

**Re-evaluation of native plant species for seeding and grazing by livestock on the semiarid prairie of western Canada.**

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## Abstract

There is a growing interest in the re-vegetation of disturbed prairie sites, including annual crop lands, with native species. Previous research from the Mixed Grassland ecoregion, or semiarid prairie region, of western Canada found that introduced forage species, such as crested wheatgrass, produced more spring forage with better nutritive value than native species and concluded that native species exhibited little agronomic merit. However, new research indicates that native species may be useful for extending forage productivity and the grazing season into the late summer, fall and winter. Native species contribute to biodiversity, reduce nonforage invasive species problems, and enhance wildlife habitat in this region. They may also contribute to increased soil carbon sequestration, and increased ecosystem stability despite increasing aridity due to climate change. Future opportunities in native plant research and development include a focus on developing methods of reliable native seed production by either genetic enhancement or agronomic practices or both.

## INTRODUCTION

European settlement of the Mixed Grassland ecoregion of southwestern Saskatchewan and southeastern Alberta occurred in two waves. Corporate ranching based on very large tracts of native grasslands leased from the federal government followed the construction of the Canadian Pacific Railway in the 1880's, but inadequate cattle feed during extreme winters resulted in large death losses and subsequent bankruptcies (McGowan 1975). Despite concerns about low and variable precipitation and low organic matter soils that are marginal for annual crop production, the federal government's settlement policy was changed by 1900 to encourage the development of small farms and a supporting rural infrastructure such as railway branch lines. Immigrants farmers or "sod-busters" received 160 acres or a quarter-section of land in exchange for plowing native grass for crop, mainly wheat (*Triticum aestivum* L.), production for export to Europe. This culminated in the plowing of 80% of the native grasslands of this ecoregion in Saskatchewan and Alberta (Selby and Santry 1996). When the unsustainable nature of some homesteads became evident during the major droughts of the 1930s, introduced or exotic forage species, such as crested wheatgrass (*Agropyron cristatum* L. Gaertn. and *A. desertorum* (Fisch. Ex Link) J.A. Schultes), were used for reseeding millions of hectares (Gray 1996). Introduced forage grass species from central Asia have been extensively studied since the 1950's for improved adaptation, forage yield, forage quality and persistence under ruminant grazing pressure. At the same time, *in situ* native species were considered to have low forage yield, poor seed production, low forage quality, and low carrying capacity for grazing by domestic livestock.

Over the last decade, however, there has been a renewed and growing interest in native

1 plant species and this interest has contributed to the formation of the provincial Prairie  
2 Conservation Action Plans (PCAP Partnership 2003), the popular Native Plant Summit  
3 conferences, and the formation of specialist groups such as the Native Plant Society of  
4 Saskatchewan. This revival can be attributed to several emerging trends and changes to the  
5 agriculture industry. These trends include increasing demand for wildlife habitat, an increasingly  
6 ecological perspective on grassland management by cattle ranchers, greater respect for the role of  
7 grasses in soil organic carbon sequestration, and a better understanding of the invasive  
8 characteristics of some introduced forage species. Invasion of native rangelands by exotic  
9 species has been highlighted as a problem of previous revegetation efforts. The introduction of  
10 the *Species at Risk Act 2003* in the federal parliament, an act to promote the preservation of  
11 endangered species in Canada, has heightened awareness of the need for the preservation of  
12 native mixed prairie rangelands and habitats.

13 Private and public organizations that manage native prairie landscapes have recognized  
14 the importance of re-vegetating disturbed sites with native rather than introduced plant species.  
15 For example, Ducks Unlimited Canada has promoted the value of seeded native species for  
16 ground-nesting waterfowl habitat on land adjacent to permanent water bodies. In the ecologically  
17 sensitive Great Sandhills of southwestern Saskatchewan, the petroleum industry is now re-  
18 vegetating pipeline rights-of-way, well-sites, and other disturbed areas with native species. In  
19 Alberta, the use of native species has been increasing steadily for public and private land  
20 reclamation, resulting in the need for new guidelines (Native Plant Working Group 2001).

21 Cattle producers' appreciation for native rangelands has increased due to years of range  
22 experience and to training in intensive grazing management based on ecological principles.

1 Native rangelands in the Mixed grassland ecoregion can support good summer weight gains on  
2 yearling steers (Karn and Lorenz 1983) and are similar to some introduced grasses (Smoliak and  
3 Slen 1974; Hofmann et al. 1993). Stocking rate, grazing rotation among paddocks, and grazing  
4 duration can be managed to improve range condition and maximize economic productivity (Hart  
5 et al. 1988). Seeded native species will be important forage sources to complement existing  
6 native rangelands for improved grazing management and range condition. As changes to  
7 transportation and input costs make grain production uneconomical on some soils, the investment  
8 in re-seeding native species for summer, fall and winter grazing by cattle has grown. Fall and  
9 winter grazing of beef cattle, particularly pregnant non-lactating beef cows, is one strategy to  
10 reduce the cost of beef production in this region.

11 Lessons can be learned from the Conservation Reserve Program (CRP) in the United  
12 States which promotes the re-vegetation of land that is marginal for annual crop production and  
13 emphasizes native species. One benefit of the CRP is increased soil organic carbon  
14 concentration on fragile soils in the Northern Great Plains (Gebhart et al. 1994). A forage  
15 seeding program for Canada has been funded and it will support conversion of marginal crop  
16 land to perennial vegetative cover but also has an component for re-seeding native species  
17 (Agriculture and Agri-Food Canada 2003). Soil re-seeded with native species could be a sink to  
18 sequester carbon removed from the atmosphere via photosynthesis and stored as soil organic  
19 matter carbon (Christian and Wilson 1999; Janzen et al. 2000). This process could contribute to  
20 Canada's international commitment to reduce greenhouse gas emissions (Environment Canada  
21 2002).

22 Native prairie has higher floral biodiversity than monoculture cropping systems used in

1 modern agricultural production. Conserving biodiversity on landscapes utilized for ruminant  
2 livestock pastures provides many opportunities as well as challenges (Paoletti et al. 1992). Little  
3 biodiversity data are available to compare undisturbed prairie ecosystems to agroecosystems  
4 (Paoletti et al 1992). Native prairie is one of the most threatened ecosystems because major  
5 portions have been converted to annual and perennial crop production for export grains and  
6 forage production with introduced species. On a continental scale, there has been a 64%  
7 reduction of the mixed-grass prairie region of North America. In the Canadian provinces of  
8 Alberta, Saskatchewan and Manitoba, native prairie grasslands have declined 61, 81, and 99%,  
9 respectively. The Tall-Grass prairie of Manitoba has been completely converted to crop  
10 production and Saskatchewan has lost 6% of its Mixed-Grass prairie (Samson et al. 1998).

11 Many native plants were used by the first peoples of Canada for medicinal purposes and  
12 there is renewed interest in such plants as a source of pharmaceutical and nutritional products  
13 (Lewis and Elwin-Lewis 2003). A recent market assessment of native plants in Saskatchewan  
14 commissioned by the Native Plant Society of Saskatchewan (Solutions 2000+ 1997) forecasts a  
15 15% yearly increase in market size for native plants including species with medicinal value. In  
16 urban settings, there has also been a growing demand for native plants for low-input xeriscaping.  
17 The pharmaceutical and landscaping uses of native plant species are beyond the scope of this  
18 review.

19 The purpose of this paper is to review revegetation research involving native plant species  
20 of the semiarid prairie region in light of these trends. A second objective is to identify  
21 opportunities for further research and development of native plants for seeding on the prairie  
22 landscape.

## ATTRIBUTES OF NATIVE VS. INTRODUCED FORAGE

### Adaptation

Establishment of plant species from seed is key to the re-vegetation of disturbed sites, development of new pastures for livestock grazing, or range improvement. Research results suggest that native grasses are difficult to establish. For example, Kilcher and Looman (1983) reported very low establishment of big bluestem (*Andropogon gerardii* Vitman.) and prairie sandreed (*Calamovilfa longifolia* (Hook.) Scribn.) at Swift Current, Saskatchewan (lat. 50° 16' N, long. 107° 44' W, 825 m elevation) (Table 1). However, more recent results (Jefferson et al. 2002; Jefferson unpublished) indicate that varieties of these native grasses from Montana and North Dakota can be successfully established from seed at Swift Current (Table 1) and other sites in western Canada (Jefferson et al. 2002); although cool-season (C<sub>3</sub>) grasses established better stands than warm-season (C<sub>4</sub>) grasses. Jefferson et al. (2002) have also observed good seedling vigour and excellent stand establishment for other warm-season species (Table 1). The earlier work of Kilcher and Looman (1983) was based on varieties from Kansas, Nebraska and Colorado, whereas recent results were based on varieties from Montana and North Dakota. These states are adjacent to southern Saskatchewan and can provide varieties that are better adapted to western Canada than varieties from further south (Tober and Chamrad 1992).

[insert Table 1 near here]

Lawrence and Ratzlaff (1989) concluded that native grass species were not persistent when seeded at Swift Current, Saskatchewan. The native grasses they tested included five slender wheatgrass (*Elymus trachycaulus* (Link) Gould ex Shinners) varieties, four awned wheatgrass (*Agropyron subsecundum* (Link) Hitchc.) varieties, two northern wheatgrass (*Elymus*

1 *lanceolatus* (Scribn. & J.G. Sm.) varieties and one streambank wheatgrass (*Elymus lanceolatus*  
2 (Scribn. & J.G. Sm.) Gould ssp.*lanceolatus*). The forage yield and plant density of these species  
3 were compared to three introduced forages, crested wheatgrass, intermediate wheatgrass  
4 (*Elytrigia intermedia* (Host) Nevski) and meadow brome grass (*Bromus riparius* Rehmman).  
5 These authors conclude that slender wheatgrass lacks winterhardiness or persistence as it died in  
6 the fifth year after establishment. This conclusion was then extrapolated to all native species  
7 relative to introduced grasses for the semiarid region of western Canada. However, these authors  
8 failed to recognize that slender wheatgrass and awned wheatgrass are known to be short-lived  
9 perennials and die out in three to five years. Thus their primary conclusion, and its extrapolation  
10 to all native species, was erroneous. In contrast to the authors' negative conclusion about native  
11 grasses, northern wheatgrass exhibited no stand loss in this trial but this result was not  
12 acknowledged (Lawrence and Ratzlaff 1989).

13 Current research projects (Waller et al. 1994; Schellenberg and Jefferson 1998; Banerjee  
14 and Schellenberg 2000) have succeeded in establishing various native grass, shrub and forb  
15 ecotypes in southern Saskatchewan, although more research is needed to: establish proper  
16 seeding and establishment procedures and optimum seeding density; determine the advantages of  
17 mixtures versus species monocultures; determine the role that grazing animals play in  
18 perpetuating the local plant population; develop proper grazing management strategies; and  
19 evaluate the productivity of the stands in the short and long term.

## 20 **Forage production**

21 Direct comparisons of native and introduced species at Swift Current have generally  
22 examined above-ground biomass productivity as the main criteria and conclude that introduced



1 species produce more forage biomass than native species (Lawrence and Troelsen 1964;  
2 Lawrence 1978; Kilcher and Looman 1983; Lawrence and Ratzlaff 1989). However, 90% of the  
3 variation in forage production among native and introduced species in the report of Kilcher and  
4 Looman (1983) are explained by variation in stand establishment. Similarly, forage yield  
5 comparison of native versus introduced species was confounded with stand establishment in the  
6 intermountain region of the USA (Asay et. al 2001). Other studies (Coupland 1974; Dubbs et al.  
7 1974; Hanson et al. 1976) show native grasses comparing favorably with introduced species.  
8 Knowles (1987) reports that western wheatgrass excelled in pasture yields and deserves attention  
9 for seeding long-term pastures. He also notes that introduced grasses were less productive during  
10 the summer period than native species, which continue to grow. Jefferson et al. (1999) report  
11 that sites seeded with an introduced species mixture produced more forage than sites seeded with  
12 native species in Manitoba and Alberta, while there was no difference between the two types in  
13 Saskatchewan.

14 In a direct comparison of forage production of native cool- and warm-season grasses with  
15 five introduced cool-season grasses, the timing and frequency of forage harvest affected the yield  
16 differences. Introduced species produced superior forage yield when harvested in late May in  
17 1991 and 1992 (Table 2) compared to cool-season native grasses at the first of three harvests per  
18 year (Jefferson, unpublished data). The native warm-season grasses had not produced  
19 measurable forage biomass by the end of May each year. The harvest timing was changed to  
20 once (mid-July) per growing season in 1993 and 1994. By 1994, native grasses produced forage  
21 yields equivalent to the introduced species (Table 2). These results suggest that previously  
22 reported forage yield comparisons may have been biased by harvests that occurred too early and

1 too frequently during the growing season.

2 (Insert table 2 near here)

3 The biomass productivity advantage of introduced species over native species appears to  
4 depend on soil fertility (Johnston et al. 1968). Introduced species yield more forage than native  
5 range only when fertilizer is applied; unfertilized introduced species actually yield less than  
6 unfertilized native range (Johnston et al. 1968; Knowles 1987). However, ranchers in the  
7 semiarid prairie region find fertilizer application to forages to be economically risky due to  
8 variation in rainfall amount and inconsistent responses to fertilizer application. Earlier forage  
9 biomass productivity comparisons may reflect the fact that the species were grown on the Swift  
10 Current Research Centre where available soil nutrients and weed control are significantly above  
11 average. The yield of introduced grasses peaks at 2 to 3 years after seeding and decline thereafter  
12 (Knowles 1987) so forage yield comparisons may be biased by short (1 to 3 years) trials. The  
13 biomass productivity advantage of introduced species is likely less on semiarid prairie pastures  
14 than that reported from research centre trials. Crested wheatgrass may be an exception, as it  
15 appears to maintain its above-ground productivity advantage over native rangeland for long  
16 periods of time without fertilization (Smoliak et al. 1967). Crested wheatgrass pastures can be  
17 two to ten times more productive than adjacent native range (Smoliak et al. 1967; Looman and  
18 Heinrichs 1973).

19 In summary, forage yield production comparisons of native and introduced species are  
20 difficult to interpret due to the interaction of soil type, fertility, testing period, harvest  
21 management (date), climate and possibly other edaphic factors. We conclude that the advantage  
22 in forage productivity of introduced forage species under intensive agronomic management is the

1 primary reason for continued use of these species for hay and spring pasture production in the  
2 semiarid prairie region.

### 4 **Grazing and Forage quality**

5 Native grasses evolved to withstand extreme environmental conditions and buffalo  
6 grazing pressures of the original Mixed Grass prairie while introduced grasses evolved in other  
7 parts of the globe. Kamstra (1973) reported that individual native grasses each have specific  
8 seasonal growth characteristics that can vary their nutritional quality as phenological  
9 development proceeds. Therefore, direct comparison of quality components between introduced  
10 and native grasses at equivalent maturity stages cannot be made since the usual definitions do not  
11 consistently apply to range grasses. For example, many range grasses produce seed only during  
12 favorable years. In addition, Knowles (1987) and Coupland (1974) reported that western  
13 wheatgrass and northern wheatgrass exhibited a greater degree of senescence compared with  
14 cultivated grasses. Although the nutritional contents and digestibility among different native  
15 species can be quite variable during the growing season (Abouguendia 1998), cattle producers  
16 have recognized that several native species common to the prairies of western Canada retain a  
17 relatively high nutritive value during late summer and throughout fall and early winter. In  
18 addition, these native species are able to preserve their physical form; stems and particularly  
19 leaves do not decompose to any extent for some months after growth has ceased (Table 3).  
20 Referred to by cattle producers as “curing”, this remarkable property is one reason why native  
21 pastures can be grazed by cattle later in the grazing season or in moderate winter conditions with  
22 little or no supplemental feeding. Curing normally occurs during late July but can also take place

1 in mid-June or late August, depending on the season (Pigden 1953). In economic terms, the  
2 excellent curing ability of many native species can reduce animal feed costs by shortening the  
3 winter feeding period.

4 (Insert table 3 near here)

5 Cattle ranchers may not have sufficient land base of native range to exploit summer and  
6 fall grazing potential of native species and are interested in seeding native species mixtures  
7 specifically for late-season grazing. Based on seeded native-pasture in 1993 and 1994 at Swift  
8 Current, calf weight gains on pasture in fall and early winter were nearly as good as those  
9 observed in feedlots (Jefferson et al. 1997). Estimates of grazing capacity (grazing days per ha)  
10 on the native grasses were similar to those reported for introduced grasses. A monoculture of  
11 western wheatgrass exhibited better forage quality for winter grazing than a mixture of northern  
12 wheatgrass, western wheatgrass and green needlegrass. In another study, the digestibility of  
13 western wheatgrass harvested in September was 14% higher than that of northern wheatgrass  
14 (Jefferson et al. 2004). Western wheatgrass maintained good forage quality throughout the  
15 grazing season in North Dakota (Frank and Bauer 1991; Hofmann et al. 1993) but can have low  
16 quality when harvested at a late phenological stage (Smoliak and Bezeau 1967). However,  
17 Jefferson et al. (2004) results agree with Knowles (1987) that western wheatgrass has better  
18 forage quality than northern wheatgrass and has good potential for fall grazing.

19 The quantity and quality of forage produced on native rangelands are highly cyclical,  
20 within and between years and one would expect similar variation for seeded native mixtures.  
21 Precipitation, plant species, and the proportion of cool- and warm-season species would affect  
22 overall forage quality of seeded native pastures at any given point in time and as a result lead to

1 seasonal patterns of livestock gains. In general, diets from dormant native grasses contain 4 to  
2 7% crude protein with higher concentrations occurring from late summer to early fall and lower  
3 concentrations occurring from late fall through winter. Plants in a vegetative state and some  
4 shrubs such as winterfat can contain over 10% CP (Abouguendia 1998) in late fall or early  
5 winter.

6 Native rangeland consists of a diverse community of forbs and shrubs as well as grasses  
7 so forage quality of seeded native species mixtures may be enhanced by their inclusion. Shrub  
8 species, such as winterfat (*Krascheninnikovia lanata* (Pursh) Meeuse & Smit syn. *Eurotia lanata*  
9 (Pursh) Moq.), have superior forage quality for late fall and winter grazing (Smoliak and Bezeau  
10 1967; Abouguendia 1998). Winterfat can be successfully established from seedings (Romo et al.  
11 1997; Schellenberg unpublished data) and could contribute to significant improvements in cattle  
12 gains on fall and winter pastures of seeded native species. Gardner's saltbush (*Atriplex gardneri*  
13 (Moq.) D. Dietr.) has similar nutritional qualities to winterfat (Smoliak and Bezeau 1967) and  
14 could also contribute to cattle nutrition for fall grazing.

15 Livestock productivity during the grazing season can be predicted from forage quality  
16 estimates such as digestibility and protein. The digestibility of most native grasses from May  
17 until September (Abouguendia 1998) are able to meet the nutritional requirements of a lactating  
18 beef cow or a growing yearling (0.45 kg gain d<sup>-1</sup>) based on the guidelines developed by Holechek  
19 and Herbel (1986). Phosphorus (P) is the most limiting mineral to range livestock production  
20 and adequate plant P concentrations for growth or lactation occurs only for a brief period early in  
21 the growing season, i.e., vegetative phase. Calcium concentrations of native grasses are adequate  
22 for maintenance, growth and lactation throughout the year (Abouguendia 1998). Cattle grazing

1 on only native grasses in late fall, winter and early spring may require additional protein and P  
2 supplementation. Phosphorus supplementation may also be needed during the growing season to  
3 satisfy the needs of lactating cows and young cattle (Abouguendia 1998). However, including  
4 forbs and shrubs in cattle diets improve cattle performance during periods when grasses were  
5 dormant and low in quality (Holechek et al. 1989). Several studies reviewed by Holechek et al.  
6 (1989) found that leaves from forbs and shrubs contain more protein, P, and cell solubles than do  
7 grasses at comparable stages of maturity. Schellenberg and Jefferson (1998) report that two  
8 native woody shrubs, winterfat and Nuttall's saltbush (*Atriplex nuttallii* S. Wats.), found in  
9 southwest Saskatchewan and southeast Alberta retain their nutritive value well into the fall and  
10 early winter (protein concentration was 11.5%). Although information is limited on associative  
11 effects between forage species on intake, Milchunas et al. (1978) report that shrub species in the  
12 diet may increase digestibility of grasses and increase the overall digestibility of the total diet.  
13 During winter, shrubs with a higher protein concentration could improve the intake of grasses  
14 with protein levels below 7% by providing rumen microbes with a source of nitrogen (Cordova  
15 and Wallace 1975). Arthun et al. (1992) concludes that adding forbs or shrubs with low-quality  
16 grass had a similar effect on ruminal digestion kinetics and fermentation process of cattle as  
17 including alfalfa hay.

18           Research by Abouguendia (1998) revealed wide variations in nutrient contents and  
19 digestibility both among growth forms and among species in these forms. Therefore, it is  
20 important to identify the dominant species and their proportions in each field in order to make  
21 efficient use of the available nutrient supply over the entire grazing season and across the  
22 landscape. In southern Saskatchewan, the native Mixed Grass prairie is dominated by C<sub>3</sub> species

1 (Coupland and Rowe 1969); however, some C<sub>4</sub> grasses are found (Budd et al. 1987; Tober and  
2 Chamrad 1992). Since C<sub>3</sub> and C<sub>4</sub> forage grasses grow at different rates and patterns throughout  
3 the growing season, it is plausible that grazing management could alter their growth response and  
4 overall productivity in the field (Waller et al. 1994). Since C<sub>4</sub> grasses grow well in mid-  
5 summer, they can support increased grazing livestock production during the summer decline of  
6 C<sub>3</sub> forage yield and quality. Currently, a research study started in 2001 at Swift Current is  
7 evaluating the nutritional quality, above-ground biomass production and grazing performance of  
8 two native mixtures: a simple grasses/forb mixture containing cool-season species and a complex  
9 grasses/shrubs/forb mixture containing both cool- and warm-season species. Preliminary results  
10 from this study indicate that forage material harvested from the complex native mixture in  
11 August and September had protein concentration at 20 to 26% and digestibility concentration at  
12 3 to 8% greater than the simple native mixture, respectively (Iwaasa and Schellenberg 2003).  
13 Average daily gains (ADG) of beef steers on the complex native mixtures was consistent during  
14 the July to August grazing period, while ADG for the simple native mixture declined rapidly  
15 after July. In agreement, other studies (Hall et al. 1982; Ward 1988; Jackson 1999) have  
16 concluded that the incorporation of C<sub>4</sub> grasses into a pasture system can improve cattle weight  
17 gains during the summer months compared with grazing only C<sub>3</sub> grass pastures. Also, the  
18 complex native mixture can provide a forage with higher nutritional value that is better able to  
19 meet the nutritional needs of ruminants later in the growing season (Cook 1972).

20 Selective foraging by cattle (preferring some plants and avoiding others) affects the  
21 character and composition of rangelands and nutritional quality of the diet (Wallace et al. 1972)  
22 and is a possible explanation for seasonal patterns of livestock gains (Hart et al. 1983). Efficient

1 management of rangelands depends on the identification of plants that are both palatable and  
2 nutritious to grazing livestock. Vavra et al. (1977) working in Colorado and Samuel and Howard  
3 (1982) in Wyoming reported that blue grama (*Bouteloua gracilis* (H B.K.) Lag. ex Steud.) ranked  
4 the lowest in preference compared to western wheatgrass and needle-and-thread (*Stipa comata*  
5 Trin. & Rupr.) grass. Even when compared among warm-season grasses (i.e., blue grama, big  
6 bluestem, little bluestem, side-oats grama, switchgrass and sandreed grass), blue grama was  
7 consistently less preferred (Rogler 1944). However, increased consumption and selection of blue  
8 grama was observed as other, more palatable, plants become less abundant in the pasture as the  
9 grazing season progressed (Varvra et al. 1977; Samuel and Howard 1982). Some studies  
10 (Caswell et al. 1973; Kautz and Van Dyne 1978) have reported that cattle appear to avoid warm-  
11 season species and select for forbs and cool-season grasses, but Tomanek et al. (1958) found that  
12 cattle prefer big and little bluestem grasses over other warm-season grasses and western  
13 wheatgrass during the grazing season (May to August). Some plant species are relatively  
14 unpalatable or not preferred by grazing animals, yet were found to have a high nutrient  
15 concentration. Hart et al. (1983) reported that the forage quality of blue grama was high in the  
16 spring but its quality decreased more rapidly than needle-and-thread. Thus, proper grazing  
17 management may enable utilization of such plants (Abouguendia 1998). Bai et al. (1998)  
18 reported that moderate stocking rates tended to favor greater plant species diversity. Therefore,  
19 increased diversity would improve the productivity of the pasture and the nutritional status of the  
20 grazing animal. Additional research in this area is needed to understand the livestock-plant  
21 interface and how to best manipulate cattle behavior to improve rangeland forage production,  
22 forage quality, and beef production.



1 Cruz and Ganskopp (1998) found that crested wheatgrass was selectively grazed by beef  
2 steers over native grasses at vegetative and anthesis growth stages. Furthermore, some native  
3 grass species were more preferred at a mature phenological growth stage than crested wheatgrass  
4 while others were similar to it. This preference behaviour was observed both in a pasture where  
5 crested wheatgrass made up a large proportion of available forage and in a rangeland site where  
6 crested wheatgrass was more limited. These authors concluded that native grasses can provide  
7 summer and fall grazing while crested wheatgrass should be used in spring.

8 The diets of grazing cattle can also be improved by integrating native rangeland into a  
9 grazing system. Complementary grazing is currently being promoted in western Canada and may  
10 allow pastures to sustain higher stocking rates than continuous season-long grazing. In this  
11 system, cattle are moved through a sequence of pastures with forages that mature in sequence  
12 over the season. This allows the cattle access to the forage when it has its best quality (Martin  
13 and Fredeen 1999). Crested wheatgrass pastures are grazed in spring while native rangeland  
14 pastures are grazed in summer and fall. This type of system provides a method of integrating the  
15 use of native range plants with seeded pasture to delay grazing of the native range and to improve  
16 the nutrient status of grazing cattle over a longer grazing season (Adams et al. 1996). A diverse  
17 mixture of seeded-native species exhibiting improved forage quality and palatability combined  
18 with managed grazing systems will likely improve livestock performance and provide an  
19 alternative to over-grazing and potential degradation of our remaining native rangeland  
20 resources.

## 21 **Seed production**

22 Native grass species exhibit large annual and environmental seed production variation

1 (Phan and Smith, 2000; Jefferson et al. 2002). Thus, there are inadequate and inconsistent seed  
2 supplies of adapted varieties for many native plant species in the northern Great Plains of  
3 Western Canada. Phan and Smith (2000) found significant variation for seed yield and seed  
4 yield-component traits within collections of blue grama and little bluestem obtained from  
5 southern Manitoba. Generally, the most northern collections of both species showed earlier  
6 anthesis, produced less biomass, and had lower seed yield than more southern collections when  
7 grown at one location. These findings indicate that indigenous plant collections of blue grama  
8 and little bluestem show high levels of genetic diversity for seed yield and seed yield  
9 components. Genetic diversity is the basis for the development of adapted varieties through  
10 directed selection pressure for enhanced seed production capability.

11 Northern wheatgrass and western wheatgrass plants exhibit strong rhizomatous growth  
12 with reproductive tiller density declining over time, as vegetative tillers eventually dominate the  
13 sward. Slender wheatgrass seed production has been commercialized in western Canada and  
14 high seed yields are reported for this species (Lawrence and Ratzlaff 1989). While high seed  
15 yield results in low seed costs for this species, it can contribute to excessive proportions of  
16 slender wheatgrass in native species mixtures for revegetation projects. Slender wheatgrass can  
17 dominate native stands for several years after establishment due to its rapid establishment and  
18 competitive advantage over other grass species (Hammermeister and Naeth 1999).

19 Shattering of seed is common in most of the native plant species as a method of natural  
20 seed dispersal. However, it results in a major reduction in both the quantity and quality of seed  
21 harvested. The development of methods to improve seed retention may be the most important  
22 requirement to enhance the use of native plant species for seeding by improving both

1 productivity and quality of seed. Consideration must be given to risks of naturalizing native  
2 species such as reduced adaptation if seed shattering is reduced in varieties of native species.

3 Most native species have undergone limited if any selection for agronomic characteristics  
4 such as increased germination, improved seed processing and handling, better seedling  
5 establishment or reduced seed dormancy (Young and Young 1986). Baskin and Baskin (1998)  
6 note that the seeds of forbs and many native grasses are dormant. Most shrubs have varying  
7 forms of seed dormancy combined with varying lengths of viability once dispersed from the plant  
8 (Baskin and Baskin 1998). For example, winterfat seed remains viable for only a few months at  
9 ambient temperatures. Many native seeds have structures which increase difficulty of handling.  
10 White prairie (*Petalostemon candidum* (Willd.) Michx.) clover hulls are difficult to remove and  
11 inhibit germination. *Stipa* spp. have awns as well as barbs at the tip which result in lodging  
12 within seeding and cleaning equipment. Winterfat has hairy bracts which decreases flow of seed  
13 within a seeder. Nuttall's saltbush seed is encapsulated within woody bracts that protect the seed  
14 but also decrease imbibition and make assessment of seed size difficult.

15 Recent research efforts have focussed on the collection of a few native plant species in  
16 western Canada by government and non-government organizations like Agriculture and Agri-  
17 Food Canada (AAFC), Alberta Research Council, Ducks Unlimited Canada, and Prairie Seeds  
18 Ltd. Current research efforts at AAFC are focussed on characterization and further selection and  
19 development of varieties of a few native plants from collections of ecotypes made within the  
20 prairie provinces and was based on a genetic diverse population that captured the maximum  
21 genetic diversity from the original ecotypes. While genetically diverse native varieties, called  
22 ecovars™, are currently under development (Fig. 1) for large scale revegetation projects (Smith

1 and Whalley 2002), it is unknown whether these varieties have maintained genetic diversity and  
2 broad adaptation after selection for seed yield.

3 (Insert Figure 1 near here)

4 Additional research is needed to confirm the genetic diversity of the resultant populations,  
5 evaluate their range of adaptation across the region, and develop seed production technologies to  
6 ensure their commercialization.

### 7 **Soil fertility and carbon**

8 Perennial forages are usually grown on low productivity soils, and ranchers seldom  
9 manage fertility for them with the care they do for their annual grain crops (Follett and Wilkinson  
10 1995). The use of chemical fertilizers on rangelands may not be desirable because sustainable  
11 production systems are those that rely on minimal inputs of resources, such as chemical fertilizer,  
12 to achieve long-term productivity and environmental compatibility (Poincelot 1987).

13 Consequently, any sustainable production system must depend on efficient nutrient management.  
14 Improved nutrient utilization requires greater understanding of the role of biological processes in  
15 the release of nutrients from soil organic matter.

16 Soil organic matter concentration is fundamental to maintenance of soil fertility because  
17 nutrients are critical to plant growth. The rate at which nutrients are released from soil organic  
18 matter is influenced by the chemical composition of the organic matter (including crop residues  
19 and root biomass), landscape position, and climate (Gregorich et al. 1995). Plant litter, a layer of  
20 dead leaf and stem tissues found at the soil surface, is an important source of carbon input to the  
21 soil. In addition, litter is essential in sustaining the prairie ecosystem as an energy inputs for soil  
22 microbes and as a sink for plant nutrients (Wilms et al. 1994). Thus, characterization and

1 manipulation of soil organic matter (including forage residues and root biomass) concentration  
2 and nutrient mineralization rates in forage fields in the prairies is an integral part of sustainable  
3 forage production.

4           When soils are cultivated for crop production, particularly annual crops, the natural  
5 plant-soil system is modified (Gregorich et al. 1995) and soil organic matter concentration  
6 decreases. This is due to increased decay of existing soil organic matter as a result of tillage and  
7 alterations in soil temperature, water, and aeration as well as changes in the nature of crop  
8 residue (straw and root) additions (Swift et al. 1979). The planned conversion from arable  
9 agriculture to continuous grass production, either as an introduced species pasture or as a  
10 reseeded-native pasture, will result in an increase in soil organic matter levels (Dormaer and  
11 Carefoot 1996), and thereby enhance soil carbon (C) sequestration. Sequestration of current  
12 carbon in soil by enhancing soil organic matter (which is mostly carbon) has been proposed as a  
13 carbon “sink” in Kyoto protocol negotiations. In the initial implementation years of the protocol,  
14 carbon sequestration in sinks can be used as “offsets” against CO<sub>2</sub> emissions (Environment  
15 Canada 2002). Efforts to meet national targets to decrease carbon emissions for Kyoto could be  
16 aided by planting perennial native plants on land that is marginal for annual crop production. The  
17 Conservation Reserve Program land in the USA has greater soil organic carbon concentration  
18 compared to land that was in annual crops (Follett et al. 1999). Soil microbial biomass levels in  
19 the 0-60 cm depth were 28% higher in CRP soils and 81% higher in native rangeland soil  
20 compared to soils from cropland. Janzen et al. (2000) noted that soil organic carbon in rangeland  
21 soil may exceed all above-ground portions of a temperate forest and this amount can be increased  
22 by returning previously-cultivated land back into grassland.

1 Bremer et al. (1994) found crested wheatgrass accumulated more total organic soil C and  
2 light fraction C than wheat. Soil from a long-term (23 years) stand of crested wheatgrass had  
3 less soil organic carbon than adjacent native rangeland (Smoliak and Dormaar 1985). Frank et  
4 al. (1999) found that native mixed prairie had greater potential as a carbon sink than a  
5 monoculture of western wheatgrass. This may have been due to increased root mass and greater  
6 exploration of different soil strata by various species. Christian and Wilson (1999) suggested that  
7 since total C was less in soils under crested wheatgrass than under native prairie, the planting of  
8 crested wheatgrass on millions of hectares of the Great Plains may have left  $3.3 - 4.8 \times 10^8$  tonnes  
9 of C in the atmosphere that otherwise would have been stored as soil organic matter by native  
10 grass. Thus, if C sequestration is a management goal, then native species should be preferred to  
11 introduced forage species for sequestration projects on the prairies.

12 Grazing stimulates aboveground production, increases tillering, and rhizome production,  
13 and may stimulate root respiration and root exudation rates (Schuman et al. 2002). All of these  
14 factors can result in a change in the amount of C or N being released or stored in the soil system.  
15 Several studies (Schnabel et al. 2001; Schuman et al. 2002 ) have concluded that some grazing  
16 management strategies (i.e., grazing intensity) can assist in the rapid incorporation of C into the  
17 soil, leading to increased soil organic carbon (SOC) levels. The study by Schnabel et al. (2001)  
18 further concluded that the SOC sequestration potential was considerably higher for lightly and  
19 heavily grazed pastures if they were hayed monthly ( $1.5$  and  $1.8 \text{ MT C ha}^{-1} \text{ yr}^{-1}$  vs  $0.3 \text{ MT C ha}^{-1}$   
20  $\text{yr}^{-1}$ , respectively). Henderson (2000) measured SOC storage in grazed and ungrazed areas at  
21 nine native grassland sites on the southern Canadian prairies and found soil C tended to be higher  
22 under grazing than in ungrazed exclosures at semi-arid sites (mean annual precipitation of 328 to

1 390 mm). However, at sub-humid sites (mean annual precipitation of 476 mm) the trend was  
2 reversed, suggesting that SOC sequestration depends on factors, such as climate, soils, previous  
3 management and potential net primary productivity (Follett 2003). In Canada, it is estimated  
4 that about 22 M ha of land is rangeland and improved forage lands while about 5 M ha of land is  
5 cultivated marginal land (CLI 4, 5 & 6) that is economically and environmentally unsustainable  
6 across the three western provinces (Smith and Hoppe 2000). Through the potential reseeding of  
7 native forage species, this large land resource, could greatly contribute towards decreasing  
8 greenhouse gases by sequestering more C into the soil sink.

## 9 ECOLOGICAL CONSIDERATIONS

### 10 **Biodiversity**

11 Biodiversity is essential for livestock production on native prairie. By increasing the  
12 number of species present, there are more choices of nutritious and palatable forage resources for  
13 grazing ruminant livestock (Smoliak and Bezeau 1967). As described above, later maturing forb  
14 or shrub species can improve nutritional quality. Ecosystem productivity increases as  
15 biodiversity increased on Tall-Grass prairie in Minnesota (Tilman et al. 1996). Tilman and  
16 Downing (1994) also found primary production was more resistant to drought stress with  
17 increased biodiversity. Current research suggests that a more diverse and complex mixture of  
18 cool and warm season grasses combined with shrub and forb species produced more steer gains  
19 in late summer compared to a simple mix of cool-season grasses (Iwaasa and Schellenberg  
20 2003). Mixed prairie was the forage of choice in August and September as opposed to  
21 monoculture crested wheatgrass (Schellenberg et al. 1999). The proportion of shrub species,  
22 including winterfat, in revegetation seed mixtures was higher when biodiversity and habitat

1 restoration were primary objectives compared to mixtures seeded for watershed protection and  
2 soil erosion control in Nevada, USA (Richards et al. 1998). These authors concluded that the  
3 cost of diverse native species seed mixtures frequently restricts their use, even by government  
4 agencies or NGOs whose own policies promote the use of natives.

5         Increased plant biodiversity can decrease resource limitations such as N through  
6 biological N fixation (Schellenberg and Banerjee 2002) thus increasing forage productivity.  
7 Wilson (2000) found that increased biodiversity can also increase heterogeneity of abiotic  
8 resources. Heterogeneity of nutritional resources often vary over time as well as space and small  
9 differences may have impacts on plant physiology and competition (Bakker 2000). Increased  
10 biodiversity can result in several levels of competition for soil nutrient resources (Wilson 2000).  
11 Davis (2003) suggests the available soil nutrient resources is often the deciding factor in the  
12 success of invasive species. There exists the possibility then that diverse mixtures of re-seeded  
13 native species may be less susceptible to invasion by exotic weeds but this hypothesis needs to be  
14 examined with additional research.

15         The decision between native or introduced species in rangeland seeding is a multiple  
16 component process that includes philosophy, objectives, site potential and limitations,  
17 availability and cost of plant materials, weed invasion, desired community seral stage, and  
18 economic limitations (Jones and Johnson 1998). Critics of varieties developed from native  
19 species suggest that they introduce undesirable genetic change in natural landscapes (Jones and  
20 Johnson 1998). However, Jones and Johnson (1998) document several known, naturally-  
21 occurring interspecific hybrids on grasslands to support their position that genetic change and  
22 intra-specific diversity can occur without human intervention. While genetically diverse



1 populations or localized varieties of native species would be ideal for re-vegetation, such ideals  
2 are often unavailable or too expensive for large scale projects. Knowledge of an individual  
3 species' genetic variation in relation to its ecological adaptation and their interactions with other  
4 ecosystem components is needed to make the best decisions.

### 5 **Climate change**

6 In the near future, climate change will alter crop species and their productivity in the  
7 current agricultural regions of the USA (Antle 1997). World Resources Institute (1990) predicted  
8 that the mean May-August temperatures will rise by 3.5 °C, and the frost-free growing season  
9 would lengthen by four to nine weeks with increased frequency of drought in July and August on  
10 the Northern Great Plains of North America. Environment Canada (2001) projects a similar 3 °C  
11 annual temperature increase for the prairie region of western Canada. As the climate warms up,  
12 plant communities would shift in favour of species that tolerate water and high temperature  
13 stress. Cutforth et al. (1999) examined long term (50 y) weather records of an area 15,000 km<sup>2</sup>  
14 of semiarid prairie southwest of Swift Current, Saskatchewan and found that winter and spring  
15 maximum and minimum temperatures have increased and precipitation has decreased. Climate  
16 change has been linked to plant species migration (Root et al. 2003) and to shifts in species  
17 ranges (Higgins et al. 2003). Pastures and rangelands are thought to be very sensitive to climate  
18 change (Gregory et al. 1999). These changes in species composition may have large impacts on  
19 livestock production capabilities due to possible changes in nutritional quality and time of  
20 availability (Gregory et al. 1999). Species richness has declined with climate warming (Sala et  
21 al. 1999). Climate warming over several centuries in southwestern Saskatchewan has favoured  
22 C<sub>3</sub> species over C<sub>4</sub> species at Grasslands National Park located in the semiarid prairie region near

1 Val Marie, Saskatchewan (Peat 1997). Perhaps this result should not be surprising given the  
2 biochemical advantage of C<sub>3</sub> photosynthesis compared to C<sub>4</sub> photosynthesis at ambient CO<sub>2</sub>  
3 concentrations. Analysis of long term vegetation data in Colorado (Alward et al. 1999) found a  
4 similar shift in production in favour of C<sub>3</sub> species over several decades. Native species may  
5 provide useful genetic resources to respond to future climates of the Northern Great Plains.  
6 Further research is required to elucidate the potential economic of climate change on livestock  
7 production and society's appreciation of grassland landscapes.

### 8 **Bio-invasion**

9 Re-seeding native species for forage and grazing may be preferable to seeding introduced  
10 forage species because some introduced forage species have contributed to bio-invasion of  
11 neighbouring native plant communities. Bio-invasion involves the replacement of native species  
12 by exotic species, which were usually introduced to the environment through human activity. As  
13 many as 80% of the world's endangered species are threatened due to the competitive pressures  
14 of introduced or exotic species (Armstrong 1995). However, Davis (2003) states that no  
15 introduced plant species has caused extinction of another plant species but may have contributed  
16 to extinction via competition-mediated reduction in fitness. The primary cause of extinction is  
17 habitat loss which can be associated with climate change and bio-invasion working together with  
18 human development pressure. Sala et al. (1999) found that the invasion of exotic species into  
19 natural systems is a powerful driver of global change. Both climate change and exotic plant  
20 invasion contribute to habitat fragmentation and decline in biodiversity.

21 Bright (1998) provides the following example from Australia's attempt to identify  
22 superior forage species. During European settlement of Australia 466 plant species were

1 introduced for hay and/or pasture production but only 21 species showed merit. Seventeen of  
2 these 21 forage species were deemed to be invasive of adjacent native rangeland. Thus, only four  
3 out of the 21 species with merit were deemed non-invasive.

4 Davis (2003) concluded that 4000 plant species have been introduced into North  
5 America. Most were introduced for food, fibre and ornamentals for humans (Pimental et al.  
6 2000). Further introduced species account for 98% of the food production in the U.S.A. Among  
7 the introduced forage species, D'Antonio and Vitousek (1992) conclude that alien grass species  
8 invasion is most severe in the arid and semi-arid west of the U.S.A. Annual grass invasions were  
9 largely unplanned, while many perennial invasive grasses were purposely introduced for  
10 livestock forage or to prevent soil erosion (D'Antonio and Vitousek 1992). This use of  
11 introduced forage grass species throughout North America for pastures and erosion control led to  
12 the widespread distribution and dominance of several species (Haber 1996). Smoliak and  
13 Dormaar (1985) estimated that 1,000,000 hectares have been seeded to crested wheatgrass alone  
14 in the Canadian prairie provinces and this area has undoubtedly increased in the 20 years since  
15 1985. White et al. (1993) consider smooth brome grass (*Bromus inermis* Leyss.), yellow  
16 sweetclover (*Melilotus officinalis* (L.) Pall.), and white sweetclover (*Melilotus alba* Medic.)  
17 moderately invasive and alfalfa, crested wheat grass, and Kentucky blue grass (*Poa pretensis* L.)  
18 minor invasive species of uplands. It is noteworthy that all these species were introduced for  
19 pasture or hay production in Canada.

20 The proportion of exotic flora on the prairies of western Canada was estimated to be 16%  
21 (Haber 1996) and Davis (2003) estimated that it was 20% for North America. In Saskatchewan,  
22 smooth brome grass and crested wheatgrass were deemed invasive in native fescue grassland

1 (Romo and Grilz 1990). Crested wheatgrass pasture was not invaded by native plant species  
2 until stands were more than 15 years old (Looman and Heinrichs 1973). Even when native  
3 species were found in old crested wheatgrass stands, their contribution to above ground biomass  
4 did not exceed 10% of the total annual forage production. Thus, crested wheatgrass  
5 monocultures seedings appear to resist successional species change even under heavy grazing  
6 utilization. Similar results were found in crested wheatgrass pastures of southern Alberta  
7 (Smoliak et al. 1967). The bio-invasive risk of introduced forage plant species has not been  
8 systematically evaluated for most introduced forage species of the semiarid prairie.

9       Caution must be used in recommending restrictions on the use of these introduced forage  
10 grass species. A large proportion of the range livestock industry of the Northern Great Plains  
11 depends on these introduced species and economic losses could occur if a wholesale move to  
12 natives only was forced by legislation or government policy. Firstly, there is not sufficient seed  
13 for such action. Secondly, more research is necessary to assess the capabilities of native species  
14 varieties. To date only a relative few native species have been examined and some lack even the  
15 basic agronomic information. One must also realize that many of these lands were seeded to  
16 reduce erosion (Gray 1996) and removal of the introduced species and the vegetative cover they  
17 provide without an adequate plan for replacement native species could result in environmental  
18 disaster.

19       The issue of exotic bioinvasion in Canada lacks practical action on the Government's part  
20 (Commissioner of the Environment and Sustainable Development 2002) . Efforts are being  
21 made to address the issue within Agriculture and Agri-Food Canada's research portfolio.  
22 Management of invasive introduced species, their impact on native plant communities in the

1 agricultural context, and the environmental context as well as invasive potential of native species  
2 require further research.

### 3 **MANAGEMENT IMPLICATIONS**

4 The controversy over the relative advantages and disadvantages of using native versus  
5 introduced species for forage production and grazing has raged for decades in the Northern Great  
6 Plains region. A new paradigm for selecting plant species was proposed by Brown and Amacher  
7 (1999). They suggested that introduced or exotic species are those which dominate early in  
8 ecological succession (early seral) and are characterized by high biomass yield, fast growth rates,  
9 high seed production, aggressive growth habit, and responsiveness to soil fertility. Native  
10 species can be characterized as those which dominate late successional (late seral) stage  
11 communities and exhibit slower growth rate, variable seed production, compatibility with other  
12 species, and adaptation to low soil fertility. Brown and Amacher (1999) present a model where  
13 all species would be considered depending on the goals and objectives of the restoration project.  
14 Our review has shown that both native and introduced species have distinct advantages  
15 depending on the intended use.

16 Native plant species will contribute to sustainable agricultural systems of the new century  
17 in the semiarid prairie. We conclude that more research is needed on several topics. The genetic  
18 diversity of new native plant varieties needs to be established and the value of intra-variety  
19 genetic diversity compared to intensively selected varieties confirmed. In addition, the  
20 geographic range of adaptation of native varieties and their role in summer and fall grazing by  
21 beef cattle needs to be determined. Seed production technology to permit efficient  
22 commercialization of these species needs to be studied. For some species, this may be as simple

1 as documenting techniques developed by individual producers, while for other species, research  
2 into seed dormancy will be required. The establishment of shrub species to improve rangelands  
3 for fall and winter grazing also needs further study. Changes in soil organic carbon after seeding  
4 native species on previously cropped land need to be quantified, including the impact of species  
5 type and grazing management on the rate and extent of carbon sequestration.

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Table 1. Establishment of native grasses in three studies.

Common name	Latin name <sup>1</sup>	Kilcher and Looman 1983	Jefferson et al. 2002	Jefferson unpublished data
<u>Introduced species</u>		-----%-----		
Crested wheatgrass	<i>Agropyron desertorum</i> (Fisch. ex Link) J.A. Schultes	100	--	100
Russian wildrye	<i>Psathyrostachys juncea</i> (Fisch.) Nevski	100	--	100
<u>Native species</u>				
Northern wheatgrass	<i>Elymus lanceolatus</i> (Scribn. & J.G. Sm.)	90	98	--
Western wheatgrass	<i>Pascopyrum smithii</i> (Rydb.) A. Love	80	94	--
Green needlegrass	<i>Nasella viridula</i> (Trin.) Barkworth	90	98	96
Big bluestem	<i>Andropogon gerardii</i> Vitman.	5	89	94
Little bluestem	<i>Schizachyrium scoparium</i> (Michx.) Nash	3	44	--
Prairie sandreed	<i>Calamovilfa longifolia</i> (Hook.) Scribn.	5	68	95
Indiangrass	<i>Sorghastrum nutans</i> (L.) Nash	11	32	80
Switchgrass	<i>Panicum virgatum</i> L.	--	86	100
Sand dropseed	<i>Sporobolus cryptandrus</i> (Torr.) Gray	6	--	23
LSD <sub>0.05</sub>		NR <sup>2</sup>	7	21

<sup>1</sup> Nomenclature after Alderson and Sharp 1994<sup>2</sup> NR- Not reported.

Table 2. Forage yield ( $\text{kg ha}^{-1}$ ) of introduced and native forage grass species clipped 3 times per season for 1991 and 1992 and once per season for 1993 and 1994 at Swift Current, Saskatchewan. Least significant difference (LSD) values and probability of contrasts between groups of species are shown.

Species	1991			1992			1993	1994
	May 30	Jul 9	Aug 20	May 28	Jul 15	Oct 22	Jul 16	Jul 14
<u>Introduced Grasses</u>								
Crested wheatgrass	3810	2800	700	840	560	500	920	4430
Intermediate wheatgrass	2500	3370	2050	270	1670	100	960	4050
Russian wildrye	1740	1950	850	960	710	270	1220	3910
Tall Fescue	1740	4240	1470	720	1250	650	760	4210
Tall Wheatgrass	2030	4690	1150	700	1530	610	1070	4540
<u>Native cool-season</u>								
Beardless wildrye	400	1080	410	50	670	160	460	4130
Green needlegrass	650	1730	1160	460	920	410	1120	5400
Junegrass	280	20	--	240	0	--	150	3300
<u>Native warm-season</u>								
Big Bluestem	--	200	220	--	660	100	410	4830
Blue grama	240	280	280	--	800	430	400	4690
Indian ricegrass	--	--	--	--	70	60	230	3110
Indiangrass	--	230	780	--	590	280	--	3590
Prairie sandreed	190	560	270	--	600	180	660	5400
Sideoats grama	--	190	580	--	260	300	--	3150
Switchgrass	--	560	460	--	1340	310	650	4900
Sand dropseed	--	--	--	--	--	--	500	3200
LSD	720	900	920	600	560	350	NS	1200
P>F Introduced vs Native	<0.001	<0.001	0.001	0.007	<0.001	0.024	--	0.75
P>F cool- vs warm-season	0.487	0.013	0.228	N.A.	0.519	0.669	--	0.565

Table 3. Native grass and shrub species that exist in the prairie areas of Saskatchewan and Alberta that demonstrate the ability to cure to a greater or less degree (Pigden 1953)

Common name(s)	Latin Name
Speargrass, Needle-and-thread	<i>Stipa comata</i> Trin. & Rupr. <sup>2</sup>
Blue grama grass	<i>Bouteloua gracilis</i> (Willd. ex Kunth) Lag. ex Griffiths <sup>1</sup>
Western wheatgrass	<i>Pascopyrum smithii</i> <sup>1</sup>
Northern wheatgrass	<i>Elymus lanceolatus</i> <sup>1</sup>
June grass	<i>Koeleria gracilis</i> Pers. <sup>2</sup>
Rough fescue	<i>Festuca hallii</i> (Vasey) Piper <sup>2</sup>
Porcupinegrass	<i>Stipa spartea</i> Trin. <sup>2</sup>
Salt sage	<i>Atriplex nuttallii</i> S. Wats. <sup>2</sup>
Winterfat	<i>Krascheninnokovia lanata</i> (syn. <i>Eurotia lanata</i> (Pursh) Moq. <sup>2</sup>

<sup>1</sup> Nomenclature after Alderson and Sharp 1994

<sup>2</sup> Nomenclature after Budd et al. 1987

Figure 1. Scheme for development of varieties or ecovars™ of native plant species (adapted from Smith and Whalley 2002).

