Appendix 2
Compilation of Monitoring Protocols

This Appendix summarizes our extensive review of monitoring protocols gathered from peer-reviewed and gray literature, relevant webinars and conferences, discussions with managers, and the stakeholder meeting convened under the EPA Grant to Bourgeau-Chavez (http://mtri.org/phragmiteswetlandmanagementandscience.html) and on-going discussions with the *Phragmites* Adaptive Management Framework Team. Literature sources are shown in the table that follows. A range of protocols from Tier 1 (least effort) to Tier 3 (highest effort) were selected and adapted from this review that we considered most practical and/or field ready to implement for this project. The selected protocols were quantified in terms of time required to complete them, experience level needed and monitoring measures achieved. They are described and compared in detail in the main body of this report.

Summary

Generally, monitoring methods for *Phragmites* research and treatment effectiveness span a wide range of complexity, measures, and statistical rigor. Methods being used lack standardization and consistency. For the most part, methods being implemented today for assessing *Phragmites* treatment outcomes are of low statistical rigor, which is a mismatch given the millions of dollars in treatment efforts that are spent on routine or sometimes novel treatments. This is in large part due to the complexity of the problem, the variation in geographies and site specific conditions, urgency with which responses have been required, and capacity and funding. In short, monitoring of invasive *Phragmites* treatment is a problem that is not easily solved. For large infestations in particular, on-the-ground monitoring can be unsafe, and nearly impossible to capture a sufficient amount of data in a reasonable time frame with reasonable expenditures. Monitoring of both large and small infestations should be designed to consider not only *Phragmites* kill but also ecosystem impacts and progress towards specific management goals. Further, monitoring should also consider landscape scales, including watersheds.

Key findings from our stakeholder meeting of Great Lakes managers, highlighted below, provide a realistic glimpse into the status quo and we encourage readers to review the more detailed summary that is posted at **http://mtri.org/phragmiteswetlandmanagementandscience.html**

- For many reasons, numerous managers make manage decisions based on anecdotal information and measure their success by gut-level assessments; this doesn't mean they are wrong, but it makes it difficult to convince critics and funders of true success when actual quantified measures of success are not available.
- Attention to explicit goals and practical, consistent monitoring that is tied to those goals is needed to improve *Phragmites* management and provide funders scientifically sound justification for funding management efforts (see also Attachment 3).
- Adequate, practical monitoring protocols are not easily available and funding is frequently lacking to implement effective monitoring; long-term monitoring is virtually lacking with the exception of the Great Lakes Coastal Monitoring Program (GLCMP). This program, however, is measuring and comparing benchmark conditions over time throughout the Great Lakes and is not tied to measuring *Phragmites* treatment efficacy or management goals. There are a few specific research projects and well-funded management endeavors that have spanned many years, but these are not common.

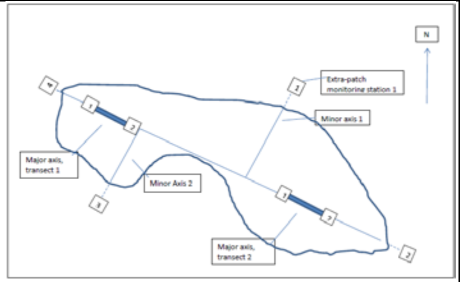
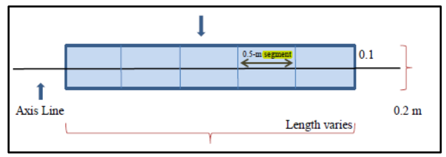
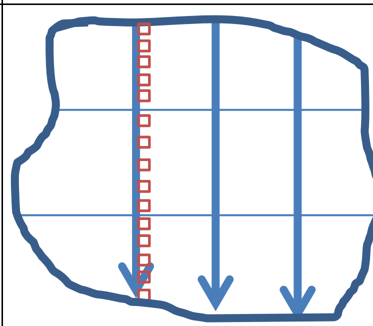
- Many funding sources require measures of success by the number of acres treated or % *Phragmites* kill which is simply inadequate to measure success towards well-crafted management goals. It ignores unintended consequences and tells you nothing about desired future condition, native species response or measures of biodiversity. It also does not reflect potential secondary invasions, which commonly occur.
- Management goals should go beyond *Phragmites* kill to defining a desired future condition and monitoring to determine if management is moving the site or region towards an identified desired future condition.
- In addition to identifying desired future condition, ultimate causes of *Phragmites* invasion must be addressed, particularly high nitrogen levels, for long-term success of *Phragmites* control efforts.
- There is a need to move beyond site level management to considering landscape scale approaches, including watersheds, which may provide greater regional efficacy.
- There is a need to bring managers together more frequently to brainstorm on larger scale efforts and learn from one another.
- Use of high resolution satellite imagery and drones will ultimately be a necessary part of *Phragmites* management and monitoring, not only for covering large, inaccessible areas, but also for detecting outliers and leading edges. Efforts to prioritize outliers to keep them from spreading is still a strongly recommended practice due to the suggested likelihood of harboring greater genetic diversity than that of established stands and higher likelihood of more rapid, successful control.
- Access to high resolution imagery has improved dramatically. Using 60 cm or better resolution data of multiple bands allows even small infestations to be detected and distinguishes small patches of surviving shoots from dead standing biomass following treatment. This enables much more targeted and cost-effective site selections, initial treatments and follow-up treatments.
- Sustainability of management and funding priorities are major concerns of managers.
- Private landowners must be a key part of the solution to sustaining and monitoring management of *Phragmites*, yet they are not well represented and have fewer funding opportunities.

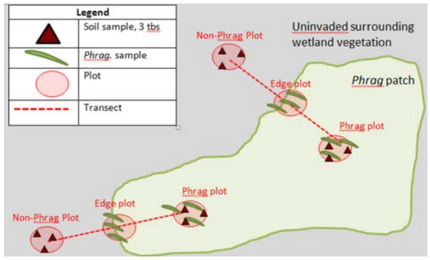
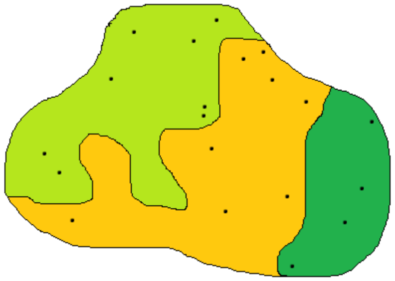
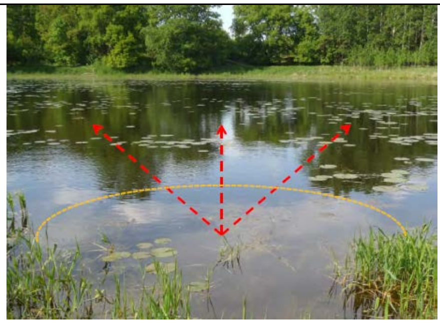
The Phragmites Adaptive Management Framework (PAMF) is an important first step at bringing communities together to learn from each other. However, at this stage it is also simply measuring *Phragmites* kill or change in biomass, and not focusing on a desired end goal for each site (e.g. improved native habitat) or increase in native species post-treatment.

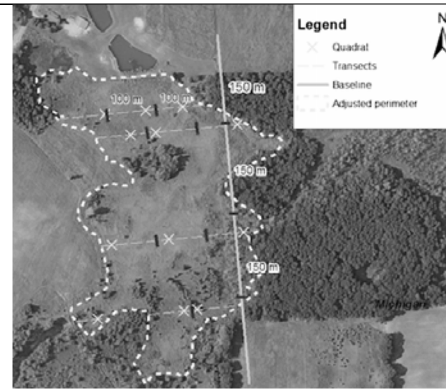
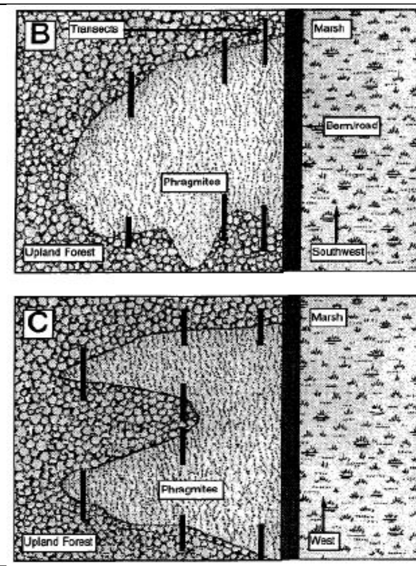
The following section provides a table of examples from the many studies we reviewed for this project. It provides a useful quick-look at various studies, indicating the parameters that were measured and pros cons for each. Where available, a sketch of the monitoring design was included; otherwise, a figure from the study illustrating some of the findings was inserted instead.

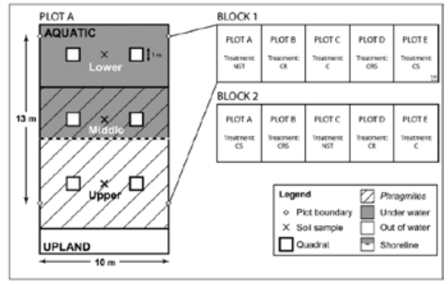
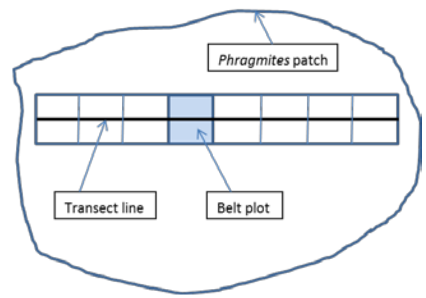
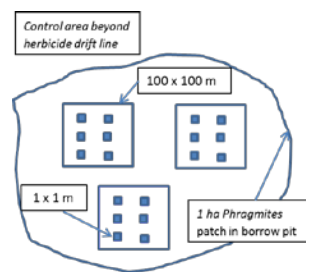
The final section provides copies of the three tiers of monitoring protocols and data forms that were tested and used to train observers for this project.

Appendix 3 provides further discussion regarding the need to tie the monitoring protocols utilized at a treatment site to the management goals.

Source of Methodology	Description	Visual	Level of Intensity	Questions and issues
USFWS *Phragmites* Vegetation Monitoring Protocol for Adaptive Management *Moore et al., 2014, Moore, 2015* Based on: Native Prairie Adaptive Management Protocol Notebook	• Belt Transects along longest axis of patch, 5m from edge, min 65m apart • Number of and length of belt transects scaled with size of patch, USFWS has methods for calculating number and length of belt transects that are not accessible to us – can potentially have Michelle VandeHaar (USFWS) get this. • Every .5m, broad cover type (within .1m of transect) decided by cover classes: • Phragmites • Desirable species (determined a priori) • Other species • Bare ground • Mixed • Quadrat sampling at start and finish of each belt transect • Extra-patch quadrats at four point, 15 meters from the 1 major axis and 2 minor axes - to measure surrounding ecosystem	 One long transect along the longest major axis possible with multiple best transects along the same transects. Occurs on 2 or more belt transects that are determined based on patch size. Observations are made along the belt using .2 x .5 meter areas in sequence for length of transect. 	Medium	• Patches in Saginaw Bay are much longer than 50m • Does this go through the center of the plot? On the edges? • Misses gradient of invasion along wetness gradient • How are the number of plots determined. • Do the exterior plots really capture the ecosystem status adequately? • Would counting the number of desirable species add any value (e.g. # of desirables and % cover instead of just % cover of class)
Great Lakes Monitoring Protocol *Burton et al. (2008)* *Uzarski et al. (2017)*	• 3 transects per wetland, running from lake landward across gradient (upland to bay) • 3 zones per transect: - Wet Meadow - Emergent - Submergent • 5 1m^2 plots per zone, equally spaced • % cover of each plant species		High	• Very time consuming • Requires expert knowledge of plant species • How is starting point determined? • How far apart are transects? • Same number of transects for larger sites? • Through the *Phragmites* or ecosystem? • What are boundaries of sampling area?

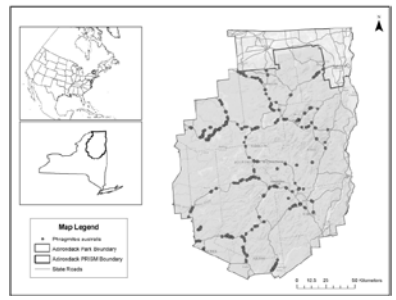
Phragnet Protocol *Vicky Hunt* *Chicago Botanic Garden* *1000 Lake Cook Rd* *Glencoe, IL 60022* *vhunt@chicagobotanic.org* https://sites.google.com/site/phragmitesnet/home	• Number of transects based on size • Each transect has edge, *Phragmites*, and non-*Phragmites* plots • GPS points, soil samples, and veg samples taken		Low	• No diversity information • Set up of plot accessible for volunteers, but information collected needs to be changed • Edge effects on Phragmites growth considerable • Doesn't capture variability within patch
Performance standards and monitoring protocol for permittee-responsible non-tidal wetland mitigation sites in Maryland *USACE, 2015*	• Stratified random points split between cover types (or maybe wetland gradient?) • Number of points based off of patch size • 3 m^2 plots • Dominant species ID, Ground Cover, % dominant wetland species, percent survival of any plantings, assessment of invasive species (with % cover)		Medium	• Difficulties accessing points • Definitely time intensive • ID of wetland vs. upland plants needed (why upland plants?) • May not be feasible of safe in large untreated Phragmites stands
Properties and Performance of the Floristic Quality Index in Great Lakes Coastal Wetlands. 2006. *MPCA, 2014, Bourdaghs, 2012, Bourdaghs et al., 2006*	• Field teams of 2-3 people trained together • 1 m^2 quadrats; random placed transects • # of quadrats based on wetland size (20 quadrats/60 ha); min. of 10–15 quadrats • Divide trans. in 20-m segments; randomly locate quadrat in each 20-m segment • From continuous shrub zone/upland boundary to 1 m depth of standing water • % cover estimated for all species; Braun-Blanquet cover class ranges	 Exception for open water: example shallow water open shore	High	• Requires highly skilled botanists • Logistically difficult in dense *Phragmites* stands
Long-term Management of an Invasive Plant: Lessons from Seven Years of *Phragmites australis* Control	• Density/abundance used Coleman (2003) - broad categories: • Density: 0: No live Phragmites stems present 1: Light: <=200 stems 2: Moderate: > 200 stems	• Abundance: 0: No live *Phragmites* 1: <25% cover 2: 25-49% cover 3: 50-75% cover 4: >75% cover	Low	• No details about where observations were made • Seems only feasible for small sites where observer can see whole patch

Lombard et al. 2011	3: Heavy: P*hragmites* dominant, significant thatch	• prevalent native species list		
Evaluating a sampling protocol for assessing plant diversity in prairie fens. *Hackett et al. 2016*	• Area proportional, random design • Determine best sampling method for capturing diversity of prairie fen • Sampled both spring and summer to capture full diversity • Baseline drawn across the longest portion of the adjusted, ground-truthed perimeter • 1 m^2 plot per 100 m of transect; minimum of 20 plots for all sites • Compared to simulated random samples from 10-40 plots per site • 25 plots adequate to capture diversity, regardless of size		High	• Shows how to do area-proportional random design • More detail than is needed for determining change trajectory of Phragmites • Good diversity data, but very time consuming • Requires species level expertise • Good comparative study of sample sizes needed for high power diversity analyses where diversity is management goal
Common Reed *Phragmites australis:* Control and Effects Upon Biodiversity in Freshwater Non-tidal Wetlands. *Alistock et al., 2001*	• Pre and 4-years of post-treatment transects Short belt transects arranged on the outside of dense *Phragmites*, starting 1 m outside of patch edge • 3.16m X .32m plots along transect until 5 consecutive plots of only Phragmites • Plants within plots identified to species and counted • SDI calculated		Medium	• Unclear how to place transects • How determine number of transects? • How determine plot size? • Needs extensive plant ID • Doesn't capture variability within whole patch

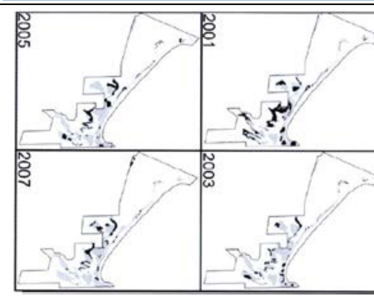
Promoting Species Establishment I a Phragmites-Dominated Great Lakes Coastal Wetland. *Carlson et al. 2009*.	• randomized complete block design • estimation of % cover all plant species in six 1-m2 quadrats per plot pre (YR0), two months (YR1) and 14 months (YR2) following treatments • 1% intervals up to 10% percent; 5% intervals for values > 10 percent. • Plants were identified to species.		High	• Suitable for controlled research • Time intensive • High level of botanical experience required
Monitoring Native Prairie Vegetation: The Belt Transect Method. *Grant et al., 2004*	• Identify dominant plant group (morphotype) in 0.1 m X 0.5 m plots, continuously along line transect • Transect length determined by application objective • Random or stratified random array based on aspect of site • % occurrence or frequency of plant groupings (morphotypes) in plot		Low	• Minimizes need to identify to species level • Uncertain if efficacy translates from upland prairie system to coastal wetlands • More research needed on coastal wetland plant morphotypes; what groups are meaningful to management goals?
Efficacy of Imazapyr and Glyphosate in the Control of Non-Native *Phragmites australis.* *Mozdzer et al. 2008*	• Randomized complete block design • Number of living *Phragmites* stems • Mean height of *Phragmites* stems • % cover of living *Phragmites* foliage • % cover of living non-*Phragmites* vegetation		Medium	• Suitable for controlled research • Diversity of measures for *Phragmites* • Low level of botanical expertise required • No biodiversity measures
Integrated Management of Common Reed (*Phragmites australis*) along the Platte River in Nebraska. *Rapp et al. 2012*	• Randomized complete block design • Plots 15m wide and 30-90 m, depending upon location • Weed control (injury) estimated visually ~every 30 d after treatment; 0%: no *Phragmites* control; 100% complete *Phragmites* control.	• % flowering estimated - 0: none, 100% all flowering; measured end of each growing season. • Stem density in 1-m2 quadrats; measured end of each growing season.	Myrium	• Suitable research design for assessing *Phragmites* impact • Diversity of *Phragmites* measures • No biodiversity measures Not clear how plots were arranged

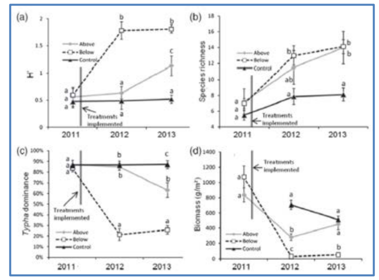
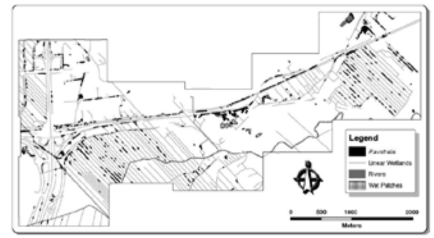
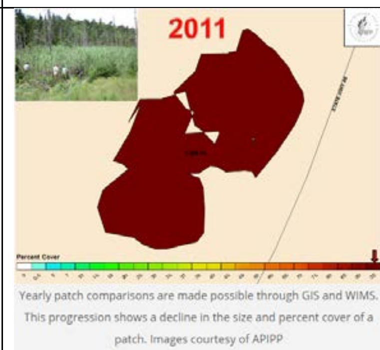
<table>
<tr>
<td>Chemical Control of Invasive Phragmites in a Great lakes Marsh: A Field Demonstration.

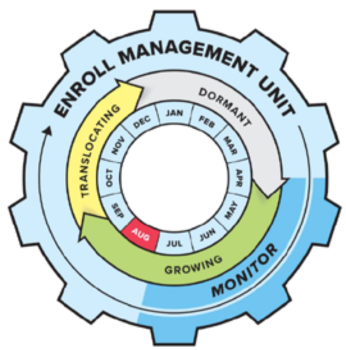
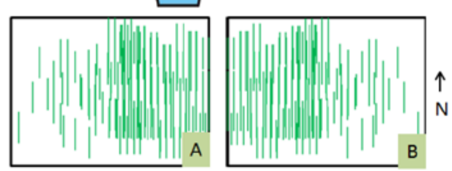
Getsinger et al. 2013</td>
<td>Three 8 ha plots in middle of larger treatment area.
Five 100 m permanent transects in each;
5 m2 plots per transects, every 20 ft.
% cover & freqency all species,</td>
<td></td>
<td>High</td>
<td>Real world scenario in natural setting
Time intensive
High botanical skill level required</td>
</tr>
<tr>
<td>Management of invasive Phragmites australis in the Adirondacks: a cautionary tale about propects of eradication.

Querion et al. 2017</td>
<td>Spatial extent of Phragmites mapped using WIMS 3; including outlier patches
Estimated Phragmites cover to 1 of 5 classes:
< 1%, 1-10%, > 20-25, > 25-50, >50-100%
Photo-documentation of cover ratings
Repeat annually</td>
<td>
</td>
<td>Low</td>
<td>Applicable mostly to small infestations
Variability by surveyor GPS tracks and estimates,
Photo-documentation provides backup
No biodiversity measures</td>
</tr>
<tr>
<td>Common reed (Phragmites australis) control is influenced by the timing of herbicide application.

Knezevic et al. 2013</td>
<td>Split plot design; 30 treatment, 3 reps each at 2 sites, 3 x 10 m
Visual ratings of % Phragmites control approx. every 30 days post-treatment
Quadrats 1 m^2
0% control to 100% complete control
Stem densities beginning & end of 2nd growing season (live stems above surface)</td>
<td><table>
<tr><td></td><td></td><td colspan="5">Phragmites australis</td></tr>
<tr><td></td><td></td><td colspan="3">Control (%)</td><td colspan="2">Density (stem m^{-2})</td></tr>
<tr><td>Application time and herbicide treatment</td><td>Dose (g a ha^{-1})</td><td>275 DAT</td><td>360 DAT</td><td>450 DAT</td><td>275 DAT</td><td>450 DAT</td></tr>
<tr><td>Vegetative stage</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Imazapyr</td><td>280</td><td>100</td><td>93</td><td>92</td><td>1</td><td>12</td></tr>
<tr><td>Imazapyr</td><td>560</td><td>100</td><td>100</td><td>100</td><td>0</td><td>1</td></tr>
<tr><td>Glyphosate + imazapyr</td><td>760 + 140</td><td>100</td><td>97</td><td>94</td><td>0</td><td>7</td></tr>
<tr><td>Glyphosate</td><td>1520</td><td>96</td><td>88</td><td>78</td><td>9</td><td>45</td></tr>
<tr><td>Glyphosate</td><td>3030</td><td>100</td><td>94</td><td>87</td><td>0</td><td>20</td></tr>
<tr><td>Imazamox</td><td>280</td><td>31</td><td>17</td><td>8</td><td>142</td><td>168</td></tr>
<tr><td>Imazamox</td><td>560</td><td>43</td><td>31</td><td>21</td><td>126</td><td>160</td></tr>
<tr><td>Glyphosate + imazamox</td><td>760 + 140</td><td>63</td><td>41</td><td>29</td><td>80</td><td>141</td></tr>
<tr><td>Imazamox + imazapyr</td><td>140 + 140</td><td>99</td><td>94</td><td>89</td><td>2</td><td>19</td></tr>
<tr><td>Control</td><td>0</td><td>0</td><td>0</td><td>0</td><td>171</td><td>178</td></tr>
<tr><td>LSD (0.05)[b]</td><td></td><td>9</td><td>10</td><td>12</td><td>23</td><td>28</td></tr>
<tr><td>Flowering stage</td><td></td><td>245 DAT</td><td>330 DAT</td><td>420 DAT</td><td>245 DAT</td><td>420 DAT</td></tr>
<tr><td>Imazapyr</td><td>280</td><td>99</td><td>99</td><td>99</td><td>1</td><td>2</td></tr>
<tr><td>Imazapyr</td><td>560</td><td>100</td><td>100</td><td>100</td><td>0</td><td>1</td></tr>
<tr><td>Glyphosate + imazapyr</td><td>760 + 140</td><td>100</td><td>98</td><td>98</td><td>0</td><td>5</td></tr>
<tr><td>Glyphosate</td><td>1520</td><td>100</td><td>97</td><td>96</td><td>1</td><td>6</td></tr>
<tr><td>Glyphosate</td><td>3030</td><td>100</td><td>98</td><td>98</td><td>0</td><td>3</td></tr>
<tr><td>Imazamox</td><td>280</td><td>84</td><td>63</td><td>50</td><td>37</td><td>97</td></tr>
<tr><td>Imazamox</td><td>560</td><td>86</td><td>67</td><td>53</td><td>29</td><td>88</td></tr>
<tr><td>Glyphosate + imazamox</td><td>760 + 140</td><td>88</td><td>80</td><td>74</td><td>23</td><td>49</td></tr>
<tr><td>Imazamox + imazapyr</td><td>140 + 140</td><td>100</td><td>93</td><td>91</td><td>1</td><td>14</td></tr>
<tr><td>Control</td><td>0</td><td>0</td><td>0</td><td>0</td><td>177</td><td>179</td></tr>
<tr><td>LSD (0.05)[b]</td><td></td><td>16</td><td>16</td><td>18</td><td>33</td><td>43</td></tr>
<tr><td>Seed filling stage</td><td></td><td>215 DAT</td><td>300 DAT</td><td>390 DAT</td><td>215 DAT</td><td>390 DAT</td></tr>
</table></td>
<td>Medium</td>
<td>Useful for research design – subsample of infestation
2 measures for Phragmites: cover & density
No biodiversity measures</td>
</tr>
<tr>
<td>Long-term spread and control of common reed (Phragmites australis) in Sheldon Marsh, Lake Erie.

Back & Holomuzki, 2008</td>
<td>Change in Phragmites patches via aerial imagery interpretation with ground-truthing</td>
<td>
</td>
<td>Medium</td>
<td>Demonstrates value of aerial imagery to track Phragmites
Improved imagery available and used in our study
Also testing drone imagery in our study
Requires remote sensing expertise</td>
</tr>
</table>

Biomass harvest of invasive *Typha* promotes plant diversity in a Great Lakes coastal wetland. *Lishawa et al. 2015*	• 2 stand x 3 treatment factorial, 4 repl. • Four 1 m^2 subplots within 16m^2 macroplot • % cover for all species in subplots • List all species in macroplot • Estimate of root/rhizome biomass from sediment subsamples • Estimate aboveground biomass by harvest, dry weight from 25 cm^2 quadrats		High	• Suitable for research • Extremely time-intensive • Not feasible for most treatment monitoring
Landscape Ecology of Phragmites australis invasion in networks of linear wetlands. *Maheu-Giroux and deBlois, 2005, 2007.*	• Large scale color aerial imagery with extensive ground sampling: • Height, stem abundance (% cover), and inflorescence abundance (% cover) • Abundance of other plant species using semi-quantitative cover classes.		High	• Demonstrates potential of aerial imagery • Using more current imagery in our study • Also testing drones in our study • Requires remote sensing expertise
Detroit River – W. Lake Erie CWMA Case Study. *May Chris, 2016 Posted on Great Lakes Phragmites Collaborative Web Site*	• Remote sensing with ground-truthing • 19 transects as baseline for various communities • Most effort is on rapid assessment of success of *Phragmites* kill and native plant regeneration • Photo-monitoring plots • Anecdotal reports of species of conservation value		High	• Requires significant ecological expertise to evaluate transects and determine future treatment • Baseline data quickly out of date by pace of treatment • Difficult to align and share data due to differing partner formats • However, exemplary in its application for long-term
Adirondack Park, NY; Adirondak Park Invasive Plant Program (APIPP) Case Study. *Querion & Simek, 2016 Posted on Great Lakes Phragmites Collaborative Web Site*	• Photo-monitoring • Spatial data via WIMS documents change in size • Native species richness and density at several sites with site with patch and outside patch		Low to High	• Photos and WIMS provide quick assessment of *Phragmites* change • Biodiversity measure limited and acknowledged as such

Lambton Shores, Ontario Cast Study. *Vidler and MacDonald, 2016*	• Several 1 m2 plots in each treatment site • Richness, diversity – all species • Wildlife observations • FQI • Water depth • Soil composition	 LOCATION (911 address or block name from maps) DESCRIPTION OF PHRAGMITES Size of Area / Height (m) / Density (select one): Sparse, Thick / Age (select one): Newly established, Well established / Site description (select one): Dry ground, Shoreline, Wetland, Water body Wildlife Observations (Turtles, birds, snakes, etc.) SPECIES OBSERVED / NUMBER OF INDIVIDUALS Other Plant Observations SPECIES OBSERVED / NUMBER OF INDIVIDUALS or THICKNESS	High	• Requires high level of botanical expertise • Plots may not capture site diversity • May work for small sites
Wymbolwood Beach, Ontario Case Study. *Short, 2016*	• Non-formal visual inspections are conducted each year to assess the non-native *Phragmites* populations. • Residents informally report the return of frogs and wildflowers to the program coordinator.	 	Low	• May be feasible for very small sites • Better than nothing
Phragmites Adaptive Management Framework Participant Guide *GLC, USGS, U of GA, 2017*	• Establish treatment patch boundary (MU) • Get 5 monitoring locations from PAMF Hub • At each location, using 0.25m^2 quadrat: • Live *Phragmites* stem count • 3 live *Phragmites* stem diameters -2 closest to marked corners of quadrat -1 in center of quadrat • Look for signs of non-treatment stress -Environmental, pathogen, insect • % live Phragmites establishment within entire (MU) (density doesn't matter) -0-10%, -1-50%, -51-100% • Potential for spread Y/N • One of 16 potential treatment scenarios per treatment phase (translocating, dormant, growing) will be recommended by PAMF, each year	  	Medium	• Well researched, model driven, scalable adaptive management protocol • Oversight and assistance from PAMF team • Includes monitoring protocol, predictive model, and results-database • Focus is on treatment impacts to *Phragmites* in specifically designated patches • Site specific treatment recommendations annually • Can only do sites where in-field monitoring can be conducted. • May not be feasible in large or difficult-to-access patches • No biodiversity data or measures (may be the PAMF

<table>
<tr>
<td></td>
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<td></td>
<td>hub does this?)</td>
</tr>
<tr>
<td>Common Reed (Phragmites Australis) Response to Mowing and Herbicide Application

Derr, 2008</td>
<td>

Randomized complete block; 4 replicates
% control evaluated visually in September for June applications and the following April for all applications by comparing:
Biomass in treated plots and untreated
0 = no control and 100 = complete control
Total live stems in each plot in April
Shoot fresh weight

</td>
<td>
<table>
<tr><th></th><th></th><th colspan="3">Common reed</th></tr>
<tr><th></th><th></th><th>Shoot fresh weight</th><th>Regrowth number of shoots</th><th>Regrowth shoot fresh weight</th></tr>
<tr><th>Treatment[b]</th><th>Rate</th><th>1 MAT</th><th>2 MAT</th><th>2 MAT</th></tr>
<tr><td></td><td>kg ai/ha</td><td>g</td><td>no.</td><td>g</td></tr>
<tr><td>Untreated</td><td></td><td>87.3</td><td>20.5</td><td>41.2</td></tr>
<tr><td>Fosamine</td><td>20.2b</td><td>63.9</td><td>0.0</td><td>0.0</td></tr>
<tr><td>Imazapic</td><td>0.16</td><td>68.4</td><td>21.0</td><td>4.8</td></tr>
<tr><td>Glyphosate</td><td>2.24</td><td>24.0</td><td>0.0</td><td>0.0</td></tr>
<tr><td>Imazapyr</td><td>1.12</td><td>59.5</td><td>4.5</td><td>0.5</td></tr>
<tr><td>Triclopyr</td><td>1.12</td><td>63.3</td><td>12.8</td><td>24.9</td></tr>
<tr><td>Triclopyr</td><td>3.36</td><td>66.7</td><td>2.5</td><td>9.5</td></tr>
<tr><td>Triclopyr</td><td>6.72</td><td>47.6</td><td>0.3</td><td>3.3</td></tr>
<tr><td>LSD 0.05</td><td></td><td>13.9</td><td>9.6</td><td>8.3</td></tr>
</table>
</td>
<td>Low visual; high biomass</td>
<td>

Suitable for research
Somewhat subjective rating
Diversity of Phragmites measures
No biodiversity measures

</td>
</tr>
<tr>
<td>Chemical control of common reed (*Phragmites australis*) by foliar herbicides under different spray conditions.

Moreiro et al. 1999</td>
<td>

Split block design with three replicates
% cover of *Phragmites* relation to control
Estimates by two independent observers
Scale of 0 = no reduction in biomass to 100 = no living *Phragmites* present
10 DAT (days after treatment) and 1, 6, 12 and at some cases 24 MAA (months after application).

</td>
<td>
Table 2. Herbicide efficacy for common reed applied in autumn (4 October 1994) and spring (19 April 1995) after cutting(5 September 1994) at different spray volumes using two types of sprayers – motorised knapsack mistblower and a hydraulic sprayer (wheelbarrow type)
<table>
<tr><th>Herbicide</th><th>Rate</th><th>Vol</th><th>Type</th><th colspan="6">Percent weed control</th></tr>
<tr><th></th><th></th><th></th><th></th><th colspan="3">Autumn application</th><th colspan="3">Spring application</th></tr>
<tr><th></th><th>(kg a.i./ha)</th><th>(</th><th>l/ha)</th><th>10 DAT</th><th>6 MAA</th><th>12 MAA</th><th>1 MAA</th><th>6 MAA</th><th>12 MAA</th></tr>
<tr><td>Glyphosate</td><td>3.24</td><td>300</td><td>mistblower</td><td>0 b</td><td>100 a</td><td>85 a</td><td>50 b</td><td>90 a</td><td>85 a</td></tr>
<tr><td>glyphosate</td><td>3.24</td><td>800</td><td>mistblower</td><td>0 b</td><td>100 a</td><td>85 a</td><td>75 a</td><td>90 a</td><td>80 a</td></tr>
<tr><td>glyphosate</td><td>3.24</td><td>1100</td><td>sprayer</td><td>0 b</td><td>95 a</td><td>80 a</td><td>75 a</td><td>90 a</td><td>80 a</td></tr>
<tr><td>glaphosinate</td><td>1.38</td><td>800</td><td>mistblower</td><td>100 a</td><td>30 b</td><td>0 b</td><td>50 b</td><td>25 c</td><td>0 b</td></tr>
<tr><td>glaphosinate</td><td>1.38</td><td>1100</td><td>sprayer</td><td>100 a</td><td>40 b</td><td>0 b</td><td>75 a</td><td>50 b</td><td>0 b</td></tr>
</table>
</td>
<td>Low</td>
<td>

Phragmites measures only
In some cases up to 2 years monitoring
No biodiversity measures

</td>
</tr>
<tr>
<td>Manual Control of Phragmites australis in Freshwater Ponds of Cape Cod National Seashore, Massachusetts, USA

Smith, 2005</td>
<td>

Live stem densities in three permanent 0.25 m^2 sampling plots randomly established in each stand.
Water depth within each
Circumference (c) of each treatment stand measured to nearest meter
Stand size calculated as π(c/2π)2

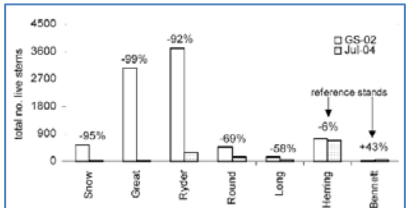
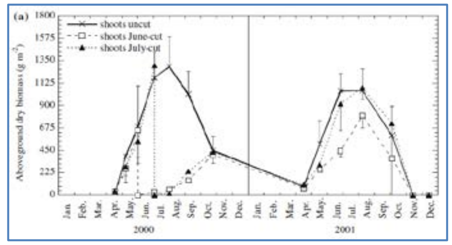
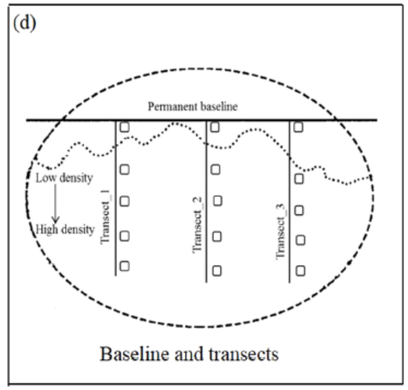
</td>
<td>

Figure 2. Number of live stems within whole stands before and after treatment (percent values indicate increase or decrease in total population size; GS-02 = calculated values for the growing season of 2002).</td>
<td>Low</td>
<td>

Phragmites measures only
Density and stand size
No biodiversity measures

</td>
</tr>
</table>

The effect of summer harvesting of *Phragmites australis* on growth characteristics and rhizome resource storage. *Asaeda et al. 2004*	• Biomass of shoots and different age rhizomes • Shoots harvested at substrate level 0.25 m_0.5 m (0.125 m2). • Rhizomes and roots excavated to minimum depth of ~ 0.6 m; same area • Non-structural carbohydrates extracted		High	• Phragmites shoots and rhizomes only • No biodiversity measures

Responses of plant species diversity and soil physical-chemicalmicrobial properties to Phragmites australis invasion along a density gradient.
 	
Uddin and Robinson 2017
	• 75 m baseline; 3 transects across density gradient, random quadrats along each
	• Density and cover of *Phragmites*
	• All species and number of each
	• Soil properties:
	  ▪ water content
	  ▪ dehydrogenase activity
	  ▪ microbial biomass
	  ▪ except pH
	  ▪ electrical conductivity
	  ▪ phenolics,
	  ▪ organic carbon
	  ▪ endophyte spore density
			High	• Cover *and* density of *Phragmites*
				• Plant diversity
				• Intensive soil and microbe samples
				• Suitable for research

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Tier 1-3 Protocols

Tier 1 Protocol

The Tier 1 protocol is a one page sheet to provide a qualitative pre- and post-treatment overview of treated areas of *Phragmites* (Fig. 1). The protocol includes gathering and recording a minimum set of standardized photos of the site, information on the treatment methods and timing of the monitoring, and qualitative assessment of overall amount of *Phragmites* and other species at the site, as well as a qualitative assessment of the aesthetic, recreational and human safety impacts of the infestation.

Photos

Standardized photos are taken from the outside of the patch, in three directions: straight towards the patch, to the left of the viewer, and to the right of the viewer. If any other nearby patches of *Phragmites* exist and may provide a seed source, these are also photographed from the same point and noted. The location of the photo point is the same place the Lat/Long is taken, on the start point of a Tier 2 transect (if available), or near the center of one exterior edge. Observers can opt to take additional photos from within the treatment area if desired, and should record details of where and why they were taken.

Percent cover of *Phragmites*, desirable and undesirable species assessment

Presence and percent cover of *Phragmites*, other undesirable species, and other desirable species are estimated by category and recorded. Depending upon the skill level of the observer, other desirable and undesirable species observed can also be listed. However, emphasis is placed on identifying undesirable species that could pose a risk of secondary invasion to the treatment site. This is recommended for all *Phragmites* treatment efforts.

Treatment methods and monitoring specifics

Six check boxes pertain to treatment and monitoring specifics and are recorded by checking the appropriate box: monitoring timing, treatment type, herbicide, herbicide application, treatment date and treatment area.

Aesthetic, recreational, and human safety hazard assessment

These categories are based on the DNR's Phragmites Treatment/Management Prioritization Tool. They provide qualitative assessments of three significant values that are important to consider when determining if treatment of *Phragmites* is warranted.

Ecosystem type

Observers select the general natural community type that best fits the site and record any comments about its quality. This category can be used as the desired future condition for the site or another desired future condition can be recorded with an explanation.

TEIR 1: FULL PATCH INFORMATION

Site Name:	Transect #:	Date:
First Unknown: Last Unknown:	Azimuth:	Time:
Samplers:	Weather:	

	No	Yes	% cov	List other invasive species observed, desirable dominants
Is Phragmites currently present?				
Are other invasive species present				
Are desirable species present?				
Comments				
Photos #'s:	Center:		Right:	Left:

Monitoring Timing:	☐ Pre-Treatment ☐ Post Treatment ☐ Other:______________
Treatment Type:	☐ Herbicide (describe below) ☐ Mow ☐ Burn ☐ Rest ☐ Other
Herbicide Used:	☐ Glyphosate ☐ Imazapyr ☐ Imazamox ☐ Surfactant Brand names and proportions, if known:
Herbicide Application Method:	☐ Boom Spray ☐ Backpack Spray ☐ Aerial ☐ Hand ☐ Other
Treatment Dates:	Start date:____________ End date:_____________ Treater:________________
Treatment area:	☐ Entire Patch ☐ Other:____
Aesthetic Impacts Scale	☐ Severe ☐ Moderate ☐ Mild
Recreational Impacts Scale	☐ Severe ☐ Moderate ☐ Mild
Human Safety Hazard Scale	☐ Severe ☐ Moderate ☐ Mild
Natural Community Type(s) and dominant cover:	
Notes on site access:	

Cover categories (morphotypes)	**Aesthetic scale**
P: phragmites	· **Severe:** entirely blocking shoreline views, inhibiting public scenic road or waterways...
U: undesirable species (non-phrag)	· **Moderate:** some (but not entire) blockage of shoreline or other public scenic views
D: desirable vegetation	· **Mild:** little to no blockage of shoreline or other public scenic views
B: bare soil/mud	**Recreational scale**
O: open water	· **Severe:** inhibiting boat/walking access to water, reduced waterfowl, fish use of area,
Natural Community Type	reduced visibility inhibiting bird watching, hunting, etc.
Great Lakes - Emergent Zone	· **Moderate:** moderate impacts to boat/walking access to water, reduced waterfowl,
Great Lakes - Wet Meadow Zone	fish use of the area, or reduced visibility for bird watching, hunting, etc.
Great Lakes - Submergent Zone	· **Mild:** little to no impacts on recreational activities
Southern Wet Meadow	**Human Safety Hazard Scale**
Emergent Marsh	· **Severe:** blocking views along major roads, intersections, fire-prone dry thatch .
Lakeplain Prairie	accumulation adjacent to homes and buildings, etc
Shrub Swamp	· **Moderate:** Currently not, but potential to block views along roads, intersections, some
Forested Swamp	dry thatch adjacent to buildings, etc.
Other	· **Mild:** little to no apparent safety hazard

Figure 1: Tier one data sheet, complete with variable definitions at the bottom.

Tier 2 Protocol

The new system uses belt transects for every 1m of the entire transect, and 5 1X1m plots for percent cover by class spread along the transect. Transects, start and end points, and a random number (between 0 and 50 for transects over 100m, between 0-20 for those under 100m) are produced in the office ahead of time based off of the size of treatment polygons. All of this information is printed on laminated field maps.

Workers Carry:

- Sighting compass (each)
- GPS
- Camera
- $1m^2$ quad
- Clipboard with field sheets and maps
- Calipers

Before the transect is begun, metadata (date/time, azimuth, etc.) is collected at the start point, including a photo along the azimuth towards the patch. One member of the field team walks the transect using compass and GPS unit, calling the dominate cover and any invasive species for each plot.

Cover types are:

- Live Phragmites (P)
- Dead Phragmites (PD)
- Desirable Species (D)
- Undesirable Species (U)
- Open Water (W)
- Bare soil/mud (B)

Undesirable and invasive species are:

- Asiatic sand sedge (AS)
- Bittersweet Nightshade (BN)
- Canadian Thistle (CT)
- Curly pondweed (CP)
- Eurasian water milfoil (EWM)
- European frog-bit (EFB)
- European water clover (EWC)
- Himalayan balsam (HB)
- Hydrilla (HD)
- Non-native cat-tails (CAT)
- Parrot-feather (PF)
- Purple loosestrife (PL)
- Reed canary grass (RCG)
- Water chestnut (WC)
- Water hyacinth (WH)
- Water lettuce (WL)
- Water soldier (WS)
- Yellow-floating heart (YFH)

The second person writes down the information, flags the path, and carries the remaining equipment. Once the end point is reached, the distance between full 1x1m plots is calculated using the distance to the start point from the current point, less the random distance assigned to that transect:

$$Distance\ to\ Plot = \frac{Total\ distance\ of\ transect - 2 * (Random\ number)}{5}$$

The first plot is this number, plus the random number. At each plot, there is a GPS point, a photo taken along the transect azimuth, and a plot photo taken. 4 stems, the largest in each quad (Fig. 2), are measured for basal diameter and approximate height. Water depth is also taken at one point in each plot. Percent cover, both live and dead, of each of the above Undesirables, as well as Phragmites, is recorded. Percent cover of both live and dead desirable species is recorded by the following categories:

- Rushes
- Sedges
- Grasses
- Forbs and Herbs
- Woody
- Vines
- Bulrush
- Native cattails
- Emergent
- Floating Aquatic
- Submergent
- Non-Vascular

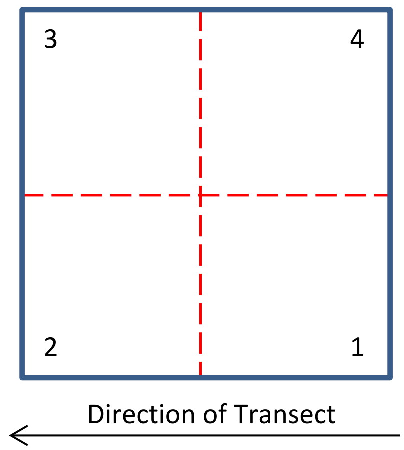

Fig. 2. Quads for measuring basal diameter and heightheight quat

If possible, a 10cm soil sample is taken and labeled with plot name and date for nitrogen sampling. At plots where soil samples are taken the top fully grown live and dead leaves are collected from the stems measured for height and diameter.

For all transects over 500m in length, UAV transects should be used to collect data.

The data form for Tier 2 montoring is provided in Figure 3.

TIER 2 Plot Data	Date:		Time:		Site Name:				Transect #:	
Zone (E, M, S)	Plot 1:		Plot 2:		Plot 3:		Plot 4:		Plot 5:	
GPS	LAT	LONG	LAT	LONG	LAT	LONG	LAT	LONG	LAT	LONG
PHOTO #	Azmith	Nadir	Azmith	Nadir	Azmith	Nadir	Azmith	Nadir	Azmith	Nadir
Camera:										
Biophysical										
Water Level										
Leaf Sample?										
Soil Sample?										
Number of Phrag Stems										
Stem Diameter 1										
Approx. Stem Height 1										
Stem Diameter 2										
Approx. Stem Height 2										
Stem Diameter 3										
Approx. Stem Height 3										
Stem Diameter 4										
Approx. Stem Height 4										
Desirable:	% Cover	# of spp.	% Cover	# of spp.	% Cover	# of spp.	% Cover	# of spp.	% Cover	# of spp.
Rushes										
Sedges										
Grasses										
Forbs and Herbs										
Woody										
Vines										
Bulrush										
Native cattails										
Emergent										
Floating Aquatic										
Submergent										
Non-Vascular										
Undesirable:	% Cover	# of spp.	% Cover	# of spp.	% Cover	# of spp.	% Cover	# of spp.	% Cover	# of spp.
Phragmites Live (P)										
Phragmites Dead (PD)										
Asiatic sand sedge (AS)										
Bitters't nightshade (BN)										
Canada thistle (CT)										
Curly pondweed (CP)										
Eur. water-milfoil (EWM)										
European frog-bit (FB)										
Eur. water clover (WC)										
Himalayan balsam (HB)										
Hydrilla (H)										
Non-native cat-tails (CAT)										
Parrot-feather (PF)										
Purple loosestrife (PL)										
Reed canary grass (RCG)										
Water chestnut (WCH)										
Water hyacinth (WH)										
Water lettuce (WL)										
Water soldier (WS)										
Yel. floating heart (YFH)										
NOTES:										

Figure 3. Tier 2 Plot Data Sheet, page 1.

Live Phrag (PL) Dead Phrag (PD) Desirable natives (D) Undesirable invasives (U) Open Water (W) Bare soil/n											
TIER 2 BELT			Date:		Time:		Site Name:				
Observers:					Azimuth:				Transect #:		
Start point:			Start Photo:			End Point:			End Photo:		
Plot #	Class	Undesirables	Plot #	Class	Undesirables	Plot #	Class	Undesirables	Plot #	Class	Undesirables
1			51			101			151		
2			52			102			152		
3			53			103			153		
4			54			104			154		
5			55			105			155		
6			56			106			156		
7			57			107			157		
8			58			108			158		
9			59			109			159		
10			60			110			160		
11			61			111			161		
12			62			112			162		
13			63			113			163		
14			64			114			164		
15			65			115			165		
16			66			116			166		
17			67			117			167		
18			68			118			168		
19			69			119			169		
20			70			120			170		
21			71			121			171		
22			72			122			172		
23			73			123			173		
24			74			124			174		
25			75			125			175		
26			76			126			176		
27			77			127			177		
28			78			128			178		
29			79			129			179		
30			80			130			180		
31			81			131			181		
32			82			132			182		
33			83			133			183		
34			84			134			184		
35			85			135			185		
36			86			136			186		
37			87			137			187		
38			88			138			188		
39			89			139			189		
40			90			140			190		
41			91			141			191		
42			92			142			192		
43			93			143			193		
44			94			144			194		
45			95			145			195		
46			96			146			196		
47			97			147			197		
48			98			148			198		
49			99			149			199		
50			100			150			200		
Notes:											

Figure 3. Tier 2 Plot Data Sheet, p. 2.

Live Phrag (PL) Dead Phrag (PD) Desirable natives (D) Undesirable invasives (U) Open Water (W) Bare soil/n											
TIER 2 BELT TRANSECT DATA Page 2					Date:		Site Name:				
Observers:					Azimuth:				Transect #:		
Plot #	**Class**	**Undesirables**	**Plot #**	**Class**	**Undesirables**	**Plot #**	**Class**	**Undesirables**	**Plot #**	**Class**	**Undesirables**
201			251			301			351		
202			252			302			352		
203			253			303			353		
204			254			304			354		
205			255			305			355		
206			256			306			356		
207			257			307			357		
208			258			308			358		
209			259			309			359		
210			260			310			360		
211			261			311			361		
212			262			312			362		
213			263			313			363		
214			264			314			364		
215			265			315			365		
216			266			316			366		
217			267			317			367		
218			268			318			368		
219			269			319			369		
220			270			320			370		
221			271			321			371		
222			272			322			372		
223			273			323			373		
224			274			324			374		
225			275			325			375		
226			276			326			376		
227			277			327			377		
228			278			328			378		
229			279			329			379		
230			280			330			380		
231			281			331			381		
232			282			332			382		
233			283			333			383		
234			284			334			384		
235			285			335			385		
236			286			336			386		
237			287			337			387		
238			288			338			388		
239			289			339			389		
240			290			340			390		
241			291			341			391		
242			292			342			392		
243			293			343			393		
244			294			344			394		
245			295			345			395		
246			296			346			396		
247			297			347			397		
248			298			348			398		
249			299			349			399		
250			300			350			400		
NOTES:											

Figure 3. Tier 2 Plot Data Sheet, p. 3.

Plot Zones:	Acronym	Description
Emergent Zone:	E	Permanently flooded in most years; bulrushes *(Scirpus, Schoenople* rushes (*Juncus*), spike-rushes (*Eleocharis*) cat-tails (*Typha*) and submergent and floating plants.
Wet Meadow:	M	Shallow, saturated, organic soils; not typically with standing water through the growing season; grasses and sedges usually dominant with many forbs.
Submergent:	S	Deep water; few or not emergent species; majority of plants submersed or floating.

Cover categories (morphotypes)	
Phragmties-live	P
Phragmites-dead	PD
Desirable natives	D
Undesirable invasives	U
Open Water	W
Bare soil/mud	B

Desirable Species
Native bulrushes
Native Sedges and rushes
Native Grasses
Native forbs
Can specify certain species based upon management goals.

Undesirable Species	Acronym	Scientific Name
Asiatic sand sedge	AS	*Carex kobomugi*
Bittersweet Nightshade	BN	*Solanum dulcamara*
Canadian Thistle	CT	*Circium arvense*
Curly pondweed	CP	*Potamogeton crispus*
Eurasian water milfoil	EWM	*Myriophyllum spicatum*
European frog-bit	EFB	*Hydrocharis morsus-ranae*
European water clover	EWC	*Marselia quadrifolia*
Himalayan balsam	HB	*Impatiens glandulifera*
Hydrilla	HB	*Hydrilla verticillata*
Non-native cat-tails	CAT	*Typha angustifolia, Typha Xglauca*
Parrot-feather	PF	*Myriophyllum aquaticum*
Purple loosestrife	PL	*Lythrum salicaria*
Reed canary grass	RCG	*Phalaris arundinacea*
Water chestnut	WC	*Trapa natans*
Water hyacinth	WH	*Eichhornia crassipes*
Water lettuce	WL	*Pistia stratioides*
Water soldier	WS	*Stratioides aloides*
Yellow-floating heart	YFH	*Nymphoides peltata*

Figure 3. Tier 2 Plot Data Sheet, p. 4.

Tier 3 Protocol

Overview:

Each polygon contains three transects which run parallel to the flow of water from the upland edge into open water. Along each line, 15 1mX1m plots are recorded for all species and characteristics, 5 in each section: Meadow, Emergent, and Submergent. These plots are evenly spaced along the transect. The transect is walked once to understand the total length and the length of each zone. When walking back, the 15 plots are recorded.

Procedure:

Using GPS and maps, navigate to either end of the selected transect. Dependent on the area and landscape, it may be easier to start in the water, rather than in the meadow portion. Once reaching the point marked in the GPS, locate a reasonable start point in the field. Because the points are estimated, it may be necessary to shift a point to avoid property lines, tree lines, or other landmarks. The meadow start point should be located 1/6th the width of the Meadow zone from the tree line: this can and should be estimated. If starting in the submergent zone, measure 25m along the line from the submergent edge and mark this point. Using the pre-determined bearing, start walking a straight line towards the other point using the compass. Having both the front and back team members sighting the line helps in keeping it straight, as it is easy to get off the bearing in dense *Phragmites* stands. Having the back member note when the line shifts off allows the front member to check and recalibrate with the line and the bearing. Mark edges and points along the line with tape for later reference. This tape should be collected when leaving the area.

Along the line, from Meadow to Submergent, 4 points should be marked (in addition to those at the quadrats) with both the handheld GPS unit and the Trimble Unit: “Start” at the meadow start point, “emergentedge” at the edge between meadow and emergent zones, “submergentedge” at the edge of the emergent and submergent zones, and “End” at the point 25m into the submergent zone. ***Independent of which direction the line is walked, “Start” is always in the meadow and “End” is always in the submergent.*** At each of these points, a picture should also be taken both “forward” and “backward” along the line.

- The Meadow zone is an area dominated by herbaceous flora, with small trees and bushes possibly present, as well as grasses and sedges, and often high numbers of *Potentilla anserina*. Standing water is typically not present, though may be minimally if flooding has occurred.
- The Emergent zone is dominated typically by *Phragmites, Schenoplectus, Typha, Nuphar,* and *Lemna.*
- The Submergent zone has no vegetation above the water and is typically within the bay itself. These areas are dominated by *Potamogeton, Chara, Najas,* and various algae.

If sections are less than 11m wide:

In these cases, narrow sampling protocol must be used. Here, a transect 30m long is created perpendicular to the line being walked. Draw the reel tape the length of the transect, then mark then end point as you normally would with the GPS units. At the halfway point of the tape (IE if the transect is 8m wide, at 4m), pull the tape perpendicular to the line 30 meters, 15 meters to each side. Leave the tape lying as a marker, then take quadrate samples normally at 7m, 12m, 17m, 24m, and 27m.

If walking meadow to submergent:

Once the team reaches the submergent edge, a flag is tied on the outer edge of the emergent zone, and one member measures 25 meters into the Submergent zone using the reel tape. This is the "End" point. The quadrates are placed at 2.5m, 7.5m, 12.5m, 17.5m, and 22.5m along this line. This measurement can be estimated by "rolling" the quadrat, which is 1m on each side, along the line. The distances between points for the emergent and meadow zones are determined the same as when walking submergent to meadow.

If walking submergent to meadow:

The point decided as your meadow edge is marked as "Start". The distance between this point and the "Emergent edge" point taken earlier is the length of the meadow zone. This is divided by 10 to gain the distance to the first point, than multiplied by two for the distance to each of the following 4 points. Numbers should always be rounded down. For example:

- Emergent edge is 57m from START. Therefore the first point is 5m from start (57/10=5.7, rounded down is 5), and each following point is 11m from the last (5.7*2=11.4 rounded to 11). Therefore, points are at 5m, 16m, 27m, 38m, and 49m.
- Once the emergent edge is reached, the same calculation is used between the "emergent edge" and "submergent edge" points to determine the distance between emergent points. The submergent zone is measured the same way as above.

NOTE: If walking Submergent to Meadow, measuring the submergent edge before entering the emergent zone is advised.

At each quadrat:

At each quadrat, the measurement frame is laid as level as possible. A picture, handheld GPS, and Trimble point are taken. All plants are recorded by species, and percent cover of each is estimated. It is advised to record all species present first, placing a dot in the corresponding box, then estimating percent cover once all species are accounted for. In the submergent and emergent zones, the rake is used to make 3 passes over the bottom of the quadrate, collecting vegetation growing on the substrate. If a species is unknown, it is collected and assigned an individual number. If submergent, it is placed in a ziplock bag with a small amount of water and the number is marked on the bag. If emergent or a meadow plant, a piece of duct tape is attached with the number. All unknown plants are placed in a large ziplock bag to be brought back to the hotel later that night. It is advised that a hole be made in the top corner of the larger ziplock, then reinforced with duct tape, so it can be attached to one's waders for easy access. If two teams are being used, one marks all unknowns with an "A", the others with a "B". When entering unknowns on the field sheets, include short descriptions of the plant next to the number on the page: this allows for it to only be collected once along the transect.

The percent cover of detritus, or decaying plant matter is estimated, as is standing (defined as rooted) dead. The type of soil (Sand, clay, silt, or any mix thereof) and the depth of the organic matter on top are noted. In zones where the water is shallow enough, this is done by digging a small hole with the trowel, elsewhere the handle of the rake can be used to measure the changes in texture. Where applicable the depth of water is recorded using the marked rake, and the visibility is also noted. Visibility is defined as whether the bottom is "Visable" or "Not Visable" BEFORE walking through the area, as this can kick up sediment. Looking at the plot from a "bird's eye" view, the total vegetated and unvegetated area should also be estimated. This is NOT the sum total of all vegetation, as layering may mean that the sum total percent covers are above 100%. For total veg cover, however, the number cannot exceed 100.

Location:					Wetland:							Date:			
First Unknown:					Last Unknown:							Time:			
Samplers:			Azimuth:				Water Clarity: Bottom Visible (V) or Not Visible (NV)								
Sample Point															
Substrate Type															
Organic Depth (cm)															
Detritus (%)															
Standing Dead (%)															
Water Depth (cm)															
Water Clarity															
Marsh Zone															
Sample Point															
Species															
Algae spp.															
Anemone canadensis															
Apocynum cannabinum															
Asclepias incarnata															
Calamagrostis canadensis															
Chara spp.															
Cicuta bulbifera															
Cladium mariscoides															
Eleocharis palustris															
Elodea canadensis															
Eragrostis spectabilis															
Eupatorium perfoliatum															
Eutrochium purpureum															
Eythamia graminitolia															
Grass spp.															
Impatiens capensis															
Juncus															
Juncus															
Juncus															
Lemna minor															
Lycopus americanus															
Lycopus uniflorus															
Lythrum salicaria															
Najas flexilis															
Nitella sp.															
Phalaris arundinacea															
Phragmites australis															
Potamogeton															
Potamogeton															
Potentilla anserina															
Sagittaria															
Salix spp.															
Schoenoplectus acutus															
Schoenoplectus pungens															
Schoenoplectus tabernaemontani															
Stuckenia pectinata															
Symphyotrichum lanceolatum															
Typha angustifolia															
Typha latifolia															
Typha x glauca															
Utricularia															
Utricularia															
Vallisneria americana															

Figure 4. Tier 3 Data Form, Page 1.

Species															
VEGETATED TOTAL															
UNVEGETATED TOTAL															

NOTES:

Figure 4. Tier 3 Data Form, Page 2.

Photos and GPS

Camera Number:	Garmin #		Trimble #	
	Photo Number		GPS	
Photo Location	**Upland**	**Bay**	**Lat**	**Long**
UPLAND EDGE				
UPLAND/EMERGENT EDGE				
EMERGENT/SUBMERGENT EDGE				
SUBMERGENT EDGE				
Plot 1				
Plot 2				
Plot 3				
Plot 4				
Plot 5				
Plot 6				
Plot 7				
Plot 8				
Plot 9				
Plot 10				
Plot 11				
Plot 12				
Plot 13				
Plot 14				
Plot 15				
Extra 1				
Extra 2				
Extra 3				
Extra 4				
Extra 5				

Figure 4. Tier 3 Data Form, page 3.

NOTE: *Independent of which quadrat is sampled first, the plot closest to the meadow "Start" point is always 1, the submergent point closest to "End" is always 15*. This expedites later data entry. Points 1, 2, 3, 4, and 5 are in the Meadow. Points 6, 7, 8, 9, and 10 are in the Emergent section. Point 11, 12, 13, 14, and 15 are in the Submergent zone. If any zone is skipped, those plot number are not used.