SELECTING PLANT MATERIALS FOR RECLAMATION PROJECTS IN NORTHERN ECOSYSTEMS

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Abstract

Revegetating mine sites in the mountains and sandy soils of Alberta is often difficult due to the high stress environments found at such sites. One problem with using native plant materials is to find an inexpensive seed/plant material source. In many cases, the choice for plant materials is limited and we may not know how well the plant materials will do in its destined environment. The reasons for wide use of introduced species are that the seeds are readily available and are inexpensive. In 1983, the Alberta Research Council (ARC) undertook a native plant development program to address the lack of the seed source for native species on the commercial market. Our experiences working on plant development and revegetation studies suggested that the native species are actually well-adapted to the region and often out-perform tame and non-indigenous species thus limiting the adverse effects on biodiversity and landscape fragmentation that result when introduced plant cultivars are used. In fact, the use of indigenous species in reclamation projects ensures the long-term sustainability of the ecosystem. To avoid many problems associated with using non-native species, programs like the ARC's can be aimed at developing stable sources of plant species, along with appropriate revegetation techniques to meet the needs of mining and other resource industries in the north.

Key Words: reclamation, plant development, restoration, native grasses, revegetation, high elevation, sensitive environments.

Introduction

Increasing public awareness of environmental issues has led to increasing concern about the need to protect the natural environment and conserve biodiversity. Past revegetation efforts in North America were based on general adaptability of introduced grasses and their availability. Because of the competitive nature and persistence, these introduced species have out competed the native species in places where they have been seeded (Adams et al. 2003), resulting in landscape fragmentation, reduced soil quality (Dormaar et al. 1995), reduced range productivity and decreased ecosystem diversity and functioning as they will not allow native species to invade the disturbed area (Martens and Younkin 1989). To address this concern, for example in Alberta, several government agencies such as Alberta Environment, Alberta Sustainable Resources Development now recommend that disturbed sites be revegetated with appropriate native plant species.

There are many advantages to using native plants, including better adaptation to local climate and soil conditions such as to low nutrient conditions, require fewer inputs to establish and maintained a vigorous stand. For example, at high elevations, such as those found in the mountains of Alberta, native grasses are adapted to the short, harsh growing seasons where introduced grass cultivars do not grow well and may require high amount of fertilizer to maintain their vegetative cover (Thornburg 1982). At lower elevations or in less stressful conditions, many introduced species are highly competitive and do not allow re-invasion of native plants from surrounding areas and they may even invade into areas where they are not wanted.

In northern regions (Northwest Territories and Yukon) industrial development such as mining and oil and gas extraction has created a need to balance economic development with environmental stewardship. In other words, for industries to reduce their footprint on the landscapes, they must demonstrate a low net impact from operations and have the ability to achieve reclamation goals. To date minimal native species are available for reclamation activities in northern climates. As a result, industries have tended to rely on the use agronomic seed mixes or native species non-indigenous to the area for their reclamation projects. A recent report conducted for the Department of Resource, Wildlife and Economic Development, NWT (Gartner 2003, Personal communication with Larry Roy) identified many research gaps including the need to determine long-term recovery rates of disturbed vegetation communities and the need to research the use of native plant materials and their successes for revegetation of disturbed lands.

In this paper I will discuss the Alberta Research Council's native plant development research in two different environments: the Eastern Slopes of Rocky Mountains of Alberta and the Ribstone Creek Ecological Area. Both areas have harsh environmental conditions similar to northern climates. I will also draw from the experiences we gained in these studies and attempt to apply it to reclamation projects in the north.

Methods

The ARC's Native Plant Development Program started in 1984. We conducted systematic collections of early successional species such as slender wheatgrass (*Agropyron trachycaulum* (Link) Malte) and alpine bluegrass from the eastern slopes of the Rocky Mountains. Plants of these species were collected from over 300 sites ranging from the Canada-United States border to Jasper National Park. Collected plants were transplanted to field nurseries at the Alberta Research Council, in Vegreville, Alberta. The best plants were selected based on the performance in the field nurseries and in progeny trials. The best lines of alpine bluegrass and slender wheatgrass were then evaluated in provenance trials located at Vegreville (elevation 640 m), Columbia Icefields (Jasper National Park, elevation 1860 m), Lookout Mountain (Banff National Park, elevation 2400 m), and Mountain Park (south of Cadomin, elevation 1800 m). Both seeded and transplanted trials were used. Lines of each species were developed using a pedigree selection method (self-pollinated species only). Therefore, each line was derived from the seed of a single collected plant and maintained separately through successive generations. In this paper I only discuss the performance of wheatgrasses as they have a wide geographical distribution and are commonly used by reclamationists.

In the Ribstone Creek Ecological Area, we followed similar procedures and collected seeds of early successional species such as Canada wild rye (*Elymus canadensis* L.), awned wheatgrass (*Agropyron subsecundum* Link A. S. Hitch. of Ed. 1), nodding brome (*Bromus anomalus* Rupr. ex Fourn), blue grama (*Bouteloua gracilis* [HBK] Lag.) and Indian rice grass (*Oryzopsis hymenoides* Michx.) from several locations within the sandy uplands of east central Alberta. Seeds were germinated in the greenhouse and the germinants transplanted in the Vegreville field nurseries. Since plant lines of each species from the performance nurseries show no morphologically distinct differences and have similar maturity dates, an equal amount of seeds of each population within similar species were used to create a single line. These lines were then tested in provenance trials at Edgerton (seeded in 2002) and Beaverlodge (seeded in 2003). We used a randomized complete block designs with 6 blocks for most of these trials except for the Ribstone Creek plots where we used four blocks. Data from these trials were subjected to SAS analysis of variance (SAS Institute, Inc. 1989) and were used to support the commercial releases of the best lines as plant varieties.

Results

In provenance trials at Columbia Icefields and Mountain Park in 1993, many of the selected lines and ARC varieties outyielded the check varieties, Revenue and Elbee northern wheatgrass (*Elymus lanceolatus*) (Table 1). ARC mountaineer, line 72, and ARC highlander produced the most seed and seed heads. There were few differences among lines for plant height and plant width. Among the selected lines, broadglumed wheatgrass lines matured earlier while the awned wheatgrass matured later. Revenue was not mature by early September prior to the first frost.

Table 1. Mean performance of selected wheatgrass lines in transplanted provenance trials at Columbia Icefields and Mountain Park in 1993

	Number of heads per plant[†]	Seed yield mg/plant	Plant height cm	Plant width cm
Trial (n=60)[‡]:				
Columbia Icefields (T1)	0.5A	34.3A	35.3A	5.8A
Mountain Park	0.4A	6.3B	28.7B	7.4A
LINE (n = 10)[¶]:				
72	1.5a	69.2a	28.1ab	7.1a
ARC Mountaineer	1.7a	76.3a	23.6b	6.4a
ARC Highlander	0.5b	28.6a	36.3ab	5.9a
281	0.3b	18.5a	34.1ab	5.2a
283	0.3b	18.6a	39.8a	5.8a
286	0.5b	24.4a	39.2a	5.6a
290	0.3b	3.5a	31.0ab	10.2a
292	0.0b	0.0a	-	5.8a
296	0.1b	3.4a	31.0ab	5.6a
ARC Hillcrest	0.0b	0.0a	-	4.8a
Revenue	0.2b	0.7a	24.3b	4.0a
Elbee	0.0b	0.0a	-	12.9a

[†]Means within columns followed by the same letter are not significantly different by Duncan's new multiple range test ($P \leq 0.05$).

[‡] T1 at Columbia Icefields was established in 1988. The trial at Mountain Park was established in 1989.

[¶]Lines 72 and ARC Mountaineer are broadglumed wheatgrass; ARC Highlander and lines 281, 283, 286, and 290 are slender wheatgrass; lines 292, 296, and ARC Hillcrest are awned wheatgrass.

Percent of row covered by plants for these grasses at the mountain trials was reduced from 1992 to 1993, reflecting the harsh environmental conditions (Table 2). The trials at Mountain Park had better plant stands than those at Columbia Icefields in year 2. Among lines, there were no consistent trends, although lines ARC Mountaineer and M1 (ARC Mountaineer and another broadglumed wheatgrass) had the highest cover in both years.

Table 2. Mean percent cover of selected wheatgrass lines in multi-location trials at Columbia Icefields and Mountain Park in 1992 and 1993

	Percent cover	
	1992[†]	1993
LOCATION (n = 48):		
Columbia Icefields - Trial I[‡]	80.4A	22.6C
Columbia Icefields - Trial II	45.2C	17.0C
Mountain Park - Trial I	55.7B	46.7A
Mountain Park - Trial II	36.9D	37.0B
Line (n = 24):		
M1 (137+144)[¶]	62.1a	36.0a
137	54.2abc	31.5a
ARC Mountaineer	59.2ab	36.2a
M2 (279+281+286)	51.2bc	29.0a
ARC Highlander	53.5abc	29.4a
M3 (292+296+299)	47.5c	23.8a
ARC Hillcrest	55.0abc	27.5a
Revenue (check variety)	53.8abc	33.1a

[†]Means within a column followed by the same letter are not significantly different by Duncan's new multiple range test ($P \leq 0.05$).

[‡]Trial I was seeded in 1990 and Trial II was seeded in 1991. At the mountain sites, none of the varieties produced seed heads by 1993 even though plants in Trial I were in their fourth year of growth.

[¶]M1, 137, and ARC Mountaineer are broadglumed wheatgrass; M2 and ARC Highlander are awnless slender wheatgrass; M3 and ARC Hillcrest are awned slender wheatgrass.

At Ribstone Creek, we noticed considerable differences among the locally collected species and their check varieties (Table 3). For example, the prairie awned wheatgrass differed in plant height, number of heads, and matured earlier compared to ARC Hillcrest ecotype. The plants also differed in colour. ARC Hillcrest is an ecotype adapted to the foothills and mountain regions of Alberta, is bluish- green in colour and has an average height of 45 cm. When tested in the prairies ARC Hillcrest shows an average height of 64-71 cm. The prairie ecotype had an average height of 79-86 cm and was green-coloured.

Table 3. Emergence, mean seed yield, number of heads, and plant height for awned wheatgrass, blue grama, nodding brome, Canada wild rye, and Indian rice grass in the first year of seed production at Ribstone Creek, Alberta

Trial (n=78)	Line/Variety	Emergence plants per metre	Plant height (cm)	Number of heads/m^2	Days to harvest (as of April 15)	Seed yield (kg/ha)
Elymus canadensis	101-1	6a	107a	45a	148a	178.2a
	101-2	8a	104a	38a	148a	177.4a
	'North Dakota'	1b	-	-	-	-
Agropyron subsecundum	102-1	4a	79a	35a	118a	100.9a
	'AEC Hillcrest'	6a	71a	17b	141a	32.6a
Bromus anomalous	103-1	9a	66	33	118a	92.5a
	'Tannas'	1b	-	1	118a	0.1a
Oryzopsis hymenoides	104-1	2a	77a	3	128a	1.4a
	'Nezpar'	3a	87a	1	118a	0.4a
Bouteloua gracilis	105-1	3b	34	39a	148	7.1a
	105-2	4b	28	32.7a	148	2.3b
	105-3	7ab	16.3	35.7a	148	1.5b
	'Bad River'	12a	15	46.9a	148	0.7c

*Numbers with different letters are significantly different by column within species according to Tukey's multiple range test of the SAS statistical package.

Among the blue grama collections, all native blue grama had similar head counts and maturity dates (Table 3). The Bad River ecotype had better emergence, was 13 to 19 cm shorter, had similar maturity dates and produced more seed heads compared to the locally collected ecotypes. The locally collected ecotypes of Canada wild rye have similar plant heights, seed heads and maturity, but differed considerably from the 'North Dakota' ecotype. 'North Dakota' Canada wild rye had poor emergence, which resulted in poor stand showing.

The native brome grass collection performed considerably better than the ‘Tannas’ brome grass collection (Table 3). The ‘Tannas’ brome grass collection had poor emergence, which resulted in poor plant performance. Nine plants per metre were recorded for ARC native brome grass line compared to none for Tannas brome grass. The seeds we received were three years old and we did not check for germination prior to planting, which resulted in poor seedling emergence. Comparing ‘Nezpar’ to ARC line 104-1, we noticed that the locally collected ecotype was shorter in height, produced more seed heads and matured 10 days later than ‘Nezpar’ Indian rice grass.

Compared to the Beaverlodge location (Table 4), the experimental lines showed better adaptation to northern Alberta conditions than ‘North Dakota’ wild rye, ‘Tannas’ brome grass, ‘AEC Hillcrest’, and ‘Bad River’ blue grama. These check varieties need a longer growing season to produce mature seeds. This location was chosen as it is within a major seed production region.

Table 4. Emergence, plant vigor, plant height, days to harvest and mean seed yield, for awned wheatgrass, blue grama, nodding brome, Canada wild rye, and Indian rice grass in the first year of seed production at Beaverlodge, Alberta in 2004

Species	Line/Variety	Emergence plants per metre	Plant vigor	Plant height (cm)	Days to harvest (as of April 15)	Seed yield (kg/ha)
Elymus canadensis	101-1	12a*	5a	151a	127a	1330a
	101-2	9a	5a	151a	123a	1480a
	'North Dakota'	1b	1b	-	-	-
Agropyron subsecundum	102-1	31a	5a	121a	102a	447b
	'AEC Hillcrest'	26a	5a	101b	110a	693a
Bromus anomalous	103-1	24a	5a	96a	116a	1175a
	'Tannas'	1b	1b	-	-	0b
Oryzopsis hymenoides	104-1	43a	5a	72a	123a	681a
	'Nezpar'	35a	5a	80a	123a	523b
Bouteloua gracilis	105-1	3b	1.3b	.	32b	0
	105-2	3b	1.3b	.	25b	0
	105-3	11ab	2.0ab	.	36b	0
	'Bad River'	12a	2.3a	.	45a	0

*Numbers with different letters are significantly different using Tukey's multiple range test of the SAS statistical package (SAS Institute Inc, 2002).

Discussion

Our research demonstrated the importance and usefulness of native grasses as compared to introduced species or native non-indigenous to the region. Native plant species are adapted to the environment in which they have evolved. The lines of slender wheatgrass used in this project were collected from the mountains and foothills of Alberta. In trials at mountain sites, these lines performed better than the introduced species. Also in the Ribstone Creek Ecological Area, the native test lines perform better than the check varieties. This confirms the results of previous researchers who found that over the long term native plants grew better than introduced species in harsh environments such as those found at high elevations, or in sandy soils (Brown et al. 1976). Our test results show that most of the ARC test lines had better emergence and earlier maturity compared to the check varieties. Early maturity of these species is an important adaptation characteristic. These plants are therefore capable of reproducing viable seeds where as the introduced species may not.

Using available commercial native species in reclamation projects may cost the industries more dollars due to the poorer adaptation and later maturity of some of these available varieties (Figure 1). Plant lines that fail to mature and produce viable seeds within the short growing season can neither contribute to the genetic integrity of the plant community nor to the long-term sustainability of the plant community. Therefore choosing appropriate plant materials to reclaim man-made disturbances can have important consequences such as short-term success versus long-term failures; the plants appear vigorous in the first few years and die back slowly.

Figure 1. Revegetating the shoreline of a tailing pond in at a mine site in the NWT. The brown patch on the left hand side shows dead vegetation one year after seeding. The right hand side of the picture shows newly seeded vegetation.

Industries also tend to use to a heavier seeding rate to attain an 80% or better plant cover. In our study we seeded our test plot at a seeding rate of approximately 10 kg/ha compared to 16-25 kg/ha normally used by industries. Furthermore, well-adapted plants in reclamation projects not only survive and reproduce under existing conditions, but they are more adapted to the rare and infrequent events such as drought, climate change or contaminants in the soil. Revegetation criteria have in most time require a minimum of 80% plant cover for the site to be considered reclaimed and past revegetation practices have focused more on a rapid establishment of the disturbed site without considering the genetic integrity of the plant community.

We want to ensure that disturbed lands are restored to a condition comparable to the ecosystem of the area and depending on the industry's reclamation goal, locally adapted and proven plant materials can be used to restore varying degrees of plant community diversity. Some of the commercially available native species may not be suitable to the northern climate and site conditions.

Conclusion

There is an urgent need to conserve biodiversity and to reduce the impact of industry's footprint on native landscapes. However, land managers and industry may view the lack of adapted indigenous species, specific seeding techniques and seed mixes as barriers to effectively create sustainable plant communities in the north. The use of performance-tested varieties eliminates the need for trial and error when it comes to industries to decide on what species to use in a seed mix.

When reclaiming disturbed sites, native plant species are essential in returning the land to the condition it was in prior to disturbance. One problem with using native grasses is finding an inexpensive seed source. Many species from further south are widely used. Research programs, like the one at the Alberta Research Council aimed at developing ecological varieties of native plants and reclamation techniques for mining and related industrial development.

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