Successional Rangeland Weed Management

Roger L. Sheley, Tony J. Svejcar, Bruce D. Maxwell, and James S. Jacobs

Over the past several decades, many rangeland managers and owners have focused weed management on controlling weeds, with limited regard to the existing or resulting plant community. Because of environmental, ecological, and economic concerns, the appropriateness and effectiveness of rangeland weed management practices are being questioned. It has become clear that weed management decisions must consider these concerns.

The development of future weed management practices must be based on our understanding of the biology and ecology of rangeland ecosystems. Weed management education will most effectively focus on providing land managers the principles and concepts on which to base their decisions, rather than providing a prescription for weed control.

Before these decisions can be made, uses of the land must be developed and an integrated weed management plan designed. This implies that only killing weeds is an inadequate objective in most situations, especially for large-scale infestations. A generalized objective can be developed for a healthy plant community that is relatively weed-resistant and still meet other objectives, such as forage production, wildlife habitat development, or recreational land maintenance.

A healthy, weed-resistant plant community consists of a diverse group of species which occupies all the niches. Desirable plants capture a large proportion of the resources in the system, keeping the resources from weeds (Figure 1). For example, a weed-resistant plant community may include an early emerging species, such as the shallow-rooted Sandberg's bluegrass. This species uses the available moisture 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 later into the season are needed to use available moisture 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 moisture 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 provides for stability and resource capture over a wide range of unpredictable conditions. Once the desired plant community has been determined, an ecologically-based weed management system may be developed.

To understand ecologically-based rangeland weed management, it is useful to remember the basic ecological principle on which rangelands have

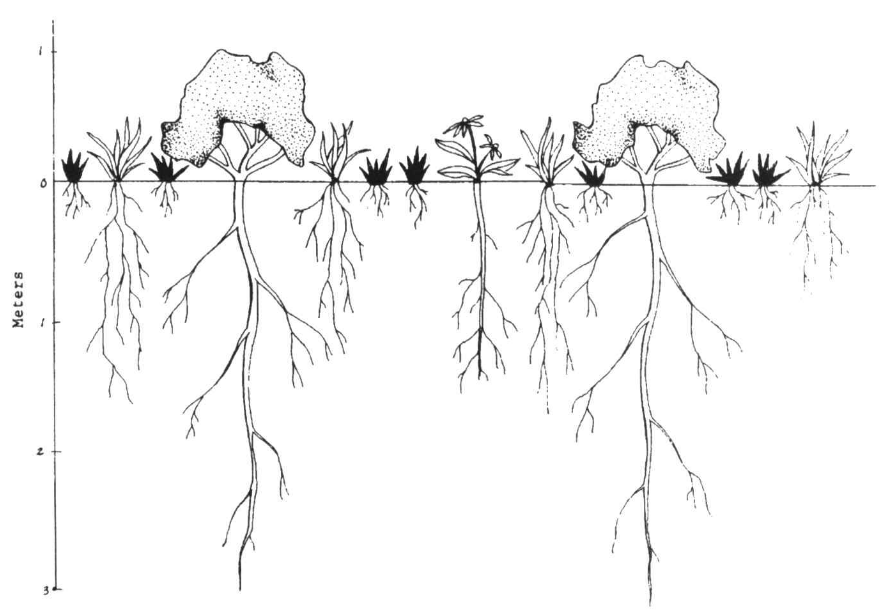

Fig. 1. *A healthy, relatively weed-resistant plant community composed of early-season, shallow rooted species (black), mid-season species with moderately deep roots (white), and late-season, deep rooted species (grey).*

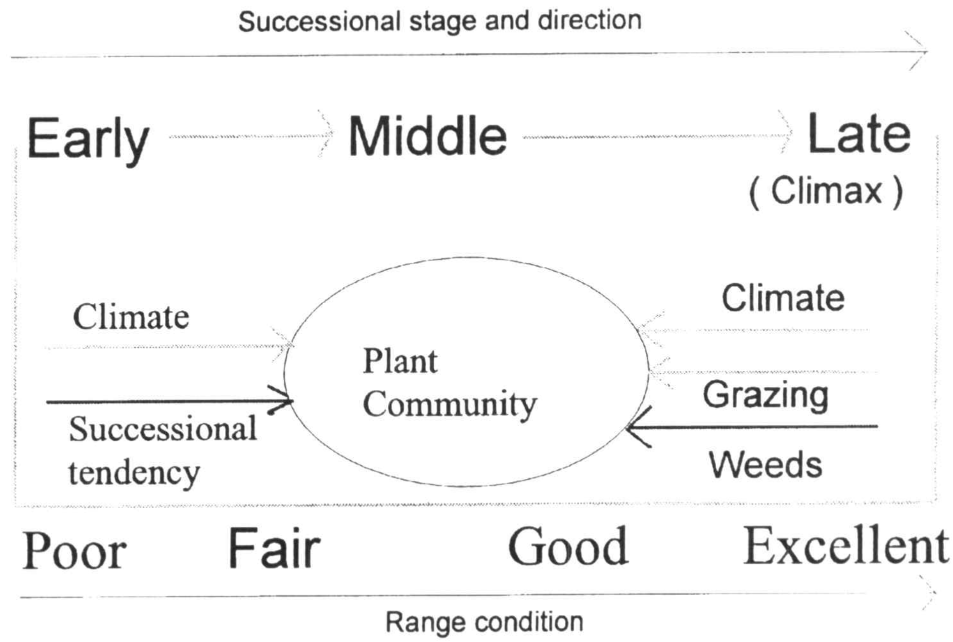

Fig. 2. *Alien invasive weeds are so aggressive they throw this successional system into disorder. The only component in this model that can shift the plant community in a desirable direction is successional tendency.*

been managed during the past 60 years (Clements 1916; Figure 2). This principle states that plant communities change over time until they reach a final and stable composition, called climax. This is termed succession. Secondary succession occurs after a site has been disturbed.

For example, in an Idaho fescue/bluebunch wheatgrass community type, 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 perennial species, such as bottlebrush squirreltail, Thurbers needlegrass or sticky geranium. Eventually, succession may progress to a climax community, codominated 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.

Rangeland management has been based on succession for decades (Sampson 1917). 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 (Figure 2).

When alien or noxious weeds invade native rangeland, they throw the successional pattern into disorder (Figure 2). Many of these weeds evolved in old world countries where a long history of very intensive disturbance has selected very competitive species. They have often been introduced without the natural enemies that help control their abundance. Alien weeds then are able to dominate native species. In a sense, they become climax or stable plant communities. How do we manage rangelands dominated be these aggressive weeds?

Based on the ecological model 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 or community dynamics. 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 (Rosenberg and Freedman 1984, Pickett et al. 1987).

A site is an area that meets the plants requirements for successful establishment, growth and reproduction. Disturbance creates available sites. Human caused disturbance includes activities that are initiated to create or eliminate site availability and are aimed at initiating and controlling succession. In part, succession can 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. 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. Usefulness of any disturbance will depend on the range site, plant community type, invading weed species, history of the site, and climate. In order for succession or community dynamics to occur, a site (niche) must be available for desirable species and unavailable for undesirable ones.

Once sites are available for desirable species, they must be occupied before the weeds establish. From a

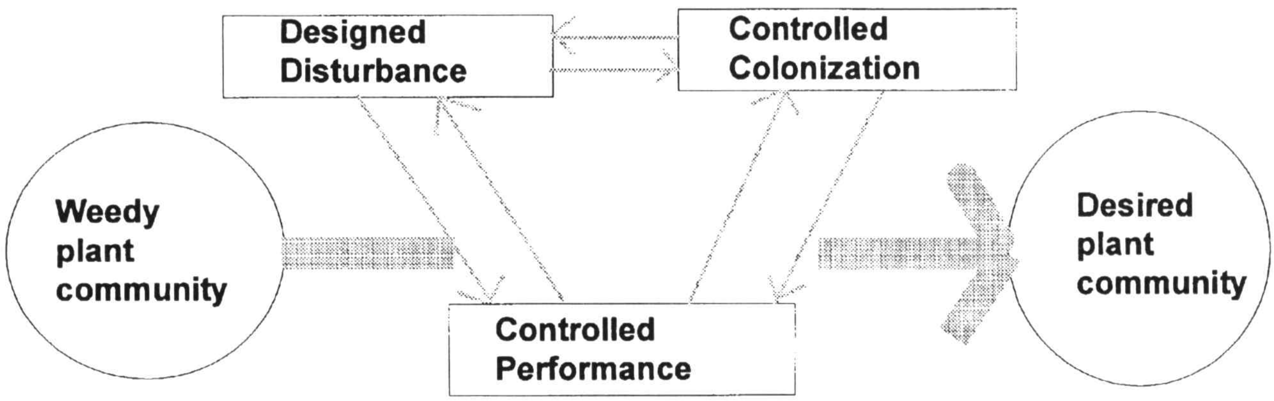

Fig. 3. *Integrated weed management must be based on the three general causes of succession: site availability, differential species availability, and differential species performance, which correspond to the management actions designed disturbance, controlled colonization, and control species performance.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

weed management standpoint, this may be termed "controlled colonization". Controlled colonization includes methods used to alter the availability and establishment of plant species within the community and are implemented to 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 may 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 they become established, species performance (controlled 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, 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.

Figure 3 shows a conceptual model which forms the ecological basis for developing integrated rangeland weed management strategies. The three mechanisms causing succession (disturbance, colonization, and performance) must be considered as a package. Implementing a portion of the successional management program is unlikely to shift the plant community in the desired direction. Designing successful rangeland weed management strategies will require integrating techniques aimed at addressing each of the three general causes of succession: site availability, differential species availability, and differential species performance. Management strategies must be carefully chosen to ensure that one technique is complementary to the other. And once this is achieved, succession 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 (Figure 4). Carefully consider and test each technique as to its 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. In many cases, there are only bits and pieces of research on these topics because information on integrating techniques is limited.

Figure 5 shows several schematics using this ecologically-based weed management planning system for spotted knapweed infested rangeland. In these examples, the plant community prior to weed management is composed of 1) 98% spotted knapweed with a very suppressed understory of cheatgrass or bluegrass, and 2) 50% spotted knapweed, 30% suppressed native plants, and 20% cheatgrass and/or bluegrass. Two successional weed management systems are tested for each situation. These examples show how integrating various weed management systems direct succes-

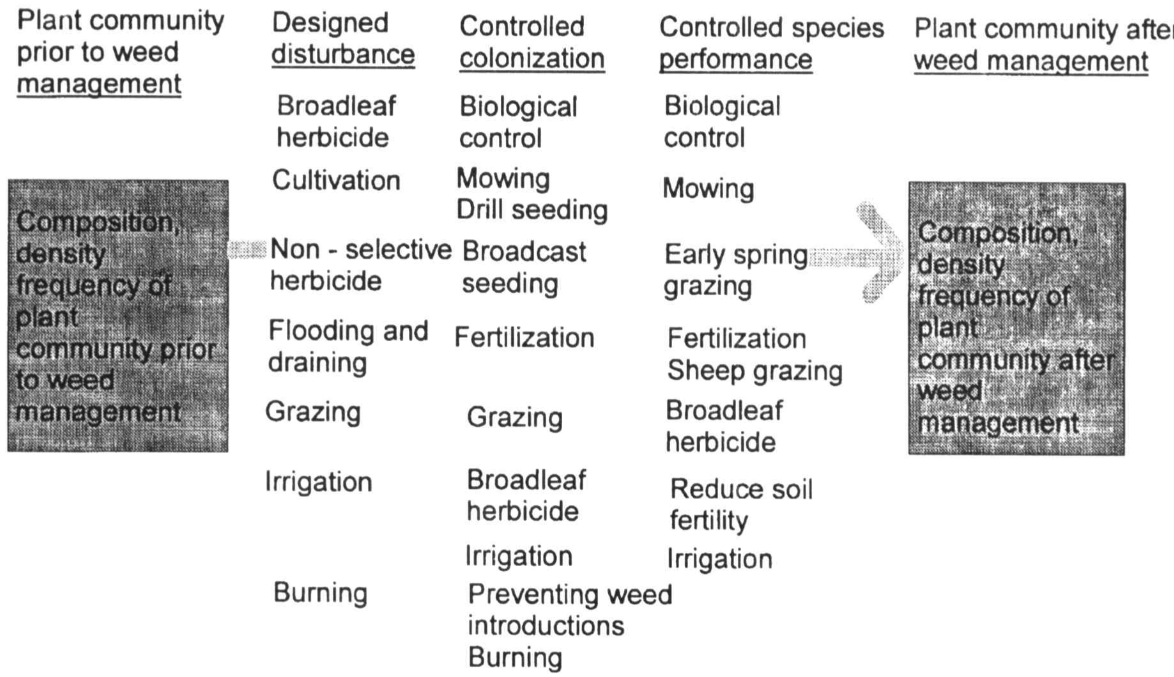

Fig. 4. *Some examples of treatments used to design disturbance, control colonization and control species performance in ecologically-based weed management.*

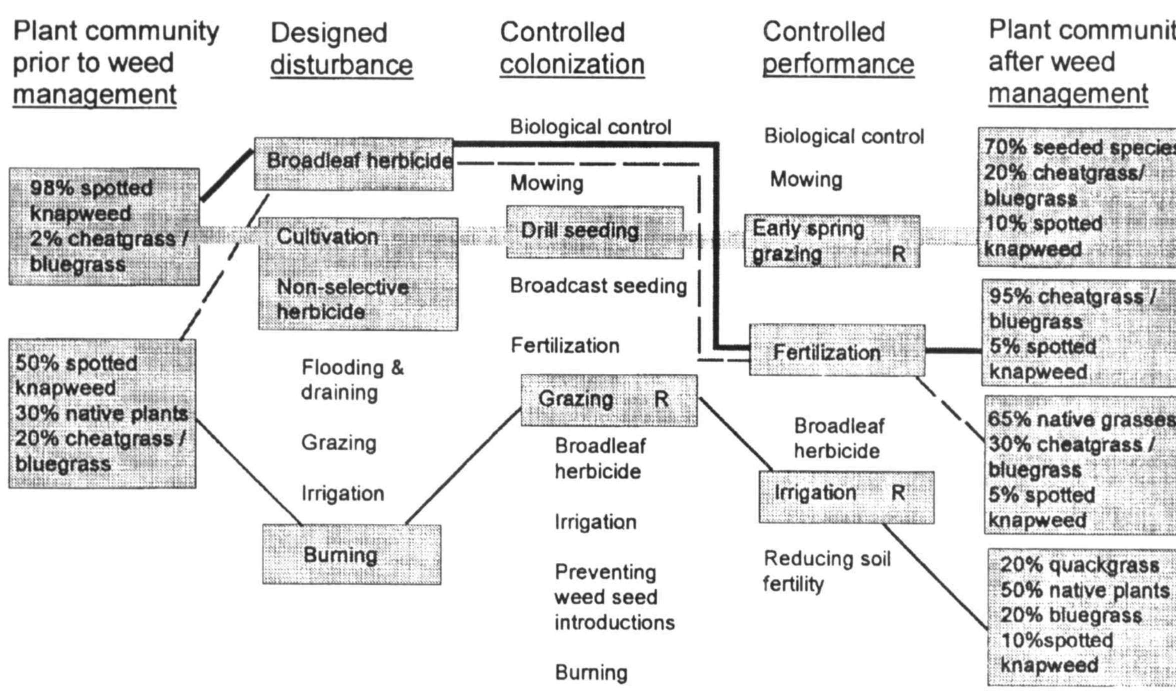

Fig. 5. *Examples of ecologically-based spotted knapweed management systems. R refers to repeated applications.*

sional processes, resulting in different successional patterns and usefulness to range managers. The plant community after implementation is dependent on the weed management system and the plant community prior to weed management. Climatic variation introduces a random element that can influence the short-term outcome. Weed management actions should be based on your land use objectives, desired degree of energy inputs, and economics.

Literature Cited

Clements, F.E. 1916. Plant succession: An analysis of the development of vegetation. Carnegie Inst. Washington Publication. 242:1-512.

Pickett, S.T.A., S.L., Collins, and J.J. Armesto. 1987. Models, mechanisms and pathways of succession. The Botanical Review. 53:335-371.

Rosenberg, D.B. and S.M. Freedman. 1984. Application of a model of ecological succession to conservation and land-use management. Environmental Conservation. 11:323-329.

Sampson, A.W. 1917. Succession as a factor in range management. J. Forest. 15:593-596.

Sheley, Maxwell, and Jacobs are Extension Noxious Weed Specialist, Asst. Prof (Weed Ecology), and Post-Doc Research Associate, Department of Plant, Soil and Environmental Sciences, Montana State University, Bozeman, Mont. 59717, respectively. Svejcar is Supervisory Range Scientist, USDA-ARS, Eastern Oregon Agri. Center, Burns, Ore. 97220. Published with approval of the Director, Montana Agri. Experiment Station, as Journal No. J-4094.