Monitoring and reporting of nonnative *Phragmites australis*

GUIDANCE DOCUMENT

2026

Great Lakes PHRAGMITES COLLABORATIVE

Great Lakes Commission des Grands Lacs

Great Lakes RESTORATION

ABOUT THE

Great Lakes *Phragmites* Collaborative

The Great Lakes *Phragmites* Collaborative (GLPC) is a network of agencies, organizations and residents who are engaged in nonnative *Phragmites* in some way, including management, research and communication. The Collaborative was established to reduce the spread and occurrence of *Phragmites* in the Great Lakes basin by improving management and research and enhancing communication and collaboration. The Collaborative also serves as a resource center for information on *Phragmites* biology, management, and research. We are led by a diverse Advisory Committee of binational *Phragmites* experts and a Core Team made up of Great Lakes Commission and US Geological Survey staff. The GLPC is organized according to the principles of Collective Impact.

Background

Nonnative *Phragmites australis* is a serious invader that has colonized over 60,000 acres of Great Lakes coastline and many inland areas. Control efforts are widespread, yet effectiveness may vary due to infestation level, application methods, environmental conditions, and other factors. The GLPC Advisory Committee, with support from the Core Team, released the Common Agenda in fall 2020. The Common Agenda is a shared understanding and an agreed-upon path for addressing invasive *Phragmites* in the Great Lakes basin.

The agenda sets goals, defines gaps and problem areas in management of *Phragmites*, and outlines the strategies collaborative members will use to fight invasive *Phragmites*. Several member strategies included in the Common Agenda focus on a need for consistent *Phragmites* management guidance, monitoring and reporting, and restoration efforts. To advance these member strategies and future outcomes, the GLPC has produced three separate guidance documents to help address these gaps. All guidance documents were created in consultation with GLPC staff, GLPC Advisory Committee members, and additional consulted experts.

How should these documents be used?

These three guides (Monitoring & Reporting, Program Development & Evaluation, and Restoration) are intended to be used together as a single resource (you will note that these documents frequently reference each other) to help managers tackle invasive *Phragmites* with access to the best resources currently available. The best practices for *Phragmites* management are constantly evolving, therefore, these are meant to be living documents and will be periodically updated as appropriate.

Note about funding

A critical aspect of all successful *Phragmites* management initiatives (including control, monitoring, and restoration) is long-term sustainable funding. Due to the biology of this invasive plant, specifically its substantial belowground rhizome (root) structure, multiple years of control are necessary to achieve local eradication or the desired impact mitigation. Further, there are multiple effective control techniques to manage *Phragmites*, all of which require substantial investments of time and resources to implement. As part of planning your comprehensive approach to *Phragmites* management, it is necessary to consider how the plan will be funded and how that funding will be sustained throughout the duration of the initiative.

Funding to address invasive *Phragmites* is available in many forms including federal, state, and local grants, philanthropic grants and awards, and in-kind support/ collaborations. It may be necessary to leverage multiple funding sources to support the entire breath and duration of the initiative. While we know that it can take five to seven years to locally eradicate a stand of *Phragmites*, funding opportunities are often limited to one- or two-year agreements, thus multiple cycles of grant funding may be required. Additionally, the scope of funding opportunities may limit the work that can be done. For example, the PAMF Active Adaptive Management Program is only able to support management and monitoring activities and does not include funding for post-control restoration. Therefore, it is essential to consider how each portion of a *Phragmites* management plan will be supported.

We would like to encourage funders of *Phragmites* management at all levels (federal, state, and local) to offer funding opportunities which allow for multi-year, comprehensive management projects that support post control monitoring and restoration activities in addition to *Phragmites* control.

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Definitions used in this document

- **Dormant phase –** Period when *Phragmites'* aboveground tissues are senesced and belowground tissues are mostly inactive, occurring from late fall through mid-spring.
- **Growing phase –** Period when *Phragmites'* aboveground tissues are growing and new shoots are emerging from the ground, occurring from mid-spring through late summer.
- **Invasion state –** A metric used to categorize *Phragmites* infestation that utilizes percent *Phragmites* establishment and stem density (per 0.25 m^2)
- **Management action –** Any type of *Phragmites* control effort (e.g., glyphosate, flooding, cutting, etc.)
- **Management area –** The area where you manage non-native *Phragmites* in a uniform manner.
- **Translocating phase –** Period when soluble materials, often photosynthetic products, primarily flow downward from leaves to the roots in preparation for dormancy, occurring during late summer through mid-fall.

INTRODUCTION

Monitoring goals by icon



Detection/Distribution



Impacts



Pre/Post Management

The Great Lakes *Phragmites* Collaborative's staff and advisory committee developed this document, in consultation with experts, to provide recommendations to improve monitoring of nonnative *Phragmites* in the Great Lakes region. The goal of this guidance document is to present baseline best practice recommendations and is not intended to detail all aspects of *Phragmites* monitoring. For additional details on specific monitoring protocols with multifaceted end goals and resource capacities, see our references to existing monitoring protocols at the end of this document. This document is divided into seven topic areas: monitoring measurements and metrics; seasonality; monitoring duration; sharing data and participatory science; utilizing technology and tools; and prioritizing limited resources.

Recommendations provided in this document are assigned to one of the following monitoring goals:

- **Detection/distribution:** the goal of monitoring is to detect nonnative *Phragmites* or record distribution
- **Impacts:** the goal of monitoring is to assess impacts, such as environmental, safety, or aesthetic impacts of nonnative *Phragmites*
- **Pre/post management:** the goal of monitoring is to understand the efficacy of an applied management action.

Each monitoring goal has an **associated icon, as seen at left,** that is used throughout the document.

Recommendations are categorized as follows:

- 'Minimum' requirements for all *Phragmites* monitoring protocols
- 'Minimum' requirements for monitoring protocols with a defined goal (see monitoring goals above)
- 'As warranted' – recommendations to follow if desired or appropriate

Monitoring Measurements, Metrics, and Sampling Design

Regardless of the monitoring goal, most *Phragmites* monitoring protocols include an assessment of the plant's physical condition and coverage. Collecting multi-year data on *Phragmites* health supports a variety of management goals, including: determining the efficacy of control treatments, understanding trends in invasion state and spread, and documenting changes in species diversity and native plant cover. Even if your sole current objective is to capture presence/absence data or treat a patch of *Phragmites*, collecting quantitative data on *Phragmites* health helps provide a more complete understanding of your management area. It also addresses subsequent questions that may arise, particularly related to data that are often underreported, such as efficacy of control efforts. This topic area details common *Phragmites*-centric health and environmental metrics across monitoring goals. Other monitoring metrics not listed may be helpful to your specific monitoring goal (e.g., canopy height, incident light, nutrient loading, water quality, sediment sampling, wildlife counts, other biotic/abiotic factors).

After deciding what monitoring metrics to include in your protocol, you will need to determine how monitoring surveys will be performed (e.g., aerial photography, photo monitoring, transects through patches). Some monitoring metrics, like water depth or stem counts, can only be assessed through in-patch physical monitoring. Monitoring methods need to be adjusted to account for staff capacity, site conditions, available funds, ease of access, and should be well thought out in advance.





Lastly, as part of creating a monitoring plan, think about your sampling design. This is especially important for those with a **Pre/Post Management** goal, as collecting data with no basis for comparison will hinder your ability to evaluate management success. The table below, from the report Implementing Adaptive Management and Monitoring for Restoration of Invasive *Phragmites,* provides sample design suggestions for monitoring and management success. A sample design that includes both temporal replication (i.e., sampling before and after management) and spatial replication (i.e., sampling at both management and reference sites) allows for robust statistical analysis. See the recommendations below for more information on beneficial metrics for an effective monitoring program.

Sample Design	Examples of Implementation
Temporal Comparisons	Compare metrics during 1 growing season before and 1 season after management
	Compare metrics during 1 growing season before and multiple seasons after management
Spatial Comparisons	Compare metrics at management site to reference sites
	Compare metrics at multiple management sites to multiple reference sites
Both Temporal and Spatial Comparisons	Compare metrics between the management site and a reference site during 1 growing season before and 1 season after management
	Compare metrics between multiple management site and multiple reference sites during 1 growing season before and multiple seasons after management

Scientific value increases, as does complexity and resources required

Table 1. Sample design considerations when assessing the success of management actions targeted at invasive *Phragmites.*
Credit: Implementing Adaptive Management and Monitoring for Restoration of Invasive *Phragmites*, Michigan Technological University.

Overview of Recommendations

A successful *Phragmites* monitoring plan should measure the health of the plant, along with any other site-specific metrics relevant to your monitoring goal. At a minimum, a successful monitoring protocol should include an assessment of the percent establishment of nonnative *Phragmites* with stem counts and stem diameter measurements at designated areas. This allows you to track invasion status and/or spread throughout time and monitor management efficacy (if management is one of your goals). However, many other monitoring metrics exist (see recommendations and example monitoring protocols in the references section) that can help tailor data collection to fit both your resource availability and monitoring and management goals.

Recommendations

1

At Minimum: *Phragmites* monitoring protocols should include an estimate of percent establishment. Percent establishment is the extent to which live *Phragmites* is present across a given area.

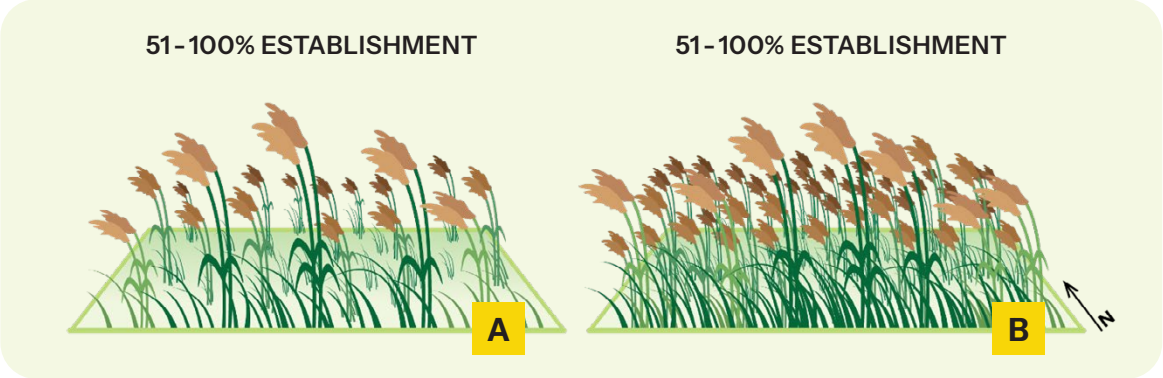

Figure 1. Percent establishment refers to the proportion of the monitoring area (green boxes) where *Phragmites* is growing, regardless of stem density. Example A and B would both fall into the 51-100% category, even though there is a clear difference in stem density between them. Credit: *Phragmites* Adaptive Management Framework Participant Guide.

- The *Phragmites* Adaptive Management Framework (PAMF) breaks down percent establishment by 0-10%, 11-50%, and 51-100% bins, although other bins may be used. If relying on visual assessments, be sure to provide surveyors with examples of the bins similar to Figure 1 above.
- This monitoring metric should also include the area of the *Phragmites* stand being monitored (e.g., 50 m^2).
- **If Warranted:** Combine this metric with stem counts (see recommendation 2 below) to create an invasion state. The PAMF Participant Guide reviews how these two metrics (percent establishment and stem counts) can be collected and used to categorize an invasion state. See the PAMF monitoring datasheet as an example of what collecting these metrics looks like.

Monitoring Goals: Detection/Distribution, Pre/Post Management

Sources:

- Facilitating adaptive management of non-native *Phragmites australis* in Wisconsin Field Protocol
- Management of invasive *Phragmites australis* in the Adirondacks: a cautionary tale about prospects of eradication
- Phrag Fighters/The Land Between's invasive *Phragmites* surveying protocol
- *Phragmites* Adaptive Management Framework monitoring protocol

2

If Warranted: To assess the health of *Phragmites*, use a quadrat to count *Phragmites* stems at a representative number of locations. The PAMF protocol uses 0.25 m^2 quadrats but other quadrat sizes will work as long as they are standardized across the site. This is the minimum standard for an effective *Phragmites* monitoring program wishing to capture **pre/post management** data. This is an optional metric for those whose monitoring goal is **detection/distribution**, as this metric can provide additional information on management planning and future management goals.

- To complete this metric, incorporate a well thought out sampling design (i.e., at how many sites will you be collecting stem counts? Are the site locations randomized or targeted? etc.).
- **Optional:** To compare the relative vigor of plants, measure stem diameter at the base of the culm/stem using a handheld caliper. Stem diameter is correlated with the stem height and is easier to measure in the field than height (Tóth et al. 2012). The number of stem diameters measured depends upon sampling design. The *Phragmites* Adaptive Management Framework (PAMF) protocol includes three stem diameters per quadrat.

Monitoring Goals: Pre/Post Management, optional addition to **Detection/Distribution**

Sources:

- Facilitating Adaptive Management of non-native *Phragmites australis* in Wisconsin Field Protocol
- *Phragmites* Adaptive Management Framework monitoring protocol
- Manual control of *Phragmites australis* in freshwater ponds of Cape Cod



3

If Warranted: Assess a subset of the *Phragmites* stand for signs of stress induced by insects, pathogens, or environmental conditions. Signs of stress indicate diminished health of the plant.

- If collecting monitoring data for **pre/post management** goals, management-induced stress (e.g., leaves browning, slowed growth rate) can be collected, assuming the stress is a direct result of the intended management action.
- Although not part of the minimum recommended standards, this metric does not require intensive additional training, is quick to collect, and may be valuable in answering additional research questions.
- Use the *Phragmites* Adaptive Management Framework (PAMF) Participant Guide as a baseline for collecting data on non-management stress.

Monitoring Goals: **Detection/Distribution**, Pre/Post Management

Sources:

- Review the PAMF Participant Guide for definitions of each type of stress

4

If Warranted: Assess native and invasive plant diversity/species richness of designated sites. To quantify *Phragmites* reduction and ecosystem change over time, standard measurements of plant diversity should be compared before and after treatment between sites.

- Measuring species diversity requires significant expertise and time. Whether species diversity assessments are taking place on the ground (e.g., line transect) or from above (e.g., Unmanned Aerial Systems (UAS) imagery), managers should determine whether this metric fits with their monitoring goal(s), funding, and timeline.
- The final report of the Comprehensive Invasive *Phragmites* Management Planning project provides examples of three-tiered monitoring protocols ranging from simple to most complex in terms of collecting plant diversity. Reviewing this document prior to monitoring can help determine what metrics and complexity level of monitoring fit your project needs.

Monitoring Goals: Detection/Distribution, Pre/Post Management, Impacts

Sources:

- A standardized method for collecting vegetation data according to Great Lakes Coastal Wetlands Consortium protocols
- Facilitating adaptive management of non-native *Phragmites australis* in Wisconsin field protocol
- Lambton Shores *Phragmites* Project- volunteer monitoring report form
- Comprehensive invasive *Phragmites* management planning
- Final Report - Appendix 3 - Tying monitoring to management goals

5

If Warranted: Assess flower/inflorescence density of nonnative *Phragmites* by counting the number of live inflorescences in a set area.

- This measure of health is not necessary if stem counts (see recommendations one and two in this topic area) are already being collected.
- Counting flower/inflorescence density is only effective when *Phragmites* are in the late growing or translocating phases. In the early growing phase, the plant's flower/inflorescence is likely less visible and peak flowering time will vary depending on the location and genetics of the plant (Clevering et al. 2001). The dormant phase may also be a difficult phase for counting inflorescence density, due to the inability to distinguish between stems from previous years.
- This measurement reduces the likelihood of species misidentification (the inflorescence is an easy-to-ID feature), which makes this monitoring metric accessible for volunteers, participatory science groups, and others that may lack plant identification skills.



Monitoring Goals: Detection/Distribution, Pre/Post Management

Sources:

- Lambton Shores *Phragmites* Project- volunteer monitoring report form

6

If Warranted: When monitoring coastal/shoreline populations of nonnative *Phragmites*, consider assessing standing water depth.

- Water depth can affect management efficacy and can inform pre/post treatment analyses.
- If water is a part of control actions (e.g., cutting *Phragmites* underwater or flooding), consider monitoring water depths. Prolonged periods of high water are necessary for successful control. Proper documentation of water levels can help evaluate and improve hydrological management techniques in the future.
- Water depth may be monitored in the field using water level gauges or remotely by accessing data from a nearby stream gauge, such as those operated by the U.S. Geological Survey's National Water Information System.

Monitoring Goals: Detection/Distribution, Pre/Post Management

Sources:

- Facilitating adaptive management of non-native *Phragmites australis* in Wisconsin field protocol
- Manual control of *Phragmites australis* in freshwater ponds of Cape Cod

7

At Minimum: Evaluations of the **Impacts** caused by nonnative *Phragmites* can be categorized as mild, moderate, and severe. Impacts can be broken into three categories for ranking: aesthetic, recreational, and human safety hazards.

- **Aesthetic impact scale:**
  - Severe: entirely blocking shoreline views, inhibiting passage through public scenic passageways (e.g., roads, trails, or waterways)
  - Moderate: some (but not entire) blockage of shoreline or other public scenic views/passageways
  - Mild: little to no blockage of shoreline or other public scenic views/passageways
- **Recreational impact scale:**
  - Severe: inhibiting boat/walking access to water, little to no waterfowl or fish use of the area, or diminished visibility impeding bird watching, hunting, etc.
  - Moderate: reduced boat/walking access to water, reduced waterfowl and fish use of the area, or reduced visibility for bird-watching, hunting, etc.
  - Mild: little to no impact on recreational activities
- **Human safety hazard impact scale:**
  - Severe: blocking sightlines along major roads and intersections, fire-prone dry thatch accumulation adjacent to homes and buildings, etc.
  - Moderate: beginning to or having potential to block views along roads, intersections, some dry thatch adjacent to buildings, etc.
  - Mild: little to no apparent safety hazards



Monitoring Goal: Impacts

Sources:

- Comprehensive invasive *Phragmites* management planning
- Final Report - Appendix 2 - compilation ofmonitoring protocols
- *Phragmites* treatment/management prioritization tool

Seasonality

Seasonality, in this guidance document, refers to *Phragmites'* growth and development as determined by annual seasonal changes. *Phragmites* has an annual biological cycle consisting of three separate phases: growing, translocating, and dormant. More detailed information on the specifics of *Phragmites'* biological phases can be found here or in Figure 2.

When developing a monitoring plan, it is important to think strategically about seasonality and when it will be most beneficial to monitor *Phragmites* to align with your monitoring and management goals. See the recommendations below for more information on how framing monitoring around seasonality can help develop a successful monitoring program.

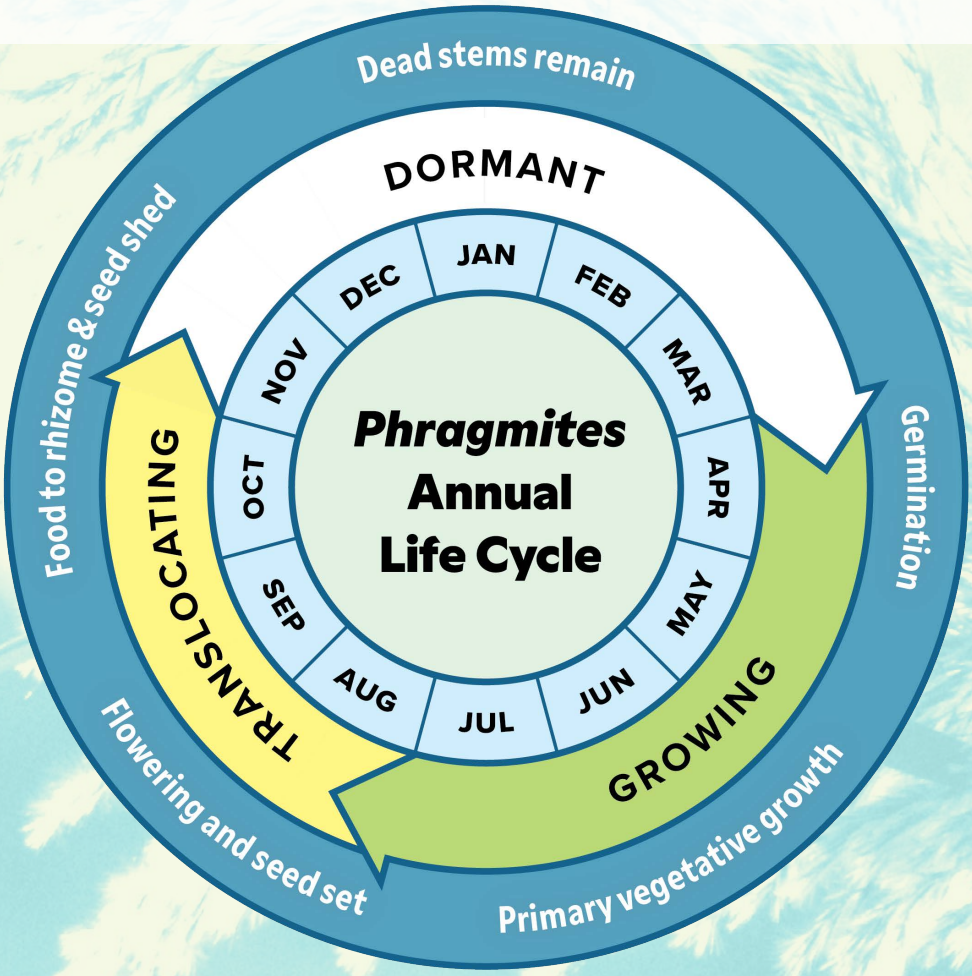

Figure 2. Approximate timing of the life stages of *Phragmites* throughout the year.

Overview of Recommendations

The ideal time to monitor invasive *Phragmites,* no matter the end goal, will likely be in the growing season. To ensure that any observed changes are directly related to your management actions, it is advisable to wait one month after your latest management action before conducting monitoring.

Recommendations

1







At Minimum: *Phragmites* monitoring should occur during the growing phase to early translocating phase. The timing of these phases depends on geographic location and climate, although they typically occur from spring to fall. During these phases *Phragmites* is mostly green and inflorescences have emerged or have started to mature.

- While this recommendation generally applies, there may be scenarios when monitoring during the growing season is not applicable:
  - If monitoring variables other than *Phragmites*' stem density or vertical growth (e.g., inflorescence density, seed bank density, etc.).
  - Timing of monitoring conflicts with desired management actions (see seasonality recommendation two).
  - The timing of monitoring for **Impacts** varies depending on the resource of concern. In many instances, impact monitoring will be most effective at *Phragmites* peak growth (e.g., impacts on visual impairment, recreation access, or safety) but there may be specific impacts that can only be captured at certain times of the year (e.g., bird nesting).
- Monitoring for *Phragmites* presence/absence and **distribution** can be performed earlier in the growing season, as new shoots may be visible in spring, but monitoring during the peak to late growing season increases likelihood of detection by surveyors. Conducting monitoring during the peak growing season also minimizes the risk of confusion when identifying similar-looking plant species, such as reed canary grass.

Monitoring Goals: Detection/Distribution, Impacts, Pre/Post Management

Sources:

- Coastal wetlands consortium's standard operating procedure for vegetation sampling: Great Lakes coastal wetlands monitoring plan
- Regional protocol framework for the inventory of invasive plants
- *Phragmites* Adaptive Management Framework
- Invasive *Phragmites australis* management within the Long Point region

2



At Minimum: Wait at least one month after your most recent management action to monitor. The increases the chance of accurately assessing management efficacy. For example, after applying systemic herbicides, it can take several weeks for visual changes (e.g., yellowing/browning of leaves, drying/withering of plant) to appear.

- Note: *Phragmites* treated with the herbicide Imazapyr may take several weeks to months to show visible signs of damage. Visible changes in the plant's health may not be captured until the following growing season. Depending on when the treatment took place, monitoring may have to be adjusted to a lag-year schedule.

Monitoring Goal: Pre/Post Management (non-research based)

Sources:

- *Phragmites* Adaptive Management Framework
- A guide to the control and management of invasive *Phragmites*

TOPIC

Monitoring Duration

Monitoring duration is simply how long you should plan to monitor *Phragmites*. Although long-term monitoring is essential to any nonnative *Phragmites* management program, monitoring duration varies depending on your monitoring goal and efficacy of management. Planning monitoring duration in advance helps with project development, such as requesting and designating appropriate funding, planning staff capacity, and ensuring long-term management success. See the recommendations below for more information on how proper preparation for an appropriate monitoring duration aids the development of a successful monitoring program (a strong possibility if other *Phragmites* stands continue to grow nearby).

Overview of Recommendations

Monitoring for invasive *Phragmites* should occur annually until your management objective(s) (i.e., full eradication, reduced density, containment, etc.) are reached at the treatment site. Regular early detection surveys help to mitigate further spread and prevent re-invasion.

Recommendations

1

At Minimum: Monitoring should be performed once annually before and after a management action takes place.



Monitoring Goal: Pre/Post Management

Sources:

- *Phragmites* Adaptive Management Framework
- Invasive *Phragmites*: Best management practices in Ontario
- Monitoring approaches for the treatment of nonnative *Phragmites australis* in Rhode Island

2





At Minimum: To ensure *Phragmites* does not reestablish, monitoring should continue for at least five years post management (or three consecutive years of *Phragmites* absence). This will allow any new growth to be detected and treated promptly. Research by Quirion et al. found that the probability of *Phragmites* reappearance significantly decreased as the number of consecutive years of absence increased, with no reappearance documented after four years of absence.

- Consider additional years of post-treatment monitoring if the area managed remains at a high risk for re-invasion (e.g., *Phragmites* is present adjacent to the management area, or the management unit is near a transportation corridor) or contains species at risk/endangered species.
- For long-term management projects (10+ years), monitoring can be shifted from annual monitoring to every two to three years.
- While full eradication may not be possible in heavily infested sites, sustained annual monitoring and control efforts will be needed to meet the desired end state.
- Long-term monitoring (more than three years) is ideal if resources allow. Reestablishment factors such as seed viability and rhizome dormancy are extremely variable and not well understood. For example, studies have found nonnative *Phragmites* seed bank densities were not significantly reduced until four years after the initial herbicide treatment (Rohal et al. 2021).

Monitoring Goals: Pre/Post Management, Impacts (if eradication is part of your monitoring goal)

Sources:

- When is eradication of exotic pest plants a realistic goal?
- Ecological performance standards and monitoring protocol for permittee-responsible nontidal wetland mitigation sites in Maryland
- Management of invasive *Phragmites australis* in the Adirondacks: a cautionary tale about prospects of eradication
- *Phragmites australis* on Wallops Island: An update of control and monitoring done by Virginia Natural Heritage Program
- Seed banks of *Phragmites australis*-dominated brackish wetlands: Relationships to seed viability, inundation, and land cover

3



At Minimum: Monitoring should be conducted to capture presence/absence and new *Phragmites* detections. Thorough attention should be paid to areas where new invasions remain likely to occur (i.e., disturbed habitats, roadways, residences, etc.).

- Surveyed locations should be well documented and inventoried; record where you both do and do not detect nonnative *Phragmites*. If possible, share locations with regional partners.

Monitoring Goal: Detection/Distribution

Sources:

- Inventory and survey methods for nonindigenous plant species

Tools:

- Invasive plant inventory and early detection prioritization tool and tool guide
- North American Invasive Species Management Association mapping standards for program managers
- Phrag Fighters/The Land Between's invasive *Phragmites* surveying protocol
- *Phragmites* Adaptive Management Framework monitoring protocol

Sharing Data and Participatory Science

When planning to monitor invasive *Phragmites*, it is also important to plan how your collected data can be used to help others managing *Phragmites*. There are many ways to report detection of nonnative *Phragmites,* from local mapping applications like the Great Lakes Early Detection Network (GLEDN) to international invasive species reporting tools like Early Detection & Distribution Mapping System (EDDMapS). If managing *Phragmites* in the Great Lakes region, joining the *Phragmites* Adaptive Management Framework (PAMF) is a great way to contribute your monitoring and management data. Ultimately, your collected monitoring data does the most good when publicly accessible.

Additionally, when drafting a monitoring plan, consider how local groups may be able to help with the data collection process! Utilizing participatory (citizen) science can increase your monitoring capacity verse relying on staff alone. These types of programs can be especially effective if your program goal includes invasive *Phragmites* monitoring over a large geographic area (see Phrag Fighters and the *Phragmites* Adaptive Management Framework (PAMF) as examples of how this type of program works). Adding a participatory science component to your program can help increase public awareness of invasive species and allow the public to act as stewards of the land in a meaningful way. Before enacting a participatory science program, consider: does your organization have the capacity to properly train volunteers? Does a participatory science component fit in the scope of your program? Is there staff capacity to handle the data management side? The paper Citizen science in environmental and ecological sciences is a great resource to get started! Depending on your circumstances, it could also be beneficial to connect with the academic community to see if students with a relevant dissertation/thesis/project topic would be interested in assisting with monitoring activities.



Overview of Recommendations

Be intentional about sharing collected monitoring data. This may mean reporting sightings to an online data-sharing tool, enrolling managed sites in the *Phragmites* Adaptive Management Framework, or planning to publish collected data in an open-access format.

Recommendations

1

If Warranted: If your agency does not have a standard reporting database for nonnative *Phragmites* detections, we recommend contributing your monitoring/distribution data to a public database.

- Some jurisdictions may have a recommended reporting database (Table 2). If your jurisdiction does not have a recommended reporting database, ideal standard options include EDDMapS and the U.S. Geological Survey's Nonindigenous Aquatic Species (NAS) Database.
- To enhance nonnative *Phragmites* reporting across jurisdictional and national boundaries, we encourage organizations to advocate for data sharing with others.

Monitoring Goal: Detection/Distribution*

*Reporting sightings is vital among those who are monitoring for nonnative *Phragmites* detection and distribution, but anyone actively monitoring is encouraged to report *Phragmites* as well!

Jurisdiction	Indiana	Pennsylvania	Michigan	Minnesota	New York	Ontario	Wisconsin
Preferred reporting method	EDDMapS or Great Lakes Early Detection Network (GLEDN)	iMapinvasives	Midwest Invasives Species Network	EDDMapS or GLEDN	iMapinvasives	EDDMapS	Wisconsin DNR Website

Table 2. Updated as of September 2023. Great Lakes jurisdictions that are not listed do not have a preferred reporting method. Note reporting recommendations are for nonnative *Phragmites* ONLY! Check your jurisdiction for reporting recommendations for other invasive species (newly detected species, watchlist species, and agricultural pests often require additional reporting metrics).



2

If Warranted: If you are in the Great Lakes region and actively manage (or plan to manage) nonnative *Phragmites*, participate in the *Phragmites* Adaptive Management Framework (PAMF).

- Submitting your management data to PAMF allows your monitoring (and management) data to be a part of a collective learning process, as the goal of PAMF is to determine best management practices for *Phragmites* in the Great Lakes. To submit data to PAMF, you must enroll a specific management unit into the program. Additionally, data can only be submitted to PAMF if you follow their monitoring protocol.
  - One benefit of PAMF is that all enrolled units receive annual site-specific management guidance. If management guidance is not necessary (i.e., your agency/organization already has a pre-determined management plan), you can still submit your data! *Phragmites* monitoring and management data, whether you followed PAMF specific guidance or not, can still be submitted and utilized by the PAMF model to aid in the collective learning process.
- While submitting your data to PAMF does require you to follow specific monitoring protocols (see their monitoring field sheet as an example), data collection is designed to be simple and effective with minimal time commitment.

Monitoring Goal: Pre/Post Management

Sources:

- *Phragmites* Adaptive Management Framework (PAMF) participant guide
- *Phragmites australis*: A statewide management strategy



3

If Warranted: If applicable to your work, publish your monitoring and management data (preferably in an open-source journal or other type of open access repository). There is a lack of available open data and resources surrounding nonnative *Phragmites* management and monitoring for treatment efficacy.

Monitoring Goal: Pre/Post Management

Sources:

- *Phragmites australis* management in the United States: 40 years of methods and outcomes



TOPIC

Utilizing Technology and Tools

Traditional on-the-ground monitoring may not be practical at some field sites including those that are hazardous to access, in remote locations, or too large to walk through. These sites will benefit from other forms of monitoring, such as analysis of aerial or satellite imagery. This section provides a *high-level* overview of these technologies including utilizing aerial and satellite imagery for *Phragmites* monitoring and detection is a growing and complex field. Individual research on how to best utilize these technologies in your monitoring program is necessary. See Table 3 at the end of this section for an overview of when/where different tools and technologies may be utilized.

Overview of Recommendations

When on-the-ground monitoring, follow a photo monitoring protocol to visualize and document your *Phragmites* control or changes in population density over time. If necessary, consider employing aerial or satellite imagery to enhance your monitoring program.

Recommendations

1







At Minimum: Include some variation of photo monitoring in your monitoring protocol. Photo monitoring is an easy way to enhance traditional monitoring efforts or can be the sole monitoring metric for *Phragmites* stands that cannot be accessed easily. Because photo monitoring addresses qualitative changes over time, it is a straightforward way to track **Impacts** and landscape changes due to *Phragmites* management or spread.

- To increase usability of your photo monitoring data, include the latitude/longitude coordinates and cardinal direction of the photo, and take photographs at multiple vantage points. Photo monitoring protocols from Association of Fish & Wildlife Agencies and Ash Meadows National Wildlife Refuge are good standards of a what a protocol should include.

Monitoring Goals: Detection/Distribution, Pre/Post Management, Impacts

Sources:

- Comprehensive invasive *Phragmites* management planning (See Tier 1 Protocol)

2







If Warranted: Collect aerial imagery by Unmanned Aerial Systems (UAS) or plane for large and/or inaccessible sites.

- Use a UAS equipped with a natural color red/green/blue (RGB) camera to accurately classify *Phragmites* (Brooks et. al 2021). Note that UAS images CANNOT currently accurately distinguish between invasive and native *Phragmites* subspecies, so it is vital to validate the subspecies of *Phragmites* on the ground prior to aerial monitoring.
- Before adding any sort of aerial imagery component to your program, keep in mind that many locations require proper permits for drone use. Additionally, collecting and analyzing data is labor intensive and often requires specialized software and staff expertise.
- More information on utilizing aerial collected imagery for nonnative *Phragmites* can be found in the Comprehensive invasive *Phragmites* management planning final report under the section "UAS Lessons Learned and Recommendations."
- Aerial imagery cannot provide quantitative statistical comparisons of plant diversity and is likely not appropriate for all monitoring goals.
- A protocol developed by the U.S. Department of Agriculture's Forest Service called Digital Aerial Sketch-mapping (DASM) can be used to delineate nonnative infestations without extensive training. A protocol of DASM can be found in Chapter 4: Digital aerial sketch-mapping for early detection and mapping of Inventory and survey methods for nonindigenous plant species.

Monitoring Goals: Detection/Distribution, Pre/Post Management, Impacts

Sources:

- Comprehensive invasive *Phragmites* management planning
- Inventory and survey methods for nonindigenous plant species
- Using uncrewed aerial vehicles for identifying the extent of invasive *Phragmites australis* in treatment areas enrolled in an adaptive management program

3







If Warranted: Utilize open access or contracted satellite imagery to aid *Phragmites* monitoring. Satellite images capture infrared and other wavelengths of reflected light with high accuracy, allowing them to be used to monitor plant growth and spread. This detection method is often used in tandem with on-the-ground surveys to verify results.

- Note that satellite imagery is likely to have a lower resolution than imagery captured via UAS. The comprehensive invasive *Phragmites* management planning report recommends only using satellite imagery that is 60 cm or higher in resolution.
- Satellite imagery is susceptible to cloud cover; have flexibility on what date(s) you choose to use for your monitoring images.
  - Typically, images used for detection analysis are acquired during late spring to early fall, during *Phragmites'* growing phase and longer sunlight hours.
- Accurately deciphering nonnative *Phragmites* from satellite imagery requires prior training on utilizing this type of tool and accompanying software.

Monitoring Goals: Detection/Distribution, Pre/Post Management, Impacts

Sources:

- Comprehensive invasive *Phragmites* management planning
- Development of a binational Great Lakes coastal wetland and land use map using three-season PALSAR and Landsat imagery
- Chapter 8: Remote sensing for detection of nonindigenous species

	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 locations 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; NMU		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/km2	Free for federal agencies, otherwise: $19/km^2 min. 25 km^2	Rapid Eye: $1.17/ km^2 min. 625 km^2 RADARSAT-2: $0.93/km^2 min. 4500 km^2	Landsat – Free; PALSAR-2: $0.71/km^2 min. 4000 km^2

Table 3. Remote sensing options for *Phragmites* monitoring and their uses. Credit: Bourgeau-Chavez 2016.

Prioritizing Limited Resources

Most nonnative *Phragmites* monitoring programs are uniquely limited by funding, staff time, and other available resources. Consider these limitations when developing monitoring protocols to ensure realistic objectives are set and achievable within the expected monitoring time frame. These constraints can affect how many sites can be monitored and to what extent. Ultimately, a good monitoring plan will find the right balance to maximize output while using limited resources to their fullest extent.

Overview of Recommendations

Monitoring programs focused on detection use specific criteria to identify and rank sites in order of importance for monitoring. A successful monitoring program will develop a monitoring protocol that balances program goals and resource availability. For example, protocols that collect many data points are helpful for future analyses but will require higher staff capacity to implement. Aim to collect just enough data to meet your monitoring objectives while ensuring the process is feasible in terms of staff capacity, time constraints, funding, and expertise.

Recommendations

1



At Minimum: Select sites for monitoring that meet one or more of the following criteria: near existing nonnative *Phragmites* stands, close to/within a high-quality or high-value habitat, surrounding priority species for conservation, locations of high public use/access (e.g., right of ways, railroads, other vectors), or areas of disturbance.

- If time and capacity allow, a risk assessment of vulnerable locations or a risk map can be created to narrow down sites. A risk map can include factors like susceptibility of existing plant communities to invasion, disturbance history, and proximity to current infestations to help select monitoring locations. More information on creating these types of tools can be found in Chapter 10: Beyond inventory/survey monitoring: risk assessment and management of Inventory of Survey methods for nonindigenous plant species.
- UAS, satellite, and geospatial tools may be useful in assessing if areas meet the above stated criteria. Additionally, some sites will be inaccessible or have limitations to on-the-ground monitoring capabilities. See recommendations in the "Technology & Tools" section above for ways to monitor hard-to-access locations.
- Prior to selecting monitoring sites, determine how nonnative *Phragmites* is regulated in your jurisdiction (i.e., prohibited, restricted, noxious weed, etc.) and identify any legal rulings associated with the plant.

Monitoring Goal: Detection/Distribution

2





If Warranted: Follow MTRI's comprehensive invasive *Phragmites* management planning tiered monitoring approach for selecting the appropriate monitoring approach based on available resources (time, staff capacity, funding, size of area to be monitored, etc.) and site access.

- The tier one monitoring protocol requires the least amount of time to complete but also collects the least amount of data, whereas the tier three monitoring protocol collects the largest amount of data but requires high expertise and time. Using these protocols (either directly or as a reference) helps prioritize necessary data metrics to achieve project goals and appropriately use available monitoring resources.

Monitoring Goal: Pre/Post Management, Impacts

Sources:

- MTRI's comprehensive invasive *Phragmites* management planning

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Great Lakes PHRAGMITES COLLABORATIVE

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Great Lakes RESTORATION

APPENDIX 1

Example Monitoring Protocols

Examples of monitoring protocols and field collection sheets from organizations that monitor nonnative *Phragmites* or other invasive plants.

- Comprehensive invasive *Phragmites* management planning tiered monitoring approach
- Facilitating adaptive management of non-native *Phragmites* australis in Wisconsin
    - Field data sheet
- Invasive *Phragmites* australis management within the Long Point Region
- Inventory and survey methods for nonindigenous plant species
- Phrag Fighters/The Land Between's invasive *Phragmites* surveying protocol
    - Field reporting form
- *Phragmites* Adaptive Management Framework
- A standardized method for collecting vegetation data according to Great Lakes Coastal Wetlands Consortium protocols
- Lambton Shore's volunteer monitoring report form



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