Carduus nutans
Musk Thistle, Nodding Thistle

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History

Musk thistle arrived in North America from Eurasia through the ballast water of ships. First observed in Harrisburg, PA in 1853, it is now found primarily on grasslands throughout the contiguous United States and the southern Canadian provinces with the exception of Florida, Vermont, and Maine. It is also highly invasive in Australia and New Zealand, where management similar to that in the United States has been employed in efforts to try to control the species. In Colorado musk thistle has been observed on more than 46,000 acres.[1]

Figure 1. Musk thistle. Source: Morton County, North Dakota, Available from: Morton County, http://www.co.morton.nd.us/index.asp?Type=B_DIR&SEC=%7B051CAEFB-BCEA-4063-8883-DBA0B375C902%7D&DE=%7B5EE56BEF-8429-4FBD-BC30-37A9319AA2F0%7D

The earliest records of exotic plant management in Rocky Mountain National Park (ROMO) from 1987 note that the plant has been "removed when found" at least since 1986. At this time large infestations were noted in Moraine Park and Aspenglen campground. In a survey of 108 National Forests in 1995-1996 by the Forest Service, musk thistle was found to be the second most widely distributed species throughout National Forest lands. ROMO Exotic Year-End Reports suggest that musk thistle arrived in the park as the result of horse concessionaires, likely through horse feed. As of the 2003 ROMO Invasive Exotic Plant Management Plan, musk thistle has a mid-range potential impact, but high potential for distribution. It is not currently on the Colorado list of noxious weeds.[2]

Biological Concerns

The primary concerns surrounding musk thistle relate to its "prolific reproductive capacity and seed longevity," as a single plant produces an average of 11,000 seeds and is capable of producing 20,000 seeds, which are viable for up to 20 years. Musk thistle is capable of establishing in poor soils with neutral to acidic soils and a high sand content. Wardle et al showed that the presence of musk thistle can further degrade soil, thus pushing out native species and increasing its dominance. The species has been found to be highly adaptive and to show evidence of allelopathic traits during the bolting phase and before death by inhibiting the germination of other species.[3]

Climate change and changes in weather patterns and ecological processes will likely favor musk thistle and support the expansion of its range. In studies by Zhang et al that attempted to mimic potential increasing temperatures due to climate change, musk thistle seeds germinated more quickly and at higher rates than those in ambient conditions. Seedling emergence was also sooner, although the species may not have the same defenses under climate change as Zhang et al found that it had a lower number of prickles on its leaves at higher temperatures. Changes in climate are expected to result in more intense and frequent wildfire as well as more frequent and severe flooding, both of which will likely increase the incidence of musk thistle. Monitoring data from 2006 in Mesa Verde National Park has shown musk thistle to become a dominant invader in burned areas three years following a severe fire.[4]

Management Strategies

Musk thistle treatment has been relatively well studied and documented for several years across a wide spectrum of methods. Until very recently, biological controls used in conjunction with chemical or mechanical control seemed to be favored, likely due to their low cost. Two weevils, *Trichosirocalus horridus* and *Rhinocyllus conicus*, the fly *Cheilosia corydon*, and the rust fungus *Puccinia carduorum* have been the preferred and well-documented biological controls. *R. conicus* lays its eggs within the seed head of musk thistle and the larvae and young adults feed on the plant seeds. A 2014 study by Hicks et al in ROMO, hypothesized that *R. conicus* has become so prolific that it invasive in its own right. ROMO crew leaders noted the presence of a weevil, likely *R. conicus*, in the park in 2004 and 2006 feeding on native thistles, which is believed to have been introduced into the Estes Park area and later spread into the park. *T. horridus* feeds on the plant crown but does not seem to consistently and effectively reduce seed production and rarely results in the death of the plant. *P. carduorum* functions by reducing seed production and speeding senescence. The larvae of *C. corydon* attack the roots and stems of thistle, thus decreasing the plant's viability, but its secondary effects are not well known.[5]

Mechanical control through mowing is effective when applied to flowering plants. If mowed within two days of flowering, no viable seeds were seen to be produced and those after 6 days produced a "significant" amount of viable seed. Removal of the entire plant to ground level and cutting and bagging seed heads may be preferable to mowing, though, as mowing can help disperse seeds. Mowing has not previously been practiced in ROMO, however cutting and bagging seed heads has been the primary treatment method since treatment began in the mid-1980s. The 2003 YER suggests management of musk thistle through grazing by horses, a method which was endorsed by Colorado Extension Weed Specialist George Beck.[6]

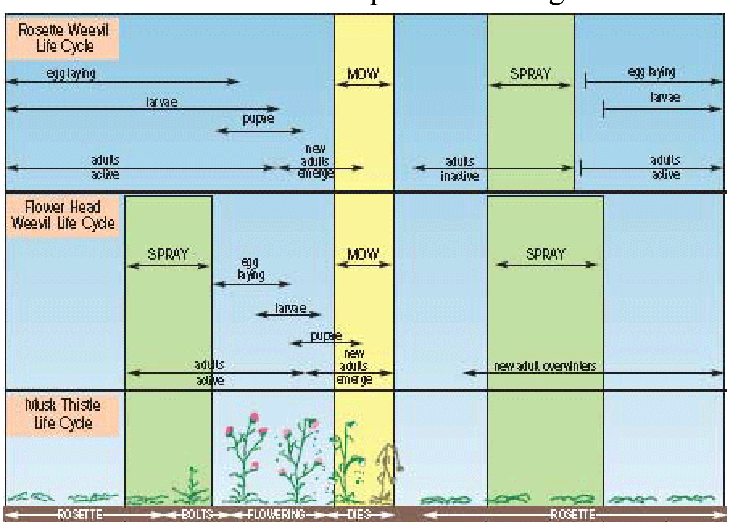

Figure 2. Treatment options for musk thistle within the context of the species' phenology. Source: Oklahoma State University Invasive Species Website.

Chemical control can provide temporary relief but is not entirely effective due to the great number of seeds that are left in the soil. Several herbicides have been approved for use on musk thistle: Tordon, Milestone, Transline, Perspective, Vanquish/Clarity or 2,4-D to rosettes in spring or fall or Escort or Telar up to the early flower growth stage. As with any method, timing is especially important with herbicide use. Tordon, Vanquish/Clarity, and 2,4-D are more effective at specific life stages while Telar can be effectively applied at different phenological points.[7]

Recommendations

Under the current ROMO Invasive Exotic Plant Management Plan, only manual and biological methods are approved for musk thistle. The author recommends continuing manual removal and collection of seed heads but recommends the addition of herbicide use. Biological controls are not recommended due to the fact that is impossible to predict fully how a new species will assimilate with its surrounding environment as past problems with *R. conicus* show. In manual removal, seed heads should ideally be removed within two days of flowering. If the management plan is altered, it is recommended that herbicide be used in conjunction with manual removal. Telar is recommended given that it can be applied at different phenological times and is currently used in the park.[7]

Endnotes

[1]A. M. Desrochers, J.F. Bain, and S.L. Warwick, "The Biology of Canadian Weeds," *Canadian Journal of Plant Science* 68 (1988): 1053-1068; "*Carduus nutans*," US Department of Agriculture PLANTS database, accessed July 2014, http://plants.usda.gov/core/profile?symbol=canu4; Eelke Jongejans, Andy W. Sheppard and Katriona Shea, "What Controls the Population Dynamics of the Invasive Thistle *Carduus nutans* in Its Native Range?," *Journal of Applied Ecology* 43, no. 5 (2006): 877-886; K.G. Beck, "Musk thistle, " last modified February 27, 2014, http://www.ext.colostate.edu/pubs/natres/03102.html; Julie Knudson, Matt Ounsworth, Michael Prowatzke, Jamie Dahlkemper, Jim Bromberg, and Brian Kolokowsky, "Rocky Mountain National Park Exotics Year-End Reports," Rocky Mountain National Park: Division of Resource Stewardship, 2000-2013; Rocky Mountain National Park, "27 Years of Exotic Plant Control in Rocky Mountain National Park: Summary and Recommendations," 1987.

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[4]Rui Zhang and Katriona Shea, "Integrating multiple disturbance aspects: management of an invasive thistle, *Carduus nutans*," *Annuals of Botany* (2011); R. Zhang, R. S. Gallagher and K. Shea, "Maternal warming affects early life stages of an invasive thistle," *Plant Biology* 14 (2012): 783-788; William H. Romme, Lisa Floyd-Hanna, and David D. Hanna, "Ancient Piñon-Juniper Forests of Mesa Verde and the West: A Cautionary Note for Forest Restoration Programs," *USDA Forest Service Proceedings RMRS-P-29*, (2003): 335-350; M. Lisa Floyd, David D. Hanna, William Romme, and Timothy E. Crews, "Predicting and mitigating weed invasions to restore natural port-fire succession in Mesa Verde National Park, Colorado, USA" *International Journal of Wildland Fire* 15, no. 2 (2006): 247-259.

[5]Julia J. Hicks, Susan W. Beatty, and Timothy R. Seastedt, "Presence of the exotic weevil *Rhinocyllus conicus* Froelick at high elevations in the Rocky Mountains of Colorado," *Western North American Naturalist* 74, no. 1 (2014): 99–107; Lindsey R. Milbrath and James R. Nechols, "Indirect effect of early-season infestations of *Trichosirocalus horridus* on *Rhinocyllus conicus* (*Coleoptera: Curculionidae*)," *Biological Control* 30 (2004): 95–109; Paul H. Dunn and Gaetano Campobasso, "Field Test of the Weevil *Hadroplonthus trimaculatus* and the Fleabeetle *Psylliodes chalcomera* against Musk Thistle (*Carduus nutans*)," *Weed Science* 41, no. 4 (1993): 656-663; L.T. Kok, "Classical Biological Control of Nodding and Plumeless Thistles," Biological Control 21 (2001): 206-213.

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[7]K. George Beck, Robert G. Wilson and M. Ann, "The Effects of Selected Herbicides on Musk Thistle (*Carduus nutans*) Viable Achene Production," Weed Technology 4, no. 3 (1990): 482-486.