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OVERVIEW OF THE BASIC BIOLOGY, DISTRIBUTION AND VEGETATIVE SUPPRESSION OF FOUR KNAPWEED SPECIES IN WASHINGTON.

by

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Well established stands of perennial vegetation can minimize the spread of many weeds. Knapweeds like other weeds function to fill voids. These voids may be actual bare ground or may be a missing key species in a plant community. It is extremely important that these voids be filled with desirable vegetation. If not, knapweed will simply recolonize the site or perhaps an even worse weed may colonize the site.

Vegetative suppression is a vital component in the weed control arsenal. **A quick review of the knapweed research will indicate:**

..It is important to understand a few biological facts about the knapweed and the species to be used for suppression before implementing a program.

..There is no plant species which will suppress a knapweed species on all sites at all times. The "silver bullet plant" simply does not exist.

..Suppression species must remove a significant amount of moisture from the soil during periods when knapweeds are most vulnerable, ie. the seedling stage.

..Knapweeds severely compete with seedlings of other species and need to be controlled prior to establishing vegetation for suppression.

..Vegetative suppression alone will not provide lasting knapweed control. Lasting control requires an integration of chemical control, biological control, proper land management, and vegetative suppression.

This review relays some information that pertains to the basic biology, distribution, and vegetative suppression of knapweeds.

INTRODUCTION

A 1987 Washington weed survey showed yellow starthistle, spotted, diffuse, and Russian knapweed occupied over 590,000 acres which resulted in an annual loss of grazeable forage valued in excess of $950,000 (Roche and Roche 1988). Knapweeds can reduce biomass production of neighboring plants as much as 90% and also can greatly reduce the species diversity of a site (Watson and Renney 1974, Myers and Berube 1983, Rice et al. 1992, Tyser and Key 1988, Watson 1980)

Knapweed impact is not restricted to only the plant community. Soil loss occurring in a spotted knapweed community was nearly three times the loss occurring on an adjacent grass community in a simulated rainfall experiment (Lacey et al. 1989). Fisheries will be impacted by increased sediments from erosion. Spoon et al. (1983) predicted that 220 head of elk would be lost annually on the Lolo National Forest due to loss of forage caused by knapweed displacement.

Vegetative suppression may entail filling voids left by successful knapweed control or secondly, occupying a site with desirable vegetation before knapweed invades. Unless filled by desirable species, voids created in the plant community by successful knapweed reduction will simply be replaced by another, and possibly more serious weed (Story 1989).

YELLOW STARTHISTLE (Centaurea solstitialis)

Biology: Yellow starthistle is a winter-annual. Seeds germinate in the fall with the onset of fall moisture and grow as a small rosette. Little aboveground growth occurs during the winter but root growth can exceed 4 feet by mid-March (Roche 1989). Yellow starthistle rosettes resume growth early in the spring and the roots utilize stored soil moisture before other species resume growth. Plants bolt in late spring and usually develop a single stem. The stem may branch several times and flowers are borne on the ends. Each flower produces both plumed and plumeless seeds. Plumed seed are primarily wind disbursed and are shed soon after maturity. Plumeless seeds are held longer in the seedhead and are disbursed by mechanical destruction and/or disturbance of the seedhead. Seeds may remain viable in the soil for up to 10 years (Callihan et al. 1993).

Yellow starthistle is utilized by cattle and sheep prior to bolting but can cause chewing disease (*Nigropallidal encephalomalacia*) in horses (Cordy 1954). Utilization drops considerably after bolting due to low palatability and long, sharp spines on the seed bracts distract livestock grazing.

It is unclear if allelopathy is a major competitive factor (Kelsey and Bedunah 1989).

Geographic and Ecologic Distribution: Yellow starthistle occurred in all 20 eastern Washington counties in 1987 with the exception of Pend Oreille, Douglas, Lincoln, and Grant counties (Roche and Roche 1988). Much of the yellow starthistle acreage is located in the southeastern counties. Northcentral Idaho and northeastern Oregon are also heavily infested with yellow starthistle. Environmental conditions for yellow starthistle appear to reach the optimum in northern California where 7.9 million acres are infested (Maddox 1985).

Yellow starthistle is well adapted to areas with Mediterranean climates - cool, wet winters and hot, dry summers. Mediterranean type climates enable yellow starthistle to grow during the winter months, bolt in the spring, and escape the summer drought.

Seedlings require close to full sunlight to grow. As a result, yellow starthistle is found predominantly on south facing slopes (Roche 1989). Roche and Roche (1991) reported that 55% shading reduced yellow starthistle foliage production 80%.

Yellow starthistle does not perform well on shallow soils because it depletes soil moisture too rapidly to allow for flowering (Roche and Roche 1991). A typical Washington site has deep soils or shallow soils which receive supplemental moisture. Yellow starthistle is intolerant of cultivation so it is rarely a problem on cultivated soil.

Vegetative Suppression: Successful establishment of desirable vegetation requires control of yellow starthistle prior to seeding. Prather and Callihan (1991) showed that yellow starthistle seedlings were more competitive than pubescent wheatgrass seedlings and were affected little by pubescent wheatgrass density. Greenhouse trials have shown root growth of yellow starthistle far exceeding growth of several other species including a perennial grass (Sheley et al. 1993). Cold soil temperatures encountered in the field would most likely amplify root growth differences since yellow starthistle is well adapted to cold soil. Suppression species must remove a significant amount of moisture in the rooting zone of starthistle seedlings and overlap the active growth period of starthistle in order to be effective (Larson and McInnis 1989).

Established stands of intermediate and pubescent wheatgrass generally provide good to excellent suppression in the northwest. Since neither species exhibits adequate seedling vigor to establish in stands of yellow starthistle as pointed out above, it is important that the starthistle competition be reduced. Unfortunately, both species are very large seeded and are poorly suited for broadcast seeding onto unprepared seedbeds. Removal of too much top growth of either species will enable yellow starthistle to recolonize a site because the shade furnished by the wheatgrass has been removed (Roche, B.F. *pers. comm.*).

Selection of species for suppression must be based on performance beyond first year results (Larson and McInnis 1989). For example, 'Ephraim' crested wheatgrass provided very good suppression the year of establishment but performed poorly the second year. 'Covar' sheep fescue, a slow establishing species, performed poorly the first year but was relatively free of starthistle the second year. 'Paiute' orchardgrass and 'Critana' thickspike wheatgrass performed similarly both years.

Idaho fescue and orchardgrass provide excellent moisture depletion early in the spring and have been shown to suppress yellow starthistle in trials conducted in southwestern Oregon (Borman et al. 1991, Borman et al. 1992). Both grasses initiate growth early in the spring, remain semiactive during the winter, and mature early in this region.

SPOTTED KNAPWEED (Centaurea maculosa)

Biology: Spotted knapweed is a short-lived perennial that reproduces by seed. Seed disseminated in the fall readily germinates in the spring. A small percentage exhibit primary dormancy and can remain viable in the soil for at least 8 years (Davis et al. 1993). The fast growing taproot enables spotted knapweed to exploit soil moisture and nutrients. The seedlings grow as low growing rosettes which escape grazing and produce carbohydrate reserves for next year's growth. Flowering generally occurs after the first year and occurs each year until death of the plant. Flower heads are borne on the ends of the stems which arise from a single crown.

Early reports showed that spotted knapweed produced an allelopathic compound, cnicin, which inhibited plant growth and seed germination. As a result, allelopathy received considerable attention as an important competitive mechanism. Allelopathy is not a major factor in the competitiveness of spotted knapweed because concentrations of cnicin are too low to be herbicidal (Kelsey and Bedunah 1989). Prolific seed production, rapid seedling establishment, and depletion of soil nutrients are probably much more important competitive factors enjoyed by spotted knapweed. Spotted knapweed's ability to recolonize a site from dormant seed long after herbicides have degraded is another asset enjoyed by this species.

Spotted knapweed tolerates shade poorly and this can reduce its spread. It is also sensitive to several broadleaf herbicides, is readily utilized by sheep, and several insects (bioagents) have provided promising results in the reduction of spotted knapweed.

Geographic and Ecologic Distribution: Spotted knapweed was located in 19 counties in Washington in 1987 (Roche and Roche 1988). West of the Cascades and the arid-interior scablands appear to be the upper and lower climatic limits for spotted knapweed. Most of the spotted knapweed acreage in Washington is located in the Northeast corner of the state.

Disturbed areas such as roadsides, gravel pits, and abandoned cropland are frequently the first areas to be invaded by spotted knapweed. It also readily colonizes pasture and rangeland especially if overgrazing is evident. Overgrazing is not a prerequisite for invasion (Lacey et al. 1990). Spotted knapweed will invade pristine, excellent condition range in the complete absence of livestock grazing (Lacey et al. 1990, Tyser and Key 1988). It is less adapted to forested areas where sunlight is limited but readily invades open areas such as roadsides (Losensky 1989). Cultivation effectively controls spotted knapweed so it rarely is a severe problem on cultivated land.

Vegetative Suppression: Reseeding knapweed infested sites without implementing a herbicide program to remove knapweed competition has been very ineffective in studies comparing the effects of several management practices (Roche 1991). Reseeding was unnecessary if a remnant stand of desirable grasses was present. Herbicide control of spotted knapweed and proper management of the remnant grasses would be more cost effective than reseeding the site.

Screening plant materials for suppression of spotted knapweed has received little attention. Losensky (1989) stated that a species mix which provides quick establishment and early growth was necessary for preventing spotted knapweed invasion onto disturbed forest roads. Annual wild rye, crested wheatgrass and yellow sweetclover were proposed as potential species. Persistence of these materials is questionable on highly disturbed, low fertility soils.

DIFFUSE KNAPWEED (Centaurea diffusa)

Biology: Diffuse knapweed reproduces by seed and is generally a biennial. It grows as a vegetative rosette the first year and bolts after the rosette has acquired 6 or more leaves (Thompson and Stout 1991). Since vernalizing temperatures are also required, bolting rarely occurs the first year. Seedlings of diffuse knapweed readily emerge when favorable conditions occur in the spring and fall. Seedlings develop into rosettes and maximal root development occurs in this stage (Watson and Renney 1974). After overwintering, a single, many-branched stem develops from the crown. Flowers grow at the end of the branches in the summer and is followed by death of the plant. Dead plants break off at ground level and tumble with the wind, spreading the seed as it rolls (Watson and Renney 1974).

Allelopathy does not appear to be a important factor in diffuse knapweed's competitive ability. The concentrations of cnicin are too low to affect other vegetation (Kelsey and Bedunah 1989).

Prolific seed production coupled with "tumble" distribution and high seedling vigor greatly aid in the spread of diffuse knapweed. It is also very adept at depleting soil moisture.

Geographic and Ecologic Distribution: Diffuse knapweed is the most drought tolerant of the four species and is the most widely spread knapweed in Washington. The 1987 weed survey showed diffuse knapweed occurring in 20 counties and occupying over 425,000 acres. Areas of highest occurrence include Stevens, Okanogan, Kittitas, Chelan, Ferry, and Yakima counties (Roche and Roche 1988). Typical habitat subject to diffuse knapweed invasion include disturbed sites such as transportation rights-of-ways, gravel pits, and industrial areas. Semiarid rangeland and dry open forest are subject to invasion especially if vigor of the site is low.

Overgrazing is not a prerequisite for diffuse knapweed invasion (Myers and Berube 1983, Lacey et al. 1990). Diffuse knapweed moved at a rate of 40 feet/year into good condition range in a study conducted in British Columbia (Myers and Berube 1983).

Vegetative Suppression: Diffuse knapweed will readily invade practically any disturbed site in the northwest. However, its competitiveness lies within a narrow moisture range (Berube and Myers 1982). They reported that crested wheatgrass provided very good long-term suppression in a region of British Columbia which receives 6" MAP (Berube and Myers 1982). However, suppression was poor on a site which receives 12" MAP. Fertilization of grass may greatly aid in suppression in areas where moisture conditions are suboptimal for diffuse knapweed (Berube and Myers 1982). Diffuse knapweed is intolerant of cultivation and is generally not considered a problem on cultivated land.

Seedling establishment is the critical period of diffuse knapweed and suppression efforts are most effective during this period. Species which extract moisture in the spring from the top few inches of soil will stress diffuse knapweed seedlings.

RUSSIAN KNAPWEED (Acroptilon repens)

Biology: Russian knapweed is a long-lived perennial which reproduces by seed and creeping horizontal roots. Russian knapweed was originally classified as *Centaurea repens*. It does not share some characteristics common to the *Centaurea* genus and has been placed in the *Acroptilon* genus.

Russian knapweed is a very poor seed producer and germination of Russian knapweed seed rarely occurs in the field (Selleck 1964). Reproduction is primarily accomplished by spreading of horizontal roots. Roots of Russian knapweed may reach 2.5 meters by one year and reach 7 meters by the second year (Watson 1980).

Russian knapweed is extremely competitive and dense patches will totally exclude other vegetation. Plants grow radially and a patch can cover an area of 12 m^2 within 2 years. The presence of Russian knapweed in wheat is very detrimental to yield and flour quality. Wheat seed contaminated with even small amounts of will impart a bitter taste to the flour (Watson 1980).

Russian knapweed is allelopathic and can cause chewing disease in horses (Kelsey and Bedunah 1989, Young et al. 1970). The allelopathic compound, cnicin, is contained in the leaves and is released into the soil after leaves fall. Grazing animals generally avoid Russian knapweed due to the bitter taste.

Geographic and Ecologic Distribution: Russian knapweed is native to Eurasia and was introduced to North America as a contaminant of alfalfa seed. It is widely distributed throughout eastern Washington with only Pend Oreille county reporting no Russian knapweed in a survey conducted in 1987 (Roche and Roche 1988). Areas of highest occurrence in 1987 were the Columbia Basin and the Yakima and Okanogan valleys. It is less abundant than the other three major knapweeds in Washington.

Russian knapweed is commonly found on deep soils or soils which receive supplemental moisture. Basin wildrye (*Leymus cinereus*) appears to be an indicator species for sites susceptible to Russian knapweed invasion (Roche 1990). Russian knapweed is also tolerant of poorly drained and saline/alkaline soils (Roche and Roche 1991). However, it is drought tolerant and will survive on sites that receive as little as 10" MAP (Watson 1980).

Russian knapweed is well adapted to cropland and is a severe problem in dryland crops of the former USSR (Watson 1980). Cultivation can spread root fragments which regenerate new plants and mowing simply stimulates underground buds to replace lost aboveground foliage (Watson 1980, Roche and Roche 1991). Russian knapweed performs poorly in heavily forested areas or dense stands of irrigated alfalfa due to its low tolerance to shading (Roche and Roche 1991).

Vegetative Suppression: Studies have shown that a season of intense cultivation followed by a crop of smooth brome or crested wheatgrass that is sprayed with 2,4-D will eliminate a high percentage of Russian knapweed (Derscheid et al. 1960). However, if either cultivation or 2,4-D were omitted, neither grass provided effective suppression. Cultivation prior to seeding of alfalfa or alfalfa/grass did not give the crop enough advantage to suppress Russian knapweed (Derscheid et al. 1960).

Early emergence, rapid dense growth, and maintenance of high vigor until frost are attributes required by species for suppression of Russian knapweed (Rogers 1928). Few range grasses exhibit these characteristics. Pasture species which provide season-long production are probably better candidates. Trees and shrubs might also be considered.

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