ELEMENT STEWARDSHIP ABSTRACT
for

Bromus inermis

Awnless Brome, Smooth Brome

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The Nature Conservancy
Element Stewardship Abstract
For *Bromus inermis*

I. IDENTIFIERS

Common Name: AWNLESS BROME Global Rank: G4G5

General Description:
Bromus inermis is a deeply rooting, rhizomatous perennial grass.

Diagnostic Characteristics:
The ascending or stiff branches of the open panicle are a key characteristic distinguishing Bromus inermis and Bromus erectus from a group of similar native bromegrasses. The awnless lemmas, from which the species derives its Latin name, distinguish Bromus inermis from both the introduced and similar Bromus erectus and from the native Bromus pumpellianus.

II. STEWARDSHIP SUMMARY

Smooth brome is a cool season exotic that is especially troublesome in disturbed portions of old pastures in the tallgrass and mixed prairie regions. Although less invasive than Kentucky bluegrass, with which it often occurs and is managed, it is also less responsive to management.

The optimal timing for control of smooth brome by burning appears to be in boot stage, which may be as early as mid-April in the central Great Plains or in the northern plains. This is somewhat later than would be recommended for other management purposes such as control of Kentucky bluegrass. However, its habit of occurring frequently in nearly pure swards renders Bromus inermis a good target for selective control by timed close mowing or use of herbicides. One close mowing when the plants are 18-24 inches tall (followed ideally by 3 repetitions), or treatment with glyphosate at 0.5 to 1.1 kg/ha before flowering, may improve chances of selectively controlling this species.

III. NATURAL HISTORY

Range:
Bromus inermis Leyss. is a Eurasian species ranging from France to Siberia, apparently introduced in the United States by the California Experiment Station in 1884 (Kennedy 1899, Archer and Branch 1953).

Within the United States smooth brome has been introduced in the northeastern and northern Great Plains states as far south as Tennessee, New Mexico and California. It has

become naturalized from the maritime provinces to the Pacific coast north to Alaska to California and through the plains states.

Habitat:
In its native range smooth brome grows on roadsides, riverbanks, edges of fields and woods and pastures. Bromus inermis was first recognized as a potential forage grass in Europe because of its drought resistance (Kennedy 1899).

Within the United States a variety of agricultural strains have been developed from two natural strains, a "northern" and a "southern" strain. The southern strain is more tolerant of drought and heat than the northern strain (Newell and Keim 1943).

Greenhouse and field tests in Wisconsin suggest that smooth brome has better root growth in sandy than in silty soils (Lamba et al. 1949). Artificial aeration of silt loam produced better root growth than in unaerated soils (Lamba et al. 1949). Smooth brome has a high mortality rate on organic soils (Myhr et al. 1966). The possible relationship between poor soil aeration and mortality has not been investigated. Tolerance of smooth brome to spring flooding is estimated at 24 days (Seamands 1979). Salt tolerance is considered "moderate" (Seamands 1979). The sun-loving habit of smooth brome is substantiated by research showing that seed production, numbers of shoots and rhizomes, and dry weight of all plant parts are reduced by shade (Watkins 1946, Dibbern 1947).

Reproduction:
Smooth brome is a cool season grass, beginning its growth early in the spring and growing late into the fall. New shoots emerge in the Chicago region as early as mid-March, when night temperatures are below freezing (Lamp 1952). Flowering primordia first become observable in early April in the Chicago region (Lamp 1952, Gall 1947) reaching 1 to 1.5 cm in length by early May near Ames, Iowa (Knobloch 1944).

Stem elongation varies from early May (Reynolds and Smith 1962) to late April in Wisconsin and Illinois (Lamp 1952). Boot stage is reached in mid-to-late May in Illinois and Wisconsin (Lamp 1952, Reynolds and Smith 1962, Knieval et al. 1971, Okajima and Smith 1964). In Illinois, plants are fully headed and blooming occurs during the first two weeks of June (Lamp 1952) whereas in Alberta, full head occurs in mid-June and pollination in July (Evans and Wilsie 1946). Seeds ripen in July in Illinois (Lamp 1952) and in August in Alberta (Evans and Wilsie 1946). Carbohydrate levels are lowest in the spring when the plant is at boot stage, but increase during internode elongation until heading (Teel 1956). In Wisconsin field studies, Reynolds and Smith (1962) report maximum total stored carbohydrates in mid-July when seed is mature, with smaller peaks in earliest spring in the pre-boot stage and in the fall.

Because of the importance of smooth brome as a forage crop, reliable seed crops are necessary and numerous studies have been conducted to determine the requirement for floral initiation and optimal conditions for seed production.

Smooth brome generally requires a period of vernalization under short day conditions followed by a long photoperiod for panicle production (Newell 1950, Kirshin et al. 1974, 1977) best fulfilled by short autumn days and longer spring days. The required time of exposure to low temperatures is short, 1 to 14 nights (Gardner and Loomis 1951) enabling some early- emerged spring shoots to grow under short days of early spring, be vernalized during a cold spell, and develop flowering panicles within the same year.

In greenhouse studies in the Chicago area, Lamp (1952) found a relationship between internode elongation and reproductivity. A minimum of 5 to 14 leaves must be developed during or before primordia formation if the plant is to flower in any given year. Flowering occurs at daylengths of 17 to 18 hours (Gall 1947, Evans and Wilsie 1946) when temperatures are warm. In Alberta studies Evans and Wilsie (1946) observed little flowering when air temperatures were below 60 degrees Fahrenheit.

Under experimental conditions the requirements for floral induction and flowering can differ from those reported above. Sprague (1948) observed some flowering in plants that had been maintained in a heated greenhouse and Allard and Evans (1941) report a critical period of 13 hours of daylength for flowering to occur.

Smooth brome is an open-pollinated self-incompatible species. Synchronous flowering is common (McKone 1985) with pollination occurring from plants up to 50 m away (Jones and Newell 1946). In Minnesota field studies seed set of open pollinated plants were 29% and in nurseries as high as 36% (Lowe and Murphy 1955) to 37% (Nielson 1951). The number of seeds produced has a very wide range. Lowe and Murphy (1955) report 47 to 160 seed heads per plant, with 156 to 10,080 viable seeds per plant. Maturing seeds are subject to predation by Itonidid midges and Chalcid flies (Nielson and Burks 1958). Kramer (1975) suggests that seeds may be transported and sequestered by ants, resulting in creation of new brome patches on anthills.

Smooth brome is a rhizomatous, sod-forming species. The first adventitious roots develop within 5 days of germination (Knobloch 1944). Rhizome formation begins as early as 3 weeks after germination (Wagner 1952) to as late as 6 months (Knobloch 1944).

The drought resistance of smooth brome is probably accounted for in part by its deeply penetrating root system. Dibbern (1947) reports Bromus roots reaching a depth of 4.7 feet. Lamba et al. (1949) found 21% by weight of brome roots between depths of 16 and 40 inches, 10% between 8 and 16 inches and 64% in the top 8 inches. This heavy concentration of total root mass near the surface is the result of smooth brome's creeping rhizomatous habit. Individual rhizomes are reported to have a longevity of one year (Evans and Ely 1935). Old brome fields develop a "sod bound" condition in which shoot density is reduced and symptoms of nitrogen deficiency are exhibited (Meyers and Anderson 1942). Benedict (1941) attributes this condition to a carbon/nitrogen imbalance (perhaps because of the sheer mass of dead rhizomes) but Grant and Sallans (1964) suggest that the decomposing roots may actually produce an allelopathic substance inhibitory to further brome root development.

IV. CONDITION

Threats:
Smooth brome has been widely planted as a forage and cover crop. Although perhaps not as invasive as Poa pratensis, with which it often grows, it is highly persistent. It forms a dense sod that often appears to exclude other species, thus contributing to the reduction of species diversity in natural areas. Within the Rocky Mountain range of the native Bromus pumpellianus, hybrid introgression is occurring and disjunctive hybrid plants have also been found in the Great Lakes Region (Elliot 1949).

V. MANAGEMENT/MONITORING

Management Requirements:
Bromus inermis has become established in overgrazed pastures and old fields, especially around the edges and in haystack areas. It is most often a problem in discrete patches which would appear to be amenable to selective treatment, but also appears to be invading native prairie from roadsides.

One of the difficulties in understanding how best to manage for Bromus inermis is that because of its cool season habit it is often lumped together with Poa pratensis both in research results and management decisions. Yet it appears from the species' biology and its response to various management experiments that there is a difference in the timing of the most susceptible phenological stages of the two species. Because there is some overlap in the species' times of vulnerability to fire or defoliation, dual management produces partial control of Bromus. Casual observation of the two species in southwestern Minnesota suggests that there can be a 2 to 2 1/2 week lag period between the optimal spring fire date for Poa (before it is in flower) and that for Bromus (when it is still in boot) (Sather, personal observation).

More effective management of smooth brome might be achieved by first understanding the relative proportions of Bromus inermis and Poa pratensis and their spatial distribution in the mosaic of the vegetation. Treatment schedules could then be adjusted to impact smooth brome in the boot stage in areas where it is the rightful target species.

MECHANICAL: Both experimental studies and management experience indicate that cutting smooth brome in the boot stage, i.e. while the flowering head is still enclosed within the sheath, is perhaps the most effective means of control. Martin (pers. comm.) reports successful reduction of Bromus inermis in Minnesota test plots when cut during boot stage, which occurs the time it reaches a height of 18 to 24 inches, in late May. The best conditions for damage are hot, moist weather at the time of cutting, followed by a dry period (Martin pers. comm). Experimental studies comparing the effects of growth stage and height at time of cut in Saskatchewan suggest that the greatest subsequent winter injury can be attained by cuttings at the shot blade stage (i.e just before the plant changes from vegetative to early elongation of reproductive stage) than by waiting until flowers

have developed (Lawrence and Ashford 1964). Cutting at 3.8 cm produced greater subsequent winter injury than did cutting at progressively taller heights up to 14 cm (Lawrence and Ashford 1964). Cutting at "shot blade" or "boot" stage just after the apical meristem has begun to elongate within the sheath takes advantage of the low root carbohydrate levels at that time (Paulsen and Smith 1969, Reynolds and Smith 1962, Knievel et al. 1971).

Carbohydrate levels can be kept at slightly lower than normal levels throughout the summer by repeated cuttings (Paulsen and Smith 1968). Martin and Hovin (1980) found in Minnesota field trials that persistence of smooth brome over a 4-year period was more greatly reduced by 4 cuts a year than by 2 or 3 cuts. However, it should be noted that their experimental results are somewhat confounded by the fact that only the 4- cut schedule included a cut during the boot stage. Paulsen and Smith (1968) found that bromegrass harvested in boot was as adversely affected as plants managed under a 3-cut harvest schedule. Slow recovery was associated with the removal of apical meristems when tiller buds were poorly developed.

It therefore appears that a single well-timed close cut in boot stage (approximately 18 inches) may be an effective method of control. Managers of natural areas such as parks might wish to try repeated lawnmowing of brome beginning in late May and mowing at least 4 times during the season where brome patches are contiguous and pure.

FIRE: Fire does not appear as effective in reducing smooth brome as it is with Poa pratensis. Kruse (pers. comm.) reports that in North Daktoa smooth brome can be kept from spreading, but not appreciably reduced with fire. Old (1969) reports decreases in July dry matter production but not elimination of smooth brome after April fire in Illinois. One difficulty in assessing the effectiveness of burning for control of Bromus inermis is the dearth of literature that clearly separates this species from "cool season exotics" as a group.

Cosby (1972) reports the comparative effects of late May mowing and June 1 burning at Lake Andes National Wildlife Refuge, North Dakota. There biomass production in August of the treatment year was 80 lb/acre of Bromus inermis following mowing and 5 lb/acre following burning. These data suggest that a well-timed burn that treats Bromus in boot (or early bloom?) may be more effective than mowing at the same susceptible period. At Kilen Woods State Park, Minnesota, there was no visible, discernible reduction in Bromus in the first or second season after an April 22 burn (Sather 1986, 1987, pers. obs.). At Lostwood National Wildlife Refuge where nine years of burning have followed a summer schedule (mid-June and late July to mid-August) to reduce woody encroachment, smooth brome has actually increased in areas that formerly had heavy litter build-up or dense Symphoricarpos growth (Smith, pers. comm.). There, May burns are planned to help target the bromegrass. It appears that late May burns would be optimal in the northern plains for reduction of smooth brome.

HERBICIDES: Several chemicals have been tried to control cool season grasses for the purpose of sod-seeding legumes and improving pastures.

In an early study of brome control, McCarty and Scifres (1966) tested picloram, dicamba and 2,4-D and found picloram most effective at rates of 1.1 to 2.2 kg/ha, dicamba somewhat less effective and 2,4-D ineffective.

In pastures where increased legumes are desired, late April applications of paraquat, glyphosate and atrazine at 2.24 kg/ha and glyphosate at 1.12 kg/ha have been used successfuuly to shift dominance from cool to warm season grasses on Nebraska rangelands (Waller and Schmidt 1983). Herbage yields of smooth brome from atrazine treated plots were not significantly different than from glyphosate treated plots. An application of this technique is presently in the experimental stage in a brome-infested area of Sioux Prairie, South Dakota (Wells pers. comm.).

Dalapon and pronamide have been used to suppress or kill smooth brome during the establishment of birdsfoot trefoil (Martin et al. 1983, Rayburn et al. 1981). In Minnesota trials Martin et al. (1983) found both dalapon (at rates of 3.4 to 9.0 kg/ha) and glyphosate (at rates of 0.6 to 1.1 kg/ha) more effective in April and May than in June applications. In New York trials Rayburn et al. (1981) found glyphosate at 2 kg/ha more effective than dalapon (at 3.0, 4.0 and 9.0 kg/ha) or pronamide (at 0.4, 1.0 and 2.0 kg/ha). In the same study, rates of application of glyphosate as low as 0.5 kg/ha produced some effect but control was better as rates approached 2 kg/ha. In Nebraska field trials Vogel et al. (1983) found paraquat somewhat less effective than glyphosate in April applications to control smooth brome. It appears that April or May applications of glyphosate at 2 kg/ha may be an effective management technique for controlling smooth brome in pure patches.

Management Programs:
Management programs in which Bromus inermis has been specifically singled- out as the target species are few. The following individuals are involved in programs that specifically target smooth brome:

Karen Smith, Refuge Manager, Lostwood National Wildlife Refuge, R. Rt. 2, Box 98, Kenmare, N.D. 58746.

Dr. Darrell Wells, Route 4, Box 233, Brookings, South Dakota 57006.

Dr. Gary Larson, Dept. of Biology, Ag. Hall 304, South Dakota State University, Brookings, S.D. 57007.

Monitoring Requirements:
Management objectives may include eradicating populations, containing populations or preventing establishment. Monitoring should be used to track these objectives.

Because of its fairly distinctive foliage and habit of growing in solid patches Bromus inermis is easily recognized at all seasons. However, its early green-up makes it especially easy to detect during the spring months. Marking the boundaries of patches and noting their expansion or retraction over time may be the easiest method for monitoring Bromus in natural areas. Such a method has been successfully used to observe the expansion of bromegrass clones from 2.2 to 5 times their original size over a period of 3 years at Lake Andes National Wildlife Refuge North Dakota (Cosby 1972).

Monitoring Programs:
Permanent markers have been placed at the edge of brome patches at the Helen Allison Savannah, Minnesota, to allow for tracking of these patches over time. contact: Dr. D.B. Lawrence, 1420 34th Ave. South, Minneapolis, MN 55406. 612/729-8206.

The following individuals are monitoring the frequency and/or cover of Bromus as a measure of responses to prairie management practices:

Arnold Kruse, Northern Prairie Wildlife Research Center, P.O. Box 1747, Jamestown, N. Dakota 54801.

Karen Smith, Refuge Manager, Lostwood National Wildlife Refuge, R.Route 2, Box 98, Kenmare, ND 58746.

Bromus patches at Sioux Prairie, South Dakota, are being monitored to measure success of eradication methods using herbicides. Contact: Dr. Gary Larson, Dept. of Biology, Ag. Hall 304, South Dakota State University, Brookings, SD 57007.

Bromus is one of several species being monitored as part of a dissertation study on old field succession at the Cedar Creek Natural history Area, Minnesota. Contact: Barb Delaney, Dept. of Botany, University of Minnesota, St. Paul, MN.

VI. RESEARCH

Management Research Programs:
The only research program specifically addressing control of smooth brome is that at Sioux Prairie, South Dakota, where response of bromus to atrazine is being tested. Contact: Dr. Gary Larson, Dept. of Biology, Ag. Hall 304, South Dakota State University, Brookings, South Dakota 57007.

Management Research Needs:
Bromus is often considered in conjunction with Poa pratensis in management programs because both are rhizomatous, cool season exotic grasses. There is a need to relate the dates of management procedures specifically to the physiological/phenological growth stage of Bromus at the time of management and to directly measure the response of Bromus separate from Poa.

Some specific research questions that would appear to be useful to managers of natural areas in their attempts to understand and control Bromus include: Is a single cut in boot as effective in reducing Bromus persistence as the documented first cut in boot? (Most studies in which Bromus has been cut in boot have been addressing the frequency of cutting and the boot cut has been an artifact of efforts to increase cutting frequency.) Is burning in boot as effective as cutting in boot for lowering the persistence of Bromus over a period of years? What is the response of Bromus to fall fires and/or grazing, which might enhance survival of its native cool season competitors, particularly in the northern part of its range? What is the actual rate of invasiveness of Bromus into established prairie sod? Are chemical treatments such as atrazine as effective in pure brome stands as they are in mixed stands of brome and warm season natives?

VII. ADDITIONAL TOPICS

VIII. INFORMATION SOURCES

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IX. DOCUMENT PREPARATION & MAINTENANCE

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