

Effects of Fire and Restoration Seeding on Establishment of Squarrose Knapweed (*Centaurea virgata* var. *squarrosa*)

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Abstract—Squarrose knapweed (*Centaurea virgata* var. *squarrosa*), herein referred to simply as knapweed, is a noxious weed that invades both disturbed and healthy sagebrush communities. Fire, grazing, mining, recreation, and farming have all played a large part in the establishment of knapweed in Tintic Valley, Utah. This study was designed to look at the effect of fire on the establishment of knapweed in four community types, namely cheatgrass, crested wheatgrass, degraded sagebrush, and healthy sagebrush. Plots were either burned or left unburned after which subplots were seeded with knapweed. Results show that fire plays an important role in knapweed invasion especially in sagebrush communities. Knapweed establishment on cheatgrass plots did not vary between burn treatments, and knapweed establishment was lowest on crested wheatgrass sites.

Introduction

Squarrose knapweed (*Centaurea virgata* var. *squarrosa*), is a secondary weed invading the cold desert in central Utah. This perennial, native to the Middle East (Roche and Roche 1989), is well adapted to the climate of the Great Basin. Knapweed was recognized in Utah over 50 years ago, and initial research on life history and control measures began in the 1960s (Tingey 1960). By the late 1980s, knapweed was estimated to cover 40,468 ha, and organized control efforts were materializing (Fosse 98). Knapweed is currently found in high densities in five Utah counties (Roche and Roche 1989) and is increasing in acreage at a rate of approximately 10 to 15 percent per year (Fosse, unpublished data on file at the BLM Dillon, MT Field Office). It has invaded communities throughout the sagebrush-steppe ecosystem, including functional and at risk big sagebrush (*Artemisia tridentata*) communities, pinyon/juniper (*Pinus edulis*/ *Juniperus osteosperma*), primary weed communities, and communities reseeded with introduced perennial grasses.

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Tintic Valley is located in central Utah and has a recent history of high fire frequency, due in part to an increase in cheatgrass (*Bromus tectorum*) abundance. Prior to the introduction of domestic livestock, valley ecosystems were dominated by big sagebrush and associated perennial herbaceous species, particularly grasses. Current big sagebrush community condition is a good indicator of disturbance (fire, grazing) history. Healthy sagebrush sites have an abundant herbaceous understory while degraded sagebrush sites lack this component.

Much of the land is currently managed by the Bureau of Land Management and, following fire, was reseeded with introduced grasses, primarily crested wheatgrass (*Agropyron cristatum*). Other major land tracts in the valley are privately owned. Some of the private holdings were seeded with crested wheatgrass following fire; however, unseeded portions are now dominated by the introduced annual cheatgrass. This has created a patchwork of sagebrush, crested wheatgrass, and cheatgrass-dominated communities across the landscape. All of these communities appear to have the potential to be invaded by knapweed. This project addressed the question of how fire affects the invasibility of functional and degraded sagebrush, cheatgrass-dominated, and revegetated communities by knapweed. We hypothesized that all community types would be more susceptible to knapweed invasion following fire.

Methods

Three study areas, or experimental blocks, were selected in Tintic Valley. Each block contained sites from the four community types: (1) healthy Wyoming big sagebrush (*A. tridentata wyomingensis*), (2) degraded Wyoming big sagebrush, (3) crested wheatgrass, and (4) cheatgrass. Community types within each block were located as close together as possible to minimize environmental differences.

Two 20 m x 20 m plots were located on each site, one of which was designated for burning and one to be left non-burned. Within each plot, 40 1-m² permanent subplots were randomly located. Twenty of these subplots were seeded with knapweed and the other 20 were left unseeded. While knapweed was not present on the selected plots prior to seeding, knapweed occurred in varying densities adjacent to each block.

In May 2002, basal cover was inventoried with a 1-m² modified 20-point frame in all subplots prior to burning and seeding treatments. This method estimates basal cover for litter, rock, microbial crusts, bare ground, and vegetation by species at a 5 percent level of precision (Bonham 1989).

Burning was completed in June 2002 with the help of BLM, USFS, and Utah State fire crews. Drip torches were used to ignite the fires. Fall of 2002, subplots in both the burned and unburned plots were broadcast seeded with knapweed at a rate of 2.17 kg/ha (12 lbs/acre). To eliminate edge effect, a 4-m² area was seeded with the 1-m² subplot positioned in the middle. Post-treatment assessment of basal cover was conducted in May 2003 and 2004 using the same protocols as were used prior to treatments. Knapweed basal cover and density were also monitored.

Data were analyzed using Systat General Linear Model and Analysis of Variance with Tukey's pairwise comparison.

Results

Spring and summer of 2003 experienced a severe drought, which resulted in low knapweed germination. Most seed remained in the seedbed until 2004 when a flush of knapweed seedlings were observed. As a result, only data from 2004 are presented here. Seeded knapweed density was dependant ($p = 0.010$) on the interaction between community type, burn treatment, and seed treatment. Knapweed density was significantly higher on unburned cheatgrass plots than on burned cheatgrass plots (fig. 1). Conversely, knapweed density was higher after burning compared to unburned plots for both healthy and degraded sagebrush communities. In contrast, there was not a significant difference in knapweed density between treatments on the crested wheatgrass plots.

Basal cover of the vegetation was significantly different among community types. In pairwise comparisons, perennial grass cover was significantly higher ($p < 0.0001$) on crested wheatgrass sites than on all other sites. Native forb cover was significantly higher on healthy sagebrush sites than on degraded sagebrush ($p = 0.004$) and crested wheatgrass ($p = 0.028$) sites. Also in pairwise comparisons, the cheatgrass sites had higher ($p = 0.017$) annual grass and annual forb cover than did crested wheatgrass sites.

Discussion

Disturbances such as fire can cause an increase of soil nitrogen. Huenneke and others (1990) found that increasing the nitrogen in a system increases the invasibility of a community. Disturbance can also cause an increase in the duration of available soil moisture by decreasing vegetation. The loss of vegetation decreases the amount of transpiration occurring in that area, which results in greater water availability (Coronato and Bertiller 1996; Schlesinger and others 1987). With some exceptions, notably cheatgrass, early successional species such as primary and secondary weeds are typically not good competitors, but they are good colonizers and take advantage of available resources (Tilman and Wedin 1991). Fire increases both the nitrogen and water availability and creates an opening for plants to colonize. Given squarrose knapweed's invasive tendencies and the presence of these conditions, we hypothesized knapweed densities would be greatest in all community types under burned and seeded conditions. This hypothesis proved

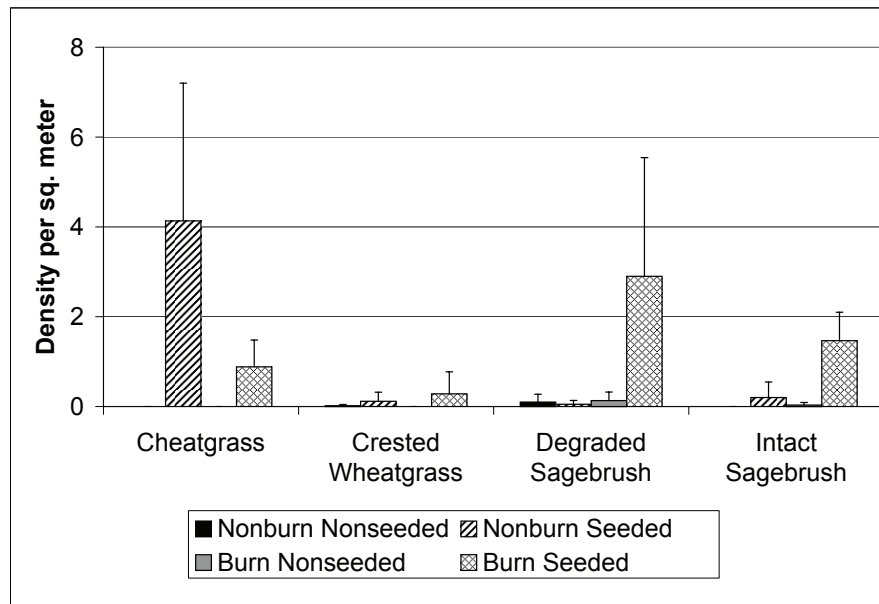


Figure 1—Mean squarrose knapweed density 2 years post treatment (May 2004) in four community types where burned and unburned plots were unseeded or seeded with knapweed propagules.

correct among healthy and degraded sagebrush sites, but was not the case on crested wheatgrass and cheatgrass sites. The crested wheatgrass sites didn't have a lot of knapweed establishment with or without fire. This is in contrast to the other three community types. The fire may not have been an intense enough disturbance to counter the competitive nature of crested wheatgrass and permit knapweed invasion, resulting in little contrast between burned and unburned seeded plots.

Invasion may also be facilitated by low biodiversity (Naeem and others 2000). The relatively low levels of biodiversity of cheatgrass, crested wheatgrass, and degraded sagebrush communities may make them more susceptible to invasion without fire. Knapweed invasion without fire, however, was only observed on the cheatgrass sites. Perennial species were not present on the cheatgrass site but dominated the other two sites. The presence of perennial species may contribute to poor knapweed establishment on these two low-diversity sites. It wasn't until after the degraded big sagebrush sites were burned and the shrub component lost that squarrose knapweed was able to establish.

Another important factor to the invasibility of a community is the presence of weed propagules (Davis and others 2000). Knapweed can be likened to a slow moving army that simply keeps plodding along. It's not necessarily an abundant seed producer, nor is it adapted to either a long-lived seed bank or excellent seed dispersion. Rather, most seed falls adjacent to the maternal plant, germinates at first opportunity, grows to maturity, and annually adds propagules that follow the same pattern. It seems to establish readily, is moderately long-lived and quite hearty. These data suggest that knapweed is capable of obtaining an initial foothold in each of these community types following fire, and most successfully in cheatgrass communities.

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