Comprehensive *Phragmites* Management Strategy

Introduction

Plant invasions are triggered by interacting factors of disturbance, nutrients (e.g. from agricultural runoff) and nearby invasive plant presence (Colautti *et al.* 2006), including *Phragmites* and new invaders that continue to arrive over time. The best approach for *Phragmites* management across a region such as the Saginaw Bay is at the watershed scale. Ideally, both the source of the problem, nutrient loading, and the symptom, *Phragmites* invasion, should be addressed at the same time. However, we recognize that this can be challenging logistically, economically and politically, and near-term control actions will be needed while long-term abatement of causes progresses. Land use changes and increasing nutrients, particularly the limiting nutrient nitrogen (N), have been documented as causational to large, perennial clonal species such as *Phragmites*, *Typha* and other non-native plant invasions (Currie et al. 2014, Kettenring et al. 2011, King *et al.* 2007, Martina et al. 2016, Silliman and Bertness 2004). Currie et al. 2014 and Martina et al. 2016 have shown that above a threshold of N loading of 4 $g/m^2/yr$, the invasive plants, *Phragmites* and *Typha* angustifolia, and *T*. X*glauca*., are able to outcompete native plants and grow to extreme heights and densities. As long as N pollution continues to be a problem, efforts to control invasive plants like *Phragmites* will be ongoing and costly, with repeated reinfestations of either the problem plant or a secondary invasion.

A prototype solution to ultimately improve ecological health of coastal wetlands is an integrative approach to control the invasive plants, restore wetland habitat and improve water quality by holistically treating the entire watershed. Within the watershed, individual invasions need to be assessed for site specific conditions and treatment plans designed accordingly. Best treatments vary by site specific conditions and need to be assessed annually. It is critical to monitor treated sites and conduct follow-up treatments as needed, applying an adaptive management strategy. The whole watershed prototype includes measuring and modeling N loading, working to improve water quality and reduce nitrogen pollution to below the threshold of 4 $g/m^2/yr$ and further developing and implementing wetland ecosystem modeling tools (MONDRIAN and PAMF). These tools are needed for determining the best site-specific treatment scenarios, including the timing and sequence of methods (herbicide, mowing, biomass removal, burning, etc.). Best treatment practices are not one size fits all, but vary by water levels, N-loading, stand age and distribution of invaders surrounding the site (Elgersma et al 2017).

The guiding principles below are suggested with emphasis on knowing your landscape and site conditions, setting goals for what success will look like and implementing adaptive management. Monitoring is critical to assess your site pre-treatment and for follow-up assessment and treatment plans. Long-term data sets are particularly important to inform models.

Guiding principles:

- Take a watershed approach and work to install buffers or implement other practices to reduce N loading while treating *Phragmites*. Know your landscape and integrate prioritization, management and monitoring with the Saginaw Bay CISMAs and other partners to achieve the desired goals.

- Use principles of adaptive management:
    - Set management goals and define the desired future condition before treatment begins;
    - Conduct pre- and post-monitoring; this will depend on budgets but the management goals should define the level and specific measurable parameters of monitoring; implement adaptive management based on monitoring results;
    - Share results widely to improve *Phragmites* management region wide and broaden support from scientists, funders and the public.

- Prioritize:
    - Use informative data layers (e.g. maps of *Phragmites* distribution, MONDRIAN modeling/LUT, high value and priority sites, invasion pathways, Great Lakes decision support tools) effectively in advance of selecting treatment areas;
    - Use MDEQ *Phragmites* prioritization tool to help select treatment areas;
        - Size, quality and desired condition, safety, aesthetics, recreation, adjacency of treatments;
    - Consider outliers, pathways and sources;
        - Outliers first (stop from spreading; some evidence for greater genetic diversity in outliers) (Hazleton et al. 2015, Kettenring et al. 2011, Kettenring et al. 2016, McCormick et al. 2010;
        - Block pathways and/or eliminate sources (cost-effective approach);
        - Push large infestations from leading edges towards their centers;
    - Consider unintended consequences; monitor for secondary invaders; e.g., will *Phragmites* treatment alter hydrology of adjacent high quality areas such as lake plain prairies, is flowering rush or European frog-bit in the surrounding area?).

- Understand the role of nitrogen:
    - Work with partners to reduce inputs into the basin (plant buffer strips, two-stage ditches, etc.);
    - Prioritize control of sites where nitrogen levels are low (not facilitating *Phragmites* expansion) so that native species can compete effectively.

- Stakeholder collaboration and support:
    - Educate all landowners and partners on the deterioration of wetlands, habitat, recreational access, aesthetics, and property values from invasion;
    - Consider cost-sharing options, especially for first time treatments which are often cost-prohibitive for private landowners;
    - Consider millage or other methods of attaining adequate funding for treatment.

- Stay abreast of scientific literature:
    - Consider and evaluate novel approaches and tools (e.g. different chemicals, endophytes, gene silencing, biocontrol), new understanding of mechanisms of invasion, and modes of nutrient reduction, frequently;

- Be prepared to seize opportunities:
  - Budgets, people and environments are unpredictable; if a new unplanned opportunity arises that meets treatment criteria, consider it by conducting a risk-benefit assessment.

Strategy:

I. Know your Landscape and the distribution of *Phragmites* across the Region; Prepare data layers

A. Map *Phragmites* throughout basin using high resolution imagery (e.g. WorldView, air photos, RapidEye or other source); Ideally need resolution of 2 m or better; 5 m resolution maximum to detect outliers and leading edges (Bourgeau-Chavez *et al.* 2016, see table below); apply to all watersheds leading to Saginaw Bay.

B. Identify and map high value and priority areas within each watershed (biodiversity, cultural, economic, public visibility, public access, pathways of spread).

C. Identify and map nitrogen levels (high, med, low) throughout basin.

D. Identify and map landscape connectivity throughout basin (This was completed for the entire basin under the EPA grant to Bourgeau-Chavez and is located on this website: http://spatial.mtri.org/phrag-viewer/

E. Identify and assess high to low restorability sites using tools such as the Great Lakes Coastal Wetland Decisions Support Tool (GLCWDST) or the Great Lakes Coastal Wetland Restoration Assessments: https://www.greatlakeswetlands.org/DST/Home.vbhtml ; https://lccnetwork.org/resource/great-lakes-coastal-wetland-restoration-assessments

II. Prioritize treatment areas by watershed

A. *Phragmites* outliers

a. Set management goal (what constitutes success):

i. 100% kill if less than ¼ acre; no other undesirables.

ii. [60 or greater] % kill if > ¼ acres; restoration of native vegetation or pre-invasion condition (i.e. open water, beach, wetland, etc.).

b. Use MONDRIAN tool to determine best treatment method for specific site conditions https://sites.google.com/uni.edu/phragmiteslookuptable .

c. Conduct pre-monitoring at the field scale; determine what level of information is needed based on management goals; – biodiversity for habitat restoration (Tier 3) or minimally percent *Phragmites* kill (Tier 1) or something in between.

d. Treat outliers using site specific treatment prescription.

e. Conduct post-monitoring at the same Tier as pre-treatment, assess site condition, determine success of treatment.

f. Adapt management based on monitoring results and MONDRIAN tool, and re-treat if needed; re-assess management goals.

g. Repeat sequence until management goals are achieved.

B. **High value areas with high restorability and low nitrogen levels** (ecological, social, economic, public visibility & access, pathways of dispersal),

   a. Set management goals:
      i. Determine goals based upon desired future condition.
      ii. Desirable future condition may be determined from historical cover.
      iii. [X]% *Phragmites* kill; [X]% desirable species; [X]% undesirable species.
   b. Use MONDRIAN tool to determine best treatment method for specific site conditions https://sites.google.com/uni.edu/phragmiteslookuptable
   c. Conduct pre-monitoring at the field scale; determine what level of information is needed based on management goals – biodiversity for habitat restoration (Tier 3) or minimally percent *Phragmites* kill (Tier 1) or something in between.
   d. Consider whether success is likely; if not, reconsider management goals.
   e. If success is likely, implement treatment using site specific treatment prescription.
   f. Conduct post-monitoring at the same Tier as pre-treatment, assess site condition, determine success of treatment.
   g. Adapt management based on monitoring results and MONDRIAN tool, and re-treat if needed; re-assess management goals.
   h. Repeat sequence until management goals are achieved.

C. **High value areas with moderate restorability** and low to medium nitrogen levels

   a. Set management goals
      i. Determine goals based upon desired future condition.
      ii. Desirable future condition may be determined from historical cover.
      iii. [X]% *Phragmites* kill; [X]% desirable species; [X]% undesirable species.
   b. Use MONDRIAN tool to determine best treatment method for specific site conditions https://sites.google.com/uni.edu/phragmiteslookuptable
   c. Conduct pre-monitoring at the field scale; determine what level of information is needed based on management goals – biodiversity for habitat restoration (Tier 3) or minimally percent *Phragmites* kill (Tier 1) or something in between.
   d. Consider whether success is likely; if not, reconsider management goals.
   e. If success is likely, implement treatment using site specific treatment prescription.
   f. Conduct post-monitoring at the same Tier as pre-treatment, assess site condition, determine success of treatment.
   g. Adapt management based on monitoring results and MONDRIAN tool, and re-treat if needed; re-assess management goals.
   h. Repeat sequence until management goals are achieved.

D. **<u>High value</u> areas with low restorability** and high nitrogen levels (to maintain genetic diversity until N levels are reduced and/or better treatments become available)

a. Consider if it is an exceptionally high value area where minimizing devastating levels of infestation is likely to sustain important native gene pools.

    i. Set management goal (what constitutes success)

        1) Determine goals based upon desired future condition.

        2) Desirable future condition may be determined from historical cover.

        3) [X]% *Phragmites* kill; [X]% desirable species; [X]% undesirable species Use MONDRIAN tool to determine best treatment method for specific site conditions https://sites.google.com/uni.edu/phragmiteslookuptable

    ii. Conduct pre-monitoring at the field scale; determine what level of information is needed based on management goals; – biodiversity for habitat restoration (Tier 3) or minimally percent *Phragmites* kill (Tier 1) or something in between.

    iii. Treat outliers using site specific treatment prescription.

    iv. Conduct post-monitoring at the same Tier as pre-treatment, assess site condition, determine success of treatment.

    v. Adapt management based on monitoring results and MONDRIAN tool, and re-treat if needed; re-assess management goals.

b. If management is not likely to sustain genetic pools or has undesirable impacts, use funds for education, promoting buffers or other means of nitrogen reduction instead of treatment.

Table – Remote Sensing for Monitoring Guide from Bourgeau-Chavez 2016.

	Field Surveys	**Aerial Imaging**	**World-view 2**	**Rapid Eye/ Radarsat-2**	**Landsat/ PALSAR-2**
Use for…	- Assessing species diversity changes - Ground-proof remote sensing data	- Planning treatment strategies - Monitoring effects of treatment - Implementing adaptive management	- Planning treatment strategies - Monitoring effects of treatment - Implementing adaptive management	- Planning treatment strategies - Monitoring effects of treatment - Implementing adaptive management	Quick, large-scale mapping to understand broadscale distribution of *Phragmites* invasion
Capabilities	- Make direct observations	- Determine location and percentage of *Phragmites* - Measure *Phragmites* within "mixed stands" - Determine if *Phragmites* is live, standing dead, or detritus	- Determine location and percentage of *Phragmites* - Determine if *Phragmites* is live, standing dead, or detritus	- Determine location of *Phragmites* patches	- Determine landscape-level distribution of *Phragmites*
Timeliness/ Limitations	-	Collection plans	Cloud cover and satellite orbits	Cloud cover and satellite orbits	Cloud cover and satellite orbits/collection plans
Resolution; MMU	-	15 cm; 15 cm	0.6 - 1.85 m; 2 m	5-8 m; 0.05 ha	10-30 m; 0.12 ha
Capture Leading Edges?	-	All	Many	Many	Some
Cost of Imagery	-	\$31.11/km^2	Free for Federal Agencies, Otherwise: \$19/km^2 *min. 25km^2*	Rapid Eye: \$1.17/km^2 *min. 625km^2* RADARSAT-2: \$0.93/km^2 *min. 4500 km^2*	Landsat - Free; PALSAR-2: \$0.71/km^2 *min.4000 km^2*

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