EFFECTS OF FIRE ON MIXED-GRASS PLANT COMMUNITIES IN BADLANDS NATIONAL PARK

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Objectives

This research had the objective of determining the influence of fire on densities and standing crops of the major grass species of the Badlands National Park mixed-grass prairie. An important goal was to evaluate the potential of prescribed fire as a management tool for Japanese brome (Bromus japonicus).

Study Areas and Methods

These studies were conducted on two range sites in Badlands National Park, South Dakota. On a clayey range site, western wheatgrass (Agropyron smithii) was the dominant perennial plant species and Japanese brome was the codominant.

Thirty 5- by 5-m plots were established with 10 treatments. Treatments were: untreated; burned, April 1983; burned, May 1983; burned, April 1983 and 1984; burned, May 1983 and 1984; clipped, April 1983; clipped, May 1983; atrazine application (1.1 kg ha^{-1}), September 1983; burned, April 1983 followed by atrazine application in September 1983; and burned, April 1984.

Tiller densities were determined in April and July of 1983, 1984, 1985 and 1986 and standing crops were determined in July 1983, 1984, 1985 and 1986. The number of developed seeds per plant was determined each year. Seed production per m^2 was determined by multiplying seed production per plant times the number of plants per m^2. Japanese brome seed banks were determined for the top 3 cm of soil in three 0.10 m^2 quadrats from each plot.

An additional set of experiments were established on an upland range site dominated by needle-and-thread (Stipa comata) and threadleaf sedge (Carex filifolia). Treatments were: untreated; burned, April 1984; burned, October 1984; burned, April 1985; and burned, October 1985. Standing crops were determined in July 1984, 1985 and 1986. Fringed sage (Artemisia frigida) plants were placed into one of three size-class categories and analyzed by % in each category.

Results

Western wheatgrass-Japanese brome experiments. Japanese brome tiller densities (Table 1) and standing crops (data not shown) were reduced during the first year following burning or atrazine application. However, during the second year, both tiller density and standing crop increased to preburn levels. Atrazine applied as a preemergent herbicide significantly reduced Japanese brome tiller density and standing crop.

The 1985 growing season was unusually dry and Japanese brome seed germination was very low. All of the previously burned plots contained reduced Japanese brome densities; probably as a result of more xeric microenvironments created by the loss of surface litter following fires. The fall of 1985 was also quite dry resulting in reduced Japanese brome seed germination. The following winter, spring, and early summer (1986) were unusually wet. Although Japanese brome densities were low, each of the individual plants became quite large. Japanese brome standing crops in July 1986 were relatively high despite the reduced densities. In July 1986, most of the previously burned plots had reduced Japanese brome tiller densities due to reduced surface litter and to the dry fall of 1985, when these plants were germinating.

Burning increased western wheatgrass tiller density (Table 1) during the first growing season after burning. However, during the second growing season, tiller density was reduced to untreated levels. Atrazine treatments reduced western wheatgrass tiller densities for the first year after application.

Spring burning reduced Japanese brome seed production for at least three growing seasons after burning (Table 2). Seed production in 1985 was greatest on the untreated plots. Seed production in the 1986 growing season was reduced on plots burned in 1984 but plots burned in 1983 were no different from untreated plots. Spring burning reduced the surface seed bank for at least the first growing season (Table 2). The soil seed bank was not affected during the first two years after burning in 1983. In July, 1986 the surface seed bank was still reduced on all the treated plots compared to the untreated plots. The Japanese brome seed bank in the surface 3 cm of soil was reduced on plots burned in 1984 or treated with atrazine in September 1983.

Needle-and thread experiments. Needle-and-thread standing crops in July 1986 were reduced on all the previously burned plots (data not shown). This was consistent with other studies indicating that most Stipa species are relatively intolerant of fire (Wright and Bailey 1982). Threadleaf sedge standing crops were increased by burning at all dates, compared to the unburned plots.

Fringed sage. Total fringed sage density was not significantly affected by any of the treatments (data not shown). Atrazine killed all the fringed sage plants and prevented establishment of seedlings for at least 3 years. In every instance burning reduced the percentage of plants in the largest size-class. There was a consistent tendency for the percentage of fringed sage in the smallest size-class to increase following burning.

Table 1. Tiller densities (per m^2) of Japanese brome and western wheatgrass in July 1983, 1984, 1985, and 1986 after treating in 1983 and/or 1984. Badlands National Park, South Dakota[1].

Contrast	Japanese brome 1983	Japanese brome 1984	Japanese brome 1985	Japanese brome 1986	Western wheatgrass 1983	Western wheatgrass 1984	Western wheatgrass 1985	Western wheatgrass 1986
No treatment vs.	2,360	2,617	306	467	295	375	222	206
1983 burning	908**	2,028^{NS}	213*	325*	427*	264^{NS}	149*	215^{NS}
No treatment vs.	---	2,617	306	467	---	375	222	206
1984 burning	---	23**	14**	112**	---	507**	299^{NS}	424**
No treatment vs. double burning	---	2,617	306	467	---	375	222	206
(1983 and 1984)	---	580**	81**	196**	---	333^{NS}	153*	319*
1984 burning vs. double burning	---	23	14	112	---	507	299	424
(1983 and 1984)	---	580**	81^{NS}	196^{NS}	---	333^{NS}	153*	319*
No treatment vs. Atrazine	---	2,617	306	467	---	375	222	206
(Sept. 1983)	---	19**	23**	313*	---	95**	298^{NS}	275^{NS}
1983 clipping vs.	2,360	3,250	327	291	465	297	230	235
1983 burning	908*	2,028*	213*	325^{NS}	427^{NS}	264^{NS}	149*	215^{NS}
1983 burning vs.	---	2,028	213	325	---	264	149	215
1984 burning	---	23**	14**	112*	---	507**	299*	424**
April 1983 burning followed by Atrazine	---	77	22	123	---	302	163	276
vs. Atrazine	---	19^{NS}	23^{NS}	313*	---	95*	298*	275^{NS}
Atrazine vs.	---	19	23	313	---	95	298	275
1984 burning	---	23^{NS}	14^{NS}	112*	---	507**	299^{NS}	424**

[1]NS means the contrast is not significant; * means significant at the 5% error level; and ** means significant at the 1% error level. All analyses of contrasts are within a column.

Table 2. Selected features of Japanese brome population dynamics following burning and/or atrazine application[1].

	Burned April 1983	Burned April 1984	Atrazine September 1983	No treatment
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Seedling density; April 1983	2,299a	2,516a	2,412a	2,738a
Mature plants; July 1983	908b	2,118a	2,287a	2,360a
Seed production; 1983	1,620b	67,815a	69,258a	73,160a
Seedling density; April 1984	2,417a	2,381a	38b	2,287a
Mature plants; July 1984	2,028a	23b	19b	2,617a
Seed production; 1984	46,644b	368c	1,803c	94,212a
Surface seed bank; July 1984	11,775a	700b	10,897a	12,460a
Soil surface seed bank; July 1984	10,760a	11,512a	12,250a	11,852a
Seedling density; April 1985	554a	72b	103b	578a
Mature plants; July 1985	213b	14c	23c	306a
Seed production; 1985	785b	375c	425c	1,410a
Surface seed bank; July 1985	112b	18c	35c	187a
Soil surface seed bank; July 1985	6,923a	5,754b	5,216b	7,859a
Seedling density; April 1986	523b	65c	497b	990a
Mature plants; July 1986	347b	112c	313b	466a
Seed production; 1986	29,911a	12,208b	34,626a	31,584a
Surface seed bank; July 1986	263b	89c	126c	6,712a
Soil surface seed bank; July 1986	3,712a	2,251b	887c	4,587a

1 Means within a single row, followed by the same lower-case letter, are not significantly ($P \leq 0.05$) different according to Student-Newman-Keul's test.

Conclusions

Spring burning reduced Japanese brome densities and standing crops for only one year when followed by at least average precipitation. When burning was followed by unusually dry weather, Japanese brome densities and standing crops, on previously burned plots, were significantly reduced compared to unburned plots. Western wheatgrass density benefited from Japanese brome reductions but was reduced to preburn levels in the following season if sufficient precipitation occurred. Preemergent atrazine applications (1.1 kg ha^{-1}) reduced Japanese brome density for two years and western wheatgrass density was reduced for one year.

Carryover of Japanese brome seed in the seed bank was sufficient to establish populations similar to untreated plots in the next generation following a spring fire if sufficient soil moisture was available. Since many of the seeds germinating in the fall are from the previous years seed crop, the loss of a single seed crop may not affect the next generation. No treatment-related reductions in the postburned generations of Japanese brome were observed until the dry 1985 growing season. Some Japanese brome seeds are destroyed by spring burning but the seed bank appears to have sufficient reserves to renew the population in the next generation.

Spring burning only significantly affected the generation of annual plants being burned. Subsequent generations were not affected until a dry year was encountered. As a result, spring burning cannot be considered a suitable method of controlling Japanese brome in western wheatgrass communities. Atrazine had a carryover influence on subsequent generations for at least two years. Atrazine damage to western wheatgrass was significant for only one year. Western wheatgrass standing crops increased during the second growing season following application of atrazine.

The major influence of burning on subsequent generations of Japanese brome is through modification of the microsite, principally surface litter abundance. Japanese brome, like downy brome (Bromus tectorum) requires some litter on the soil surface for germination (Evans and Young 1984). Reducing surface litter reduces subsequent generations of Japanese brome, with the effect being greatest in dry years. This creates a paradox for natural resource managers. It appears that management practices designed to improve the health of this grassland (i.e. reduced grazing which increases litter contribution to the soil) create a more desirable microenvironment for this introduced, exotic species. This can also be observed indirectly, by comparing the abundance of Japanese brome in the grasslands of Badlands National Park with that of surrounding private grasslands which are generally grazed heavily by domestic livestock. Japanese brome abundance of the surrounding Forest Service lands appears to be intermediate between Badlands National Park and private grazing lands. Periodic burning can have the effect of maintaining a reduced litter level; thereby maintaining reduced populations of Japanese brome. However, surface litter has many beneficial attributes for the grassland environment and should not be considered as a problem in itself.

Burning, in either spring or fall, was detrimental to needle-and-thread.

Threadleaf sedge, which appears to be an important early-spring forage, increased production following all of the burning dates. Burning upland sites during dry years, such as 1985, resulted in almost no regrowth, but the community seemed to recover during the following year.

Fringed sage is killed by fire but recovers rapidly, through new seedling establishment, within 2 years. A burning program which burns upland sites every 7 to 10 years and lower sites every 4 to 8 years should result in healthy populations and age distributions of fringed sage.

Literature Cited

Evans, R. A. and J. A. Young. 1984. Microsite requirements for downy brome (Bromus tectorum) infestation and control on sagebrush rangelands. Weed Science 32 (supplement 1): 13-17.

Wright, H. A. and A. W. Bailey. 1982. Fire Ecology. John Wiley and Sons, NY. 501 p.