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# Need and Effectiveness of Control Measures on *Phragmites australis* in Restoration Situations

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## Introduction

Exotic and invasive species are becoming a major concern throughout the world. They have been blamed for many problems including impairment of transportation, loss of economic opportunities, and loss of biodiversity. Combating this loss of biodiversity is one of the greatest challenges facing the world today. Restoration of natural communities and the control of exotic and invasive species have both been used to slow the rate of biodiversity loss. These two approaches are by no means mutually exclusive. In fact, they are often so interdependent that one cannot be achieved without the other. Sites that require restoration are almost always dominated by aggressive or exotic species, if anything grows there at all, because conditions at the site have deteriorated to the point that the natural community cannot perpetuate itself. In addition, sites that are in the process of being restored are often susceptible to invasion because of restoration-related disturbances associated with the need to create conditions optimal for target community establishment. The fact that control of invasive species followed by natural re-colonization is often relied upon as a restoration technique, displays the interconnectedness of restoration and invasive species control. *Phragmites australis* is a unique plant in that it is considered crucial to the maintenance of biodiversity throughout Europe while, at the same time, it is considered an invasive species threatening biodiversity in the United Sates. Due to *Phragmites'* varying impact in these different regions, invasive species management will be needed in the United States whereas restoration or protection will be needed throughout Europe. The importance and differing impacts of *Phragmites* on these two continents makes management critical. It is hoped that through a combination of restoration and invasive species management of *Phragmites* and many other organisms, the loss of biodiversity may be controlled.

## Species Description

The management of *Phragmites* depends heavily on the biological characteristics of the plant. Without a general knowledge of these characteristics, management activities are likely to be ineffective or counterproductive. *Phragmites australis*, also called common reed, is a perennial grass that grows to a height of 2-4 meters in wetland habitats (Eggers et al. 1997). Native populations of *Phragmites* are found on nearly every continent resulting in one of the largest distributions of any freshwater wetland plant. Almost any freshwater wetland type can be inhabited by *Phragmites* including sedge meadows, coniferous bogs, lake and stream margins, shallow and deep marshes, and at times open water up to two meters in depth (Eggers et al.1997). Although it is more common in freshwater wetlands, it is also found in brackish and saltwater marshes (Eggers et al. 1997). Vegetative spread by rhizome extension and budding results in very large pure stands that are often clones of a few individuals (Thompson et al. 1985). The ability of these few individuals to cover large areas and shade out competitors with a dense, tall canopy is why stands often become monotypic. Although large values of seed production have been reported, seed viability is variable and can be low (Haslam 1970). In addition, the seeds that do germinate often do not grow vigorously for 2-4 years, hiding the initial population (Haslam 1970). High mortality due to flooding, frost, salt, and competition is also common in juvenile *Phragmites* (Haslam 1970). Low seed viability and high seedling mortality result in low reproductive rates. However, the low rate of reproduction is thought to be sufficient because once established, *Phragmites* populations can live for long periods of time and spread by rhizome extension (Haslam 1972). The vigorous vegetative spread of *Phragmites* creates interesting management situations. Many of the small plot studies mentioned below could, and most likely are, dealing with plants that continue well beyond the study plot or even into adjacent plots.

## Management Needs

*Phragmites* is somewhat unique because it is considered an important keystone species in some areas and an invasive species threatening biodiversity in others. Unfortunately, in areas where *Phragmites* is considered an important keystone species, such as throughout Europe and to some extent the Western United States, its population is declining rapidly (Marks et al.1993). In the Eastern, Midwestern, and the Mississippi River Delta regions of the United States, *Phragmites* has been shown to be very invasive (Marks et al.1993).

### *Status in Europe*

*Phragmites* is considered a very important plant throughout much of Europe for several reasons including the ability to prevent bank erosion, the ability to be very highly productive, and the ability to act as a keystone species (Ostendorp 1989). These attributes and the rapid decline of *Phragmites* have stimulated research into why the population is declining and how to best protect it. The reasons behind the decline are not well known although several have been postulated including direct damage from mowing and recreational activities, mechanical damage by wave action and floating matter, grazing, eutrophication, and alterations of the lake water budget (Ostendorp 1989). Although several of these mechanisms have the potential to limit *Phragmites* populations, and under certain circumstances have been shown to limit populations, none are thought to act on a regional scale. Instead it is thought that the declines, and the reasons behind the declines, are very site specific (Ostendorp 1989).

Preservation activities in Europe are also very site- specific and they are mostly attempts to minimize the effects of the disturbances mentioned above. As is the case with many other conservation strategies, the largest sites are often preferred. A minimum size of 2 hectares is thought to be necessary to maintain the diversity associated with *Phragmites* stands in Europe (Tscharntke 1991). In addition, mowing along the perimeter of *Phragmites* stands is thought to remove many of the invertebrate specialists and is strongly discouraged (Tscharntke 1991). Although much of the effort in Europe is focused on conservation, control measures are sometimes used on *Phragmites* stands to free transportation routes, provide fish habitat, and eliminate competition in agricultural fields.

### *North America*

Unlike Europe, throughout much of the Mississippi River Valley and the East Coast of the United States *Phragmites* population expansions are occurring very quickly. Major concern exists over this expansion because the communities that are being invaded are often very diverse and rare while *Phragmites* stands in the United States are not. Sedge meadows are an example of a community that has been impacted by the growth in *Phragmites* populations. *Phragmites* is by no mean the only threat to sedge meadows but it can have a significant effect on these communities, and others, that harbor rare species. *Phragmites* is a native component of some North American wetlands and in parts of the western United States it is not considered invasive. Areas with stable native populations should be left intact although careful monitoring is suggested (http://tncweeds.ucdavis.edu/esadocs/phraaust.html). Although thought to be much more limited than in Europe, *Phragmites* stands in North America can provide wildlife habitat including nesting habitat for some marsh birds, important winter habitat for white tailed deer, cottontailed rabbit, and ring-necked pheasant (Eggers et al. 1997). The reason some populations in the United States seem stable while others do not is unknown. The discovery of two distinct genotypes within a region has led to speculation that a more aggressive genotype has been recently introduced from the Old World (Marks et al.1993). The genetic mixing associated with hybridization can increase the competitive ability of some populations beyond that of the original parental stock (Galatowitsch et al. 1999). Distinctively different genetic populations could, at least in part, explain the wide swings in behavior and performance from one geographical area to the next.

## Management Options

Several different management techniques can be used to manage *Phragmites* populations. The goals of management, site conditions, and safety concerns often dictate the choice of control techniques. Several different management techniques are discussed below. A summary table (Table 1) is also included describing the control method, the effect the specific treatment has on the population, the source of that information, and any other additional comments.

As is the case with most management, thorough monitoring prior to, during, and after treatment is the only way to measure success. Quantifying the results of *Phragmites* management is often difficult because of the colonial growth form it exhibits. In Europe, most of the decline in populations has been assessed with the use of aerial photographs (Ostendorp 1991). This method seems to be most appropriate when looking at relatively large changes over a fairly long period of time. On smaller scale projects, visual estimates of percent cover, density of shoots, above ground biomass, and belowground biomass have all been used. However, problems have been reported with the use of above ground biomass because of the difficulty in separating living and dead shoots and for this reason it is not recommended. Due to the fact that belowground production is a reliable measure of vegetative spread, estimates of below ground biomass should be used to evaluate the effectiveness of control (Thompson et al. 1985). Unfortunately, the difficulty of acquiring belowground biomass estimates results in the use of percent cover estimates and shoot density data in most studies. Additional problems with above ground estimates are due to very large areas being covered by just a few plants and the importance of belowground production.

Table 1. Control methods and results

| Treatment | Effect | Source | Comments |
|---|---|---|---|
| Spray application Glyphosate | Total control in first year, followed by a slow recovery. | Caffrey (1996), Kay (1995) | Non-target plant effects severe. |
| wipe-on application Glyphosate | 38% control in the first year. <br><br> total recovery in 3 years. | Kay (1995) | 50% most effective application rate. |
| wipe-on application Imazapyr | 75% control in the first year. <br><br> total recovery in 3 years. | Kay (1995) | 25% most effective application rate. |
| Spring or Fall burn | Increases buds, root biomass, and general performance. | Thomson (1984) | Useful in Europe to promote stand vigor. |
| Summer burn | Controls vegetative spread. | Thomson (1984) | Results in the frost kill of sensitive emerging shoots |
| Cutting | Decreases number of plants per square meter and percent cover. | Monteiro (1999) | Less control then herbicide with similar non-target effects. |
| Cutting & herbicide | Decreases number of plants per square meter and percent cover. | Monteiro (1999) | More effective control then cut or sprayed alone. |
| Biological control | Unknown, species specific herbivores not available. | Tscharntke (1992) | May be limiting in Europe. |

### *Prescribed Burns*

The use of prescribed burning is one of the techniques that has been effective in manipulating *Phragmites* populations. The timing of these prescribed burns is critical to *Phragmites* management. For this species, the timing of a burn can either promote or control the population. For this reason, burns may be a very important management tool in both Europe and North America. Burns at any time of year will increase vegetative shoot densities and mean shoot weights in the short term (Thompson et al. 1985). Burns in mid summer can be used for control however, because they will decrease the below ground standing crop and the number of over-wintering buds (Thomson et al. 1985). Removal of above ground biomass in mid summer stimulates substantial re-growth from buds that would normally be dormant until spring (Thomson et al. 1985). The young shoots that result are susceptible to frost kill, which is more likely due to lower snow accumulation as a result of canopy modification (Thomson et al 1985). In contrast to summer burns, both spring and fall burns only strengthen *Phragmites* populations. Thomson (1985) found that spring burns enhanced *Phragmites* performance as measured by flowering stem density, vegetative spread, and aerial biomass. Similarly, fall burns, if done late enough not to initiate re-growth before winter, have been shown to stimulate *Phragmites* populations (Thomson et al. 1985). Safety issues with the use of fire are particularly acute in stands of *Phragmites.* Dead standing canes can outweigh living biomass because they often persist for up to 4 years (Thompson et al. 1985). Over time the accumulation of dry litter can be very substantial. In addition to very large fuel loads the extensive nature of *Phragmites* stands in relatively inaccessible areas makes fire difficult to manage.

### *Herbicide Treatment*

Although also not free of safety concerns, herbicides can be used to control *Phragmites* stands. Often herbicides are one of the only ways to control a species or population and they can provide excellent results. Species with long-lived and extensive seed banks and those with efficient long to mid range colonization strategies are often hardest to control chemically. Fortunately *Phragmites* has not been shown to have either of these adaptations.

Chemical control of *Phragmites australis* is normally achieved with the use of ‘Rodeo’, a glyphosate herbicide, which is approved for use in aquatic environments in the United States. Caffrey (1996) studied the long-term effectiveness of glyphosate on a group of plants termed ‘reeds’. The group of plants included was primarily *Schoenoplectus lacustris* (bulrush), *Glyceria maxima* (reed manna grass), *Phragmites australis* (giant reed grass), *Sparganium erectum* (bur-reed), and *Typha latifolia* (cattail). In this study the ‘reeds’ were sprayed once with glyphosate in August of 1992 to increase boat access to a river channel (Caffrey 1996). Percent cover estimates following treatment fell from 75% to 1% by 1993 and only recovered to 5% by 1994 (Caffrey 1996). A large flow event clearing the channel of most affected rhizomes and an inability to determine the relative effect on *Phragmites* as opposed to other reeds makes it difficult to draw conclusions from this study.

Kay (1995) compared the effectiveness of wipe-on application and spray application of ‘Rodeo’ (glyphosate) and ‘Arsenal’ (imazapyr). In plots sprayed with Rodeo nearly total control resulted followed by a slow recovery. The best wipe-on results were not considered acceptable and only resulted in 75% of the treated plants dying. In addition to lower initial control, two years after application there were no significant differences between the wipe-on treatments and controls but the *Phragmites* in the sprayed plots were nearly completely suppressed. Although control of Phragmites was best with the sprayed application, it also resulted in complete control of non-target emergent and submersed plants for the length of the study.

### *Cutting*

Mechanical cutting has been looked into as a method of control that may decrease the potential environmental impact of herbicide application. Cutting is often done in aquatic environments from boats or on foot with hand held trimmers because farm equipment used for similar terrestrial applications is often not useable on saturated soils. Unfortunately, sever non-target plant impacts have been found with this method, too. Kay (1995) found that while providing as effective control as herbicide application, mechanical cutting resulted in as large an impact on non-target emergent plants as herbicide application did. Still, in areas with low public acceptance of herbicide use or in food production areas, it seems to be a usable control method.

Cutting and herbicide application have also been used in conjunction with each other. In all cases of fall cutting followed by spring herbicide use, more effective control was observed than with the use of just one method (Monteiro et al.1999).

*Biological Control*

Biological control is another management technique that has been used on other invasive species. This method is based on the use of natural predators to limit the population of invasive species. Biological control can be achieved by either promoting a native population of predators or by introducing a new predator from the native range of the invasive species. Although *Phragmites* is native to the United States, predators in Europe are reported to be more numerous. Some are thought to have significant effects on the *Phragmites* population there, including the European moth *Archanara geminipuncta* which, has been shown to damage 96% of *Phragmites* shoots during outbreaks (Tscharntke 1991). Unfortunately, none of the European organisms that sufficiently damage *Phragmites* are species specific, and no naturally occurring parasites have been shown to control *Phragmites* populations (Marks et al.1993). For these reasons, it does not seem that biological control in the United States is possible.

## Conclusion

The conservation of *Phragmites* throughout Europe is a necessity due to its role as a keystone species. Although the cause of the decline is unknown, it is thought that each situation may have its own stressor and therefore a unique solution. The most effective management of these areas is to identify the stressor and try to eliminate its effect. The use of prescribed burning could be an additional management tool if conducted in the spring or summer.

In the United States, the control of an aggressive strain may also be imperative to the preservation of biodiversity. *Phragmites* stands are replacing sedge meadows and other very diverse and rare aquatic ecosystems. Restoration of these systems demands the control of many invasive species including *Phragmites*. Biodiversity depends on managing invasive species, including *Phragmites*, as effectively as possible. Proper management requires selection of the appropriate control strategy, unfortunately, none of the control methods discussed above works, or is appropriate, in every situation. The responsibility of weighing the costs, risks, and success rates of each control technique falls on the land manager. In the United States, *Phragmites* control depends on several techniques. Biological control has not yet been attempted for *Phragmites* because no suitable predators have been found. Similarly, safety issues and variable results with summer prescribed burns limit effectiveness. Herbicide application, cutting, or a combination of these techniques have been the most reliable control methods and for that reason they will be the methods most commonly used in the United States. Unfortunately, considerable negative public opinion, effects on non-target species, and often the need for regular re-treatment plague these control options. It is thought that with proper management restoration on *Phragmites* dominated sites can be very successful even though re-invasion is a threat (Marks et al.1993). Unlike many other invasive species which often have high reproductive capabilities, *Phragmites* can be eliminated region by region in restoration situations simplifying its removal. Often once control of *Phragmites* stands has been achieved native communities can return and have an excellent chance of recovery (Marks et al.1993).

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