# Restoration Notes

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## Effects of Selectively-targeted Imazapyr Applications on *Typha angustifolia* in a Species-rich Wetland (Wisconsin)

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*Typha angustifolia* (narrow-leaved cattail) is an aggressive invader of North American wetlands. Once established, substantial litter accumulation and rhizomatous expansion enable *Typha* to become the dominant species in a vegetation stand. Previous research into *Typha* suppression was conducted in well-established monotypic stands (Levi 1960, Apfelbaum 1985, Solberg and Higgins 1993), but there is a need to develop suppression protocol for mixed vegetation stands where *Typha* is not yet dominant. We conducted a feasibility study to evaluate the use of selectively targeted imazapyr applications to reverse a *Typha* invasion in a species-rich wetland in southeastern Wisconsin. The 16.3 ha study site was located along the Mukwonago River within The Nature Conservancy's (TNC) Lulu Lake Preserve with a baseline Floristic Quality Index (FQI) of 68.9. Forty-nine species had a coefficient of conservatism value ≥ 7; twenty-four had a value ≥ 8. Although *Typha* has been present at the site since 1963, it was expanding at a geometric rate and by 2010 it occupied 1.8 ha (11%) of the wetland (Boers and Zedler 2008).

We tested the effects of coupling mowing to directed herbicide application for reversing the *Typha* invasion. From late June to early July 2011 and in July 2012, culms were mowed to a stubble height of 10–15 cm with a STIHL FS90 clearing saw equipped with a circular blade (STIHL USA, Virginia Beach, VA). Imazapyr (Polaris®, Nufarm Ltd, Chicago Heights, IL) was applied to freshly cut culms at a rate of 3.85% (5 fluid ounces/gallon) with small-capacity sprayers at low output pressure. Since Polaris® is formulated as an IPA salt, a water conditioning agent (ReQuest®, Helena Chemical, Collierville, TN) was added to mix water at 2% (2 fluid ounces/gallon) prior to herbicide dilution. To enhance herbicide uptake and translocation, we added fertilizer (Miracle Grow®, Scott's Company, Marysville, OH) at a rate of 7g/gallon. To prevent overspray, an aquatic use-approved sticking agent (Induce®, Helena Chemical, Collierville, TN) was added to spray mixtures at 4% (5 fluid ounces/gallon). Spray pattern indicator dye was employed to prevent duplicate cut-surface treatments and allow applicators to monitor overspray. Litter accumulation is a driver of *Typha* invasions (cf. Farrer and Goldberg 2009, Vaccaro et al. 2009), so the entire study site was burned by TNC staff in 2011 and 2014 to remove accumulated litter. Initial mowing and herbicide applications occurred in late June and early July 2011, when regrowth potential was minimal after *Typha* rhizome carbohydrate reserves had been depleted by drains for seed production (Grace and Harrison 1986, Lardner 2003). Treatment responses were first measured in early June 2012. Vegetation sampling determined that a small number of *Typha* culms survived the initial treatment, so we conducted a follow-up treatment on these persistent culms in July 2012. Community responses to the follow-up treatment were measured in June 2013.

To determine if *Typha* suppression was maintained during subsequent growing seasons in the absence of continued management, post-treatment responses were monitored for an additional two years (June 2014 and 2015). Stem density of all species was measured in ten randomly-placed ⅛-m² rectangular quadrats in both treated and untreated areas. We estimated *Typha* abundance, species density (all species present), Shannon diversity (H'), and floristic quality (expressed as mean coefficient of conservatism, values from Bernthal 2003) from stem density data. Diversity estimates were converted to the same scale as species density with the Hill transformation (where $N_1 = e^{H'}$). Since the experimental design consisted of only a single replication, treatment means were separated by comparing overlap in their 95% confidence intervals; statistical tests were carried out in IBM SPSS Statistics, v. 25.0. We made both within-year and among-year comparisons for each response variable (Table 1).

Compared to untreated plots, initial treatment reduced *Typha* stem density by 90% and follow-up treatment reduced

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**Table 1. Within- and among-year comparisons of *Typha* density, species density ($S_d$), diversity ($e^{H'}$), and floristic quality (coefficient of conservatism, c) (mean ± SE). Means with different letters were different at $\alpha = 0.05$.**

| | Control | | | | Treated | | | |
|---|---|---|---|---|---|---|---|---|
| Year | *Typha* | $S_d$ | $e^{H'}$ | c | *Typha* | $S_d$ | $e^{H'}$ | c |
| 2012 | 5.8 (0.6) a | 6.0 (0.4) c | 3.9 (0.1) d | 4.4 (0.2) e | 0.6 (0.5) b | 5.6 (0.6) c | 3.6 (0.1) d | 5.2 (0.3) e |
| 2013 | 7.1 (1.2) a | 9.2 (0.7) f | 5.7 (0.1) g | 4.8 (0.2) e | 0.1 (0.1) b | 7.5 (0.6) f | 3.6 (0.1) d | 4.8 (0.2) e |
| 2014 | 12.6 (2.1) h | 5.4 (0.6) c | 2.3 (0.1) j | 5.4 (0.2) e | 0.4 (0.2) b | 11.5 (0.6) i | 6.6 (0.1) k | 5.9 (0.2) e |
| 2015 | 10.0 (1.4) h | 9.5 (0.5) f | 3.8 (0.1) d | 5.4 (0.1) e | 2.2 (0.8) l | 7.9 (0.6) f | 6.2 (0.1) k | 5.5 (0.2) e |

it by 99%. In the 2014 survey (one-year post-treatment), *Typha* stem density in treated plots remained low, at only 3% of the untreated control. However, by the 2015 survey (two-years post-treatment), *Typha* had resurged to 22% of the control. We did not conduct belowground sampling to determine the source of resurgence (rhizome vs. seed bank), but Grace and Wetzel (1982) and Grace and Harrison (1986) reported that *T. angustifolia* could form new tillers from dormant rhizome buds several years after aboveground suppression treatments. The mean half-life of imazapyr in plant tissues is 23.9 days (Fantke et al. 2014); thus, it is possible that metabolically dormant portions of the *Typha* rhizome network were able to survive imazapyr's effects long enough for herbicide concentrations to decay to non-lethal levels, after which replacement tillers developed. Across years, *Typha* stem density nearly doubled in the untreated plots, consistent with a geometric rate of expansion (Boers and Zedler 2008). Species density in treated plots was more than double that of untreated plots in the 2014 post-treatment survey but was similar during all other within-year samplings. Across years, species density fluctuated similarly in treated and control plots. Diversity was similar in treated and untreated plots following the initial *Typha* treatment, but 26% higher in untreated plots after the follow-up treatment, possibly the result of collateral damage from two rounds of mowing followed by herbicide application. During the post-treatment survey, diversity was higher in treated compared to untreated plots, evidence that a two-year restoration lag had occurred as native vegetation began reestablishing a dominance hierarchy after treated plots were released from competition with *Typha*. Floristic quality was similar in both treatments for all within- and among-year comparisons.

*Lythrum salicaria* (Purple loosestrife) was detected at low density in treated quadrats during post-treatment surveys (average of 3.1 and 0.6 stems/quadrat in 2014 and 2015) but was absent from control plots. The majority of sampled *L. salicaria* plants presented signs of herbivory by *Galerucella* beetles, which are annually released by TNC near the study site. *Typha* suppression efforts might have affected a competitive release of *L. salicaria*, causing the latter to increase in abundance.

We conclude that the treatment protocols presented here were effective at suppressing *Typha* with minimal collateral damage in mixed vegetation stands for two growing seasons, after which *Typha* began to slowly recolonize treated areas. We recommend the release of *Lythrum salicaria* biocontrol agents concomitant with *Typha* suppression efforts to address secondary weed outbreaks in managed wetlands.



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