Evaluating the effects of management of the invasive hybrid species *Typha x glauca* in a Great Lakes marsh

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Abstract

The invasive cattail Typha x glauca *(referred to hereafter as* Typha*) decimates species diversity and abundance of native flora after its introduction to Great Lakes marshes. In some areas the conservation and restoration of marshes is of high priority, however, the optimum management option for controlling* Typha *growth and reproduction has yet to be determined. This study, conducted in a marsh in the northern Lower Peninsula of Michigan, examines the impacts of different types of management (removal of above ground* Typha *biomass, and removal of above and below ground* Typha *biomass) on the changes in species diversity in the marsh and on the biomass and height of* Typha *populations following management. We found that* Typha *biomass decreased significantly with removal of above and below ground biomass, and decreased insignificantly with removal of above ground biomass. Removal of above ground biomass significantly decreased* Typha *height, but removal of above and below ground biomass did not have a significant impact. Species diversity increased more with removal of above and below ground biomass than removal of only above ground biomass. Our conclusions are that removal of both above and below ground biomass is optimum to achieve higher species diversity and increase the abundance and number of native species in the marsh, but that removal of only above ground biomass due to limitations on labor or available funding for removal would still result in benefits to the native plant community while reducing* Typha *success. However, we caution that removal of only above ground biomass may have to be repeated over time as the* Typha *community regenerates from the rhizomes left behind.*

Introduction

Over the past few centuries, human travel from place to place around the globe has had many ecological consequences, especially in regards to the introduction of invasive species in new areas. New species like zebra mussels and cane toads compete with endemic species and often drive the nativespecies to endangered levels. Invasive species of plants can also overcrowd native species and create a habitat more hospitable to their own needs, rather than that of the endemic plants.

Typha angustifolia is native to Europe and likely came across the Atlantic in the ballast water of ships. *T. angustifolia* then naturalized to the U.S. eastern seaboard (Mills et al. 1993, and spread to the Laurentian Great Lakes where the native species, *Typha latifolia,* dominated Great Lakes coastal wetland habitats. Where the species were found together, they reproduced to form a sterile hybrid *Typha x glauca* that now dominates some coastal wetlands in the Great Lakes (Selbo and Snow 2004). The hybrid cattail exhibits some characteristics not seen in the native species that heavily affect the ecosystem of the wetland. *T. x glauca* is an efficient nutrient assimilator, decomposes slowly and releases many nutrients when it does decompose (Davis and Van der Walk 1978), leading to a cycle of subsistence in *Typha* populations. The fallen litter from *Typha,* because of its slow decomposition, limits the amount of sunlight available at the sediment level, which limits and impedes the germination of seeds from native plants (Tuchman et al. 2009). As a result, native marshes that have been invaded by *T. angustifolia* and *T. x glauca* have seen their species richness and species diversity plummet (Mitchell et al. 2011).

A current focus in the Great Lakes is the introduction of management plans to reduce the amount of *T. x glauca* in the coastal wetlands, promoting the reintroduction of native wetland plants. A prominent study, located in Cheboygan Marsh of Cheboygan County of northern Michigan, has been ongoing over the past decade researching management plans to extrapolate to other wetland areas (citation). Lishawa et al. (2012) documented the history and expansion of *T. angustifolia* and *T. x glauca* in the Cheboygan Marsh, determining that the oldest stands date back to 1963 and that the invasive cattails had a hold on a large part of the marsh by 1970, which has expanded rapidly over the past several decades.

In 2011, management plots throughout Cheboygan marsh were established with several different treatments to examine the effects and efficiency of different management methods (Shane Lishawa, personal communication). These management plots included removal of only above ground biomass, and removal of above ground and below ground biomass, including the root system of the *Typha,* and control plots. A study done in mesocosms that mimicked conditions of Cheboygan Marsh investigated how management impacts porewater nutrients in a controlled setting (Rodriguez 2014).

This study seeks to investigate the impact of management on predominantly *Typha* marsh in a field setting. Macrophyte species diversity analysis supplements water chemistry data and above ground biomass evaluations to qualitatively and quantitatively describe the habitat produced by management. We predict that species diversity and richness will be highest in plots of above and below ground biomass removal, and lowest in control plots. Our hypothesis is that removal of *Typha x glauca* reduces interspecific competition for light and nutrients between *T x glauca* and native plants by removing the *Typha* biomass that limits light penetration to the soil, and removing *Typha* which has been shown to be better able to exploit high nutrient concentrations than native plants (Woo and Zedler 2002). We also predict that available nutrients will be lowest in plots of above and below ground biomass removal, and highest in control plots. Our hypothesis is that the removal of biomass reduced the amount of decomposing litter in the plots, limiting nutrient availability from decomposition.

Methods

This study was conducted in Cheboygan Marsh, Cheboygan County, Michigan, USA (45°39’29”N, 84°28’47”E). 12 total plots from older stands of *Typha* (>30 yrs.) with areas of 16 m^2 were sampled. 4

plots of each treatment type, control plot, above ground removal, and above and below ground removal, were tested.

Porewater was sampled three times from each site at 10 cm depth. A PVC pipe (2 cm diameter) was installed at 10 cm deep at each plot. Each pipe included four holes drilled 1.5 cm from the bottom to increase water filtration. A fiberglass mesh filter around the bottom of the pipe was used to reduce the amount of sediment contamination in the water samples. A battery powered water pump was used to draw water from the pipe. The water was then kept in acid wash bottles of volume 125 mL per plot. Bottles of water were kept in a cooler until they could be processed. Water samples were taken to the University of Michigan Biological Station for processing and testing for ammonium, phosphate, and nitrate.

Vegetation survey data, including *Typha x glauca* height and above ground biomass, collected by the Rivers, Lakes, and Wetlands class was used to supplement the water chemistry and water property data we collected (Dennis Albert, unpublished data). This data was collected over the same timespan as our data was collected.

ANOVA tests and post hoc Tukey pairwise comparison tests were used with all variables to determine if there were significant differences between plots. Pearson correlation tests were run to look for any correlation between variables. The Shannon-Weiner diversity index was used to compare vegetative community composition between management treatments.

Results

No significant differences were found between management treatments when comparing nitrate ($F(2,33) = 1.356$, $p = .272$), ammonium ($F(2,32) = 1.511$, $p = .236$), or phosphate ($F(2, 33) = .681$, $p = .513$). However, trends were observed, an upward trend in nitrate (Figure 1), and downward trends in ammonium and phosphate (Figures 2 and 3), from above ground removal to below ground removal to control plots.

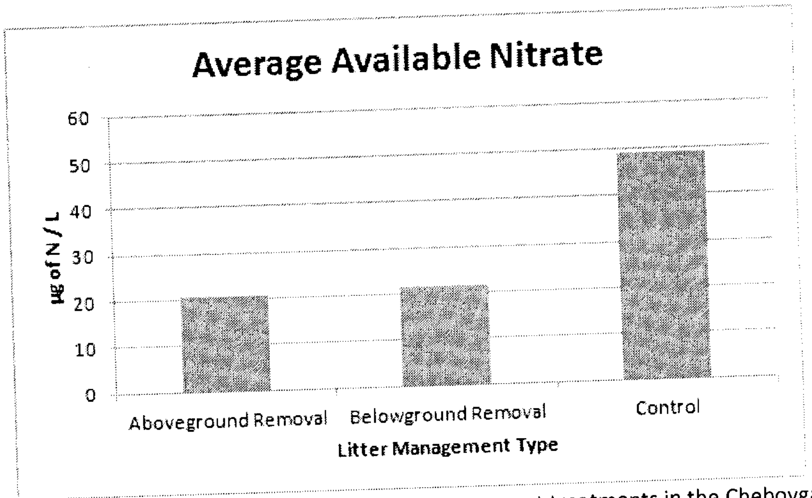

Figure 1. Mean available nitrate between management treatments in the Cheboygan Marsh (n = 11, 12, 12)

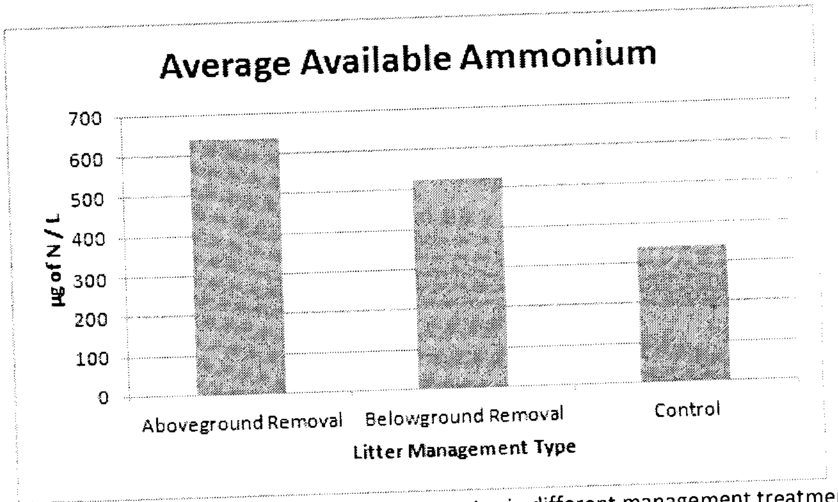

Figure 2. Mean available ammonium in porewater in different management treatments in the Cheboygan Marsh. (n = 12, 12, 12)

A significant difference was found in above ground *Typha* biomass between management treatments (Figure 4; $F(2,9) = 6.975$, $p = 0.015$). The control treatment differed significantly from the below

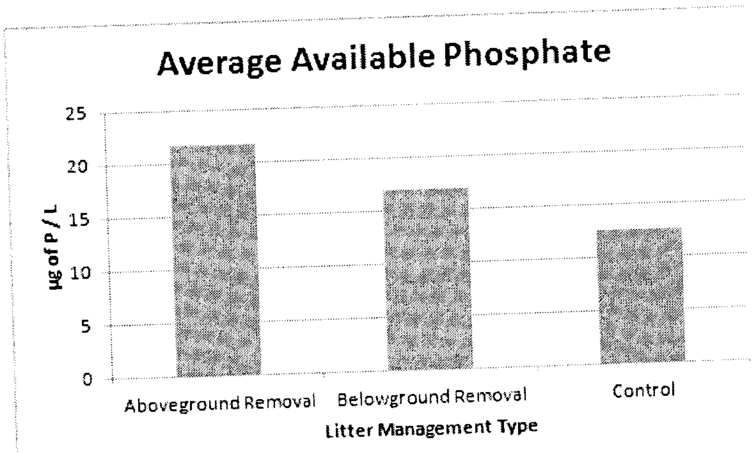

Figure 3. Mean available phosphate in porewater in different management treatments in the Cheboygan marsh. (n = 12, 12, 12)

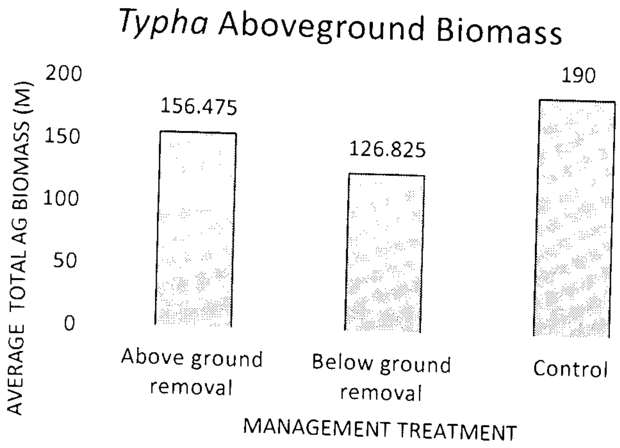

Figure 4. Average above ground biomass of *Typha x glauca* at different treatment plots. There is a significant difference between below ground removal treatments and control treatments ($P < 0.05$).

ground removal treatment ($p < 0.05$). The above ground removal treatment did not differ significantly from either the control treatment or the below ground removal treatment.

Typha height differed significantly between treatments as well (Figure 5; $F(2,9) = 48.738$, $p = 0.000$). Above ground removal treatment was significantly different from both the control treatment ($p < 0.05$) and the below ground removal treatment ($p < 0.05$).

Below ground removal treatment did not significantly differ from control treatment in *Typha* height ($p > 0.05$).

Control treatments had the lowest Shannon-Weiner species diversity index of 0.49 (Figure 6). Above ground removal treatment had an intermediate index of 0.755, and below ground removal treatment had the highest index, equal to 0.9875.

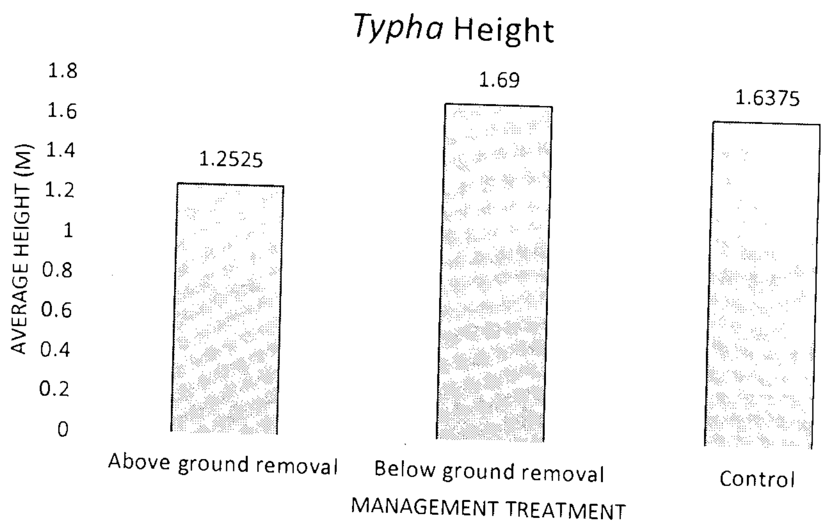

Figure 5. Average height of *Typha x glauca* at different treatment plots. There are significant differences between the above ground removal treatments and the other two treatments ($P < 0.05$).

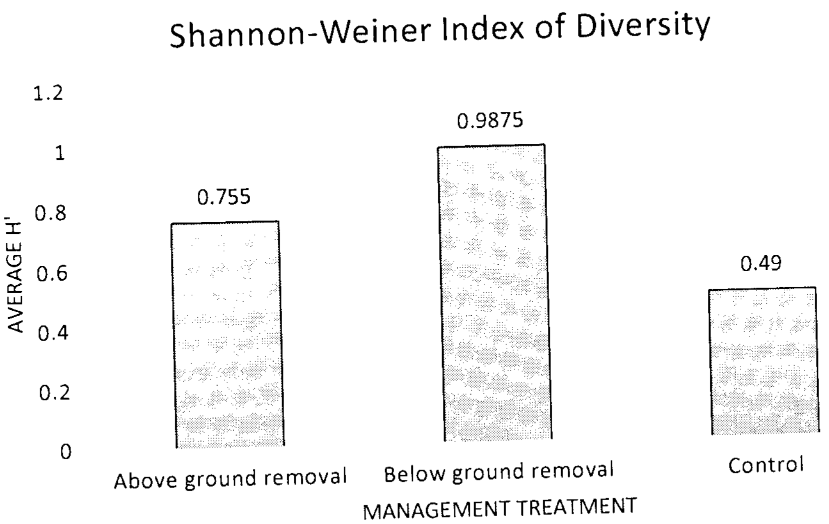

Figure 6. Average diversity index of macrophytes at different treatment plots.

Discussion

Although there were not any statistically significant differences in any nutrient analysis performed, there were trends present in all nutrient analysis. Ammonium and phosphate were both lowest in the control treatment and highest in the above ground removal treatment, while nitrate was highest in the control treatment and lowest in the above ground removal treatment. We posit that the below ground biomass left behind in the above ground removal treatment released more nutrients into the water from increased decomposition rate, compared to control treatments, and higher levels of decomposing organic matter, compared to below ground removal treatments. *Typha* has been shown to uptake nitrogen more efficiently and retain it more strongly than native plants. *Typha* especially is more efficient at recycling nitrogen found in its own litter than native plants can recycle it, which leads to a positive feedback loop enabling *Typha* to become the dominant species in an area by limiting the resource availability for other plants.

Typha biomass was highest in control treatments, which was an expected result as no biomass was removed in those treatments. Biomass in control treatments only differed significantly from below ground biomass removal, however. *Typha x glauca* and its parent species reproduce via rhizomes (Selbo and Snow 2004, Mitchell 2011), so the removal of rhizomes in the below ground removal treatment would limit the growth of *Typha* in the that treatment, but because rhizomes were not removed in the above ground removal treatment, growth would not be as significantly limited. This explains why there is no significant difference between control treatments and above ground removal treatments. Above ground removal treatment did not differ significantly from below ground removal treatment, however, which indicates that the *Typha* population does suffer reduced growth with only the removal of above ground biomass, but not enough to differ significantly from control treatments.

Typha height in above ground removal treatments was significantly lower than height in below ground removal and control treatments. This supports the hypothesis that intraspecific competition limits the growth of *Typha* when above ground biomass is removed (Larkin et al. 2012). Height was not significantly different between below ground removal treatments and control treatments. However, biomass was higher in control plots, which indicates that although *Typha* grew equally tall in both plots, fewer plants were found in below ground removal treatments, likely a result of equal competition between the native plants and *Typha*. Normally, competition is not equal due to the higher efficiency of conversion of *Typha* litter to recycled nutrients in living *Typha*. Therefore, below ground removal treatment is more effective at limiting *Typha* spread than above ground removal treatment, which limits the success of individual plants but overall has similar biomass to control treatments.

Our conclusions regarding height and biomass of *Typha* are reflected in Shannon-Weiner species diversity index results. Highest diversity was found in below ground removal treatments, and lowest diversity was found in control treatments. The removal of rhizomes in below ground removal treatments enabled the old seed bank of native plants to receive increased and resulted in their germination (Lishawa, unpublished data). This resulted in increased diversity in these treatments. Leaving rhizomes behind in the above ground removal treatments limited the light available to the seed bank, and the rhizomes likely limited the growth of plants that did manage to germinate, so the diversity increased from the control treatments but was less than that of the below ground removal treatments.

Tuchman (2009) showed that there were significant correlations between *Typha* stem density and soil nutrient concentrations, however we did not find these same results. This is likely due to the much higher sample size (n = 144 for nitrogen, n = 53 for phosphate) used by Tuchman compared to our sample size (n = 36). A reevaluation of soil nutrients in the marsh would benefit from a higher sample size than we were able to obtain, and is encouraged in light of the trends that were documented in this study and the significant differences found by Tuchman (2009).

In light of all data gathered, we conclude that the best method for increasing species diversity in the marsh is removal of both above ground and below ground biomass. However, should that method be very expensive, inefficient, or otherwise not favorable, removal of only above ground biomass results in increased species diversity and limitations on the success of individual *Typha* plants. Removal of only above ground biomass does not result in a significant reduction in biomass, but does result in some reduction. Therefore, if above ground removal is chosen as the best management option to decrease *Typha* in the marsh and increase native plant diversity and abundance, the removal may have to be repeated to continue controlling *Typha* populations. Available resources and the goal of removal should be considered when determining the appropriate removal method in order to choose the removal method best suited for meeting that goal.

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