Biology, Ecology, and Management of Invasive Plants

Clayton Antieau

Botanist and Watershed Planner
206-233-3711
clayton.antieau@ci.seattle.wa.us
Seattle Public Utilities, City of Seattle,
Watershed Management Division, Cedar River Watershed
19901 Cedar Falls Road SE, North Bend, WA 98045-9681

Abstract

Weeds are often not the cause, but symptoms of depleted ecosystem integrity_often legacies of on-going or past poor management practices. Unless ecological causes of weed invasions are understood in integrated, ecosystem-scale frameworks, weed management projects are often doomed to fail. It may be useful to consider weed management tools as either "ecosystem" tools or agricultural-scale tools. Ecosystem tools are minimally disruptive and have longer-term impacts on community development, but act slowly. Agricultural tools may be used on larger scales, but usually have highly disruptive, short-term effects on ecosystems.

Several lessons emerge from experiences managing weeds in their ecosystem contexts. These include needs to understand relevant ecological concepts and the importance of integrated approaches, to implement regular monitoring with provision for true adaptive management, and to pursue new technologies/strategies. There is also need for information clearinghouses where interested parties share weed management experiences and seek information resulting from others' experiences.

Keywords

weeds, invasive species, weed management, ecosystem management, *Phalaris arundinacea, Polygonum cuspidatum, Cytisus scoparius*

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Introduction

Noxious weeds pose serious challenges to the management and restoration of ecosystems throughout the Pacific Northwest. Aggressive weeds displace desirable habitat and species diversity, often persisting in the face of active weed control efforts. Weed management is a large topic, covering myriad weed species, growing in many places, and involving many management strategies and tools. Further, effective weed management is strongly situational, paying close attention to the details of space and place. The limited time allotted this paper precludes detailed discussion of specific weed management situations or problems. However, a useful global approach might be to contrast a traditional weed management philosophy with an alternative philosophy that fits more snugly with the goals and objectives of watershed restoration. Such exploration may help you more fully understand the complexities of the weed infestations you might be working on in your specific restoration efforts. Thus, this paper reviews foundational considerations in managing some of the more widespread invasive weeds in the maritime Northwest. The "foundation" component focuses on understanding weed infestations in the contexts of the ecosystems in which they occur and of the key ecosystem processes they disrupt. Understanding these ecosystem contexts provides insights into possible management strategies for those weeds, and promises greater success in achieving restoration goals.

Traditional Approaches to Weed Management

I'm a botanist and planner on a team of biologists and other scientists that manage the Cedar River Watershed, the main source of drinking water for 1.3 million citizens of Seattle and surrounding communities. The 91,000-acre Watershed is closed to unrestricted public access and managed for abundant, high quality water and fish and wildlife habitat. Contrary to how that may sound, the Watershed is far from pristine, having endured 150 years of timber extraction, road building, stream channelization and cleaning, mining, and urban development. Land management is guided by a Habitat Conservation Plan (developed under the Endangered Species Act), which is essentially a watershed restoration plan that directs us to repair past damages. Team members who manage the Watershed use working definitions of restoration to broadly guide their work. The definition I like is from Apfelbaum and Chapman (1997):

> ...a practical management strategy that uses ecological processes in order to maintain ecosystem composition, structure, and function with minimal human intervention."

One of my responsibilities on the Watershed management team is to set the direction of weed management in the Watershed by developing weed management plans, implementing weed management projects, monitoring, and so forth. In addition to being a botanist and planner, I am also a horticulturist trained within the traditional agricultural context of that discipline. I consider the traditional or "agricultural" approaches to weed management that I am familiar with and contrast those with this definition of ecosystem restoration. Two contrasts appear immediately. The first is that traditional approaches to weed management embed an implicit assumption that humans will always be involved in managing weeds, whereas a goal of restoration strives to eventually eliminate the need for human interventions. The second inconsistency focuses on ecosystem processes. Traditional weed management focuses strongly on the weed itself, purposefully removing it from the ecological context in which it occurs. Traditional weed management asks "How do I control this weed?"

We are familiar with the traditional tools used to answer that question: row-cropping or strip-cropping; intercropping; rotations; cover or competition crops; cultivation (e.g. disking); fallow; herbicides; mowing/chaining; predation (grazing; biocontrols); fire; and so forth. Some of these have a long track record, with a commensurately long legacy of adverse impacts to natural and social resources: Widespread Herbicide Use (contaminated surface/ground waters, altered soil floras, altered wildlife, estrogenic activity, threats to human health, etc.); Introduced Organisms/Pests (escaped biological controls, escaped seedings of exotic grasses etc.); and Large-scale

Habitat Modification (biodiversity loss, increased erosion/sedimentation, flooding/drought, etc.).

Ecosystem Concepts in Weed Management

What is the right question to ask? Or, what are useful ecosystem themes in weed management?

What happens if we stop asking "How do I control this weed?", and we start asking "Why do I have this weed?" Upon contemplation, answers to this question generate several themes, three important themes being the following:

1. Weeds are not the cause, but symptoms of depleted ecosystem integrity - often the legacy of ongoing or past poor management practices. This is illustrated by historic overgrazing in the shrub- and desert-steppe of the Columbia Basin. Grazing destroyed the microbiotic crusts that were integral to the health of that ecosystem, leading to erosion, biodiversity loss, and catastrophic biological invasions.
2. Unless ecological causes of weed invasions are addressed and understood in an integrated, ecosystem-scale framework, weed management efforts are often doomed to fail. This is illustrated by frequently observed replacement of one managed weed with a non-managed weed, as in the case of bio-predated purple loosestrife *(Lythrum salicaria)* being replaced by reed canarygrass *(Phalaris arundinacea)*.
3. Ecological restoration takes time and operates on scales much different than the regulatory, political, and fiscal timescales that humans are used to. This is illustrated by formerly forested wetlands that are now swards of reed canarygrass. Placement of coarse woody debris initiates a key ecosystem process in these ecosystems that operates on a scale of centuries.

Weeds compromise ecosystem integrity

If weeds are placed back into the *ecosystem* contexts in which they occur, we discover some enlightening facts about the biology and ecology of those weeds. In particular, one of the more enlightening areas of discussion is how weeds disrupt key ecosystem processes. Altered key ecosystem processes and services include the following, among others:

- nutrient cycling and carbon cycling (Scot's broom)
- sediment erosion and deposition rates (spartina)
- disturbance intensities and frequencies (cheat grass)
- evapotranspiration, water cycling, and hydroperiods (tamarisk; reed canarygrass)
- soil chemistry and soil biological processes (Russian knapweed)
- habitat availability for native plants/animals/other organisms (reed canarygrass)
- primary productivity (ryegrass)
- food web interactionslcharacteristics (trophic levels)
- genetic integrity (hawkweeds)
- resilience to disturbance (incl. biological invasions) (Scot's broom)
- biodiversity (spotted knapweed; cheat grass; reed canarygrass)

If this is what weeds do, can humans intervene specifically to interrupt these disruptions, effectively using ecosystem processes as weed management tools? Recent scientific research and field experiences confirm this is possible. Successful weed management may not be about managing individual species, but rather managing natural ecosystem processes essential to *ecosystem* integrity.

"Ecosystem" Tools Contrasted with "Agricultural" Tools

It may be useful to consider weed management tools as either "ecosystem" tools or agricultural-scale tools. Ecosystem tools are minimally disruptive and have longer-term impacts on community development, hut act slowly. Agricultural tools may be used on larger scales, but usually have highly disruptive, short-term effects on ecosystems. What are some "ecosystem" tools that have been used to manage weeds?

- Allelopathy
- Competitive Exclusion (Planting, Mulching, Seeding, Shading)
- Microbiotic Soil Crusts

- Soil Health (Flora and Fauna)
- Downed/buried Wood (Feed the Carbon Cycle)
- Micro- and Macro-topography (De-leveling)
- Biodiversity
- Soil Chemical Properties (Ph/ nutrient Management)
- Predation (Biological Controls; Grazing)
- Hydroperiod Alteration (Flooding/drainage)
- Edge Effects (Planting Circles)

To illustrate the implementation of some of these "ecosystem" tools, I'll use macro-nutrient management (anti-fertilization), edge effects (planting circles), soil health, and downed and buried wood.

Macro-nutrient management

Many weed species are known to be especially competitive in the presence of free (ionic) macro-nutrients such as nitrogen and phosphorus. Native plants are generally more competitive when soils are less fertile or lack free macro-nutrients. In disturbed ecosystems, nutrient cycling is altered to distinctly favor weeds. A technique for immobilizing free nutrients adds large quantities of carbon (such as compost or sugar). The soil fungi and bacteria increase on this energy source, immobilizing any available nitrogen and phosphorus. Desirable native species and their mycorrhizal associates are introduced during this 1 to 2 year window and benefit from reduced weed vigor. This process, sometimes called "anti-fertilization," is best used on soils that naturally have low fertility (such as sands or sandy-textured soils) and was first described by St. John (1988).

Edge effects

The zone where two or more different plant communities come together is known as "edge." Edge environments are areas of ecological tension deriving from gradients of light, moisture, cover, and food. For those weed species forming monocultures (such as reed canarygrass), large-diameter planting circles or blocks have been used to successfully introduce "edge" (Antieau 2000). Herbicides are typically used to eliminate the weed from within a planting *circle*. Once the grass is dead, the blocks or circles are densely planted with desirable native vegetation such as willows, appropriate conifers, and/or deciduous shrubs. As planted areas of dense vegetation grow, their canopy begins to reduce the vigor and cover of adjacent areas of weeds, largely due to shading. As shaded weeds decline in vigor and density, desirable native plants become established and the planting circles "enlarge" into the weed infestation.

Soil health

Biological soil processes have only recently come to light as integral *ecosystem* processes. Much is still unknown, but work by Elaine Ingham, Michael Amaranthus, and others has demonstrated the intimate and essential relationships that above-ground vegetation has with fungal, bacterial, and non-vertebrate soil inhabitants (Amaranthus 2001, Ingham and Molina 1991, Perry and Amaranthus 1990, USDA, NRCS 1999). Mycorrhizal associations have been shown to impart ecosystem resiliency to weed infestations (St. John 1999).

Downed and buried wood

Until recently, the role of wood in ecosystems was poorly understood. We now know wood is integral to key ecosystem process because it houses and feeds fungal and animal organisms, provides critical moisture reserves, and becomes germination and growing substrate for natural (shade-tolerant) conifer regeneration (in wetter parts of the maritime Northwest). In forested ecosystems, canopy loss facilitates and supports the invasion of invasive herbaceous species through a variety of mechanisms. The absence of wood in these ecosystems continues to impede natural successional processes.

Ecosystem Concepts Applied to Specific Species

Reed canarygrass *(Phalaris arundinacea)*

Reed canarygrass is a typical disturbance-response species, often indicating past clearing, cultivation and leveling, altered hydroperiods, purposeful seeding, etc. However, it is also thought to be native in at least some parts of the Pacific Northwest (Antieau 2000). Infestations in formerly forested habitats are thought to dramatically alter soil flora. Long-term management themes focus on establishing forests that cast deep year-round shade (where appropriate, as in Puget Trough), getting wood back into/onto the soil, and introducing biodiversity. Innovative means of getting there include planting circles (edge effects), pole plantings, de-leveling (micro-topographic diversity), and coarse woody debris placement (carbon cycling; soil flora; plant succession).

Japanese knotweed *(Polygonum cuspidatum)*

Japanese knotweed is increasingly a problem in wetter parts of the Pacific Northwest. This species is generally considered a disturbance-response species, following road-building, clearing, and cultivation activities. It is also known to invade flood-disturbed zones in riparian and wetland ecosystems. The species is suspected of altering soil flora in formerly forested areas. Long-term management themes focus on competitive exclusion (establishing tree canopies that cast deep shade during the growing season and getting wood back into/onto the soil. Innovative means of getting there include competitive exclusion using made materials (cardboard, carpetsÖ .) and then followed by dense plantings of desirable species. Untested ecosystem methods include micro-nutrient management (boron) and managing soil pH, but the environmental impacts of such approaches have not been well-examined.

Scot's broom *(Cytisus scoparius)*

Scot's broom is often a typical indicator of soil disturbance (road-building, clearing, and cultivation), but is also known to invade grassland and oak ecosystems that have damaged microbiotic crust systems. Infestation is thought to lead to dramatically altered soil biota and altered nutrient cycling. Long-term ecosystem management themes focus on limiting seedling establishment by establishing plant canopies that inhibit germination/establishment (to wit, re-establish microbiotic crusts, i.e. competitive exclusion) or re-establishing fire regimes. Innovative means of getting there include re-establishing microbiotic crusts via "seeding."

Conclusion

Weeds are often not the cause, but a symptom of depleted ecosystem integrity-often the legacy of on-going or past poor management practices. It is important to be able to assess the potential ecological causes of weed invasions, and then address and understand these in an integrated, ecosystem-scale framework. Successful weed management may not be about managing individual species, but rather managing natural ecosystem processes essential to ecosystem integrity.

Several lessons emerge from our experiences in managing weeds as components of ecosystems. These include needs to understand relevant ecological concepts and the importance of integrated approaches, to implement regular monitoring with provisions for true adaptive management, and to pursue new technologies and strategies. There is also need for information clearinghouses where interested parties can share weed management experiences and seek information resulting from others' experiences.

Literature Cited

Amaranthus, M. 2001. Mycorrhizal management: a look beneath the surface at plant establishment and growth. Land and Water, September/October: 55-59.

Antieau, C. 2000. Emerging themes in reed canarygrass *(Phalaris arundinacea* L.) management. Proceedings, American Water Resources Association 2000 Summer Specialty Conference (Riparian Ecology and Management in Multi-land Use Watersheds). August 28-31, Portland, Oregon.

Apfelbaum, S. and K. Chapman. 1997. Ecosystem Management. Yale University Press, New Haven, Connecticut.

Ingham, E.R. and R. Molina. 1991. Interactions between mycorrhizal fungi, rhizosphere organisms, and plants. In Microorganisms, Plants and Herbivores, P Barbosa (ed.). John Wiley and Sons, New York.

Perry, D. and M. Amaranthus. 1990. The plant-soil bootstrap: microorganisms and reclamation of degraded ecosystems. In Environmental Restoration, John Berger *(ed.).* Island Press, Washington, D.C.

St. John, T. 1999. Nitrate immobilization and the mycorrhizal network for control of exotic ruderals. California Exotic Pest Plant Council News 7(I): 4-5, 10-11.

St. John, T. 1989. Soil disturbance and the mineral nutrition of native plants. In Proc. 2nd Native Plant Revegetation Symposium, April 15-18, 1987, J. P Rieger and B.K. Williams (eds.).

U.S. Department of Agriculture, Natural Resource Conservation Service (USDA, NRCS). 1999. Soil biology primer. Publication PA-1637. August.