INVASIVE PLANTS IN UTAH

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An increasing threat to rangeland biodiversity and health is the invasion by non-native plant species (Frost and Launchbaugh, 2003; SRM, n.d.). Some of the most prevalent and problematic invasive plants include diffuse knapweed (*Centaurea diffusa*), spotted knapweed (*Centaurea maculosa*), yellow starthistle (*Centaurea solstitialis*), leafy spurge (*Euphorbia esula*), and cheatgrass (*Bromus tectorum*) (DiTomaso, 2000). The vast majority of invasive plants have been introduced from other continents. Cheatgrass, the most widespread and dominant invasive plant in the Intermountain West, was introduced during the mid- to late-1800s by means of imported grain from Eurasia (DiTomaso, 2000; Knapp, 1996). The first records of cheatgrass in the Great Basin came from Provo, Utah, in 1894; Elko, Nevada, in 1905; and Reno, Nevada, in 1906 (Knapp, 1996).

The dispersion of non-native plants was originally linked to direct human activity, particularly along railroad lines (Knapp, 1996). However, decades of grazing in the Intermountain West during the open range era, and poor grazing management practices facilitated the invasion, establishment, and spread of non-native plant species (Frost and Launchbaugh, 2003; Vavra et al., 2007). Prior to the introduction of non-native plants, Intermountain rangelands were predominantly characterized by perennial bunchgrasses, forbs, and shrubs (Hull and Hull, 1974). As the livestock industry expanded and human populations began to flourish, the proportion of non-native plant species began to increase. Many native plant communities became destabilized and the spread of non-native plants was encouraged. The process of destabilization was intensified because many native perennial grasses lack high seedling vigor and some do not readily recover from grazing (DiTomaso, 2000). In contrast, invasive winter annual grasses, such as cheatgrass and medusahead (*Taeniatherum caput-medusae*), have high seedling vigor, and they outcompete native plants by exploiting valuable resources and completing their life cycle prior to the summer dry period (Frost and Launchbaugh, 2003). The reduced competition from native plants perpetually favors the spread of invasive plants because many are unpalatable, aversive, or toxic to livestock (DiTomaso, 2000).

Livestock and human activity can also promote the spread of non-native plants through ground disturbance and the physical dissemination of seeds. Disturbance appears to be an important aspect in the establishment of non-native plant populations because many invasive plants are adapted to soil disturbance, such as that caused from trampling or off-road vehicle use (Vavra et al., 2007). Invasive plant seeds, such as cheatgrass and houndstongue, are dispersed by adhering to the coats of animals, while others are dispersed as they pass through digestive tracts (Frost and Launchbaugh, 2003; Fleischner, 1994).

EFFECTS OF INVASIVE PLANTS

Invasive plants can have a significant impact on an array of ecological facets. Invasive plants have reduced species richness, plant diversity, and community productivity. Wildlife habitat and forage have been degraded; soil erosion and stream sedimentation have increased; soil moisture and nutrient levels have been depleted; and fire regimes have been altered (Frost and Launchbaugh, 2003; Wallace et al., 2008). As cheatgrass has become a common component of sagebrush steppe vegetation communities, the nutritional quality of forage has been reduced, the intensity and frequency of fires have changed, and water cycles have been altered. Although many factors are involved, several native animals, such as sage grouse, may have declined as a result of these changes (SRM, n.d.).

Invasive broadleaf species that have deep taproot systems, such as yellow starthistle, have modified surface runoff, stream sediment yields, soil moisture, and soil nutrients (DiTomaso, 2000). Yellow starthistle can extract soil moisture from the entire soil profile and outcompete native shallow- and deep-rooted annual and perennial species (Wallace et al., 2008). Woody plant species, such as saltcedar (*Tamarix* spp.), have invaded wetland and riparian systems throughout the western United States. Dense populations of saltcedar lower water tables, reduce the volume of surface water, alter flood frequency, increase soil salinity, and reduce the diversity and productivity of the herbaceous understory (Masters and Sheley, 2001; DeLoach et al., 2000). These changes combined suggest that invasive plants can significantly alter ecosystem processes, cause ecosystem instability, displace native plant species that are vital to wildlife and livestock, and reduce the capacity for ecosystems to provide the services required by society (Knapp, 1996; Masters and Sheley, 2001).

The invasion of non-native plant species not only produces various ecological modifications, but also results in substantial socioeconomic impacts, particularly to the livestock industry and land management agencies responsible for fire suppression. Invasive plant species cause more economic loss on rangeland than all other pests combined.

Invasive plants reduce the carrying capacity for livestock by lowering the forage yield. Consequently, the costs of managing and producing livestock increase (DiTomaso, 2000).

Research has demonstrated that leafy spurge and knapweed species can reduce grazing capacity by more than half. However, some rangelands have deteriorated to the point that desirable species are either not present or in such low abundances that plant community recovery is slow or will not occur without revegetation efforts (Masters and Sheley, 2001). Although cheatgrass is used to some degree as livestock forage, in some years it only provides 10 percent of the productivity of the perennial species it replaced. Cheatgrass can be a nutritious and palatable forage crop during the growing season, but it is often an unreliable source because of its dependency on annual precipitation, and awned cheatgrass can pose severe health problems to livestock after it has matured (Knapp, 1996).

Invasive plant species, specifically cheatgrass, have altered the fire regimes of many environments in the western United States, and consequently imposed an economic burden on management agencies faced with fire suppression. Prior to the invasion of cheatgrass in sagebrush steppe ecosystems, the fire return interval was approximately 60 to 110 years; however, cheatgrass has changed the fire frequency to 3 to 5 years (Pimentel et al., 2005). Cheatgrass fires are common because the amount of fine fuel that accumulates is greater than what occurs in sagebrush-bunchgrass communities (Knapp, 2005). The increased fire frequency does not permit establishment by native annuals and perennials, and therefore, native plants are diminishing and monocultures of cheatgrass are dominating (Knapp, 2005; Pimentel et al., 2005). The cost of wildfire suppression on public land is rising with the federal fire bureaucracy spending hundreds of millions of dollars annually on resource losses, suppression costs, presuppression costs, fire management, and rehabilitation programs (Dombeck et al., 2004; Knapp, 1996).

MANAGEMENT STRATEGIES

Attempts to manage and eradicate invasive plant species have been made utilizing various control methods. Historically, mechanical and chemical control techniques were the predominant invasive plant management methods; however, biological and cultural control techniques have been implemented and integrated with other practices. Mechanical control techniques include hand-pulling, hoeing, mowing, tilling, chaining, and bulldozing. Hand-pulling and hoeing are effective in controlling small infestations of shallow-rooted weeds in loose, moist soils (DiTomaso, 2000). Mowing is commonly used to control invasive range annuals and some perennials; however, the success of mowing is highly dependent on timing. Annuals and some perennials can be suppressed and controlled if mowing occurs before viable seeds form. If not properly timed, mowing can promote the spread of invasive plants by encouraging the spread of seeds and stimulating the production of new stems from vegetative buds (DiTomaso, 2000; Masters and Sheley, 2001). Tilling practices can control annual species, but they rarely provide control of perennial species. In fact, perennial or biennial species, such as spotted knapweed and perennial pepperweed, often spread as a result of tilling (DiTomaso, 2000). More expensive mechanical control techniques, such as chaining and bulldozing, are effective in controlling invasive shrub and tree species. Although these methods require gentler terrain and are becoming increasingly expensive, they are effective in controlling shrubs and trees that do not readily resprout from root systems (DiTomaso, 2000; Masters and Sheley, 2001).

Chemical control techniques include the application of herbicides, such as 2,4-D, glyphosate, picloram, and teburthiuron. Herbicides are the primary method of invasive plant control in most rangeland systems (DiTomaso, 2000; Masters and Sheley, 2001). However, most herbicides do not provide adequate control without several successive annual applications (Knipe, 1983), and they seldom provide long-term control (DiTomaso, 2000). Timing of herbicide application is also essential to effective control because it is highly dependent on the species and the herbicide being applied. Additionally, herbicides that are effective in controlling invasive plants are often toxic to native herbaceous plants and have the potential to contaminate surface and ground water (DiTomaso, 2000; Masters and Sheley, 2001).

Biological control includes the planned use of living organisms to reduce the reproductive capacity, density, and effect of invasive plant species (Masters and Sheley, 2001). The primary goal of biological control techniques is to exert environmental stress on invasive plants by reestablishing interactions with natural enemies (DiTomaso, 2000; Masters and Sheley, 2001). Although there have been many attempts to control invasive plants on rangelands, the success has been variable and limited. Biological control has been moderately effective in controlling leafy spurge and saltcedar. For example, recent research indicates that the use of an Asian leaf beetle (*Diorhabda elongata deserticola*) has been successful in controlling up

to 85 percent of saltcedar populations in research sites in Grand County, Utah (Johnson and Higgs, 2007; Lewis et al., 2003). Important factors that have contributed to the limited success of biological control are often attributed to a high level of genetic diversity in the target species (Masters and Sheley, 2001).

Cultural control techniques include prescribed burning, reseeding or revegetation efforts, the modification of grazing management plans, and the implementation of prescription or targeted grazing (Masters and Sheley, 2001). Prescribed burning is often used for long-term suppression of woody species in sagebrush and juniper ecosystems and it can stimulate native annual and perennial grass growth (DiTomaso, 2000). Seeding and other revegetation efforts are often alternatives for managing invasive plants in areas that lack desirable species. Revegetation with competitive grasses and forbs may suppress non-native plants, enhance plant community resistance to further invasion, and improve forage production and quality (Masters and Sheley, 2001).

Recent cultural control techniques have focused on the modification of grazing management plans and the implementation of prescription grazing. Properly managed livestock can minimize the spread of invasive plants on rangelands (Wallace et al., 2008; DiTomaso, 2000). Moderate grazing levels can minimize the impact to native plants, whereas intensive grazing can counteract the dietary preferences of cattle, resulting in equal impacts to all forage species including invasive plants. Grazing by multiple species, such as sheep, cattle, and goats, can distribute the impact of livestock more uniformly among desirable and undesirable species. Adjusting the timing of grazing to coincide with the susceptible life-cycle phases of invasive plants can also have substantial control impacts (DiTomaso, 2000).

Targeted or prescription grazing is the application of livestock at a specified season, intensity, and frequency to achieve specific vegetation management goals, such as the control of invasive plants (Wallace et al., 2008). Successful prescription grazing should cause significant damage to the target plant, limit damage to native vegetation, be consistent with livestock production goals, and be integrated with other control methods. Prescription grazing also entails the modification of livestock grazing behavior (Frost and Launchbaugh, 2003). The species of livestock suited for control of invasive plants depends on the species of concern and the production setting.

Research has evaluated the effectiveness of cattle, sheep, and goats in targeted grazing. Although cattle can manage fibrous herbaceous vegetation, they appear to offer the least potential for control of invasive plants. Sheep are considered an excellent species to accomplish control of herbaceous plants, such as leafy spurge, due to their ability to tolerate substantial fiber content (Frost and Launchbaugh, 2003). Goats are the most well-known domestic grazer that function as plant control agents (Brock, 1988). Goats are classified as browsers, and their physical characteristics allow them to select individual leaves or chew entire branches. Although they can be very selective herbivores, goats are reputed to utilize a wider range of vegetation than other livestock species (Knipe, 1983). They also have a large liver mass relative to cattle or sheep, and can therefore process plants that contain secondary chemical compounds, such as tannins or terpenes (Frost and Launchbaugh, 2003).

INTEGRATED MANAGEMENT STRATEGIES

The implementation of one control method is rarely effective in achieving the desired results for curtailing the spread of invasive plants. Successful long-term and cost-effective management programs should integrate a variety of mechanical, chemical, biological, and cultural control techniques (DiTomaso, 2000). Integrated management involves the deliberate selection, combination, and implementation of effective invasive plant management strategies with due consideration of economic, ecological, and sociological consequences (Sheley et al., 2004).

Although integrated management emerged as a viable concept in the 1970s, the practice has not been systematically implemented until recently because effective integrated management plans and programs require a thorough understanding of the ecology and biology of invasive plants and invaded plant communities (Masters and Sheley, 2001). Presently, there are several examples of integrated strategies used to manage invasive plants and improve rangeland communities. Much attention has been focused on the integration of targeted or prescription grazing with other control methods, as the incorporation of grazing management is an essential component in successfully addressing invasive plant problems (Frost and Launchbaugh, 2003).