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Healthy Plant Communities: Ecologically-based Rangeland Weed Management

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This MontGuide is designed to help landowners make economically and ecologically sound weed management decisions. It explains how plant communities develop, how weeds invade and how you can work toward developing a useful plant community that is relatively weed-resistant.

Most rangeland managers and land owners have focused their weed management efforts on controlling weeds and have paid limited attention to the existing or resulting plant community. However, it is becoming increasingly clear that weed management decisions must be based on environmental and ecological principles as well as economic ones. Weed management education should provide land managers with the principles and concepts on which to base their decisions, rather than provide a simple prescription for weed control. This publication presents a conceptual, ecologically-based framework to aid in making economically and ecologically sound weed management decisions.

Land-use objectives must be developed before weed management decisions can be made. An integrated weed management plan can be designed once the uses of the land are determined. Simply killing weeds is an inadequate objective in most situations, especially for large-scale infestations. The generalized objective should be to develop a healthy plant community that is relatively weed-resistant while meeting other land-use objectives—for instance, forage production, wildlife habitat development, recreational land maintenance or natural area conservation.

Figure 1. A healthy, weed-resistant plant community consists of a diverse group of species occupying all the niches (sites) and using all the resources in the system, keeping them from weeds.

A healthy, weed-resistant plant community consists of a collection of species diverse enough to occupy all the niches (Figure 1). Desirable plants capture a large proportion of the resources in the system, keeping the resources away from weeds. The soil resources, particularly moisture, are most limiting in the shortgrass prairies and intermountain regions where we must pay more attention to developing plant communities that effectively use the soil resources over time and space.

A weed-resistant plant community may include an early emerging

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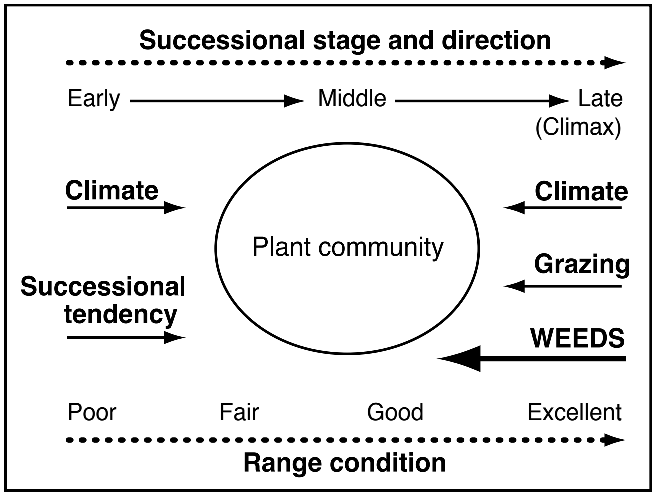


Figure 2. Alien invasive weeds are so aggressive they throw this successional system into disorder. The only component in this model that can shift the plant community in a desirable direction is successional tendency.

species, such as the shallow-rooted Sandberg's bluegrass, which uses the resources that are available in the upper soil profile early in the growing season and during periods of light precipitation. As the season progresses, species which initiate growth later and continue growth further into the season are needed to use available soil resources from moderate soil depths. Finally, the diverse plant community may include a deep taprooted, very late maturing species, such as alfalfa or big sagebrush. These species are capable of extracting resources from deep in the soil profile and throughout much of the growing season. Although little is known about the role of many species within the plant community, it is generally accepted that maximum diversity is optimum for energy flow through the system as well as nutrient and water cycling. Once a desired plant community has been chosen, an ecologically-based weed management plan can be developed.

The succession model

To understand ecologically-based rangeland weed management, we must remember the basic ecological principle on which rangelands have been managed during the past 60 years. This principle states that plant communities change over time until they reach a final and stable composition, called climax. This process of change is called succession. Secondary succession occurs after a site has been disturbed. Immediately after a disturbance, the plant community is comprised of fast-growing, short-lived species, typically annual and biennial plants. As succession progresses, these species alter the site enough to allow the establishment and colonization of short-lived perennial plants. Soon these short-lived perennial species dominate and alter the site in favor of long-lived perennial plants, eventually producing a stable, climax plant community.

In land once dominated by Idaho fescue and bluebunch wheatgrass, the plant community immediately after a disturbance might be composed primarily of annual and biennial mustards and a few legume species. As succession proceeds, that community might become dominated by short-lived perennial species, such as bottlebrush squirreltail, Thurbers needlegrass or sticky geranium. Eventually, succession may progress to a climax community, co-dominated by Idaho fescue and bluebunch wheatgrass.

Most land managers agree that succession occurs. However, there is some disagreement as to whether succession has a fixed end-point for a particular site, or whether succession varies depending on assorted environmental and managerial circumstances. The processes and mechanisms causing succession are not yet well understood.

Rangeland managers have condition-classed, monitored and managed rangelands based on succession for decades. Plant communities dominated by early-successional species have been considered in poor condition, whereas the condition of those rangelands composed mostly of late-successional species have been considered excellent.

Rangeland managers have used grazing management as their major tool. Their objective has been to balance stocking rates so that grazing is a force equal and opposite to natural successional tendency when the range is in good or excellent condition. Adjustment of stocking rates is a continual process based on short-term climatic variation and compensating for minor vegetation fluctuations. Much of range management has focused on techniques to allow increased stocking rates without causing retrogressive changes in the plant community. Many techniques, such as fencing, salting and watering systems, are aimed at encouraging uniform forage utilization through increased animal distribution. Managing rangelands using grazing systems has worked well in many cases, **but only in the absence of invasive alien weeds**.

When weeds invade

When alien or noxious weeds invade native rangeland, they throw the successional pattern into disorder (Figure 2). Many of these weeds evolved in the eastern hemisphere where a long history of intensive disturbance has selected for very competitive species. The weeds have usually been introduced without the natural enemies that help control their abundance in their place of origin. These factors allow alien weeds to dominate native species. The weeds become climax or stable plant communities. How do we manage rangelands dominated by these aggressive weeds?

According to the ecological model on which range management has been based for the past 60 years, the only component shifting plant communities in a desirable direction is the natural successional tendency. Ecological weed management systems must be developed that are based on our understanding of the causes of succession. As mentioned, we know little about the mechanisms of succession, but a conceptual model for weed management can be developed based on the general causes of succession: site availability, differential species availability and differential species performance.

The role of disturbance

In order for succession to occur, a site or niche must be available for desirable species and unavailable for undesirable ones. Disturbance creates available sites. Thus, succession can, in part, be controlled by altering the size, severity, frequency and patchiness of disturbance in a manner favorable to desirable species.

Historically, weed management strategies have included designed disturbance, such as cultivation, timed grazing, burning and herbicide applications. However, in an ecologically-based weed management system, the disturbance is used to alter the processes driving succession in a desirable direction which minimizes the need for continuous high-energy inputs. The usefulness of any disturbance will depend on the range site, plant community type, invading weed species, history of the site and climate.

Once sites are available for desirable species, they must be occupied before the weeds can establish. This "controlled colonization" will intentionally affect succession. Processes that must be exploited are seed dispersal and vegetative reproduction. Introductions of desirable species must be enhanced, while those of the weeds must be limited. Procedures which shift seed banks are also important in controlling colonization. Factors affecting establishment or encouraging germination and seedling survival may also be used to favor desirable species. Using techniques to prevent weed encroachment or altering environmental or managerial conditions to exploit dispersal mechanisms or germination requirements will favor establishment of desirable species. This puts the emphasis on encouraging the desired species rather than simply controlling weeds.

When sites for desirable species are created and become established, species performance must be altered to favor desirable species over weeds. Controlled species performance includes using methods to alter growth and reproduction of specific plant species, thus contributing to a desirable shift in the plant community. This requires understanding the factors that influence competitive balance, such as grazing, disease, resource availability, allelopathy (the inhibition of growth in one species by chemicals from another species), predators, growth rates and their complex interactions. Shifting the plant community from weedy to desirable plants requires understanding the stages in the weed's life cycle that are most vulnerable to stress or control and understanding those stages and procedures in the desirable species' life-cycles that can enhance their performance. In many cases, controlling species performance requires repeated applications, such as repeated grazing.

Site: an area that meets the plant's requirements for successful establishment, growth and reproduction.

This conceptual model forms the ecological basis for developing integrated rangeland weed management strategies (Figure 3). The three mechanisms causing succession (disturbance, colonization and performance) must be considered as a package. Designing disturbances to either create sites for desirable species alone, controlling colonization without making sites available, or increasing their relative performance without making them available, is unlikely to shift the plant community in the desired direction. Designing successful rangeland weed management strategies will require carefully integrating techniques aimed at addressing each of the three general causes of succession, Management strategies must be carefully chosen to ensure that one technique is complementary to another. Once this is achieved, conversion from a weedy plant community to a desirable one can occur.

When developing an ecologically-based weed management plan, options can be placed in categories of designed disturbance, controlled colonization and controlled species performance. Carefully consider and test each technique for effectiveness in directing plant succession and determine if the proposed procedures complement one another. Integrated weed management systems can be designed, tested and documented using this ecologically-based conceptual model.

Several schematics using ecologically-based weed management planning are shown for spotted knapweed

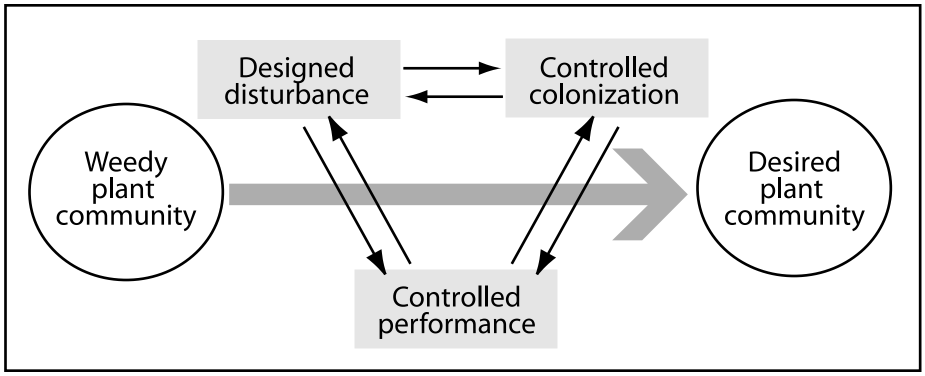
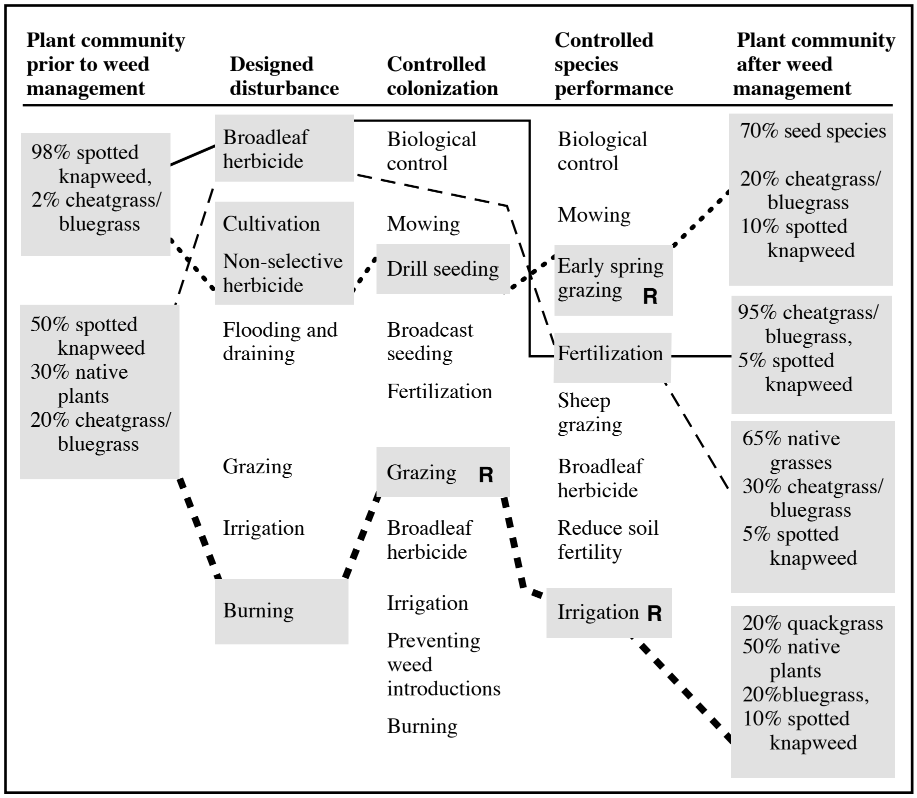


Figure 3. Integrated weed management must be based on the three general causes of succession: site availability, differential species availability and differential species performance. These correspond to management actions: designed disturbance, controlled colonization and controlled species performance. The appropriate combination of these causes of succession can alter the plant community in a favorable direction.

infested rangeland in Figure 4. Two levels of infestation are examined and two successional weed management plans are tested for each situation. These examples show how integrating various weed management systems direct successional processes, resulting in different successional patterns and usefulness to range managers. The plant community after implementation depends upon the weed management system and the plant community prior to weed management. Climatic variation introduces an uncontrolled random element that can influence the short-term and long-term outcome. Weed management actions should be based on your land use objectives, desired degree of energy inputs and economics.

The successional weed management model presented here allows for integration of currently available tools. With conceptual models of this type, there are seldom large comprehensive research projects that have tested all possible options for a particular plant community. Development of successional weed management plans will require use of existing research information, management experience and monitoring of successes and failures to adjust future plans.

Figure 4. Some spotted knapweed management strategies.



This chart lists the various choices that could be made in devising a strategy to manage spotted knapweed infestations. Follow the track from hypothetical situations in the left hand column through treatment options that design disturbance, control colonization and control species performance to find the expected results in the right hand column. "R" refers to repeated aplications.

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