Ecological Restoration as a Strategic Framework for Invasive Species Management Planning: The University of Wisconsin Experience

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Abstract

The UW–Madison Arboretum uses an evolving, strategic approach to invasive species management that aims to develop comprehensive, integrated protocols for removing pest plants and subsequently replacing them with appropriate native species. We seek to provide managers with the decision-making tools to develop appropriate tactics to encourage native plants and discourage pest plants. This approach relies upon: 1) a rigorous invasive species risk assessment that yields an action priority ranking matrix; and 2) invasive species management conducted within an ecological restoration framework; and 3) incorporation of research findings into management actions in an adaptive management feedback loop. I use *Phalaris arundinacea* (reed canarygrass) as an example of invasive species management problems in Arboretum prairies.

Keywords: invasive species management, ecological restoration, adaptive management

Introduction

Invasive species management—as opposed to simple weed control and removal efforts—is a comprehensive, coordinated, and strategic approach that is conducted within an ecological restoration framework. This approach to invasive species management planning has as its goal the development of comprehensive, integrated protocols for removing invasive plants and subsequently replacing them with appropriate assemblages of native species (Egan and others 2005).

The goals of restoration plans may vary according to the situation, but often include the enhancement of native species diversity, habitat improvement, or restoration of ecosystem structure, function or processes. A restoration plan also contains an implementation schedule, a monitoring protocol, and provisions for adaptive feedback to improve performance (Egan and others 2005).

Land managers sometimes use the phrases "invasive species removal" or "pest plant control" as shorthand for the process of ecological restoration, and they often judge successful invasive species removal (or the initial "kill rate") as equal to restoration success. But stopping at this point and hoping for the best is rarely sufficient to meet the goals of a restoration project. In fact, invasive species control or removal is just a small part of t invasive species management that includes these steps:

- Identification of the most threatening invasive species.
- Mapping of locations of invasive species and surrounding vegetation.
- Determining appropriate replacement vegetation that will have a chance to succeed under extant or modified conditions.
- Prioritization of management needs.
- Development of strategies that assess the effects of invasive species control.
- Explicitly stated goals and objectives that describe the desired end-states or products of the restoration and the ways in which invasive species control will help achieve these goals.
- Avoidance of activities that exacerbate invasions and domination (e.g., clearing too much ground too fast or failure to perform follow-up herbicide applications).
- Coordinated invasive species management on a whole-site basis.
- Sequencing and timing of control techniques to maximize effectiveness.
- Management goals and objectives that are evaluated and modified regularly in an adaptive management feedback loop.

Invasive Species Management Planning

An invasive species management plan can be either simple or complex, based upon the number of sites or management units, the number of different goals and objectives, the number of invasive species it contains and the seriousness of

the infestations. At a minimum, an invasive species management plan for a site like the 1,200-acre UW–Madison Arboretum in Madison, Wisconsin with multiple, and possibly conflicting, biological goals and objectives for its more than 50 plant community types, should consider these factors:

- The likelihood that the species will have an effect on the plant community.
- The seriousness of the ecological impact of the species.
- Monitoring program for early detection of new invasive species.
- Capability for swift action to contain or eradicate new invasions.
- The degree of threat posed to the site and its goals.
- The ease of control efforts.
- The likelihood or feasibility of controlling the species.
- The effect of one action on the rest of the ecosystem and on the pest species.

Consideration of these factors makes it necessary to conduct a risk assessment of the invasive species a land manager deals with. I conducted such a risk assessment for a small number of the dozens of invasive plant species that occur in the Arboretum (Glass 2001a). For the purposes of Arboretum planning, 16 species were selected 1) that had been identified as established for more than a decade and/or are reproducing on-site; 2) that are expanding their on-site ranges; 3) that had been determined to warrant management action because they were known or thought to interfere with plant community structure, function or processes; and 4) for which control—although it might be difficult—was considered feasible. Examples of these species include: *Rhamnus cathartica* and *R. frangula* (buckthorn), *Lonicera* x *bella* (honeysuckle), *Alliaria petiolata* (garlic mustard), and *Phalaris arundinacea* (reed canarygrass). Other species, such as *Amphelopsis brevipedunculata* (porcelainberry), are suspected of being invasive and are on a "watch list."

We used a risk analysis protocol developed by Acadia National Park (Reiner and Gregory (2000) and modified from Hiebert and Stubbendieck (1993). We scored on three categories: "potential for impact in the Arboretum," "significance of impact," and "feasibility of control." However, we did not use the "potential to invade" category used by Reiner and Gregory (2000) because we were performing essentially a risk triage of already-established species.

Scoring was a combination of objective assessment based upon the literature and subjective estimates derived from personal experience and observation. Results of the scoring were used to complete the pest plant risk assessment (Figure 1). The higher the species' score meant that it had more potential for impact, a greater significance of impact, and was easier to control. Different people may provide different scores and rankings for the same site, but for setting management priorities, it is the relative scores that are important. The results of the pest plant risk ranking enabled us to create a four-cell matrix (Figure 2) that ranked pest plants on a high/low threat to the community of concern and high/low ease of control. The degree of threat combines measures of potential impact and significance of impact, while ease of control is a measure of feasibility of control and abundance within and near to the Arboretum. Ease of control is based upon control techniques used by and developed at the Arboretum (Glass 2003). These may differ from those used elsewhere and hence may yield ratings that differ from the reader's experience. For example, honeysuckle is rated as harder to control than common buckthorn. Both species are well established and widespread in the Arboretum, often occurring in monotypic stands with few groundlayer species. Efficient and effective control requires the careful and targeted use of herbicide by trained applicators at the optimum time each year. The difference has to do with the greater difficulty of applying herbicides to shrubs as compared to trees. The multiple and many-sized stems of a honeysuckle usually require several herbicide applications over time whereas buckthorn can reliably be killed with a single herbicide application. Hence, honeysuckle is rated at the UW Madison Arboretum as harder to control than buckthorn.

Using the Risk Ranking System

Because the pest plant risk ranking matrix yields relative results that are specific to a particular site or region, the results may be used to guide management activities at various scales. The results help set management priorities and guide invasive species management on a whole-site basis, but the rankings may also be scaled down to guide work on a smaller management unit basis or scaled up to plan work at larger cross-boundary or landscape scales. For best results, the risk assessment should be updated annually to account for progress and to assess the risk of new invasive species that have entered the site. The risk ranking system may have to be modified when scaled up or down to relatively larger or smaller sites and tempered by experience to account for the role of logistics in ease of control. For example, species that are hard to control on a large site, such as honeysuckle, may turn out to be easier to control on a smaller scale, while species that are a high priority on a small scale, such as common buckthorn and glossy buckthorn, may be replaced on the priority list of larger sites by an even more dynamic invasive species, such as garlic mustard.

Priorities and Sequencing of Invasive Species Management Activities

It should be remembered that there is a difference between the priority ranking and the actual timing and sequencing of management activities. With the risk ranking system it is not a question of *if*, but rather of *when*. Since invasive species often have a narrow window of maximum vulnerability each season, management actions must be timed for maximum efficiency and effectiveness. This fact of life may mean that on an

annual basis, action against a lower priority species may be taken earlier in the year than a higher priority species.

Restoring Native Vegetation

There is no cookbook answer to restoring native vegetation that has been cleared of invasive species. Restoring native vegetation to a site that has been cleared of invasive plant species requires studying the site conditions (soil chemistry, soil structure, hydrology and disturbance patterns) and, if necessary or possible, returning them to their previous state. Planting appropriate native plant communities (prairie, savanna, woodland, wetland) on the site follows such a study.

Site condition, disturbance history, length of time since invasion, the kinds, abundances and distribution of invasive species, and their affects on ecosystem structure, function and processes, among other factors, may vary from site-to-site and will determine the restoration recipe the restoration ecologist uses. For example, the site due for restoration may have been invaded only recently by a few pest plants and still retain many native species or at the other extreme may have been dominated for many years by a variety of invasive species and thus have only a few remaining native species, either as plants, seeds, or vegetative propagules.

Re-mediating the degraded site conditions—depending upon site history, methods and native species used, among other factors—may or may not deny invasive plants the environment that allowed them to thrive, and planting the cleared area with native plant community species—depending upon the species used as well as other factors—may or may not provide the competition to keep invasive species out or at very low levels. In fact, the site may be degraded or disturbed to such a degree that restoration to a previous condition may no longer be feasible or desirable. In this case a novel assemblage of native plants suited to the current site conditions must be devised.

If the restoration site is lightly disturbed by invasive species, native plants, especially those that grow from corms, bulbs or rhizomes, sometimes return on their own after invasive plant species are removed. However, in some cases, the native species may no longer exist as plants or in the soil seedbank.

Simply reseeding or replanting the area is not as simple as it sounds. Restoring or naturally landscaping an area involves considerable planning and work prior to and after the planting to make it successful. This is especially true in urban reserves, such as the UW–Madison Arboretum, where disturbances to ecological processes, disruptions of ecosystem structure, and changes in soil chemistry or structure have occurred. Surrounded by upland development in the cities of Madison and Fitchburg, the Arboretum's hydrological, aquatic, and terrestrial ecosystems have been subjected to the effects of urban storm water management practices (University of Wisconsin–Institute for Environmental Studies 1999). For example, marshland has been degraded, resulting in a possible loss of sustainability; groundwater hydrology has been depleted, possibly interrupting certain biotic interactions; in other plant communities, erosion may be result in reduced nutrient retention (Glass and Liebl 2003). It is suspected that these effects have resulted in a proliferation of invasive species across the Arboretum.

Potential for impact in the Arboretum 40 points possible	Significance of Impact 50 points possible	Feasibility of Control 100 points possible
40 Multiflora rose	42 Reed canarygrass	38 Norway maple
	41 Purple loosestrife	31 Wild parsnip
		31 Purple loosestrife
40 Reed canarygrass	37 Oriental bittersweet	30 Japanese barberry
	37 Leafy spurge	
38 Oriental bittersweet	36 Buckthorn	26 Multiflora rose
38 Leafy spurge	33 Canada thistle	25 Leafy spurge
36 Honeysuckle	30 Garlic mustard	25 Burning bush
36 Buckthorn	29 Multiflora rose	25 Amur maple
33 Japanese barberry	29 Honeysuckle	25 Garlic mustard
33 Purple loosestrife	28 Wild parsnip	24 Sweet clover
30 Garlic mustard	27 Dame's rocket	20 Dame's rocket
29 Canada thistle		
28 Dame's rocket	25 Norway maple	18 Buckthorn
	24 Sweet clover	17 Canada thistle
26 Burning bush	11 Amur maple	15 Oriental bittersweet
25 Sweet clover		
24 Wild parsnip		
23 Norway maple	11 Japanese barberry	15 Reed canarygrass
23 Amur maple	9 Burning bush	9 Honeysuckle

Figure 1. Pest plant risk assessment score card.

	Relatively easy to control	Relatively hard to control
High threat to communities of concern	First priority Garlic mustard (*Alliaria petiolata*) Dame's rocket (*Hesperis matronalis*) Buckthorn (*Rhamnus cathartica* and *Rhamnus frangula*) Purple loosestrife (*Lythrum salicaria*)	Second priority Oriental bittersweet (*Celastris orbiculatus*) Reed canarygrass (*Phalaris arundinacea*) Honeysuckle (*Lonicera* x *bella*) Canada thistle (*Cirsium arvense*) Leafy spurge (*Euphorbia esula*)
Low threat to communities of concern	Third priority Norway maple (*Acer platinoides*) Japanese barberry (*Berberis thunbergii*) Multiflora rose (*Rosa multiflora*) Sweet clover (*Meliotus officionalis*) Wild parsnip (*Pastinaca sativa*)	Fourth priority Burning bush (*Euonymus alatus*) Amur maple (*Acer ginnala*)

Degree of threat combines measures of potential impact and significance of impact
Ease of control is a measure of feasibility of control and abundance within and near to the Arboretum.

Figure 2. Priority ranking on an Arboretum-wide basis of pest plants that pose the most serious threats to the resource.

Egan and his colleagues (2005) suggest that it is necessary to: "Determine if any of the existing site conditions (soil chemistry, soil structure, hydrology or topography) will need to be changed and the ways and costs of doing so. This is a very important step because invasive weeds often signal a more basic problem with the land." Corrections of an underlying problem or disturbance may have to be addressed before invasive species control can begin. At the Arboretum, for example, unabated storm water runoff from the surrounding urban area has eroded a channel through Curtis Prairie. Storm water runoff has deposited and dispersed seeds of reed canarygrass throughout the prairie so that now reed canarygrass forms a near monoculture across about 20% of the prairie. Research conducted at the Arboretum (Mauer and others 2002) has described the mechanisms by which storm water facilitates the invasion of wetlands by reed canarygrass . Elimination of the reed canarygrass and restoration of the site cannot begin until the storm water is brought under control and thus Arboretum staff and faculty are working to develop comprehensive, integrated protocols for removing reed canarygrass and replacing it with appropriate native species. Part of this effort includes working with surrounding municipalities to develop a comprehensive storm water management plan that will address this and other such problems at the watershed level.

Furthermore, recent research suggests that some aspects of current restoration management protocols at the Arboretum—early spring prescribed fire and the use of herbicides, in particular—may not be feasible methods to control reed canarygrass and may even be counterproductive. Reyes and Zedler (2004) found that experimental burning with a propane torch to simulate prescribed burning had no significant effect on bud mortality. They suggest that because of the high number of dormant rhizome reed canarygrass buds (3,000 to 6,500 per/m to a depth of 15 cm), prescribed burning in the field is unlikely to kill these buds, although fire kills aboveground biomass. Since reed canarygrass is shade intolerant, early spring burning probably stimulates and favors reed canarygrass growth by removing the shading of last season's growth and thus giving it a jump start in the spring (J.B. Zedler personal communication). Annen (2006) has shown that while common foliar-applied herbicides, such as glyphosate, may top-kill the active growing, they have no effect on dormant buds. In fact, because of apical dominance in reed canarygrass, the death of top growth stimulates a regrowth from the dormant buds.

The Arboretum's draft report card on invasive species management (Glass 2001b) recommends that staff "strengthen the adaptive management feedback loop between research findings and management activities." Planning is underway to develop experimental management protocols that will at least not exacerbate the reed canarygrass problem in Curtis Prairie and that may help control it, even in the face of unabated storm water runoff.

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