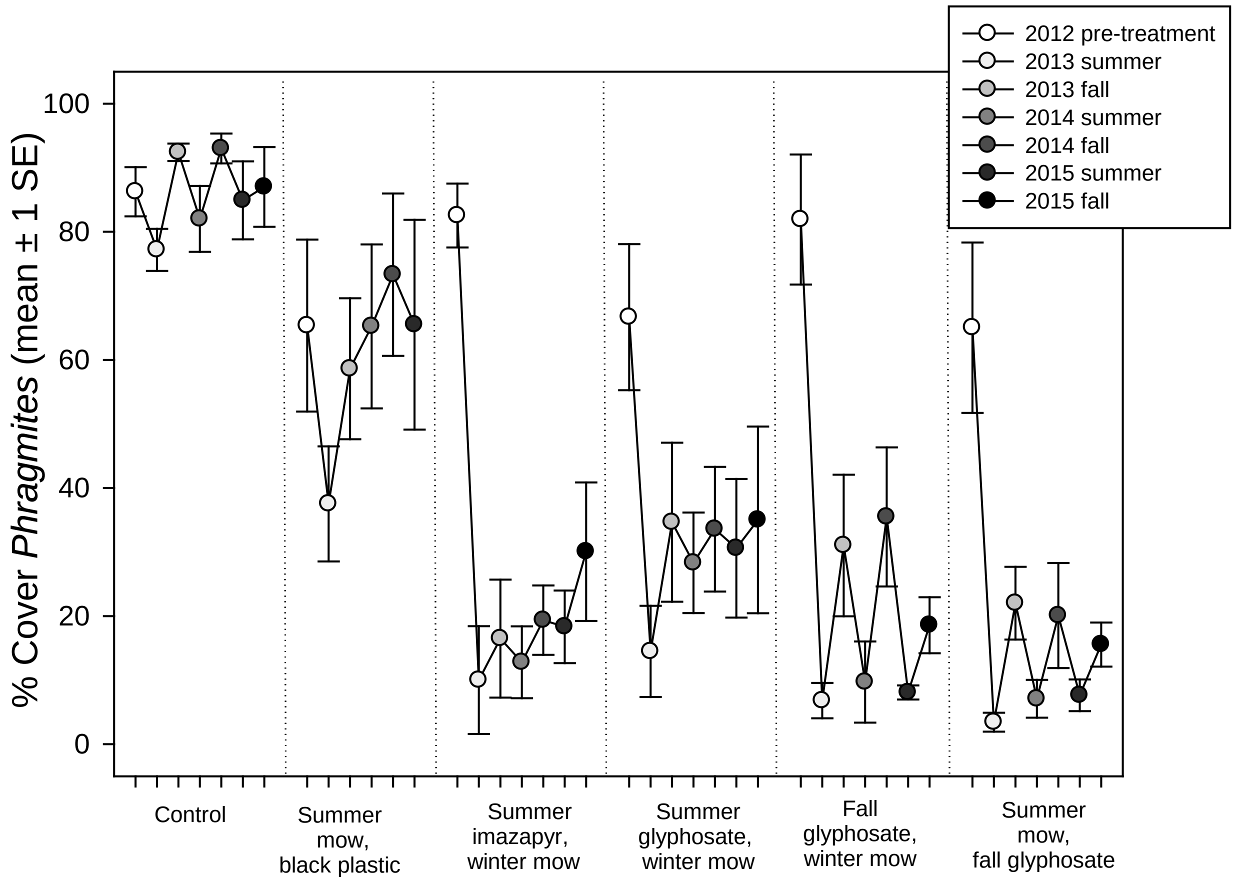


Figure 5. Effects of herbicide and mowing treatments on *Phragmites* cover in the small patch study.

Although initially the fall glyphosate treatment resulted in a high density of *Phragmites* inflorescences, over time all herbicide treatments greatly reduced *Phragmites* inflorescence density (**Figure 6**). Given that *Phragmites* spreads predominantly by seeds (Kettenring and Mock 2012), these findings indicate multiple treatments that can be used to reduce *Phragmites* invasion potential via seeds.

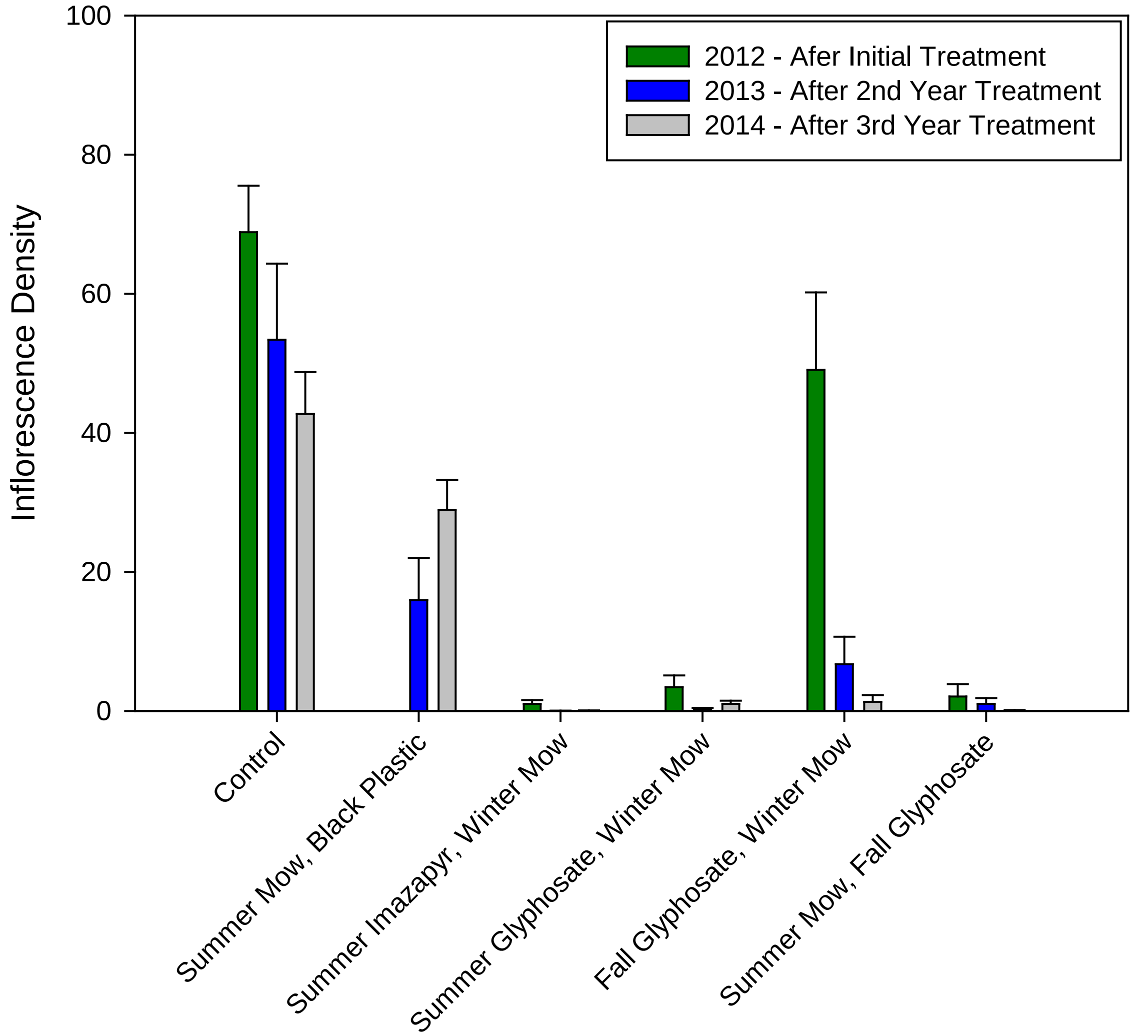


Figure 6. Effects of herbicide and mowing treatments on *Phragmites* inflorescence density in the small patch study.

There has been some recovery of native species in the various *Phragmites* treatment plots, particularly in the two fall glyphosate spray treatments and the summer imazapyr spray treatment (**Figure 7**). The species with the highest cover in 2015 in the herbicide and mow treatment plots are *Typha* spp. (cattails) and *Schoenoplectus americanus* (threesquare bulrush) (**Figure 8**).

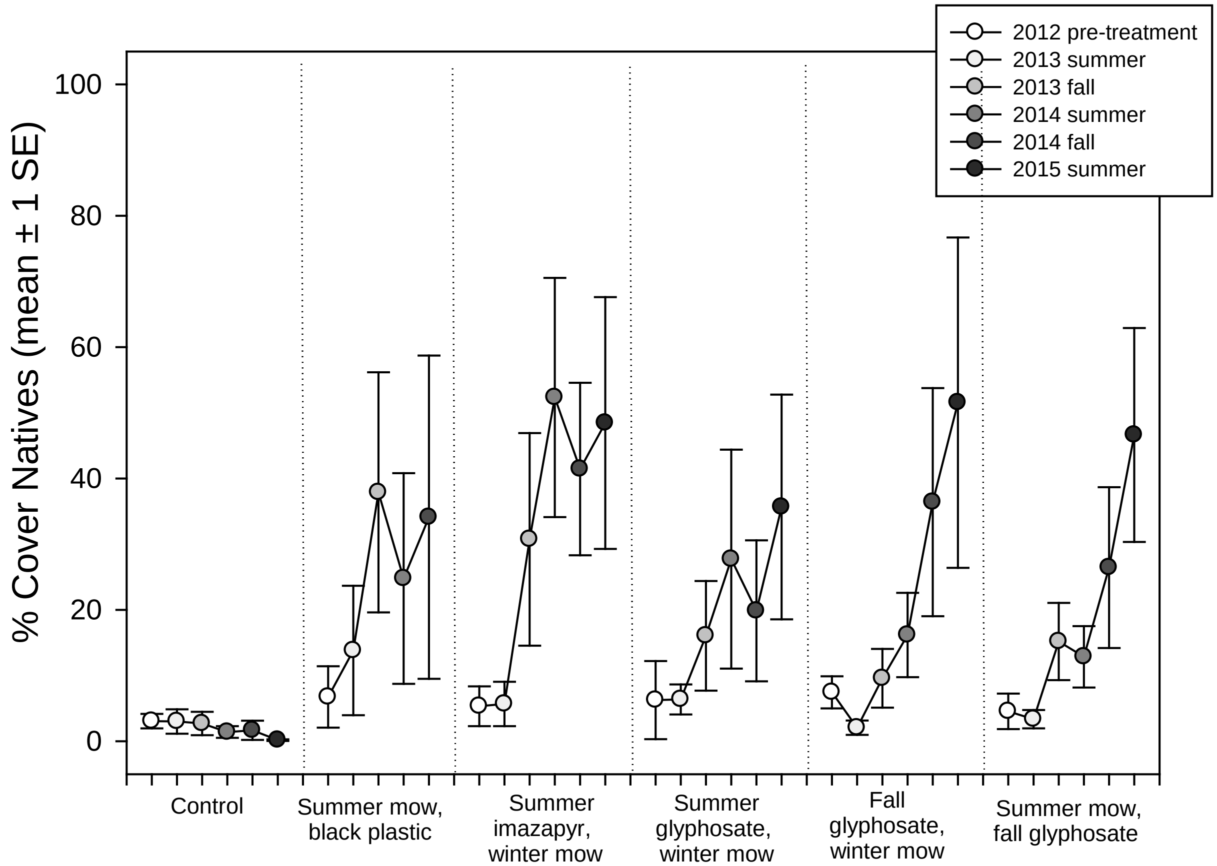


Figure 7. Total cover of native species in treated and untreated *Phragmites* plots in the small patch study.

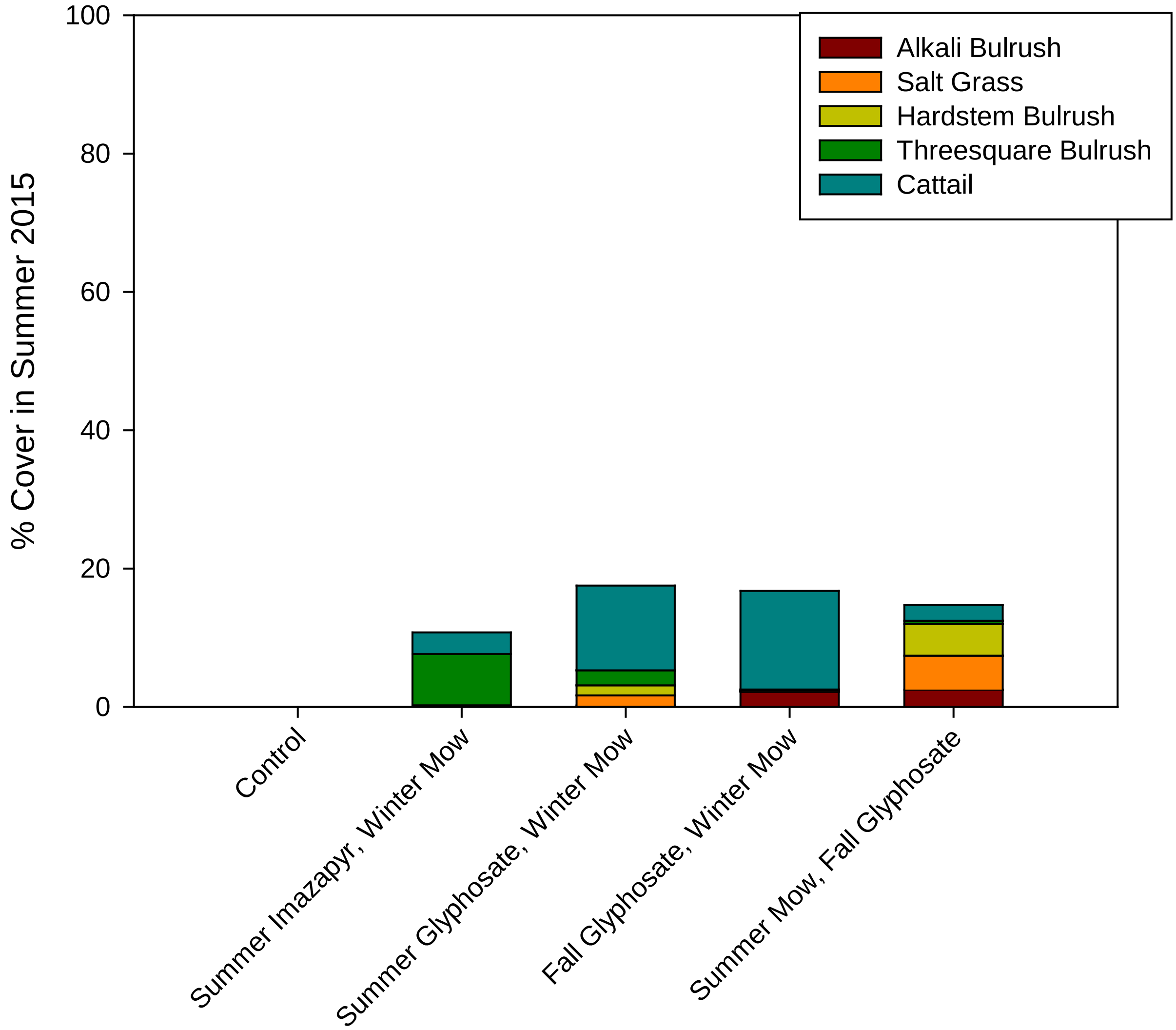


Figure 8. Cover of key native species in treated and untreated *Phragmites* plots in 2015.

The very large amounts of litter left behind from mowing initially seemed to be the most substantial impediment to the regrowth of native species in all plots, but more so in the plots that were mowed in the winter (**Figure 9**). However, by 2015, the summer mow followed by a fall glyphosate spray treatment had negligible litter remaining, but this lack of litter did not seem to have a detectable influence on the cover of native species.

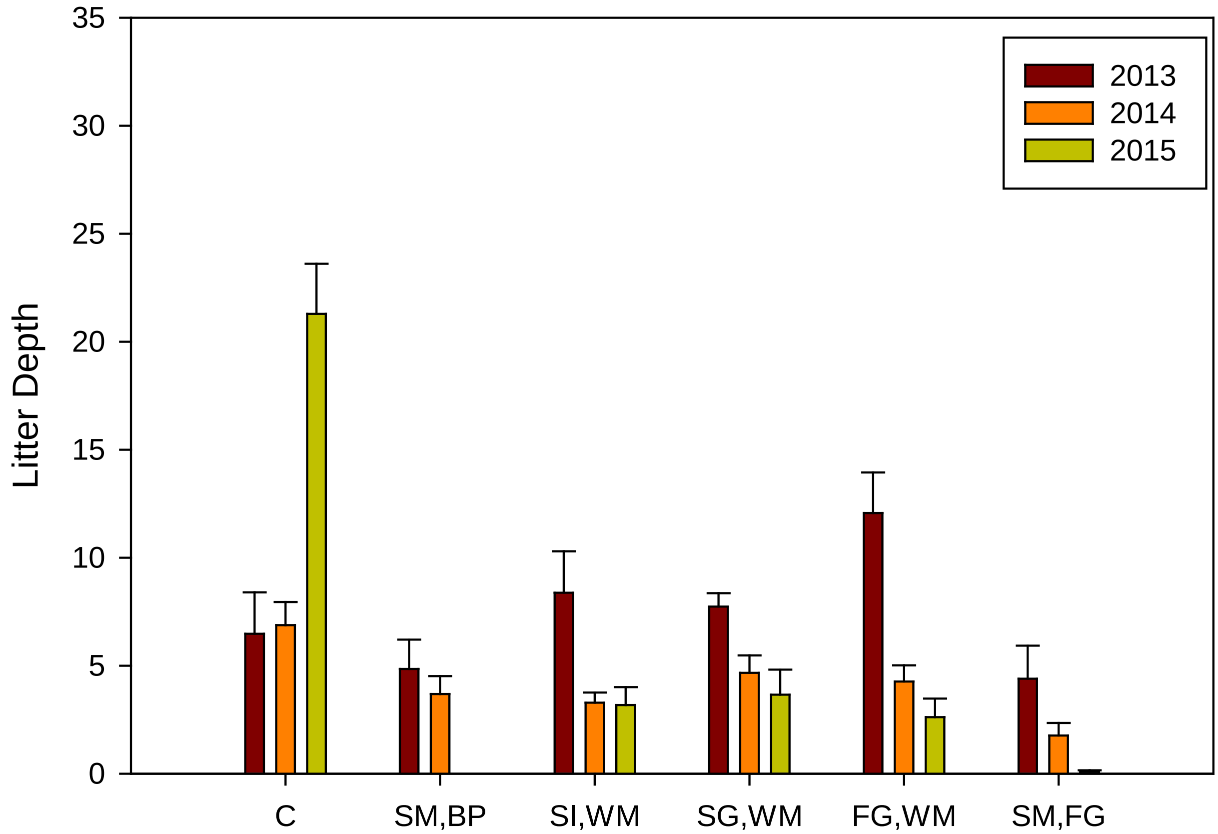


Figure 9. Effects of herbicide and mowing treatments on litter depth.

Summary of results and management recommendations from Objective 1

In contrast to previous years when we suggested that summer or fall treatments were equally effective at killing *Phragmites*, the results from the 2015 monitoring suggest that **a fall herbicide spray is most effective** based on the results from both the small patch study and the large stand study. The dramatic change between 2014 and 2015 results underscore the importance of longer term monitoring of these plots.

Native plant recovery is very limited across all treatments in the large stand study and is just beginning to rebound in some of the plots in the small patch study. Native plant recovery was likely limited by the thick litter layers remaining following *Phragmites* mowing efforts, but now that the litter depths and covers have declined, we expect to see greater native plant recovery in 2016 (if it will occur within a timeframe before *Phragmites* reinvades). Alternatively, if we still see limited native plant recovery in 2016, such findings will suggest that an even greater emphasis on active revegetation with native plants will be required.

Objective 2: to determine cost effective methods for reestablishing native, habitat-forming bulrushes (Schoenoplectus spp.) that are resistant to future Phragmites invasion.

The final data collection on this bulrush revegetation project occurred the last week of October and as such, results on the bulrush performance are not yet available. If Delta

Waterfowl would like an update on research results in early 2016, we are happy to provide such an update once we have had a chance to analyze and synthesize the data.

Literature cited

Evans, K., and W. Martinson. 2008. Utah's featured birds and viewing sites: a conservation platform for Important Bird Areas and Bird Habitat Conservation Areas. Sun Lith, Salt Lake City, Utah.

Hazelton, E. L. G., T. J. Mozdzer, D. Burdick, K. M. Kettenring, and D. F. Whigham. 2014. *Phragmites australis* management in the Unites States: 40 years of methods and outcomes. AoB Plants **6**:plu001.

Kettenring, K. M. 2012. Management of *Phragmites* in the Great Salt Lake watershed. Final report to Utah Department of Natural Resources, Division of Forestry, Fire & State Lands.

Kettenring, K. M., S. de Blois, and D. P. Hauber. 2012a. Moving from a regional to a continental perspective of *Phragmites australis* invasion in North America. AoB Plants:1-18.

Kettenring, K. M., K. Garvie, E. L. G. Hazelton, N. Hough-Snee, and Z. Ma. 2012b. *Phragmites* invasion and control in the Great Salt Lake watershed: 2012 land manager survey.

Kettenring, K. M., and K. E. Mock. 2012. Genetic diversity, reproductive mode, and dispersal differ between the cryptic invader, *Phragmites australis*, and its native conspecific. Biological Invasions **14**:2489-2504.

Kettenring, K. M., and C. Reinhardt Adams. 2011. Lessons learned from invasive plant control experiments: a systematic review and meta-analysis. Journal of Applied Ecology **48**:970-979.

Kulmatiski, A., K. H. Beard, L. A. Meyerson, J. R. Gibson, and K. E. Mock. 2011. Nonnative *Phragmites australis* invasion into Utah wetlands. Western North American Naturalist **70**:541-552.

Levine, J. M., P. B. Adler, and S. G. Yelenik. 2004. A meta-analysis of biotic resistance to exotic plant invasions. Ecology Letters **7**:975-989.

Marks, M., B. Lapin, and J. Randall. 1994. *Phragmites australis* (*Phragmites communis*): threats, management, and monitoring. Natural Areas Journal **14**:285-294.

Mozdzer, T. J., C. J. Hutto, P. A. Clarke, and D. P. Field. 2008. Efficacy of imazapyr and glyphosate in the control of non-native *Phragmites australis*. Restoration Ecology **16**:221-224.