Exotic Weed Management on National Historic Sites and Monuments in the Pacific Northwest of the United States

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The U.S. National Park Service initiated a study in 1985 to address vegetation management issues on a number of small, arid parks in the Pacific Northwest. The objective of the study was to develop demonstration and research projects that would aid in the management of exotic weed species and the restoration of historic park vegetation. The purpose of this paper is to provide a discussion of the need for ecological data in management programs that deal with exotic weeds.

HISTORICAL PERSPECTIVE

Exotic weed encroachment is not a new phenomenon in the Pacific Northwest. Most exotic weeds found within historic sites and national monuments were introduced into this region in the late 1800s and early 1900s. These species include the knapweed complex *(Centaurea* spp. L.), cheatgrass *(Bromus tectorum* L.), medusahead wildrye *(Taeniatherum caput-medusae* L.), and numerous others. Most weed introductions began as contaminants in crop seed, livestock feed, or shipping ballast that was being transported along the waterway and railway routes of the region. These initial introductions expanded as land use patterns developed within the region. Today, most rangelands, forestlands, and croplands support exotic weed species in varying amounts (1, 8).

The encroachment of exotic weeds onto park lands is associated with past and present land use. To illustrate this point, consider the land-use history of Whitman Mission National Historic Site, Fort Spokane National Historic Monument, Nez Perce National Historical Park, and John Day Fossil Beds National Monument. All these parks have a rich history of settlement, domestic livestock grazing, farming, and commodity transportation. Their landscapes reflect the cumulative influence of over 100 years of white settlement. Furthermore, many of the cultural activities that affected their landscapes were continued after these areas were incorporated into the U.S. National Park System, and some of these activities are continued today to maintain historic settings.

This historical perspective illustrates that the history of park lands and exotic weeds are not independent. Indeed, the very land uses that justified the creation of historic sites are in many cases the same attributes that aided the spread of exotic weed species. Furthermore, the process of weed encroachment will continue in the future because most historic sites and national monuments are surrounded by land use patterns that maintain exotic weed populations.

Ecological Perspective

Weed encroachment is a complex problem and successful solutions need to be based upon ecological principles. Land managers need to incorporate life-strategy information, and an understanding of the role of disturbance within plant communities, into exotic-weed management programs.

Plant communities are dynamic systems in which vegetation change and disturbance are constantly occurring. Successful plant introductions, whether exotic or native, occur because sufficient quantities of light, water, nutrients, temperature, and space are available within the plant community for new introductions to complete their life cycles. In other words, the composition of a plant community is the product of the allocation of limited resources (light, water, nutrients, temperature, and space) among potential plant species. Each new generation of an introduced species adjusts the process of resource allocation until a balance is achieved among the competing life strategies.

The encroachment of exotic weed species onto park lands is an example of an evolving ecological balance among competing life strategies. Unfortunately, weed encroachment is occurring on both deteriorated as well as undisturbed park lands. Weed encroachment is most obvious on deteriorated park lands, where it can disrupt successional processes and displace native plant species. In contrast, weed encroachment into undisturbed plant communities tends to be much more subtle. In this situation, weeds enter the community as scattered individuals, followed by the domination of localized areas of community disturbance. These two scenarios illustrate the breadth of the problem faced by park managers and the difficulty associated with the development of management strategies against the encroachment of weeds.

An Example of the Problem

The ecological complexity of weed encroachment can best be illustrated by describing life-strategy attributes that result in encroachment success. The species selected for this illustration is yellow starthistle *(Centaurea solstitialis* L.).

Yellow starthistle is an annual member of the knapweed complex and depends solely upon seed reproduction for its maintenance within plant communities. It is a Eurasian native that was introduced into the western United States at the turn of the century and currently infests millions of acres of range- and cropland (5, 6). Much of the success of yellow starthistle can be attributed to a high level of seed production and an ability to preempt resource utilization by other species.

The seed dispersal pattern of starthistle maximizes the likelihood of mature seed landing in an environment favorable to germination. This is accomplished through the production of two seed types and the utilization of two time periods in which seeds are released. Plumed seeds are produced in the outer portion of the seed head and are dispersed, through wind action during the summer and fall, away from the parent plant. Plumeless seeds are produced in the center of the seed head, are not released until winter, and then drop in the immediate vicinity of the parent plant (9).

Yellow starthistle seed germinates and initiates root growth over a wide range of conditions. Starthistle seeds have germination rates of 80-90% and can germinate during the fall, winter, or spring. Seed germination occurs rapidly, often within 24-48 hours, under a range of soil moisture conditions (0.5-0.0 –Mpa). Initial root growth by the germinated seed is tolerant to saline seedbed conditions (maximum electrical conductivity tested 12 ds/m) and root elongation is relatively unaffected by moderate (1.0 –Mpa) amounts of moisture stress (2).

The seed dispersal and germination characteristics of starthistle are well suited for the climate of the Pacific Northwest. Starthistle seeds germinate during the fall, winter, or spring depending upon yearly climatic conditions; the conditions for germination do not need to be maintained for extended time periods due to the rapid germination response. These two attributes result in a distinct advantage over many species that germinate only in the spring, and starthistle will tend to be the first species to occupy available sites within a newly disturbed community.

Starthistle seedlings become established as a tap-rooted rosette. This growth form is adapted to the cool growing conditions that prevail during late winter and early spring in the Pacific Northwest. The rosette growth form places the leaves of starthistle near the soil surface where the warmest temperatures for survival and photosynthesis are found. During this stage of growth, starthistle seedlings allocate much of their chemical energy toward the development of a tap root that is capable of extracting moisture from sources deeper in the soil profile (10). The importance of this attribute to starthistle success becomes apparent as community resources become limited during the summer months, which are often dry.

Localized ecosystem perturbation also tends to favor starthistle establishment. Increases in soil nutrient availability or soil-surface disturbance typically result in increased starthistle populations (3). These attributes suggest that starthistle exploits newly available resources more quickly than plants with which it competes.

The life-strategy attributes described so far illustrate growth form and germination characteristics that make starthistle a formidable competitor to other plant seedlings. Data are accumulating that indicate that specific plant communities can restrict starthistle (4). These communities contain dominant plants whose resource utilization patterns overlap those of the starthistle. In addition, biological controls such as *Bangasternus orientalis* show promise of being a partial solution for starthistle control in the future (7). However, biological controls do not address the fundamental process of weed encroachment and should not be viewed as a "magic bullet" that will eliminate an alien weed population.

Conclusion

The ability to predict the response of desirable and undesirable species in a given management situation is a critical element in successful vegetation management. Predictive capability in these situations can only be achieved through the development of knowledge that includes the life strategies of the species being managed. This is true whether a land manager is faced with exotic weed encroachment in a population of threatened or endangered plants or if exotic weeds are threatening the re-establishment of a native plant community. In either case, access by land managers to information on life-history strategies is the first step toward the selection of the proper course of action.

It is unrealistic to manage for exotic weed exclusion on park lands. Public access, land management, and the surrounding networks of land use ensure that a supply of weed propagules will continue to enter park lands. Once there, the natural process of vegetation change and disturbance will ensure opportunities for the establishment and spread of the weeds. With these facts in mind, programs aimed at limiting the opportunity for exotic weed encroachment would appear to be the most prudent course of action in areas that are relatively free of exotic weeds. In situations where established populations of exotic weeds exist, techniques oriented toward the disruption of their life cycle are crucial to successful vegetation management. We believe that the development of acceptable solutions to the problem of weed encroachment depends upon the ability to incorporate sound ecological principles into restoration and long-term management programs.

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