Selective Control of Crested Wheatgrass (*Agropyron cristatum* [L.] Gaertn. and *A. desertorum* Fisch.) in the Northern Great Plains

J.T. Romo
Department of Crop Science
and Plant Ecology
University of Saskatchewan
Saskatoon, Saskatchewan S7N 0W0
CANADA

P.L. Grilz
Ducks Unlimited Canada
Saskatoon, Saskatchewan S7L 6M7
CANADA

L. Delanoy
Meewasin Valley Authority
Saskatoon, Saskatchewan S7K 3G5
CANADA

Crested wheatgrass (*Agropyron cristatum* and *A. desertorum*) was introduced into North America from Russia in 1898 and has been planted for forage and stabilization of disturbed sites on millions of hectares in the western United States and Canada (Smoliak et al. 1980, Holochek 1981, Knowles and Kilcher 1983, Rogler and Lorenz 1983). In the Northern Great Plains this long-lived, perennial bunchgrass spreads by seed from extensive plantings in pastures and on road allowances. It invades native prairie and is dispersed in the feces of livestock and by vehicles, wind, and water. Such invasions of crested wheatgrass usually hinder the development of diverse plant communities (Marlette and Anderson 1986). The plants typically form nearly pure stands with few native species present. On some sites crested wheatgrass grows at lower densities and native flora is abundant.

Few methods are known that reduce abundance of crested wheatgrass. We therefore tested the combined effects on crested wheatgrass of prescribed burning and wicking application of glyphosate using a split-plot experiment in a completely randomized design with five replications. The study was conducted at the Wanuskewin Heritage Park at Saskatoon, Saskatchewan. Although the exact age of the crested wheatgrass stand here is not known, we were certain that the study sites had been seeded many years earlier.

Main plots were burn treatments and subplots were time of herbicide application; the experiment was repeated on an adjacent site one year later. Five 10-m x 15-m plots were burned in late October 1988 or early April 1989 and sampled in 1989 and 1990. Another five plots were burned in late October 1989 or early April 1990 and sampled in 1990 and 1991. Five unburned plots served as control. Plots were divided into three 5-m x 10-m subplots and a 33% glyphosate solution (2 L water:1 L glyphosate) was applied to crested wheatgrass with a wick applicator in the spring following burning. Herbicide treatments included (1) glyphosate application when crested wheatgrass had three to five leaves per tiller, (2) glyphosate application just before seedhead emergence, and (3) no herbicide. We used point sampling (Coupland 1950) to determine basal cover of crested wheatgrass and native species. Ten-point frames, each with ten points, were randomly located in each subplot and replicate in late July the first two years after treatment, and species composition was calculated. Data were analyzed using analysis of variance, and means were compared with Tukey's HSD (Petersen 1985). Statistical significance was assumed at $p \leq 0.05$.

Compared to control, burning in late fall or early spring had no significant effect on the vegetative cover of crested wheatgrass and the native flora at both sites, but glyphosate application changed species composition. At Site 1, crested wheatgrass contributed 78% of the total basal cover in the control; glyphosate significantly reduced crested wheatgrass cover to 35% when applied early and 55% of total cover when applied later. Cover of native species averaged 22% of the total in the control, and 65% and 45% after the early and late herbicide applications, respectively. In the second year, cover of crested wheatgrass (47%) and native species (53%) was not significantly different among herbicide treatments.

At the second site, crested wheatgrass cover in control plots averaged 81% of total, which was significantly greater than the 55% and 64% cover after the early and late glyphosate applications, respectively. Native species contributed 19% of the total cover in control, 45% in the early glyphosate treatment, and 36% in the late glyphosate treatment. In the second year, crested wheatgrass cover (76%) in the control plots remained significantly greater than after the early (52%) and late (61%) glyphosate applications. Cover of native species averaged 24% of the total cover in control, 48% when glyphosate was applied early, and 39% after late application.

Many seedlings of crested wheatgrass emerged the year after herbicide treatment. The soil likely has a large reserve of seeds (Marlette and Anderson 1986), and until the seed bank is depleted, repeated application of glyphosate may be needed to control this species. We recommend mowing, grazing, or the use of growth regulators such as mefluidide (Haferkamp et al. 1987, McCaughey and Cohen 1990) for three to five years before glyphosate application, to prevent seed production and thereby deplete the seed reserves in the soil.

The effects of mowing and glyphosate application were tested at two sites 50 km south of Saskatoon and repeated in 1990 and 1991. The study sites had been seeded to crested wheatgrass in 1947 and had been grazed annually in May and June. Only trace amounts of native species were present. A completely randomized design was used with six replicates of 2-m x 2-m plots. Within each plot crested wheatgrass plants were permanently marked with large nails. Treatments consisted of (1) mowing plots to a 5-cm stubble, (2) mowing and spraying 25% glyphosate (3 L water:1 L glyphosate) on individual crested wheatgrass plants, (3) glyphosate alone, and (4) control (no mowing or herbicide). Treatments were conducted in autumn, when two to three leaves had developed on tillers of crested wheatgrass, and were evaluated the following July. All crested wheatgrass plants lived in the control and in the mowing only treatment, but none survived treatment with glyphosate. We have applied the methods from this study on several sites

and observed the total elimination of crested wheatgrass. Similarly, application of 25% glyphosate to individual plants in early spring, when crested wheatgrass has two to four leaves per tiller, gives nearly 100% control.

Where agricultural activities are consistent with management objectives, crested wheatgrass can also be reduced by grazing with cattle. In the Northern Great Plains, three to five years of heavy and continuous grazing during the growing season nearly eliminates this grass (J.T. Romo, pers. obs.). The remaining crested wheatgrass plants require herbicide treatment. Native species often invade these sites after crested wheatgrass is controlled, but in some cases seeding of native species may be necessary. Complete tillage also results in good control, but diversity of native flora will be reduced. Individual plants can also be removed by digging them up.

Regardless of the control measure chosen, annual monitoring is needed, and crested wheatgrass plants that survive or establish must be eliminated.

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