Management Considerations for Controlling Smooth Brome in Fescue Prairie

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ABSTRACT: Smooth brome (*Bromus inermis* Leyss.), an introduced perennial grass, is an aggressive invader of prairie dominated by plains rough fescue (*Festuca altaica* Trin. subsp. *hallii* [Vasey] Harms). We (1) compared richness and density of plant species in brome and fescue stands that were unburned or burned in spring or fall; (2) determined the effects of wick application of a 33% glyphosate solution, applied when smooth brome was in the boot stage, on the density of brome and native flora in unburned plots and plots burned in spring or fall, and; (3) determined the composition of the seedbank for its potential contribution to natural revegetation following the control of smooth brome. Stem densities of native species and plains rough fescue were about two- and fivefold greater, respectively, in fescue plots than in brome plots. Species richness was generally slightly greater in fescue than in brome plots. Burning had no significant effect on stem density of smooth brome. At one site, changes in the density of smooth brome were affected by the interacting effects of burn treatments and glyphosate application. Glyphosate eliminated brome in the spring burn plots and reduced densities 76 and 50% (SE ±6.4) in the fall burn and unburned plots, respectively. At a second site, smooth brome densities were reduced by glyphosate but not by burn treatments. There was, however, a trend for greater reduction of smooth brome with glyphosate application in the spring burn (98%) than in the fall burn (40%) and unburned (56%) plots (SE ±15.5). Glyphosate reduced the density of native graminoids 91% (SE±10.0), but plains rough fescue and native forbs were not affected. Twenty-three species emerged from the seedbank in fescue plots, whereas twenty emerged from soils collected in brome plots. The total number of seedlings emerging from the seedbank was similar in brome and fescue plots, averaging 1794/m^2 and 2078/m^2 (SE ±252), respectively. The proportion of seedlings emerging was lower for native graminoids (33 vs 41%, SE ±2) and greater for native forbs (56 vs 48%, SE ±3) in brome as compared to fescue plots. Smooth brome seedlings emerged only from soils collected in brome plots, averaging 3/m^2. These studies indicate that excellent control of smooth brome can be achieved with spring burning followed by wick application of glyphosate; however, native species were also reduced by glyphosate. Additional glyphosate applications will be required for complete control of smooth brome. The number of seeds of native species in the soil in smooth brome stands approximates that in stands of plains rough fescue, suggesting that there is an adequate seedbank for natural recovery of vegetation following control of smooth brome.

INTRODUCTION

Prairie dominated by plains rough fescue (*Festuca altaica* Trin. subsp. *hallii* [Vasey] Harms) in Saskatchewan originally occupied the central region and the Cypress Hills in the southwestern corner of the province (Coupland and Brayshaw 1953, Coupland 1961). Although the presettlement extent of Fescue Prairie is not known for Manitoba, it is present in Riding Mountain National Park (Blood 1966). Looman (1969) estimated that about 90% of this grassland had been significantly altered on the Canadian prairies, primarily by agricultural activities. We estimate that less than 5% of the prairie originally dominated by plains rough fescue remains, primarily as small and isolated remnants.

World Wildlife Fund Canada and the Prairie Conservation Action Plan recommended that the few remaining prairies dominated by plains rough fescue be protected in Saskatchewan and Manitoba, and that management techniques be developed to perpetuate this ecosystem (World Wildlife Fund Canada 1988). A management issue that must be addressed in maintaining remnants of Fescue Prairie is the invasion by the nonindigenous perennial grass smooth brome (*Bromus inermis* Leyss.) (Romo et al. 1990).

Smooth brome was introduced into western Canada in 1896 from Eurasia (Heinrichs 1969), where it grows in an environment similar to that of Fescue Prairie (Looman 1976). After about 1900, smooth brome was used extensively for hay and pasture and is one of the most widely used forages in western Canada (Bittman 1985). Smooth brome spreads by seed and rhizomes and has a deep root system; most of the root mass is concentrated in the upper profile of the soil (Newell 1951). Wilson (1989) and Wilson and Belcher (1989) concluded that smooth brome was the most competitive of several introduced species and excluded native species in Mixed Prairie in Manitoba.

Information on the effects of smooth brome on native vegetation and the response of smooth brome to various management techniques is urgently needed to promote the conservation of prairies dominated by plains rough fescue. Burning has been used to control smooth brome in Tallgrass Prairie (Old 1969, Hulbert 1986). Grilz and Romo (1994) concluded that in contrast to grasslands dominated by C_4 species, Fescue Prairie (a C_3-species-dominated grassland) burned in fall or spring did not show a reduction in smooth brome. Combined prescribed burning and application of glyphosate is a potential method for controlling smooth brome, but the response of the brome and native flora to these treatments is unknown in Fescue Prairie. The objectives of our research were to (1) compare richness and density of plant species in smooth brome and plains rough fescue stands that were unburned or burned in spring or fall, (2) determine the effects of applying glyphosate on the density of smooth brome and native flora in unburned plots and plots burned in spring or fall, and (3) determine the composition of the seedbank for its potential contribution to natural revegetation following the control of smooth brome.

METHODS

Study Site

Studies were conducted at the University of Saskatchewan's Kernen Prairie (52°10'N, 106°33'W, elev. 510 m), located approximately 1 km east of Saskatoon, Saskatchewan. Kernen Prairie is a 130-ha grassland in the transition zone between Mixed Prairie to the south and Fescue Prairie to the north (Coupland and Brayshaw 1953, Coupland 1961, Rowe and Coupland 1984). Descriptions of the vegetation of Kernen Prairie are provided by Baines (1973) and Pylypec (1986). Glaciolacustrine deposits constitute the parent material for the sandy loam soils on higher ground and the clayey soils on lower positions (Christiansen 1979, Souster 1979). The mean annual temperature for the area is 1.6°C. January is the coldest month, with a mean minimum temperature of -24.3°C, and July is warmest, averaging 25.4°C. Precipitation averages 360 mm with about one-half falling in May and June.

Kernen Prairie is one of the larger relict areas supporting plains rough fescue. The prairie is surrounded by roads and cropland, a setting that is typical of most prairie remnants dominated by plains rough fescue. Smooth brome is one of the most common forage crops and is used extensively for stabilizing disturbed sites and road rights-of-way. This species forms a nearly continuous monoculture along the periphery of Kernen Prairie. Patches of varying size of smooth brome occur throughout the prairie; these patches probably established from seeds (Grilz and Romo 1994).

There is no record of fire in Kernen Prairie since 1917; before this time circular fireguards were established with plows to protect haystacks (Baines 1973). Rowe (1969) estimated that before settlement of Saskatchewan, fuel and weather conditions were conducive to wildfires in the prairie every 5 to 7 years. Redmann et al. (1993) described the impacts of spring and fall burning on the productivity of native species in this grassland. From 1917 to 1967 portions of Kernen Prairie were lightly grazed or mowed (Baines 1973, Pylypec 1986).

Treatments and Plot Layout

Treatments of fall burning, spring burning, and no burning were delineated in a completely randomized design with two replicates that were each about 2 ha in size for a total of six blocks per site. The study was repeated at a second site about 0.5 km from the first one. In each replicate one 3- to 5-m-diameter stand of smooth brome was selected that was representative of those scattered throughout the grassland. Each stand was divided into two permanent plots about 4- to 8-m^2 in size by

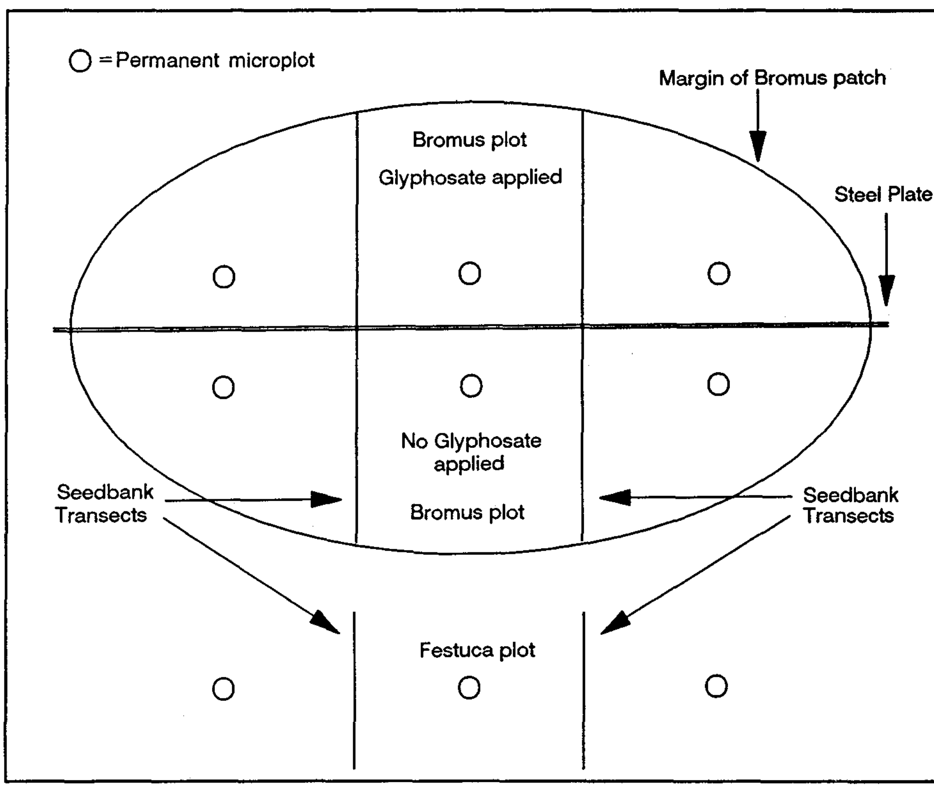

Figure 1. Schematic representation of the plot design used. The figure is not drawn to scale. See "Methods" for a detailed description.

driving a steel plate 25 cm into the ground (Figure 1). The purpose of the steel plate was to prevent the spread of rhizomatous species from either side. One fescue stand (about 10 m^2 in size), about 3 m from the brome stand, was also selected for measurements (Figure 1). Within each brome plot, three permanent-circular 0.10-m^2 microplots were established 1 m apart, with the two outer ones about 1 m from the outer edge of plots (Figure 1). Three permanent-circular 0.10-m^2 microplots were also established 1 m apart in the fescue plot at Site 1, but not at the second site (Figure 1). Two blocks were burned with headfires in October 1987, and two more were burned in April 1988 at Site 1. Another set of blocks were burned in October 1988 and April 1989 at Site 2.

One plot of brome in each replicate (Figure 1) was randomly chosen for treatment with a 33% solution of glyphosate (1 L glyphosate:2 L water) when smooth brome was in the boot stage. This concentration was used because it was the recommended rate (D. Bergh, Farm Manager, Kernen Research Farm, University of Saskatchewan, pers. com.) for wick application of glyphosate on perennial grasses at the time this research was conducted. Glyphosate was applied on June 10, 1988 at site 1, and June 17, 1989 at site 2. Early summer was selected for treatment because carbohydrates are translocated to the roots and rhizomes in smooth brome at this time (Reynolds and Smith 1962), and maximum herbicide efficacy was expected. Two application methods were used: a custom-made, hand-held wick applicator was used in 1988, and a wick applicator supported with wheels to provide a uniform height of herbicide application was used in 1989.

Data Collection

The total number of stems was determined for each species in the permanent microplots at Site 1 before burning (August 1987) and after glyphosate application in late summer (September 1988 and August 1989). Nomenclature followed Looman and Best (1979). Species were then categorized as plains rough fescue, native graminoids excluding fescue, smooth brome, and native forbs. Exotic forbs and shrubs were uncommon and stem densities are not reported here. At the second study site, only smooth brome densities were determined in September 1988 and August 1989.

Seedbank Composition

In September 1987, one soil core (8 cm diameter, 10 cm deep) was collected in each block at each of five random points on two 2-m-long transects in the brome and the fescue plots at site 1 (Figure 1). A total of ten cores was collected in the fescue and brome plots in each block. Samples were collected at this time because we felt that the number of seeds in the soil would be greatest. The cores were taken to the laboratory, spread to a uniform depth in 10-cm by 25-cm germination trays, and moistened with tap water. These samples were kept moist and incubated in a growth chamber with an 8-h/10°C dark period and a 16-h/20°C light period. Fluorescent and incandescent lights provided photon flux densities averaging 214 $\mu mol/m^2\, s^{-1}$. Seedlings emerged only in the first 30 days of incubation. Therefore, after a total of 40 days of incubation, seedlings were identified, counted, and grouped as native graminoids, smooth brome, native forbs, and exotic forbs.

Data Analysis

Separate analyses of stem densities were conducted within sampling dates with a split-plot analysis of variance in a completely randomized design (Petersen 1985). The first analyses compared stem densities using fall burn, spring burn, and unburned blocks as main plots, and fescue and brome plots as subplots for a total of six treatments with two replicates and three subsamples (microplots). The percentage change in stem densities in 1988 and 1989 from preburn densities in 1987 was also tested using the same analyses. The second analyses tested for significant differences in stem densities in brome plots that were unburned or burned in fall or spring (main plots) and where glyphosate was or was not applied (subplots) for a total of six treatments with two replicates and three microplots (subsamples). The percentage change in stem densities from pretreatment levels was also tested with the same analyses. Data from the seedbank study were subjected to split-plot analysis of variance in a completely randomized design with burn treatments as main plots (Petersen 1985). Brome and fescue stands were treated as subplots with two replicates and ten subsamples (soil cores) (Petersen 1985). The split-plot analysis of variance develops an estimate of variance associated with the whole plots, subplots, and the interaction of the treatments (Petersen 1985). These estimates of variance are then used to calculate a common standard error for the factors being tested. Two means are significantly different if their difference exceeds approximately three times the standard error (Morse and Thompson 1981). Statistical significance was assumed at $p \leq 0.05$.

RESULTS

Burning Effects in Fescue and Brome Plots

Before burning in August 1987, the total stem density for native species was significantly higher in fescue than in brome plots (Table 1). The density of native graminoids, excluding plains rough fescue, was similar in fescue and brome plots to be burned in fall or spring, but for an undetermined reason the density was lower in unburned fescue and brome plots. Density of fescue was higher in plots it dominated than in brome plots. Two to three more species were present in fescue plots than in brome plots.

In 1988 and 1989, total density of native species remained significantly higher in fescue plots than in brome plots (Table 1). In 1988 and 1989, the density of native graminoids was statistically similar in fescue and brome plots that were burned, but lower in the unburned plots. Plains rough fescue density was significantly lower in brome plots than in fescue plots in 1988 and 1989. In all years the density of native forbs was similar in the fescue and bromus plots.

In 1988, the only significant percentage change in stem densities following burning was for plains rough fescue; within the fescue and brome plots the change was not

Table 1. Density (stems/m^2) for individual species or species groups and species richness in fescue and brome plots in 1987 before burning in fall 1987 or spring 1988. Densities were redetermined in September 1988 and August 1989.

Species or species group	Fescue Plots			Brome Plots		
	Burn Treatment					
	Spring	Fall	Unburned	Spring	Fall	Unburned
August 1987						
Native species (Total)	2535a[2]	3240a	1895a	1130b	1545b	1180b
Native graminoids[1]	1355a	1345a	670b	920a	1475a	550b
F. altaica ssp. *hallii*	1065a	1860a	1190a	200b	60b	620b
Native forbs	115a	35a	30a	10a	10a	10a
B. inermis	0a	0a	0a	315b	205b	140b
Species richness	12	12	12	9	10	10
September 1988						
Native species (Total)	2985a	2370a	1935a	1140b	1390b	965b
Native graminoids	1420a	1125a	725b	980a	1345a	515b
F. altaica ssp. *hallii*	1425a	1180a	1170a	150b	40b	445b
Native forbs	140a	75a	35a	10a	5a	5a
Bromus inermis	0a	0a	0a	350b	235b	150b
Species richness	12	10	12	9	10	10
August 1989						
Native species (Total)	2830a	3345a	2045a	1410b	1590b	1045b
Native graminoids	1370a	1355a	830b	1215a	1470a	520b
F. altaica ssp. *hallii*	1275a	1905a	1110a	175b	70b	515b
Native forbs	185a	85a	100a	20a	50a	0a
Bromus inermis	0a	0a	0a	330b	220b	165b
Species richness	13	10	12	9	10	10

[1] Excluding *F. altaica* subsp. *hallii*.

[2] Within years similar letters for a species or species group in the fescue and brome plots are not significantly different ($p>0.05$). Different letters within years indicate significant differences ($p\leq0.05$).

Table 2. Density (stems/m^2) for individual species or species groups and species richness in brome plots where glyphosate was or was not applied, Site 1. Densities were determined in 1987 before burning in fall 1987 or spring 1988. Densities were redetermined in September 1988 and August 1989.

Species or species group	No Glyphosate Applied			Glyphosate Applied		
	Burn Treatment					
	Spring	Fall	Unburned	Spring	Fall	Unburned
	August 1987					
Native species (Total)	1130a[2]	1545a	1180a	1090a	1830a	565a
Native graminoids[1]	920a	1475a	550a	1035a	1165a	395a
F. altaica ssp. *hallii*	200a	60a	620a	25a	660a	145a
Native forbs	10a	10a	10a	30a	5a	10a
B. inermis	315a	205ab	140b	315a	275ab	190b
Species richness	9	10	10	11	11	11
	September 1988					
Native species (Total)	1140a	1390a	965a	185b	715b	120b
Native graminoids	980a	1345a	515a	95b	130b	10b
F. altaica ssp. *hallii*	150a	40a	445a	0a	560a	80a
Native forbs	10a	5a	5a	90a	20a	15a
B. inermis	350a	235a	150b	0c	65bc	95bc
Species richness	9	10	10	11	11	11
	August 1989					
Native species (Total)	1410a	1590a	1045a	485b	530b	275b
Native graminoids	1215a	1470a	520a	215b	150b	100b
F. altaica ssp. *hallii*	175a	70a	515a	0a	290a	75a
Native forbs	20a	50a	0a	255a	60a	70a
B. inermis	330a	220ab	165bc	5d	85cd	125bc
Species richness	9	10	10	11	11	11

[1] Excluding *F. altaica* subsp. *hallii*.

[2] Within years similar letters for a species or species group in plots where glyphosate was or was not applied are not significantly different ($p>0.05$). Different letters within years indicate significant differences ($p\leq0.05$).

significantly different among the unburned plots and those burned in spring or fall. Averaged across the burn treatments, fescue densities were reduced 56% and increased 5% (SE±14.9) compared to preburn densities within the fescue and brome plots, respectively.

Burning and Glyphosate Effects in Brome Plots

In 1987, before burning and glyphosate application, total stem density of native species, native graminoids, plains rough fescue, and native forbs did not differ between glyphosate plots and plots that did not receive herbicide (Table 2). For an undetermined reason, smooth brome densities were higher in the spring and fall burn plots than in the unburned plots. The abundance of native forbs fluctuated in all plots among years. In all years species richness totaled 11 in the glyphosate plots, whereas richness ranged from 9 to 10 where no glyphosate was applied.

In 1988 and 1989, the collective density for native species, particularly native graminoids, was lower in the glyphosate plots than in plots where glyphosate was not applied. Within the glyphosate plots and plots where herbicide was not applied, the percentage change in total density of native species and native graminoids was not significantly different among the unburned plots and those burned in spring or fall. However, the percentage change in collective density of all native species and the density of native graminoids was significantly different between the glyphosate and no glyphosate plots. When averaged across all plots, native species density in 1988 declined 9% in untreated plots, compared to a 71% (SE±13.8) decline in glyphosate treated plots. Similarly, in 1989 densities were 5% greater in untreated plots and 63% (SE±11.2) lower in herbicide plots. Compared to 1987, the density of native graminoids was 4 and 91% lower (SE±10.0) in 1988, while in 1989 densities were 9% greater and 82% lower (SE±8.7) in the no glyphosate and glyphosate plots, respectively. The percentage change in density of plains rough fescue and native forbs relative to 1987 was not significantly different between the glyphosate treatments in 1988 and 1989.

The percentage change in smooth brome was affected by the interacting effects of burn treatments and glyphosate application. In 1988, density of smooth brome increased (11, 15, and 7% [SE±6.4] in the spring burn, fall burn, and unburned plots, respectively) when glyphosate was not applied. Glyphosate eliminated smooth brome in the spring burn plot and reduced density of smooth brome by 76 and 50% (SE±6.4) in the fall burn and unburned plots, respectively.

In 1989, 15 months after glyphosate application, smooth brome stem densities increased slightly in untreated plots (5, 7, and 18% [SE±4.1] in the spring burn, fall burn, and unburned plots, respectively) compared to densities in 1987. Compared to 1987, smooth brome stem densities in 1989 were 98, 69, and 34% lower (SE±4.1), respectively, where glyphosate was applied in the spring burn, fall burn, and unburned plots.

At the second site, the preburn stem density of smooth brome was not significantly different among the fall burn, spring burn, and unburned plots (Table 3). Glyphosate application significantly reduced densities of smooth brome compared to burning only. The percentage change in stem densities was not significantly different among the plots where glyphosate was not applied, averaging an increase of 1% across treatments. Although there were no significant differences in the actual densities and percentage change in brome densities among the glyphosate treatments, there was a trend for greater reduction in the spring burn (98%), than in the fall burn (40%) and unburned (56%) plots (SE±15.5), comparable to that observed at Site 1.

Seed Bank Composition

Seedlings of 23 species emerged from soil samples taken from fescue plots, whereas 20 emerged in the soil from beneath brome plots. The total number of seedlings in each species group was not significantly different among burn treatments. Therefore data from the burn treatments were

Table 3. Density (stems/m^2) for smooth brome in plots that were burned and where glyphosate was or was not applied, Site 2. Densities were determined in 1988 before burning in fall 1988 or spring 1989. Densities were redetermined in August 1989.

No Glyphosate Applied			Glyphosate Applied		
Burn Treatment					
Spring	Fall	Unburned	Spring	Fall	Unburned
September 1988					
410a[1]	445a	485a	505a	275a	405a
August 1989					
390a	460a	505a	10b	165b	180b

[1] Within years similar letters in plots where glyphosate was or was not applied are not significantly different ($p>0.05$). Different letters within years indicate significant differences ($p\leq0.05$).

Table 4. Seed reserves (seeds/m^2) in fescue and brome plots.

Species Group	Plot type: Fescue	Brome
Total	2078a[1]	1794a
Native graminoids	855a	600b
Native forbs	988a	995a
B. inermis	0a	3a
Exotic forbs	235a	196a

[1] Within a species group similar letters in the fescue and brome plots are not significantly different (p>0.05). Different letters within species groups indicate significant differences (p≤0.05).

pooled for comparisons between fescue and brome plots. The total number of seedlings was not different in brome and fescue plots (Table 4). Native graminoid seedlings and their proportion (41 vs 33%, SE±2) of the seedbank were less in the brome than in fescue plots. In order of abundance, the most common native graminoids were *Poa cusickii* Vasey, *Carex* spp., *Muhlenbergia richardsonis* (Trin.) Rydb., *Stipa curtiseta* (A.S. Hitchc.) Barkwork, *Agrostis scabra* Willd., and *F. altaica* subsp. *hallii*.

The number of native forb seedlings was not different, but their proportion of the total seedlings emerging was higher in the soil from brome plots than in the soil from fescue plots (56 vs 48%, SE±3). *Androsace septentrionalis* L. and *Artemisia frigida* Willd. were the most common native forbs. Smooth brome seedlings (3 seedlings/m^2) emerged only from soil collected in plots that it dominated. The number of exotic forbs emerging was similar in fescue and brome plots, with *Descurainia sophia* (L.) Webb. the most abundant species.

DISCUSSION

Species richness was slightly higher in fescue than in brome plots, and the density of plains rough fescue was substantially lower in plots dominated by smooth brome. Looman (1969) also reported a reduction in native species where smooth brome had established. A cause-effect relationship cannot be established for the lower density of plains rough fescue in brome plots. The native species may decline after smooth brome establishes, the exotic may establish where density of native plants is low, or both. It is also possible that if sampling were expanded to include many sites, statistically significant differences in density would diminish.

The habitat in Eurasia from which smooth brome was introduced is similar to Fescue Prairie in Canada (Looman 1976). Thus, smooth brome may be preadapted to the environment of Fescue Prairie. Johnson and Mayeux (1992) suggested that dominant species that are functionally equivalent, whether native or exotic, may be interchangeable in plant communities. The preadaptation of smooth brome and its subsequent naturalization in North America, combined with its competitive superiority over several native grasses (Smoliak and Johnston 1968) and selection for better-adapted genotypes by plant breeders (Romo et al. 1990), probably allow this exotic species to invade and displace native species in Fescue Prairie. The long-term consequences of these smooth brome invasions in Fescue Prairie have yet to be determined. Results of the present study did, however, verify that density of native species is lower in patches where smooth brome was established than in patches of plains rough fescue.

In the present study, burning alone did not reduce density of smooth brome. Similarly, spring or fall burning did not alter the biomass production and leaf area index of smooth brome (Grilz and Romo 1994). These responses contrast with the results of Old (1969) and Blankespoor and Larson (1994), who found that burning significantly reduced smooth brome biomass in Tallgrass Prairie. Glyphosate reduced smooth brome density; the greatest reductions occurred when it was applied after spring burning. However, glyphosate also significantly reduced native species. Removal by digging up plants and removing rhizomes is an alternative to glyphosate application, if the patches of brome are few and small; but it is a labor-intensive practice and may not always be practical.

The total number of seeds in the seedbank was similar to that reported for another prairie dominated by plains rough fescue in Saskatchewan (Archibold 1981). Species richness in the seedbank was nearly twice that of the permanent microplots where stem densities were studied. Archibold (1981) also reported that the composition of the seedbank in Fescue Prairie did not closely match the plant population. This discrepancy in the number of species in the seedbank and those occupying the site probably reflects the input of seeds from vegetation on the surrounding landscape and plants that may have previously occupied the area.

The scarcity of smooth brome seeds in the seedbank indicates that extended periods of control may not be needed after it is eliminated. Hume and Archibold (1986) found more smooth brome seeds in the seed rain than in the seedbank and speculated that persistence of smooth brome seeds in the soil is short or seeds are moved offsite after dispersal from parent plants. To ensure depletion of the number of smooth brome seeds in the soil, it is probably prudent to prevent seed production by removing inflorescences from brome plants before seeds are dispersed. However, in most landscapes where plains rough fescue remains there is high potential for import of smooth brome seeds from surrounding areas.

Although the seedbank of the sites studied contained many native species, an assay of the content and composition of the seedbank may be desirable before implementing a brome control program on fescue reserves. This assessment will indicate whether sufficient propagules of native species are present to potentially reoccupy the site, or whether seeding of native species will be needed after removal of smooth brome. It will also provide an estimate of the number of brome seeds in the soil.

Implications for Managing Prairies Dominated by Fescue

Currently, managers are forced to reactive management of smooth brome in Fescue Prairie. Research is needed to determine how, why, and where this exotic establishes. Development of proactive management strategies will then be possible. Until this information becomes available, the following issues are important to consider:

- Burning in fall or spring should not be expected to reduce smooth brome in Fescue Prairie.
- Burning in the spring followed by wick application of glyphosate when smooth brome is in the boot stage will give excellent control but damages native species. Growth and productivity of native species will also recover more quickly from spring burning than from fall burning (Redmann et al. 1993).
- A single application with glyphosate will not give complete control of smooth brome; follow-up treatments such as digging up plants or applying glyphosate will be needed in subsequent years.
- Before smooth brome control is attempted, the species abundance and composition in the soil seedbank and in established plants should be measured to determine if artificial revegetation will be necessary.
- Prairie reserves dominated by plains rough fescue must be monitored regularly to detect smooth brome invasions and the success of control treatments. Because dispersed patches of invasive species facilitate invasions (Moody and Mack 1988), smooth brome should be eliminated promptly from Fescue Prairie to prevent its spread.

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