Proceedings of the 5th Annual British Columbia Mine Reclamation Symposium in Cranbrook, BC, 1981.
The Technical and Research Committee on Reclamation

INFLUENCE OF CULTIVATED GRASSES AND LEGUMES ON THE ESTABLISHMENT SUCCESS OF NATIVE GRASS MIXTURES AT TWO ABANDONED COAL MINES IN THE SUBALPINE REGION OF ALBERTA

by

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ABSTRACT

Field experiments on land disturbances in the subalpine region of Alberta have indicated that, with a great majority of the native grass species tested, plant cover development necessary for rapid erosion control is generally slower than with the cultivated varieties. The objective of the present study is to define seed mixtures that will produce erosion-controlling cover and ultimately evolve into mature native plant communities.

Identical trials were established on both raw overburden and overburden topdressed with mineral soil on two abandoned subalpine coal mines to assess the influence of cultivated grasses and legumes on the establishment and performance of native grass mixtures. This report covers assessment results after the second growing season. Parameters discussed include percent plant cover, and a general assessment of species frequency.

INTRODUCTION

Reclamation of coal-mines disturbances in high elevation alpine or subalpine environments represent unique and often difficult challenges in land management. The high value of these areas for watershed, wildlife range and recreation serve to emphasize the need for successful reclamation. Unfortunately, there is a paucity of information with respect to rehabilitation of disturbed alpine or subalpine sites. Expertise developed for more temperate zones cannot always be applied to high elevation situations where a different and/or more critical set of environmental constraints are encountered. Of particular importance is the low heat budget under which plant species must complete their life cycle (Brown and Johnston 1979, Root 1976). Brown and Johnston (1979) suggest that three important and interrelated variables must be considered for successful high elevation rehabilitation: 1) overall climatic factors; 2) physiological adaptations of the plant; and 3) factors of the disturbed environment.

One phase of the Alberta Forest Service research program is directed at evaluating the physiological adaptations of native grasses for reclamation purposes. Emphasis has been placed on species adaptability trials in subalpine regions. Experience gained has indicated that despite the adaptations of high elevation native species, their cultivated counterparts are often more adept at producing an early erosion-controlling vegetative cover (Russell and Takyi 1979, Takyi and Russell 1980). Ziemkiewicz (1979) noted that this paradox is plausible because of the genetically-enhanced capacity of most agronomic species to produce shoot biomass. Conversely, adapted native species avoid the nutrient cycling "bottleneck" of slow decomposition of dead plant material in high elevation environments by maintaining relatively high proportions of root to shoot biomass. Thus, under favourable moisture and soil fertility conditions, cultivated species may initially be far more productive.

The designated end land use objective of reclamation often requires the establishment of a self-perpetuating native plant community. However, measures implemented to meet this objective will not necessarily ensure the simultaneous production of an erosion-controlling cover in the early stages of reclamation.

The present study was initiated in an attempt to define seed mixtures which will achieve both short- and long-term reclamation objectives.

Specific objectives of the study are as follows:

1. to evaluate and compare the main effects and interactions of five companion crop treatments and four native grass seed mixtures on the establishment of a vegetative cover on raw overburden and overburden topdressed with mineral soil at two subalpine locations, and

2. to evaluate and compare the performance of three cultivated grass-legume control mixtures and four native grass mixtures on the establishment of a vegetative cover on raw overburden and overburden topdressed with mineral soil at two subalpine locations.

Assessment results after the second growing season are presented. Because of the relatively short time span since the study was initiated, conclusions pertain only to the establishment of an early erosion-controlling ground cover.

DESCRIPTION OF STUDY AREAS

The experiments were established on two abandoned surface coal mines in the Eastern Slopes of the Rocky Mountains. The sites are near Cadomin (elev. 1,695 m) in west central Alberta, and at Adanac (elev. 1,895 m) in the southwest corner of the province. The study areas fall into in the subalpine forest region (SA.1) as defined by Rowe (1972). The same climatic classification, subarctic snow forest (Dfc) according to Koppens' systems, describes both areas (Longley 1970). Abandoned in the early 1950's, the mine sites are now characterized by spoil and overburden materials that are almost completely devoid of vegetation.

Further description of the Cadomin area can be found in Root (1976) and Russell and Takyi (1979). Tomm and Russell (1981) give a description of the Adanac mine site, as well as a summary of soil and overburden analyses for both sites.

MATERIALS AND METHODS

EXPERIMENTAL DESIGN AND TREATMENTS

Two separate but identical field trials were established at each study site; on raw overburden and overburden topdressed with mineral soil. The purpose of topdressing was to evaluate species establishment and performance on different seedbed types.

Each trial consists of three replicates employing a completely randomized design. Seed mixtures for the factorial native grass-companion treatments are given in Table 1. The cultivated grass-legume control mixtures are summarized in Table 2.

ESTABLISHMENT OF FIELD TRIALS

Field trials were established in the spring of 1979. For the topdressed trials, mineral soil was stripped from nearby undisturbed sites, hauled to the mine sites, and spread to an average depth of 20 cm.

Trials were fenced to minimize outside influences. All plots measure 2 m x 2 m (.0004 ha). Seedbed uniformity was achieved by hand raking each plot before and after broadcast seeding and fertilizing. Establishment fertilization was carried out at *a* rate of 80 kg N/ha, 60 kg

TABLE 1

TREATMENT DESIGNATIONS OF THE NATIVE GRASS SEED MIXTURES AND CULTIVATED COMPANION CROPS

Native Grass Mixtures[1]

1. Slender wheatgrass (Agropyron trachycaulum), alpine sheep fescue (Festuca saximontana), alpine bluegrass (Poa alpina) and interior bluegrass (P. interior).

2. Northern wheatgrass (Agropyron dasystachyum), bearded wheatgrass (A. subsecundum), slender wheatgrass and June grass (Koeleria cristata).

3. Northern wheatgrass, tufted hair grass (Deschampsia caespitosa), alpine bluegrass and spike trisetum (Trisetum spicatum).

4. Alpine sheep fescue, June grass, interior bluegrass and spike trisetum.

Cultivated Companion Crops[2]

A. Meadow foxtail (Alopecurus pratensis, Canada No. 1 seed).

B. Timothy (Phleum pratense cv. Climax, certified seed) and white clover (Trifolium repens, Canada No. 1 seed).

C. Creeping red fescue (Festuca rubra cv. Boreal, certified seed) and alsike clover (Trifolium hybridum cv. Aurora, certified seed).

D. Perennial ryegrass (Lolium perenne cv. Norlea, certified seed).

E. Control (no companion crop).

[1]Each mixture was seeded at a rate of 4,000 seeds/m^2. The number of seeds per species is approximately equal in each mixture.

[2]Each treatment was seeded at a rate of 5 kg/ha.

TABLE 2

TREATMENT DESIGNATIONS OF THE CULTIVATED GRASS-LEGUME SEED MIXTURES

Mixture[1]	Species[2]
a.	Creeping red fescue (Festuca rubra cv. Boreal, certified seed) (40%), white clover (Trifolium repens, Canada No. 1 seed) (20%), timothy (Phleum pratense cv. Climax, certified seed) 120%) and crested wheatgrass (Agropyron cristatum cv. Fairway, certified seed) (20%)
b.	Creeping red fescue (40%), white clover (12%), timothy (24%) and Canada bluegrass (Poa compressa, Canada No. 1 seed) (24%)
c.	Creeping red fescue (32%), timothy (20%), crested wheatgrass (32%) and alsike clover (Trifolium hybridum cv. Aurora, certified seed) (16%)

[1]Each mixture was seeded at a rate of 40 kg/ha.

[2]Percent figures in brackets following each species indicate proportion of seed mixture by weight.

P/ha, and 60 kg K/ha. The sources of fertilizer nutrients were 46-0-0, 10-30-10 and 0-0-60. Subsequent maintenance fertilization (spring, 1980) was applied at one-half the above rate using the same fertilizer forms.

ASSESSMENT OF FIELD TRIALS

Initial assessments (fall, 1980) included percent plant cover and species frequency. A general assessment of the latter index was obtained by ocular appraisal for the dominant species in each plot. Plant cover was measured in a 0.5 m by 0.5 m quadrat with grid of 100 subplots. Percent cover values were estimated on the basis of the perpendicular projection of all living above-ground plant parts. Plant cover percent was expressed as the mean of four quadrat readings per plot.

RESULTS AND DISCUSSION

NATIVE GRASS-COMPANION CROP TREATMENTS

Results summarized in Tables 3 and 4 show significant differences in percent plant cover among native grass seed mixtures in all trials except the topdressed overburden at Adanac (Table 4). Highest average percent plant cover in all trials was achieved by the native mixture composed primarily of wheatgrasses (northern wheatgrass, bearded wheatgrass, slender wheatgrass and June grass). Lowest percent cover resulted from the seed mixture lacking a wheatgrass representative: alpine sheep fescue, June grass, interior bluegrass and spike trisetum.

The robust performance of the wheatgrasses suggest that these species are suitable for initial revegetation. It remains to be determined if the wheatgrasses will continue to be a significant component of plant cover beyond the maintenance (fertilization) stage or be replaced by other species in the seed mixtures. For example, both the fescues and the bluegrasses approached the wheatgrasses in frequency of occurrence although contributing little to the present plant cover. Spike trisetum, June grass and tufted hair grass occurred much less frequently than the above species.

The companion crop treatments were not significant in any of the trials. Furthermore, the interactions between native grass mixtures and

TABLE 3

PERCENT PLANT COVER OF THE NATIVE GRASS-CULTIVATED COMPANION CROP TREATMENTS AT CADOMIN
(MEANS OF THREE REPLICATIONS)

Native Grass Mixtures[1]	Companion Crop Treatments[1]					Means[2]
	A	B	C	D	E	(Native Mixtures)
Topdressed Trial						
1	31.92	21.17	22.25	29.00	22.42	25.35b
2	38.08	31.92	29.50	25.42	22.42	29.47b
3	26.92	26.83	31.00	26.83	21.00	26.52b
4	17.67	17.92	13.42	12.58	10.00	14.32a
Means (Companion Crops)	28.65	24.46	24.04	23.46	18.96	
Raw Overburden Trial						
1	7.25	12.00	5.58	14.58	12.75	10.43b
2	15.58	20.00	24.75	27.58	21.17	21.82c
3	8.83	16.75	13.67	12.75	11.25	12.65b
4	5.17	3.58	5.50	3.58	1.08	3.78a
Means (Companion Crops)	9.21	13.08	12.38	14.62	11.56	

'Treatment designations:

Native Grass Mixtures

1. Slender wheatgrass, alpine sheep fescue, alpine bluegrass and interior bluegrass.
2. Northern wheatgrass, bearded wheatgrass, slender wheatgrass and June grass.
3. Northern wheatgrass, tufted hair grass, alpine bluegrass and spike trisetum.
4. Alpine sheep fescue, June grass, interior bluegrass and spike trisetum.

Cultivated Companion Crops

A. Meadow foxtail
B. "Climax" timothy and white clover
C. "Boreal" creeping red fescue and "Aurora" alsike clover
D. "Norlea" perennial ryegrass
E. Control

-For significant main effects, means followed by a common letter are not significantly different at the five (5) percent level according to Duncan's Multiple Range Test.

TABLE 4

PERCENT PLANT COVER OF THE NATIVE GRASS-CULTIVATED COMPANION CROP TREATMENTS AT ADANAC
(MEANS OF THREE REPLICATIONS)

Native Grass Mixtures^	Companion Crop Treatments^					Means
	A	B	C	D	E	(Native Mixtures)
Topdressed Trial						
1	38.83	20.50	15.67	24.42	16.92	23.27
2	34.92	34.24	29.42	32.92	24.50	31.20
3	42.08	21.33	28.67	28.58	17.58	27.65
4	29.25	31.75	17.42	10.17	21.92	22.10
Means (Companion Crops)	36.27	26.96	22.79	24.02	20.23	
Raw Overburden Trial						
1	28.92	20.33	26.00	32.25	23.42	26.18a[2]
2	36.92	51.58	26.00	35.75	35.17	37.08b
3	39.17	38.42	34.33	24.17	20.08	31.23ab
4	29.75	32.50	33.58	28.92	22.17	29.38ab
Means (Companion Crops)	33.69	35.71	29.98	30.27	25.21	

'Treatment designations:

Native Grass Mixtures

1. Slender wheatgrass, alpine sheep fescue, alpine bluegrass and interior bluegrass.
2. Northern wheatgrass, bearded wheatgrass, slender wheatgrass and June grass.
3. Northern wheatgrass, tufted hair grass, alpine bluegrass and spike trisetum.
4. Alpine sheep fescue, June grass, interior bluegrass and spike trisetum.

Cultivated Companion Crops

A. Meadow foxtail
B. "Climax" timothy and white clover
C. "Boreal" creeping red fescue and "Aurora" alsike clover
D. "Norlea" perennial ryegrass
E. Control

-For significant main effects, means followed by a common letter are not significantly different at the five (5) percent level according to Duncan's Multiple Range Test.

companion crops were not significant, implying that these factors have independent effects on plant cover. Possible explanations are that 1) the effect of the companion crop treatments were similar on each native grass mixture or 2) the companion crops did not achieve sufficient cover to affect the establishment and growth of native species.

These preliminary results suggest that good plant cover production can be achieved through the use of native wheatgrasses. At the seeding rate tested in this study, the companion crop treatments were not essential for establishing an early erosion-controlling cover. The more successful of the companion crops in frequency of occurrence were meadow foxtail, timothy and creeping red fescue. These species may yet influence the performance of native grasses in subsequent seasons. Russell and Takyi (1979) found timothy to be one of the most promising species for erosion control at Cadomin. King (1980) and Mihajlovich and Russell (1980) noted that creeping red fescue was a successful colonizer of high elevation sites in southern Alberta. Brown and Johnston (1978) recommended meadow foxtail as one the few commercially available introduced species adaptable for high elevation reclamation.

Comparisons of average percent cover among all trials suggest contradictory results. Average percent cover for the trials at Cadomin were 23.9 (mineral soil) and 12.2 (raw overburden). Percent values for the respective trials at Adanac were 26.1 and 30.1. Despite this variation, the relationship of percent cover to species composition was relatively consistent, particularly for the native grass treatments.

NATIVE GRASS AND AGRONOMIC GRASS-LEGUME TREATMENTS

The preceding discussion intimated that the native wheatgrasses are suitable species for producing an early plant cover. Comparisons of the pure native grass mixtures with the cultivated grass-legume mixtures (Table 5) tend to support this claim.

Differences in plant cover attributable to seed mixture effects were not significant for the trials at Adanac. The summarized results (Table 5) suggest that the lower cover produced by the native seed mixture lacking a wheatgrass is responsible for the significant treatment effects for the trials at Cadomin. Native mixtures which included wheatgrasses generally compared favourably with the cultivated mixtures.

TABLE 5

PERCENT PLANT COVER OF THE CULTIVATED GRASS-LEGUME MIXTURES AND PURE NATIVE GRASS MIXTURES (MEANS OF THREE REPLICATIONS)

	Cadomin		Adanac	
Treatment[1]	Topdressed	Raw Overburden	Topdressed	Raw Overburden
a	38.33b[2]	23.50d[2]	22.33	35.50
b	35.08b	8.17ab	27.58	38.42
c	33.17b	13.25bc	29.17	38.83
1E	22.42ab	12.75b	16.92	23.42
2E	22.42ab	21.17cd	24.50	35.17
3E	21.00ab	11.25b	17.58	20.08
4E	10.00a	1.08a	21.92	22.17

'Treatment designations:

Native Grass Mixtures

1. Slender wheatgrass, alpine sheep fescue, alpine bluegrass and interior bluegrass.
2. Northern wheatgrass, bearded wheatgrass, slender wheatgrass and June grass.
3. Northern wheatgrass, tufted hair grass, alpine bluegrass and spike trisetum.
4. Alpine sheep fescue, June grass, interior bluegrass and spike trisetum.

Cultivated Companion Crops

E. Control (no companion crops).

Cultivated Grass-Legume Mixtures

a. "Boreal" creeping red fescue, white clover, "Climax" timothy and "Fairway" crested wheatgrass.
b. "Boreal" creeping red fescue, white clover, "Climax" timothy and Canada bluegrass.
c. "Boreal" creeping red fescue, "Climax" timothy, "Fairway" wheatgrass and "Aurora" alsike clover.

[2]For significant main effects, means followed by a common letter are not significantly different at the five (5) percent level according to Duncan's Multiple Range Test.

CONCLUSIONS

Results to date suggest that the native wheatgrasses are suitable species for initial revegetation of high elevation disturbances. The more successful of the native grass seed mixtures compared favourably with the cultivated grass-legume control mixtures.

The companion crops tested were not an essential ingredient for producing plant cover. These cultivated species did not significantly affect the establishment or growth of the native grasses up to the end of the second growing season after seeding.

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