Rangeland Weed Invasion

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Weeds pose a major threat to North American rangelands. Their introduction and spread negatively impacts human activity, wildlife populations, endangered species, and watershed function.

Weed invasion occurs when a weed is introduced into a plant community and increases its population status from rare to a more common occurrence (Crawley 1987). Our understanding of this process on rangelands is limited by incomplete knowledge of plant population dynamics, succession and the competitive relationships that exist between native and exotic plant species. Unfortunately, this lack of knowledge has fostered a misconception among many land managers and the general public that native plant communities are somehow resistent to weed invasion. The reality of weed invasion is that all plant communities are subject to invasion (Crawley 1987).

Successful plant invasion requires two events: 1) the plant community being invaded must contain resources (space, water, nutrients, and light) that can be utilized by an invading plant population, and 2) an invading species must be available for the invasion opportunity. The purpose of this paper is to provide a discussion of weed management in light of this two-step process.

Community Resources

The susceptibility of a plant community to invasion is determined in part by the degree and pattern with which community resources (light, water, nutrients, and space) are allocated among plants. Community resources, in any given year, are finite and will become available at specific times and in specific amounts. The allocation of these resources among competing plants is a function of species performance and results in periods of plant community adjustment and equilibrium (Radosevich and Holt 1984).

Community resources are not static. Disturbances within a community modify long- and short-term patterns of resource availability. Wet and dry climatic cycles, fire or local fluctuations in moisture and temperature patterns modify both long- and short-term resource availability. Biotic factors including grazing, natural enemies such as insects and pathogens, and plant death also alter nutrient cycling and resource availability by modifying the community and the capacity of plants (population composition and performance) to utilize resources (Pickett and White 1985, Luken 1990).

To illustrate, consider the sagebrush-bluebunch wheatgrass habitat type (Daubenmire 1970) of the Pacific Northwest (Figure 1). This habitat type is characterized by a predominance of winter and spring moisture and 3 defined layers of vegetation. The tallest, a shrub layer, is dominated by a deep-rooted semi-evergreen shrub (sagebrush) that can utilize resources throughout the soil profile and from deep in the subsoil. Bluebunch wheatgrass, a caespitose perennial grass, dominates the second layer and extracts resources from the soil solum during spring and early summer. The third layer is formed of plants that generally grow within 4 in. of the soil surface. This layer is

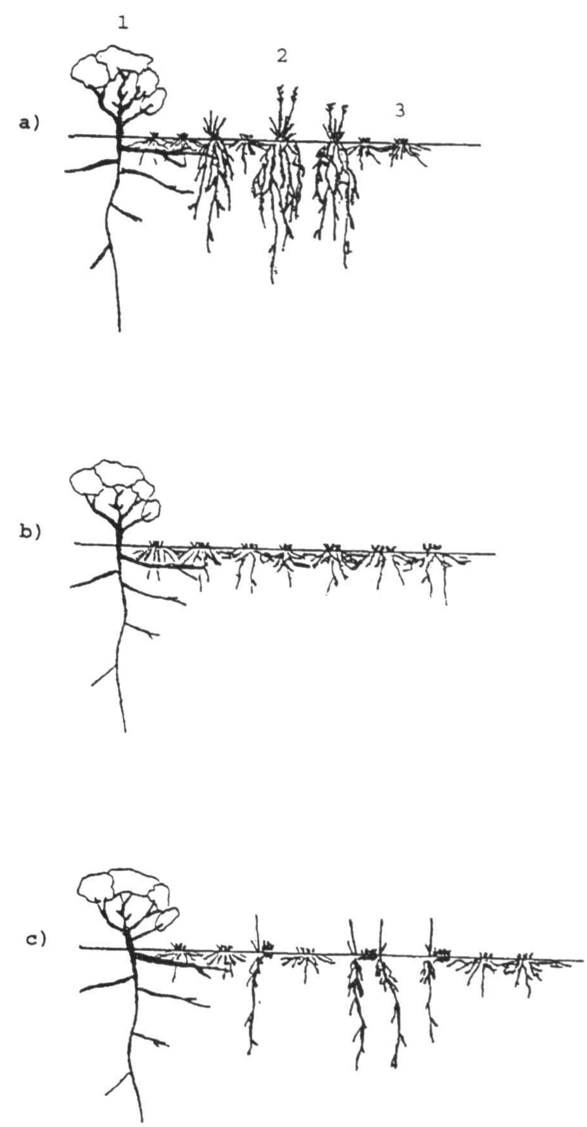

Fig. 1. *Idealized above- and below-ground structure of the sagebrush-bluebunch wheatgrass habitat type: a) structure of sagebrush (1), bluebunch wheatgrass (2), and Sandberg bluegrass (3), b) structure without bluebunch wheatgrass, and c) structure with over-mature bluebunch wheatgrass.*

dominated by Sandberg bluegrass a shallow fibrous-rooted grass that completes its growth in late spring. The structure of this habitat type results in a community that utilizes resources from increasing soil depth as soil moisture is depleted and the growing season progresses.

An example of community modification and its impact on invasion can be illustrated by removing the bluebunch wheatgrass population (excessive disturbance) or simply allowing it to over-mature (inadequate disturbance). Removal of the bunchgrass reduces the fibrous root component at mid-soil depths, thereby increasing early- and mid-summer resource availability. The remaining species will respond by increasing their share of community resources but will be unable to fully-occupy the bunchgrass niche. As a result, early- and mid-summer resources will be under-utilized and the potential for plant invasion will be increased.

Proactive management of weed seed dispersal is one of the most effective and least expensive measures to reduce weed invasion

By comparison, an over-mature bunchgrass population would create a community structure that has occupants in each type of niche but would be under-represented in the seedling, juvenile, and mature bunchgrass age-classes. The reproductive and growth potential of this population would be reduced, as well as its ability to utilize available resources. At this point it is important to recognize that both disturbance patterns modified population characteristics and community composition, and that invasion potential can be increased with either too little or too much disturbance.

Plant Introduction and Invasion

Creation of safe sites (sites suitable for plant establishment) is essential for plant population growth and/or maintenance (Harper 1977). Resource managers historically recognized the linkage between plant invasion and safe site creation through obvious sources of community disturbance such as fire. However, managers have tended to be less aware of the importance of the timing, size, intensity, and duration of all manner of disturbance to plant community stability. Disturbance (large or small) is a natural part of all communities and plays a vital role in the establishment of safe sites for indigenous recruits (i.e. seedlings) and long-term community composition (Pickett and White 1985, Harper 1977).

In the Pacific Northwest, a number of exotic species such as cheatgrass and the knapweed complex have entered communities via safe sites that were historically occupied by indigenous plant populations. In most cases these species became established as scattered individuals, then increased their presence through the spread of seed and superior species performance. These performance advantages generally include greater seed production and/or survival as well as advantages in the timing and rate of growth that result in improved resource access and conservation.

Yellow starthistle, an invasive weed of bunchgrass communities in the Pacific Northwest, illustrates a number of these performance attributes. This plant is a winter annual that has 2 types of seed (plumed and non-plumed), a rapid growth rate, tap root, and varied leaf and growth form. These attributes enable yellow starthistle populations to saturate safe sites with seed, exclude indigenous recruits, and maximize their portion of community resources (Sheley and Larson 1994, Sheley and Larson 1995). Given the compatability and performance of yellow starthistle to these bunchgrass communities, there appears little doubt that successful starthistle introduction can occur regardless of community condition. If the existing community structure and function match the pattern of resource availability, then new starthistle introductions will be maintained as scattered individuals. However, if the successional balance between seed production, resource availability and the occurrence of disturbance (biotic and abiotic) is tilted in favor of starthistle then the transition from scattered individuals to active invasion will be rapid.

Weed Management Strategy

Successful weed management requires a strategy that (1) controls invading weed species and (2) minimizes potential for weed invasion. Most weed management programs on rangelands focus upon weed control through biological, chemical, and mechanical treatment. These programs are reactive in the sense that they are directed toward plant introductions and invasions that are already in progress. To be successful we must also develop management strategies that address causes of initial introduction and subsequent invasion. In other words, develop strategies that are proactive and direct community resource availability, reduce opportunities for colonization, enhance performance of desirable species, and minimize disturbances that create safe sites for weeds (Luken 1990, Pickett and White 1985).

Proactive management of weed seed dispersal is one of the most effective and least expensive measures to reduce weed invasion. Seeds can be transported by various means, and human activities can facilitate transport. Managers should be aware that seeds are moved by wind, water, and vehicles. Viable weed seeds are distributed in animal feeds such as hay and grain, and attach themselves to animals and clothing. Seeds of some weeds, such as whitetop, and leafy spurge may be ingested by ruminants, carried to new sites and germinate from dung (Lowry 1996, Lacey et al. 1992, Wallander et al. 1995).

Resource managers can further minimize the risk of weed invasion through management of community structure and function. Management strategies that influence niche occupation, population age-class distribution, and safe site creation influence the risk of invasion by affecting resource availability and capture. Rangeland communities need to be monitored for unacceptable levels of resource availability, patterns of disturbance, and safe site occupation. Then management strategies can be developed that enhance patterns of growth above- and below-ground (time and space), facilitate resource capture by desirable species, and anticipate invasion opportunities.

Community composition is determined by safe site occupation. When safe sites are fully occupied by recruits from the indigenous population, existing community structure, patterns of resource capture, and species performance are maintained. Events that limit or reduce the ability of the indigenous plant population to occupy safe sites and sequester resources will increase the potential for weed introduction and invasion. These opportunities are often associated with changes in indigenous population vigor and periods of mortality and recruitment. Managers need to anticipate areas at risk and control (chemical, biological, and mechanical treatment) initial stages of invasion. Treated sites should be flagged, revisited through time, and if safe sites are not being occupied with indigenous seedlings they should be seeded to prevent further introductions of weeds.

In summary, successful weed management requires proactive and reactive components. Weed management should not end with selection of a herbicide, mechanical or biological treatment. Our attention should also be directed toward management of safe sites, seed sources, species performance, and resource availability.

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