Spatial and Temporal Seed Dispersal of Squarrose Knapweed (*Centaurea virgata* Lam. spp. *squarrosa* (Willd.) Gugler) in West Central Utah, a Case Study

Scott L. Jensen, Stephen. B. Monsen, and Pat Fosse

Abstract—This case study documents temporal and spatial squarrose knapweed (*Centaurea virgata* Lam. spp. *squarrosa* (Willd.) Gugler) seed dispersal from study sites in central Utah. Felt seed traps were placed along transects extending from sites occupied by squarrose knapweed into adjacent plant communities. Seed dispersal from knapweed plants occurred over an 8-month period. By 1 November 1999, 50 and 53 percent of dispersed seed had been recovered at the Knight and Cherry Creek locations respectively. By May, nearly all seed has dispersed from the producing plant. Most seed was deposited and remained within 2 m of the parental plant.

Introduction

Identifying the mechanisms, timing and extent of seed dispersal is critical to understanding potential spread of invasive species. Squarrose knapweed (*Centaurea virgata* Lam. spp *squarrosa* (Willd.) Gugler) was first documented in Juab County Utah in 1954. At that time it was reported to occur along approximately 80 km of highway in the Tintic valley, on 162–202 hectares on a ranch in Juab County and in small patches at other locations (Tingey 1960). Presently it is found on tens of thousands of hectares in Juab, Utah, Tooele, Millard, and Sanpete counties. Its occurrence has been linked to a variety of dispersal mechanisms including livestock grazing and trailing, wildlife use, as a contaminant in crop seed and hay, gravel moving activities, vehicle traffic, railroad activity, and recreation traffic (Roche and others 1992). We have seen it proliferate along ephemeral streams and drainages and increase in abundance dramatically following fire. Once established, knapweed gradually increases in density. Few plant communities appear resilient to its invasion.

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In Utah, squarrose knapweed flowering typically begins the first week of July and continues through the first week of August with about 20 percent of the population flowering per week during that interval (Jensen, unpublished data). A flower progresses from bud to senescence in 7 days or less (Jensen, unpublished data). Most seed is mature by the end of August. Seed production can vary greatly from year to year with almost no production during extended drought periods to over 4,000 seeds/m^2 during good moisture years (Jensen, unpublished data). Achenes develop within an upright encapsulated seedhead (capitula). Achene bodies are 3 to 3.8 mm long and have a pappus up to 3.5 mm long (Roche and Roche 1989). The small pappus is not capable of providing lift for airborne dispersal common to other Compositae seeds. A capitula typically contains 1–5 viable achenes (Roche and Roche 1989), and often as many nonviable achenes. Upon maturation the capitula opens partially allowing some seed dispersal if the plant is aggressively brushed or wind blown. Typical dispersion occurs several months after ripening as the capitula is separated from the plant. An abscission layer develops at the base of the capitula allowing the structure to break free from the stem (Roche and Roche 1989). Seed viability is typically greater than 85 percent with germination occurring within 7 days in warm moist conditions (Jensen, unpublished data).

Roche and others (1992) conducted a study to determine if plant distribution was due to seed carried in the wool of sheep. These authors concluded that while sheep carry and disperse seed, they are by no means the only dispersal mechanism. A plethora of unexplored mechanisms remain. In this study we document the persistent contiguous population expansion by monitoring seed dispersal from dense knapweed infestations into adjacent plant communities. This study reports the timing and volume of seed movement at two scales, <15 m and at 15 m intervals to 60 m, regardless of responsible mechanism.

This case study is the first to attempt to quantify squarrose knapweed seed dispersal by distance and time. Methods developed as the study progressed resulting in data that were not as quantitative as we would have liked. Nonetheless, this study provides useful data to land managers that is otherwise not documented.

Methods

Separate studies addressed short (<15 m) and medium (<60 m) distance seed dispersal at two study sites in the Tintic valley of Juab County, Utah. Both the Cherry Creek and Knight sites are located on previously dry farmed agricultural fields dominated by squarrose knapweed to the exclusion of almost all other species. A wildfire burned the Cherry Creek site several years prior to the initiation of the study. Rangeland communities of pinyon-juniper (*Pinus edulis, Juniperus osteosperma*), big sagebrush (*Artemesia tridentata*) rabbitbrush (*Ericameria nauseosa*) and perennial grass are adjacent to this site. The Knight site adjoins crested wheatgrass (*Agropyron cristatum*) seedings and pinyon-juniper and big sagebrush communities.

The short distance study focused on seed dispersal from an individual plant and was conducted only at the Knight study site between August 1999 and May 2000. Medium distance dispersal studies focused on distance, direction, timing, and volume of seed dispersed from dense squarrose knapweed populations. Medium distance studies were conducted at the Knight and Cherry Creek study sites between August 1999 and March 2001

Four knapweed plants were selected to document short distance dispersal. Surrounding vegetation was mowed to 15 m beyond each plant to facilitate locating dispersed capitulas. Upon cessation of flowering in August 1999, plants were painted using fluorescent orange spray paint. In the spring of 2000, the number of painted capitulas occurring within ½ m concentric circles was recorded.

To document medium distance dispersal, ten transects were established at irregular intervals along the periphery of both the Knight and Cherry Creek sites. Two transects were oriented roughly perpendicular to each field edge in the following directions: 0°, 72°, 144°, 216°, and 288°. Transects began 15 m inside the knapweed infested field and extended 60 m into the adjoining plant communities creating data points at –15 m, 0 m , 15 m, 30 m, 45 m and 60 m. At each data point, 6 seed traps were equally spaced along a 10-m line lying perpendicular to the transect. Each seed trap consisted of a 232 cm^2 piece of plush felt material held to the ground with 16 penny nails. Knapweed abundance drops off dramatically at the ecotone of the knapweed field and the adjacent plant community. Seed producing knapweed plants, occurring along transects in adjoining communities, were removed to eliminate onsite seed production.

For the 1999 seed cohort distance, volume, direction, and timing data were recorded in September and October of 1999 and April of 2000. Sampling continued at the Cherry Creek site through early July of 2000. For the 2000 seed cohort distance, volume and direction data were collected in mid-March 2001. The timing study was not conducted during the second year.

Results and Discussion

Seed Dispersal: Distance, Volume and Direction

The short distance seed dispersal study documented an abbreviated natural dispersal distance. Seventy eight percent (206) of the capitulas collected (total sample = 264) fell within 0.5 m of the producing plant (fig. 1); an additional 15 percent (40) traveled between 0.5 and 1 m, 5 percent (14) between 1 and 1.5 m, and just 2 percent (4) between 1.5 and 2 m. This dramatic decline in capitula numbers as distance

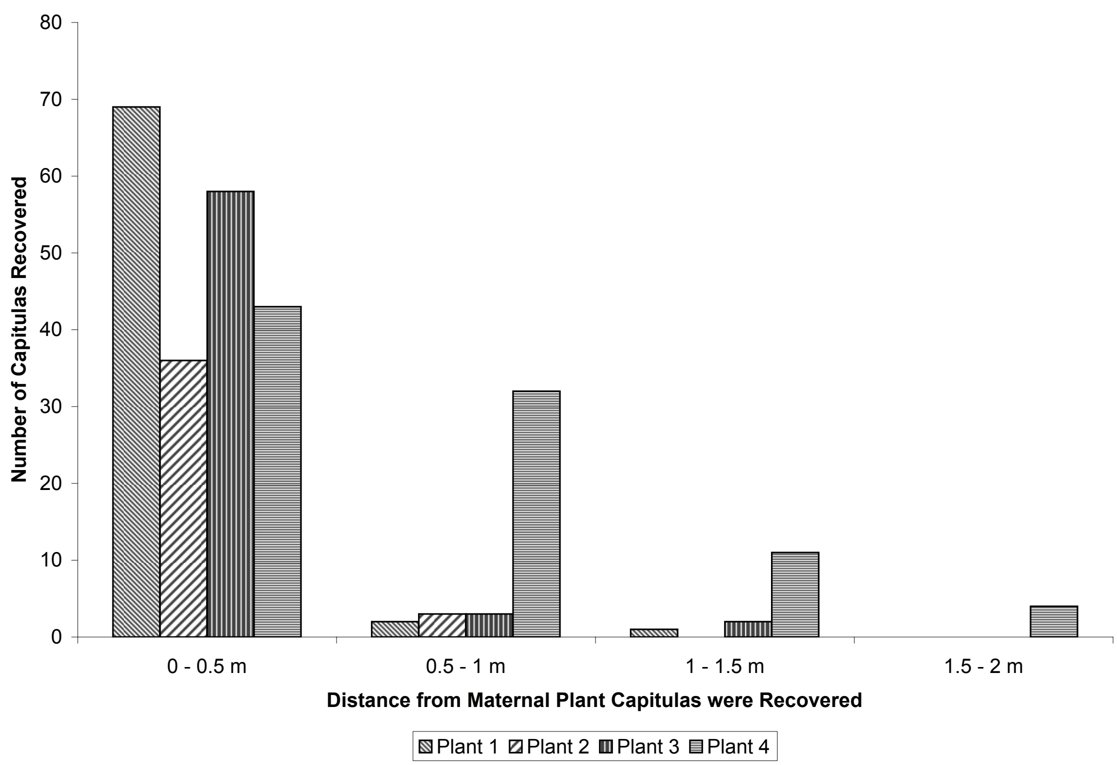

Figure 1—The number of orange painted capitulas recovered from the four painted plants is shown at ½ m increasing distance intervals.

increases suggests the majority of natural dispersion occurs within 2 m of the maternal plant.

Medium distance data that is intended to assess dispersal from the population as a whole illustrate a similar occurrence. Combining data from the 1999 and 2000 seed cohorts at both sites, 73.6 percent of recovered seed accumulated at the –15-m data points, which lie within the knapweed infested fields (fig. 2). An additional 24.4 percent of the collected seed accumulated at the 0-m data points, which occur at the ecotone of the knapweed fields and adjacent plant communities. Only at the Knight site during 1999 were achenes collected beyond the 0-m point. This amounted to 2.0 percent of the total recovered seed. The combined trap area at each distance interval was 1.39 m^2. Standardizing to a m^2 unit the equivalent of 2.9 achenes were recovered at the 15 m data point, 2.2 at 30 m, 2.9 at 45 m and 1.4 at 60 m.

We hypothesized wind transported achenes would accumulate in larger quantities along transects directed inline with predominant winds, which generally blow from the south or southwest. Because little seed was collected outside the boundary of the knapweed stands our data are inconclusive.

Seed Dispersal: Timing and Subsequent Movement

With seed maturation in August, the stage was set for propagule dissemination. By 1 September 1999 the abscission layer subtending capitulas had formed permitting detachment when heads were brushed but holding them through the strongest winds. From August to mid-October 1999, foraging grasshoppers caused considerable quantities of capitulas to accumulate on the ground. By mid-September 15.5 percent of the total seed collected at the Knight site and 25.8 percent of the total seed collected at the Cherry Creek site was recovered in traps. This early seed fall is an anomaly that will only occur during grasshopper outbreaks. Not until mid-October were capitulas observed accumulating on the ground as a result of natural fall. By the first of November 1999, 50 percent of the total seed collected at the Knight site and 53 percent at the Cherry Creek site was recovered. Winter weather conditions provide the appropriate environment for remaining capitulas to dehisce. At the Knight site, the remaining 50 percent of seed was collected from traps in April. At Cherry Creek, 47 percent of the seed was collected in April, with the final 10 percent in July (fig. 3).

A small amount of seed fall and or movement occurs over the summer months accounting for the July accumulation. We suspect this is due to several conditions. First, plants retain trace amounts of seed in non-dehisced capitulas. Secondly, soils in the Tintic valley are high in clay content. Capitulas coming in contact with the soil during wet winter and spring months adhere to the surface. As soils dry throughout the summer, seed may be released allowing further movement.

Management Implications

All data and observations indicate knapweed has not developed mechanisms for rapid and massive seed dispersal

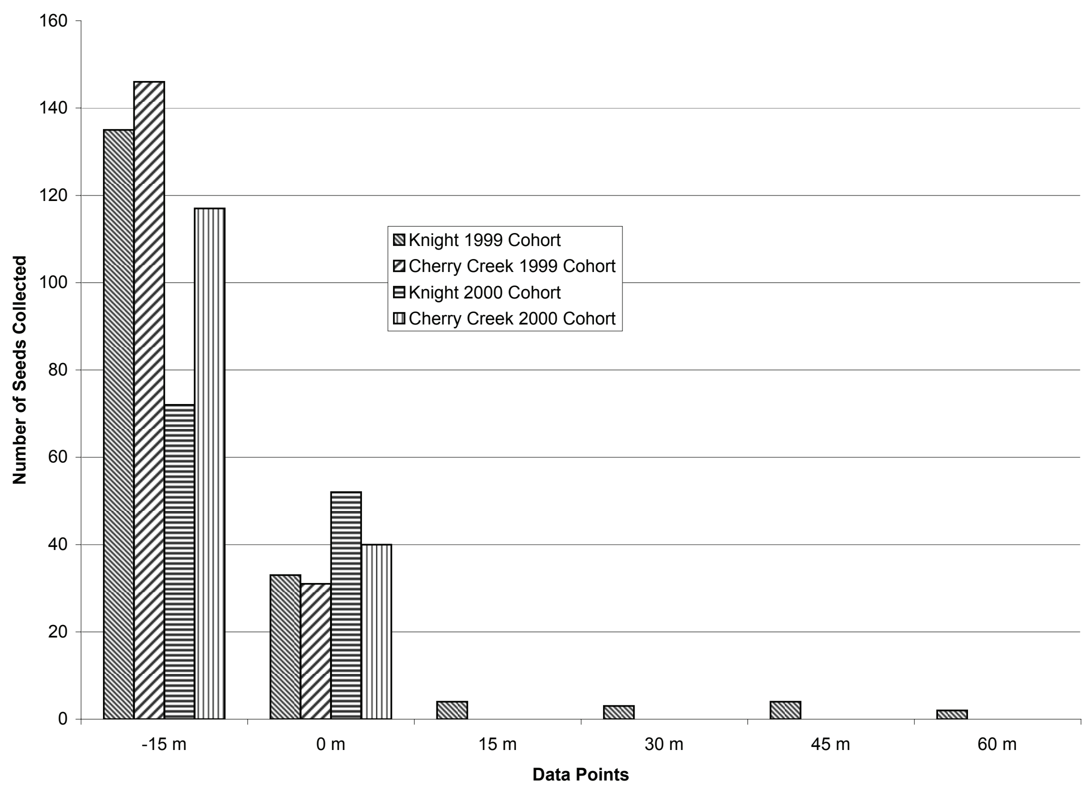

Figure 2—The number of seeds recovered at increasing distances from the knapweed field is shown for the 1999 and 2000 seed cohorts at the Knight and Cherry Creek sites.

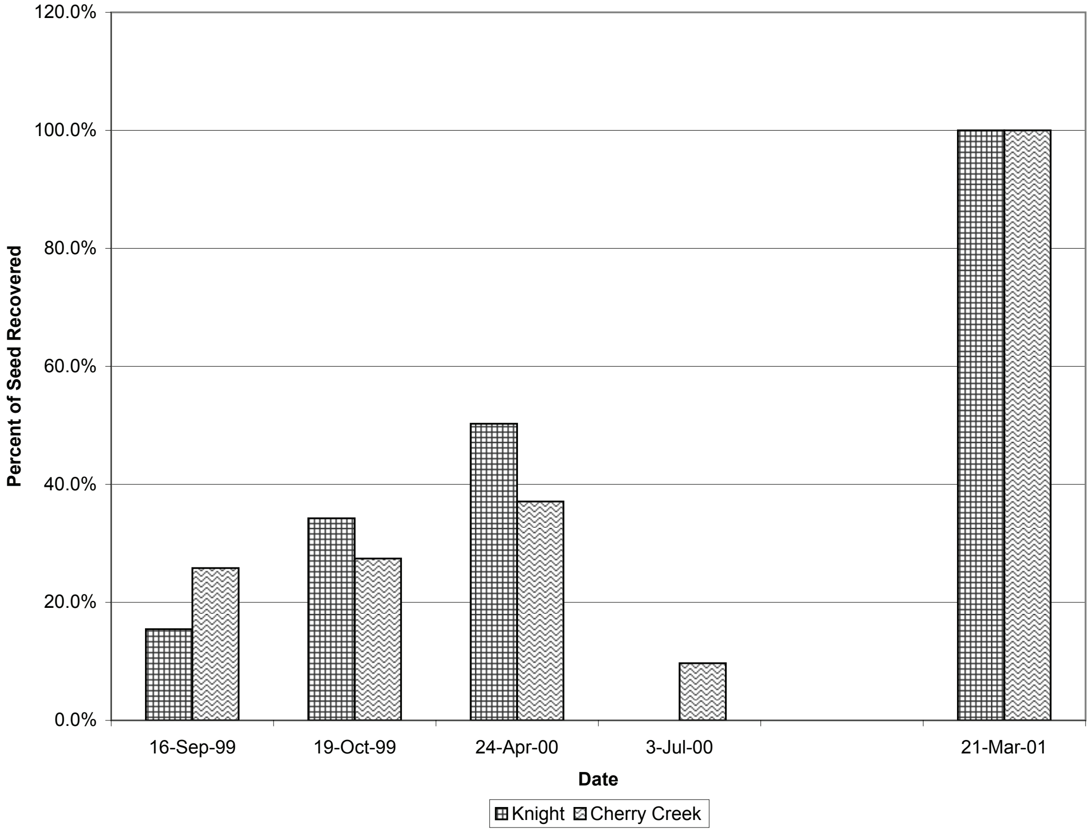

Figure 3—The percent of seed recovered by date and site is shown for the 1999 seed cohort at the Knight and Cherry Creek sites. For the 2000 cohort seed was collected from traps only in March.

over expansive areas. But the tendency to retain seed for a long duration combined with our cultural use of the lands accounts for a high probability of seed attaching to animals or vehicles for long distance dispersal. This, aided by abundant short distance dispersal and the competitive nature of the plant, results in dense stands producing large quantities of seed that advance at a relatively slow but consistent rate into new landscapes.

For nearly 8 months beginning in August, squarrose knapweed plants retain some amount of seed on their stems and large amounts of seed near their base. This prolonged retention period facilitates seed transfer by wind, animals, vehicles, water and other carriers. Many of these vectors are not readily manageable. Of those we have influence over, grazing and travel activities have the greatest potential for spreading seed and therefore the greatest opportunity to minimize expansion through management. Reducing or excluding activities in knapweed infested sites from August to April will reduce the potential for seed transfer.

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