MONTANE GRASSLAND REVEGETATION TRIALS

by

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ABSTRACT

Revegetation trials were established in 1977 on a disturbed montane grassland in Jasper National Park, Alberta. The trials were designed to test the effectiveness of topdressing, fertilizer and seeding method treatments to establish native vegetation cover.

Ground cover and yield responded negatively to topdressing with either peat or with loamy sand similar to the native soil. Positive results were achieved by fertilizing at the time of seeding. These improvements have persisted, indicating that the nutrients are being cycled. Method of seeding did not significantly affect ground cover.

The results indicate that, if weather conditions are suitable, seedbed tillage and broadcast seeding alone can be sufficient to establish a productive native community in a montane environment.

1.0 INTRODUCTION

Areas of montane grassland are not extensive in Canada. Alberta's montane grasslands are confined to the mountain parks. They provide critical wildlife habitat and, because of their limited extent, have significant interpretive and educational values. However, development pressures, such as those recently realized in Banff National Park, have eliminated or disturbed some of these grasslands. It is important that techniques be developed to encourage the re-establishment of these grasslands after disturbance.

2.0 ECOLOGICAL DESCRIPTION

As the name implies, montane grasslands have a very open physiognomy. Ground cover is variable and bare ground is not uncommon. Vegetation tends to form localized communities in relation to subtle microsite changes.

Montane grasslands are characteristically comprised of drought tolerant bunch-grasses and other plants which increase in abundance under heavy grazing. Research has shown that biomass production, seed quantity and viability are all inherently low (Stringer, 1969; Walker et al., 1977).

Montane grasslands have developed largely in response to prevailing dry environments. Moisture deficiencies related to coarse, rapidly drained soils characteristic of these grasslands are compounded by frequent occurrence of warm foehn winds which result in marked snow ablation, rapid snowmelt and runoff in spring and high rates of evapotranspiration in summer. In normal years, the montane grasslands of Alberta's mountain parks have moisture deficits from late June until late October totalling 110 mm and soil water potential is often below -15 bars (nominal permanent wilting point) for at least one third of the growing season (Stringer, 1969; Hettinger, 1975).

Alberta's montane grasslands characteristically experience a short growing season (less than 90 days). Soils are generally nutrient poor (less than 5 ppm of available nitrogen and phosphorus), strongly alkaline (pH 8.0 to 8.8) and highly calcareous (greater than 15 percent free lime). The grasslands are also subject to the combined effects of heavy grazing, browsing and trampling by native ungulates.

3.0 LITERATURE REVIEW

The site factors which characterize Alberta's montane grasslands make revegetation problematic. One obvious means of overcoming undesirable characteristics of the soil medium is to topdress the site with a more suitable material. The addition of peat to coarse-textured soils has been shown to increase moisture holding capacity (Stevenson, 1974; Fedkenheuer, 1979). However, loamy sands such as those indigenous to montane grasslands have also been successfully used as topdressing to improve revegetative success on arid grasslands (Yamamoto, 1975; DePuit and Coenenberg, 1979).

Fertilization is a proven method of restoring fertility to nutrient poor sites and in many cases revegetation has been completely unsuccessful without addition of fertilizer at the time of seeding (Vogel, 1973; Curry, 1975). Furthermore, by adding an acid forming fertilizer such as ammonium sulfate, it is possible to counteract the adverse effect of alkalinity.

The success of revegetation efforts can also be greatly influenced by the method of seeding as demonstrated by Walquist et al. (1975) and DePuit and Coenenberg (1979). Raking or packing the seed into the seedbed or covering the seed with mulch reduces desiccation of germinating seeds and thereby minimizes the effect of low soil moisture levels (Russell, 1973; Johnston and Smoliak, 1977).

4.0 METHODS

In order to test the effectiveness of topdressing, fertilizing and seeding method techniques, field and greenhouse trials were conducted. A pipeline right-of-way in Jasper National Park, adjacent to Jasper Lake, was selected as the site for the revegetation trials. The pipeline was constructed in 1952 and over the ensuing 25 years, the study site had remained generally void of vegetation. No attempt had been made to conserve topsoil during construction or to reclaim the right-of-way afterwards. Wind erosion had left approximately half of the ground surface covered with gravel size material. Mean plant cover was 9.5 percent relative to 80.0 percent on adjacent undisturbed grasslands.

The logistics involved in applying four independent variables (topdressing, fertilizer, seeding methods and plant materials) necessitated the use of a split-plot experimental design. In the spring of 1977, the site was divided into four replications (rows) and then further subdivided into four levels of plot units which represented the four independent variables (Figure 1). The plots were rototilled and hand raked to create a level seedbed.

Fibric to mesic peat derived from feather mosses and sphagnum mosses was applied to one third of the plots to a 10.0 cm depth. One third of the plots were topdressed with 7.5 cm of loamy sand textured, strongly calcareous, aeolian material. The loamy sand had properties very similar to those of the undisturbed soils adjacent to the study site (Table 1). The remaining plots were not topdressed.

One half of the topdressing plots were fertilized with 16-20-0 + 14%S while the other half were not fertilized. The fertilizer was broadcast at 785 kg/ha.

The fertilizer treatments were further divided into four seeding method units. The seeding methods tested were:

1. broadcast seeding;
2. hand raking the seed into the seedbed;
3. packing the seed into the seedbed; and
4. covering the seed with a cellulose fibre hydromulch at 1675 kg/ha.

FIGURE 1: Schematic Field Experiment Plot Design

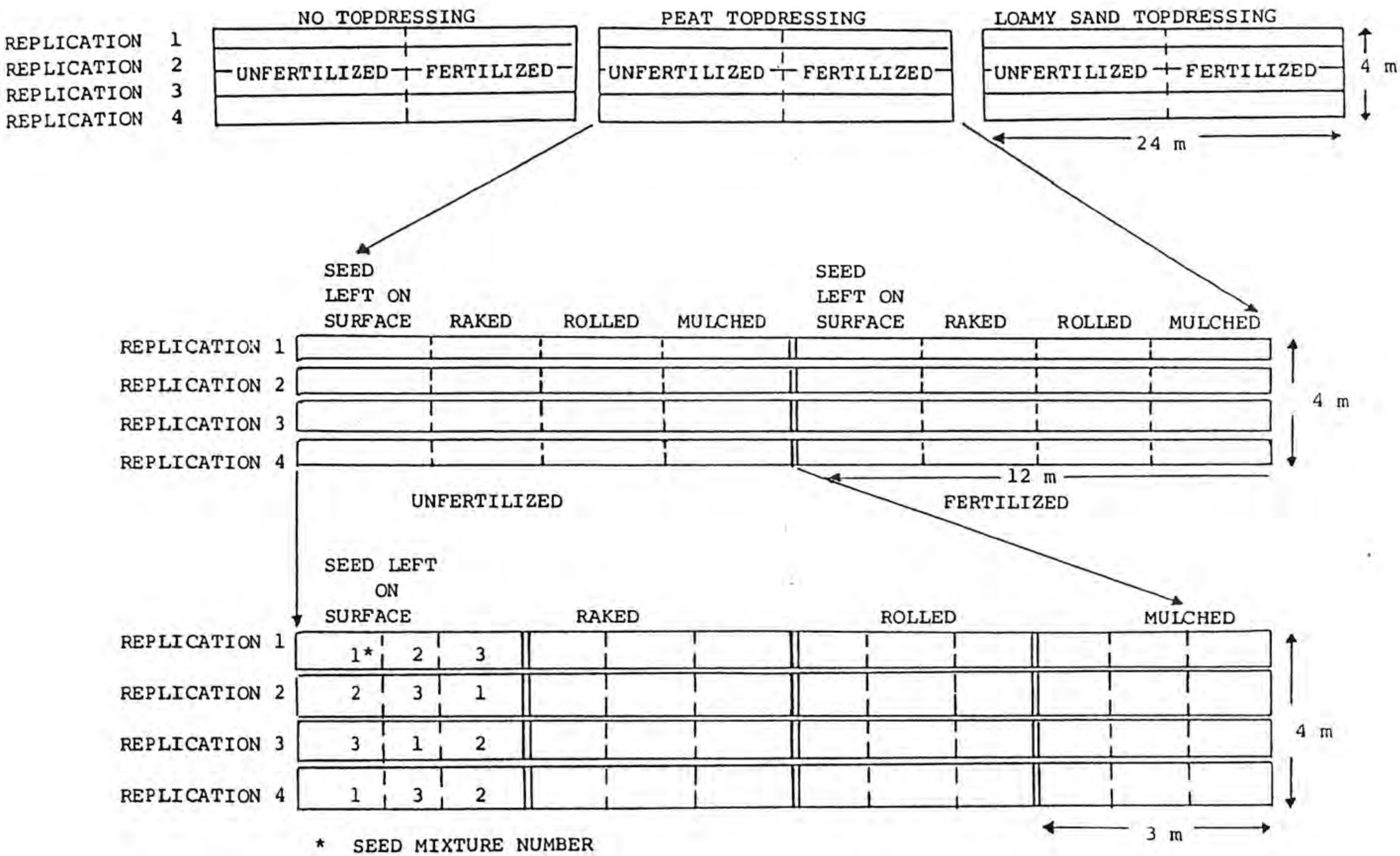


TABLE 1: Soil Test Results for Soils and Topdressing Prior to Treatment [1]

MATERIAL	SAMPLE DEPTH (cm)	AVAILABLE PLANT NUTRIENTS[2] (ppm) (N)	(P)	(K)	SULFUR[3]	SOIL REACTION (pH)	SOIL CONDUC-TIVITY (mmhos)	SULFATES	SODIUM	FREE LIME[3]	ORGANIC MATTER[3]	TEXTURE[4]
Study Site Soil	0-15	1	0	113	M-	8.3	0.4	NIL	L-	H+	L	SL
	16-30	0.5	0	66	M-	8.8	0.4	NIL	L-	H+	L	SL
Adjacent Undisturbed Soil	0-15	2	0	137	M	8.2	0.4	NIL	L-	H+	L	SL
	16-30	51	0	107	M	8.7	1.1	NIL	L+	H+	L+	L
Feathermoss & Sphagnum Peat Topdressing	N/A	1.5	0	42	M+	5.2	0.4	NIL	L-	L	H+	O
Loamy Sand Topdressing	N/A	0.5	0	59	L	8.0	0.3	NIL	L-	M+	L	LS

[1] Samples taken June 11, 1977

[2] N = Nitrogen
P = Phosphorus
K = Potassium

[3] Ranges are those of Alberta Agriculture Soil and Feed Testing Laboratory
Sulfur: L=1.1-2ppm, M=5.1-8ppm, M+=8.1-12ppm
Sodium: L=0-35ppm, L+=70.5-105ppm
Free lime: L=<1%, M+=6-8%, H+=>15%
Organic Matter: L=<1%, L+=1.1-2%, H+=>10%

[4] SL=Sandy loam, L=Loam, O=Organic, LS=Loamy Sand

The seeding method units were ultimately divided into one square metre plots to which three seed mixtures comprised of 16 native plant species were applied at a rate of 20 kg/ha (Table 2).

Research was designed to assess the response of plant species to the various treatments. However, these complex relationships are beyond the scope of this paper. For further information, see Wishart (1983).

In 1977 and 1978, data regarding percent ground cover, average plant height, vigor, soil fertility and grazing at the trial sites were collected by the author (Wishart, 1983). Ground cover data were analyzed using multiple analysis of variance. Treatments that were statistically significant using F table values at one percent level were compared using Duncan's Multiple Range Tests ($P \leq 0.01$).

The field trial studies were supplemented by greenhouse trials to determine the effect of temperature and moisture on topdressing and fertilizer treatments. Plant height and biomass data were analyzed using the same methods as those of the field trials.

In 1979 and 1980, Parks Canada collected similar field data but did not conduct statistical analyses (Harrison, 1979, Parks Canada, 1981, ed.). The author revisited the site in 1984 and the results of these qualitative assessments are included in the results.

TABLE 2: Plant Materials Used in Field Experiments

Species	Origin of Seed Stock	Native to Study Site Area	Drought Tolerant	Alkaline Tolerant	Nitrogen Fixer
Juniperus horizontalis Moench.	Kooteney Plains, Alberta	Yes[1]	Yes	Yes	No
Agropyron riparium Scribn. & Smith.	Oregon (cv. Sodar)	Yes[1]	Yes	Yes	No
Agropyron trachycaulum (Link) Malte	Beaverlodge, Alberta	Yes[1]	Yes	Yes	No
Agropyron sp.	Beaverlodge, Alberta	--[1]	--	--	No
Agrostis stolonifera L.	Poland	No	No	--	No
Elymus innovatus Beal.	Ft. St. John, B.C.	Yes[3]	No	--	No
Festuca saximontana Rydb.	Kootenay Plains, Alberta	Yes[1]	Yes	--	No
Koeleria cristata (L.) Pers.	Peace River, Alberta	Yes[2]	Yes	Yes	No
Poa alpina #1 L.	Pine Pass, B.C.	No	Yes	Yes	No
Poa alpina #2 L.	Unknown	No	Yes	Yes	No
Poa pratensis L.	Palmer, Alaska	Yes[1]	Yes	Yes	No
Rosa acicularis Lindl.	Cypress Hills, Alberta	Yes[3]	Yes	Yes	No
Astragalus sp.	Kootenay Plains, Alberta	--	--	--	Yes
Hedysarum alpinum L.	Peers, Alberta	Yes[2]	Yes	Yes	Yes
Hedysarum mackenzii Richards.	Haines Jct., Yukon	Yes[1]	Yes	Yes	Yes
Elaeagnus commutata Bernh.	High Level, Alberta	Yes[1]	Yes	--	Yes

[1] Identified by Stringer (1969)

[2] Identified by Hettinger (1975)

[3] Identified by Wells *et al.* (1978)

5.0 RESULTS AND DISCUSSION

5.1 General

Weather conditions for the first two growing seasons were more favourable to the establishment of vegetation than the long term average. Precipitation was 57 percent above the 30 year mean for the 1977 and 1978 growing seasons while temperatures were 2.1°C below average. These factors produced a more favourable soil moisture regime during the critical establishment period than normally exists and likely influenced the effectiveness of the various treatments.

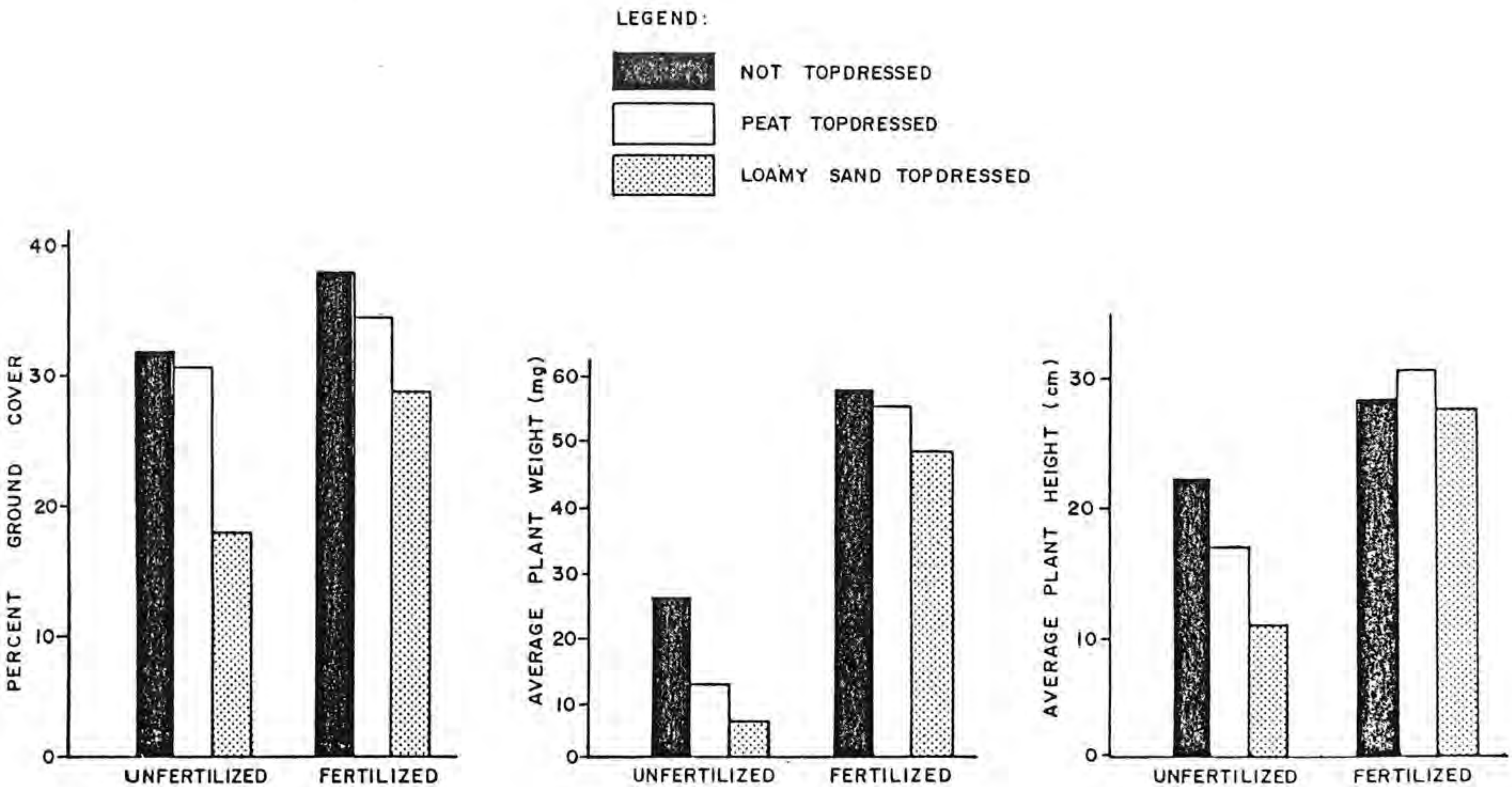
Emerged seedlings were observed at the field trial site four weeks after seeding and had produced approximately 20 percent ground cover by the end of the first growing season. Ground cover reached 30 percent by the end of the second growing season and 65 percent seven years after seeding.

5.2 Topdressing

Topdressing the seedbed was not beneficial (Figure 2). While soil analyses were unable to detect significant differences, greenhouse experiments demonstrated that both peat and loamy sand topdressings were less fertile than the original soils. Lower fertility was likely the major cause of the negative results from both topdressings.

The peat topdressing was probably too shallow to have significantly improved soil moisture levels. Research by Logan (1978) and Simard (1968)

FIGURE 2: Effect of Topdressing and Fertilizer Treatments on Ground Cover in Field Experiments and Plant Weight and Height in Greenhouse Experiments



indicates that somewhere between 25 and 66 cm may be a minimum depth at which peat must be applied to improve soil moisture and plant growth in the long term. Above-average precipitation probably overcame whatever beneficial effects on moisture-holding capability that the peat may have produced while plants became established. A delay in plant development was also noted on soils topdressed with peat. The delay was attributed to cooler spring soil temperatures which result from greater moisture levels. Significant winter kill was recorded in 1980 (Parks Canada, 1981, ed.) and may have been a result of this delayed plant maturity.

Applying loamy sand topdressing did little to improve the physical characteristics of the soil surface since simply rototilling the site had buried much of the surficial gravel that had inhibited natural revegetation. Consequently, the net effect of the loamy sand topdressing was to decrease fertility.

5.3 Fertilizer

Applying fertilizer significantly improved seed production, plant maturity rates, ground cover and plant biomass. Fertilizing increased ground cover 7 percent overall in the second year and increases in ground cover from fertilization did not diminish with time. Although soil tests indicated that the applied nutrients had become almost completely unavailable (Table 3) it is probable that fertilization encouraged the development of a more productive plant-nutrient cycle, whereby increases in

TABLE 3: Soil Test Results for Topdressing and Fertilizer Treatment Plots [1]

MATERIAL	SAMPLE DEPTH (cm)	AVAILABLE PLANT NUTRIENTS[2] (ppm) (N)	(P)	(K)	SULFUR[3]	SOIL REACTION (pH)	SOIL CONDUC-TIVITY (mmhos)	SULFATES	SODIUM	FREE LIME	ORGANIC MATTER[3]	TEXTURE[4]
No Topdressing No Fertilizer	0-15	1.5	0.5	109	L+	8.2	0.4	NIL	L-	H+	L+	SL
	16-30	0.5	0	62	L+	8.1	0.4	NIL	L-	H+	L+	SL
No Topdressing Fertilized	0-15	1	0.5	141	L+	8.2	0.4	NIL	L-	H+	L+	SL
	16-30	4.5	0.5	67	M-	8.4	0.4	NIL	L-	H+	L+	SL
Peat Topdressing No Fertilizer	0-15	1.5	0	108	M	8.0	0.4	NIL	L-	H-	H	O
	16-30	1	0	85	M	8.1	0.4	NIL	L-	H+	L+	SL
Peat Topdressing Fertilized	0-15	1.5	1.5	24	M+	7.8	0.4	NIL	L-	M+	H	O
	16-30	0.5	0.5	52	M+	8.2	0.3	NIL	L-	H+	L+	SL
Loamy Sand Topdressing No Fertilizer	0-15	0.5	0.5	57	L	8.5	0.3	NIL	L-	H+	L	LS
	16-30	0.5	0	72	L	8.4	0.2	NIL	L-	H+	L	SL
Loamy Sand Topdressing Fertilized	0-15	0.5	0	64	L+	8.3	0.3	NIL	L-	H+	L	LS
	16-30	0.5	0	65	M-	8.4	0.3	NIL	L-	H+	L	SL

1 Samples taken September 4, 1978

2 N = Nitrogen
P = Phosphorus
K = Potassium

3 Ranges are those of Alberta Agriculture Soil and Feed Testing Laboratory
Sulfur: L=1.1-2ppm, L+=2.1-3ppm, M-=3.1-5ppm, M=5.1-8ppm, M+=8.1-12ppm
Sodium: L-=0-35ppm
Free Lime: M+=6-8%, H-=8-10%, H+=>15%
Organic Matter: L=<1%, L+=1.1-2%, H=8-10%

4 SL=Sandy Loam, L=Loam, O=Organic, LS=Loamy Sand

detrital input equaled increases in mineralization or organic matter. All plant species showed a positive response to fertilization, including legumes.

Some of the fertilizer was absorbed by the growing plants. However, a significant amount of ammonium nitrogen was likely lost by volatization of ammonia which occurs as ammonium salts contact aqueous alkaline media.

Much of the applied phosphorus probably formed calcium compounds with low solubilities, a common fate of phosphorus in alkaline soil. Banding the phosphorus may have been a more appropriate method of application.

Within two years of application of a large quantity of acid-forming fertilizer, no decrease in soil pH could be detected. This is likely attributable to a loss of acid-forming material from volatization and leaching of fertilizer in conjunction with the large soil reservoir of free lime.

5.4 Seeding Methods

The method of seeding did not affect overall percent ground cover. Differences in plant establishment in the first growing season and in the early part of the second were noted. However, encroachment of established vegetation overcame the differences in a relatively short period of time.

Mulching was the poorest overall seeding method, probably because the mulch retards the rate of soil warming in spring and available nutrients become immobilized by microorganisms decomposing the organic matter.

Covering the fertilizer by raking it into the seedbed or by mulching produced a very pronounced increase in ground cover and plant biomass relative to unfertilized plots of the same seeding methods. This effect is likely due to an inhibition of volatization of ammonium fertilizer.

6.0 CONCLUSIONS

Simply broadcasting seed onto an unamended, rototilled surface produced ground cover of 35 percent after two growing seasons which was only 5 percent less than the best overall treatment, fertilizing and packing the seed. Seven years after seeding, these unamended plots where seed was broadcast still have excellent cover, which indicates that the gravelly seedbed prior to tillage and a lack of sufficient seed cast from adjacent grasslands were major limiting factors to natural secondary succession.

The results obtained from these field trials indicate the possibility of rapid establishment of a productive native plant community in a harsh mountain environment. If weather conditions are favourable while the plants become established, proper seedbed tillage and broadcast seeding alone can be sufficient to successfully establish ground cover. However, revegetation success can be enhanced by applying a suitable fertilizer composition at the time of seeding.

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