AN EVALUATION OF NON-SEEDING RECLAMATION TECHNIQUES ON AN OIL SANDS PIPELINE RIGHT-OF-WAY

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ABSTRACT

An evaluation of the revegetation success of seeded and non-seeded portions of a buried oil sands water pipeline right-of-way was conducted at the Esso Resources' Cold Lake Production Project site from 1984 to 1987.

Forty plots representing the two treatments were established along the pipeline right-of-way and measured each growing season. The following parameters were measured: vegetation cover, biomass of revegetation species, vegetation composition of adjacent forest communities, and vegetation encroachment onto the right-of-way.

Results of the four years of monitoring revegetation growth indicate the following:

1. The seeded treatment provided 100% vegetation cover within two growing seasons. The non-seeded treatment however was less than 85% cover after four growing seasons.
2. 95% of the cover on the seeded treatment was agronomic grasses and legumes; herb and shrub species were observed at 5% cover. 40% of the cover on the non-seeded treatment were herbaceous and shrub species (native invaders).
3. Mean biomass for the seeded portion was two times higher than the non-seeded.
4. The vegetation diversity on the non-seeded treatment was over two times that of the seeded treatment.
5. The revegetation of the non-seeded treatment was almost exclusively by invasion from adjacent forest communities.

The study concludes that in the Cold Lake region non-seeding of the right-of-way may be a viable reclamation technique. However, non-seeding is only effective on sites with low erosion potential and if annual monitoring of growth is planned. The data collected provides information on natural revegetaton and vegetation community development in the Cold Lake area.

INTRODUCTION

The Esso Resources Canada Limited (Esso Resources) Cold Lake District Oil Sands Operations lease is located within the Eastern Alberta Physiographic division of the Interior Plains and within the rolling morainal plain land unit descibed by Hardy Associates 1978 Ltd. (1983).

During summer 1983, Esso Resources constructed a fresh water pipeline, in a 20m wide right-of-way, from Cold Lake to the Leming Pilot Plant on the Cold Lake District Operations Oil Sands lease. Techniques used to construct the pipeline, including grubbing with a brush rake attachment, topsoil salvage and redistribution, and minimizing subsoil disturbance, were designed to maximize reclamation potential on the right-of-way. The right-of-way was reclaimed during fall 1983.

During reclamation planning two portions of the right-of-way were designated, under Development and Reclamation Approval OS-6-83 (Esso Resources Canada Ltd., 1983) for future reclamation evaluation. One portion of the right-of-way was fertilized and seeded with an agronomic seed mix, and a second portion remained unfertilized and unseeded (Figure 1).

The purpose of this study is to monitor revegetation growth on the two portions of the right-of-way, and to evaluate and compare the reclamation potential of the two treatments.

Esso Resources Cold Lake Project is primarily situated in the Green Zone public land management area of Alberta. Consequently, reclamation programs are aimed at restoring disturbed lands to commercial timber production and productive wildlife habitat. Allowing natural revegetation may provide a more suitable environment for the establishment of trees and shrubs than seeding with agronomic grasses and legumes. Natural invasion may provide less competition for space and moisture, allowing trees and shrubs to establish sooner. The data collected would also provide information on natural revegetation in the Cold Lake area, and vegetation community development in areas revegetated with agronomic species.

Few studies have been conducted that evaluate and compare the reclamation potential by agronomic species to that of native invading species in Alberta (Sims, et.al.,1984). Revegetation monitoring studies of this nature in the Oil Sands area near Cold Lake are non-existent in the published literature.

Some studies have been conducted that compare the use of agronomic and native grasses and legumes in Alberta (Takyi and Russell,1980; Macyk and Steward,1977; and Lesko, Etter and Dillon,1975). These studies have been concentrated in the foothills/mountains regions of the province and indicate that agronomic species are often more successful revegetators than the natives.

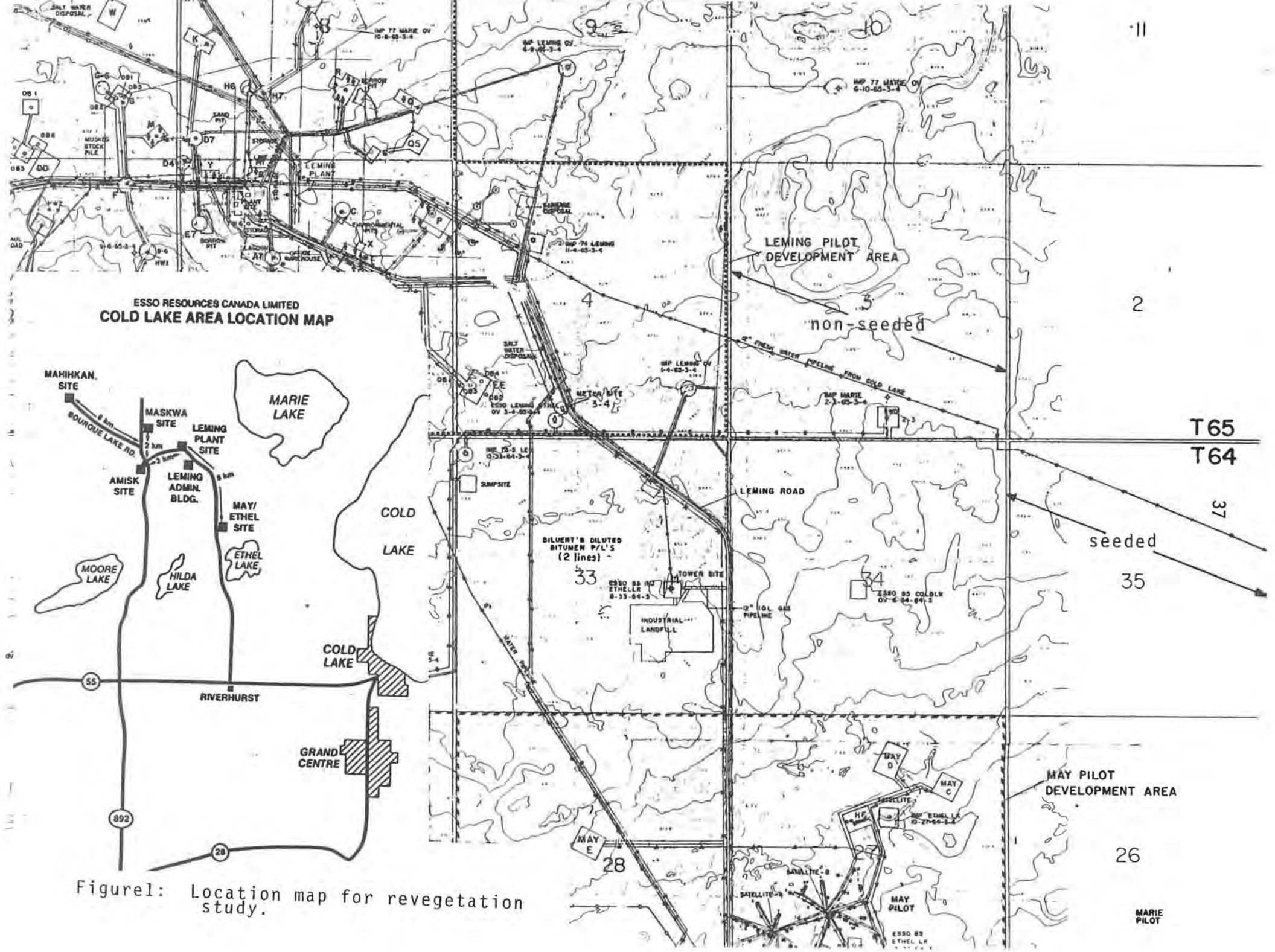

Figure1: Location map for revegetation study.

Studies conducted in northern and arctic areas (Younkin and Martens,1976; Owen and Van Eyk,1975) have shown that heavily seeded and fertilized stands of agronomic species form an effective, temporary barrier to native invasion; natives occurred after two to four years.

Some research has indicated that grasses seeded for erosion control, particularly sod-forming grasses, provide too much competition for space and moisture to allow shrubs and trees to establish. In addition, the build up of small mammal populations in grass swards has presented problems in the establishment of shrubs and trees in the Alberta Oil Sands area (Sims, et.al.,1984).

Although some pioneer vegetation species are animal-borne, and some invading species are provided in the salvaged topsoil as seeds and cuttings, the majority of native invaders appear to be windborne (Sims, et.al.,1984). Consequently, in this present study, it was expected that most of the revegetation of the non-seeded portion of the right-of-way would be by invasion from adjacent forest communities.

During the summers of 1984, 1985, 1986 and 1987, revegetation surveys were conducted on the two portions of the right-of-way. The objective of the surveys was to measure the cover and biomass of all agronomic and native vegetation species on the two predetermined portions of the right-of-way.

The data collected during the surveys allows an evaluation and comparison through time of the revegetation success by seeded species to that of native invading species. Revegetation success is defined as the establishment of a complete and self-sustaining vegetative cover that controls erosion and discourages noxious weeds.

This paper provides the results of the surveys, comments on revegetation success on the two portions of the pipeline right-of-way, and discusses reclamation potential of the two treatments.

METHODS AND MATERIALS

Construction

Pipeline construction began in June 1983 with clearing of the right-of-way. Following salvage and decking of merchantable timber (*Picea glauca*, *Populus tremuloides*, and *Betula papyrifera*) the nonmerchantable timber was felled using a D7 dozer. The dozer blade was then removed and a brush rake attached to procede with grubbing, piling and burning of the slash. A brush rake was used to minimize disturbance to the soil. After combustion was complete the dozer blade was reattached in preparation for topsoil salvage.

Luvisols, particularly Orthic Gray Luvisol, were the predominant soil types encountered on the right-of-way. The average depth of the topsoil (litter plus A-horizon) was 30cm. The topsoil was stripped on the entire right-of-way to the depth of the B-horizon and windrowed on the working side of the right-of-way.

The few fen areas encountered were corduroyed prior to the passage of any equipment, and the organic soil was excavated from the ditchline only.

Following topsoil salvage, portions of the right-of-way that required cut or fill were graded. Grading was kept to a minimum, and was not required on the study portions of the right-of-way. Concurrently, the ditch was excavated to a depth of 2.7m using a 235 backhoe and the spoil windrowed on the non-working side of the right-of-way.

The pipe lengths were then welded together, the welds covered with polycan tape, and the line lowered into the ditch using sidebooms.

Recontouring

As the line was lowered-in, the D7 dozers went to work filling in the ditch, removing fills and replacing cuts.

Once the recontouring earthworks were complete, a D6 dozer was used to redistribute the topsoil in preparation for revegetation. An experienced dozer operator ensured an even disribution of topsoil on the right-of-way.

The right-of-way was ready for revegetation in early September 1983.

Revegetation

In late September 1983, the seeded treatment was revegetated. An agronomic grass / legume seed mix with the following specifications was applied using an electric broadcaster mounted on a bombardier: creeping red fescue (13.5 kg/ha), Kentucky bluegrass (13.5 kg/ha), alsike clover (3.5 kg/ha) and alfalfa (3.5 kg/ha).

A fertilizer application of 16-N, 20-P, 0-K at 160 kg/ha was then broadcast on the seeded treatment.

No seed or fertilizer were applied to the non-seeded treatment.

Revegetation Surveys

During the summers of 1984, 1985, 1986 and 1987, revegetation surveys were conducted on both treatments.

Data Collection

Twenty - 1m^2 plots spaced at 100m intervals, were placed in both the seeded and non-seeded treatments. All plots were within 10m of the forest edge and were alternated on each side (north / south) of the right-of-way.

Within each plot, vegetation cover was estimated using four replications of a 10x50cm quadrat. Percentage cover of all observed vegetal species in each quadrat was recorded. To determine biomass, the vegetation within a fifth quadrat was cut to ground level and collected from each plot during 1986 and 1987 and the samples placed in paper bags. An estimate of vegetation encroachment (distance from the adjacent forest edge native vegetation was established on the right-of-way) was also measured and recorded at each plot during 1986 and 1987.

Adjacent forest vegetation community types were recorded at each plot during 1984 but not in subsequent surveys.

Data Analysis

The data collected in the field was percentage cover per species in four replications of a 0.05m^2 quadrat per 1.0m^2 plot, with twenty plots per treatment. The percent covers were averaged for the four replications to determine the mean percentage cover values by species for each of the forty plots. These values were then used to calculate a mean percentage vegetation cover value for each species by treatment.

The biomass sample bags were opened and the vegetation allowed to dry at room temperature for one month. The forty dried samples were weighed using an analytical balance. The values obtained were used to calculate the mean vegetation biomass per plot, and the mean biomass per treatment.

Similarly, the vegetation encroachment measurements recorded at each plot were used to calculate a mean encroachment value for each treatment.

RESULTS

The revegetation survey results are presented in sections: communities, cover, biomass and encroachment.

Botanical names of plant species are provided in Appendix 1.

Vegetation Communities

Data on adjacent forest vegetation types indicate that mixed-wood forest communities with aspen and white spruce open canopies are common along the right-of-way for both treatments (Table 1). These community types generally had high understory vegetation diversity due to their open canopies.

Spruce forest communities with black spruce and some tamarack were less common along the right-of-way for both treatments.

Vegetation Cover

Tables 2 and 3 provide the results on the mean percentage cover of vegetation for the seeded and non-seeded revegetation treatments respectively.

Seeded Treatment

The seeded treatment was planted with a cover of agronomic grasses (creeping red fescue and Kentucky bluegrass) and legumes (alsike clover and alfalfa) in the fall of 1983. These species, particularly fescue and clover, were the most prevalent during the four annual revegetation surveys. Approximately 82% of the living cover observed during 1984 were the agronomic grasses and legumes (Figure 2). Approximately 96% of observed cover during 1985, 97% of observed cover during 1986 and 98% of observed cover during 1987 were agronomic grasses and legumes, particularly creeping red fescue and alsike clover.

Herb and shrub species were recorded at moderate to low covers (3 - 9%) on the seeded treatment throughout the study period (Figure 3).

Total living cover on the seeded treatment during 1984 was estimated at 60%, and bare ground observed at approximately 30% (Figure 4). During 1985, the total living cover was observed at 104% which represented a 40% increase in cover from 1984; bare ground was estimated at 18%. The total cover was estimated at 140% during 1986, which represented a 36% increase in cover from 1985. Most of this increase was due to a higher clover cover in 1986.

Table 1: Summary of plant communities adjacent to sample plots along the seeded and non-seeded portions of the right-of-way.

PLOT No.	SEEDED TREATMENT		NON-SEEDED TREATMENT	
	Type	Dominant Canopy Species	Type	Dom. Canopy Species
1	Mixed Wood	Aspen, W.Spruce	Mixed Wood	Alder, Willow
2	Mixed Wood	Aspen, W.Spruce	Mixed Wood	Alder, Willow
3	Mixed Wood	Aspen, Birch	Mixed Wood	W.Birch,Alder,Tamarack
4	Spruce Forest	Black Spruce	Mixed Wood	Aspen, W.Spruce
5	Mixed Wood	Aspen, W.Spruce	Mixed Wood	Alder, Willow
6	Mixed Wood	Aspen, W.Spruce	Spruce Forest	Black Spruce
7	Mixed Wood	Aspen, Balsam Poplar	Mixed Wood	Aspen, W.Spruce
8	Mixed Wood	Aspen, W.Spruce	Mixed Wood	Aspen, W.Spruce
9	Mixed Wood	Aspen, W.Spruce	Mixed Wood	Aspen, Birch
10	Mixed Wood	Aspen, W.Spruce, Birch	Mixed Wood	Alder, Willow
11	Mixed Wood	Aspen, W.Spruce	Mixed Wood	Aspen, W.Spruce
12	Mixed Wood	Aspen, W.Spruce	Mixed Wood	Aspen, W.Spruce
13	Mixed Wood	Aspen, Alder	Mixed Wood	Aspen, W.Spruce
14	Mixed Wood	Willow, Birch	Mixed Wood	Alder, Willow
15	Mixed Wood	Aspen	Mixed Wood	Aspen, W.Spruce
16	Mixed Wood	Aspen, W.Spruce, Birch	Mixed Wood	Aspen, Birch
17	Mixed Wood	Aspen	Mixed Wood	Aspen, W.Spruce
18	Mixed Wood	Aspen, W.Spruce	Spruce Forest	Black Spruce
19	Mixed Wood	Aspen, W.Spruce	Mixed Wood	Aspen, Willow
20	Mixed Wood	Aspen, W.Spruce	Spruce Forest	Black Spruce

Table 2: Mean percentage vegetation cover recorded during surveys of the seeded treatment.

SPECIES	1984	1985	1986	1987
Graminoids				
Bluegrass	0.52 ± 0.81	0.04 ± 0.16	0.48 ± 2.12	
Fescue	31.13 ± 20.39	54.80 ± 23.64	58.84 ± 19.74	70.77 ±15.34
Hairy Wild Rye		0.13 ± 0.57	0.26 ± 1.14	
Northern Reed Grass		0.04 ± 0.16	0.17 ± 0.60	1.66 ± 4.00
Sedge			0.26 ± 1.14	
Total	31.65	35.01	60.01	72.43
Legumes				
Alsike Clover	15.35 ± 20.61	36.08 ± 19.71	42.99 ± 21.85	
Alfalfa	2.66 ± 2.11	8.87 ± 9.30	33.75 ± 28.47	22.73 ± 20.56
Total	18.01	44.95	76.74	43.41
Herbs & Dwarf Shrubs				
Aster				0.11 ± 0.37
Bluebells	0.75 ± 0.01			
Cinquefoil	0.35 ± 0.05			
Dandelion				0.08 ± 0.23
Fireweed	0.75 ± 0.01	0.29 ± 1.10	0.07 ± 1.67	2.50 ± 4.50
Horsetails	3.34 ± 2.29	0.78 ± 3.50	1.47 ± 4.13	0.94 ± 2.38
Labrador Tea		0.91 ± 2.2		
Northern Bedstraw	0.55 ± 0.51			
Plantain		0.18 ± 0.48		0.13 ± 0.59
Ragwart		0.01 ± 0.05	0.79 ± 3.52	
Rose	0.35 ± 0.07	0.13 ± 0.38		0.39 ±1.26
Sow Thistle			0.13 ± 0.59	0.55± 2.29
Stawberry	1.38 ± 1.09	0.13 ± 0.37		1.38± 3.10
Thistle		0.02 ± 0.07	0.04 ± 0.17	
Vetch		0.34 ± 0.82		0.30 ± 0.81
Wintergreen	0.32 ± 0.05			
Total	9.10	2.79	3.20	6.42
Shrubs				
Aspen	1.31 ± 0.51	0.27 ± 1.20	0.28 ± 0.81	
Balsam Poplar				2.03+ 3.38
Choke Cherry			0.08 ± 0.23	
Willow		0.03 ± 0.06	0.17 ± 0.60	
Total	1.31	0.30	0.53	2.03
TOTAL LIVING COVER	60.07	104.82	144.48	124.29
TOTAL BARE GROUND	30.57 ± 21.71	18.31 ± 17.05	2.96 ± 7.52	—

Table 3: Mean percentage vegetation cover recorded during surveys of the non-seeded treatment.

SPECIES	1984	1985	1986	1987
Graminoids				
Arrowgrass			0.04 ± 0.17	
Bluegrass	0.11 ± 0.37		2.44 ± 6.05	
Brome			0.29 ± 1.15	2.24 ± 6.56
Fescue	0.81 ± 0.19	4.47 ± 7.80	0.59 ± 1.41	6.01±10.84
Foxtail Barley				2.00 ± 7.06
Hairgrass			0.59 ± 2.16	1.08 ± 4.66
Hairy Wild Rye	0.58 ± 0.61	0.08 ± 0.23		
Northern Reed Grass	0.18 ± 0.17	1.31 ± 2.34	1.52 ± 2.69	2.99 ± 7.05
Sedge	0.04 ± 0.17	4.48±11.38	7.28±21.19	14.76±22.36
Timothy			0.04 ± 0.17	
Wheatgrass				0.04 ± 0.17
Total	1.72	10.34	12.79	29.12
Legumes				
Alsike Clover	1.51 ± 0.29	5.87 ± 6.10	2.07 ± 4.37	3.86 ± 6.36
Alfalfa			2.66 ± 4.56	1.56 ± 5.28
White Sweet Clover			0.17 ± 0.75	2.12 ± 7.40
Total	1.51	5.87	4.90	7.54
Herbs & Dwarf Shrubs				
Aster	0.23 ± 0.08	3.13 ± 4.96	3.46 ± 4.55	2.23 ± 4.96
Baby's-breath				0.04 ± 0.17
Bearberry			0.04 ± 0.17	
Bishop's Cap		0.73 ± 1.70		
Bluebells	0.31 ± 0.66	0.45 ± 1.45		
Bunch Berry	0.28 ± 0.63	0.59 ± 2.12	0.28 ± 0.63	
Buttercup				0.19 ± 0.41
Canada Thistle	0.86 ± 0.39			1.19 ± 3.61
Cattails		0.91 ± 2.80	0.04 ± 0.17	0.60 ± 1.53
Cinquefoil	0.41 ± 4.94			
Coltsfoot	2.40 ± 1.30	0.03 ± 0.16	0.04 ± 0.17	
Dandelion	0.80 ± 1.10	1.83 ± 3.15	2.53 ± 5.00	3.33 ± 6.17
Fireweed	3.45 ± 2.85	3.95 ± 5.84	2.88 ±3.75	1.61 ± 2.60
Fleabane		0.30 ± 1.15	0.07 ± 0.23	
Goatsbeard			1.32 ± 4.26	
Golden rod		0.33 ± 0.82	0.56 ± 0.91	0.15 ± 0.39
Goosefoot			0.04 ± 0.17	
Hawksbeard		0.04 ± 0.16	1.52 ± 3.09	0.08 ± 0.23
Hawkweed			1.27 ± 3.82	0.04 ± 0.17
Horsetails	4.63 ± 1.47	13.73±16.66	23.07±24.12	16.45±22.54
Lamb's Quarters	0.25 ± 1.14	0.08 ± 0.23	0.08 ± 0.17	

Table 3: Continued.

Mint		0.08 ± 0.23		
Miterwart	0.05 ± 0.10			
Northern Bedstraw	0.63 ± 0.53	0.91 ± 2.76		
Pineapple Weed		2.87 ± 5.78	0.39 ± 1.73	
Plantain	1.14 ± 1.50	4.30 ± 6.30	0.94 ± 1.88	1.61 ± 3.86
Ragwart		3.21 ± 4.22		0.04 ± 0.17
Raspberry				0.11 ± 0.27
Rose	0.89 ± 0.26	0.43 ± 1.06	3.82±16.75	2.52 ± 7.68
Russian Thistle			0.77 ± 2.35	
Scentless Chamomile	0.75 ± 0.65		0.26 ± 1.14	
Shooting Star			0.04 ± 0.17	
Sow Thistle			2.07 ± 3.65	1.84 ± 3.54
Stawberry	2.62 ± 2.12	3.44 ± 5.34	9.33 ± 9.52	2.40 ± 2.96
Thistle		1.37 ± 3.58	0.17 ± 0.60	
Twinflower	0.62 ± 0.58	0.17 ± 0.60	0.04 ± 0.17	
Vetch		2.82 ± 5.40	1.22 ± 2.45	0.28 ± 0.78
Western Dock				0.51 ± 2.29
Wintergreen	1.10 ± 1.49	0.59 ± 2.00	0.52 ± 1.49	
Yarrow		1.20 ± 4.30	0.92 ± 2.49	1.22 ± 4.09
Total	21.21	49.67	57.69	36.53
Shrubs				
Alder		1.80 ± 6.12	4.71 ± 7.62	1.98 ± 5.35
Aspen	0.93 ± 0.20	1.23 ± 3.01	2.66 ± 5.79	0.26 ± 0.81
Balsam Poplar			1.46 ± 3.73	0.84 ± 1.68
Birch		0.43 ± 0.94	0.92 ± 2.38	1.13 ± 3.71
Choke Cherry			0.11 ± 0.27	
Highbush Cranberry		0.17 ± 0.60		3.54±10.12
Lowbush Cranberry				0.79 ± 3.52
Spruce				0.04 ± 0.17
Willow	1.04 ± 2.25	0.68 ± 0.83	3.72 ± 5.54	
Total	1.97	4.31	13.58	8.58
Moss		6.02 ±11.30		0.24 ± 0.62
Lichen				0.04 ± 0.17
Mushroom				0.04 ± 0.17
Litter			0.11 ± 0.37	
TOTAL LIVING COVER	26.41	70.18	88.96	82.05
TOTAL BARE GROUND	65.03 + 17.34	51.52 + 20.23	26.67 + 18.24	19.20

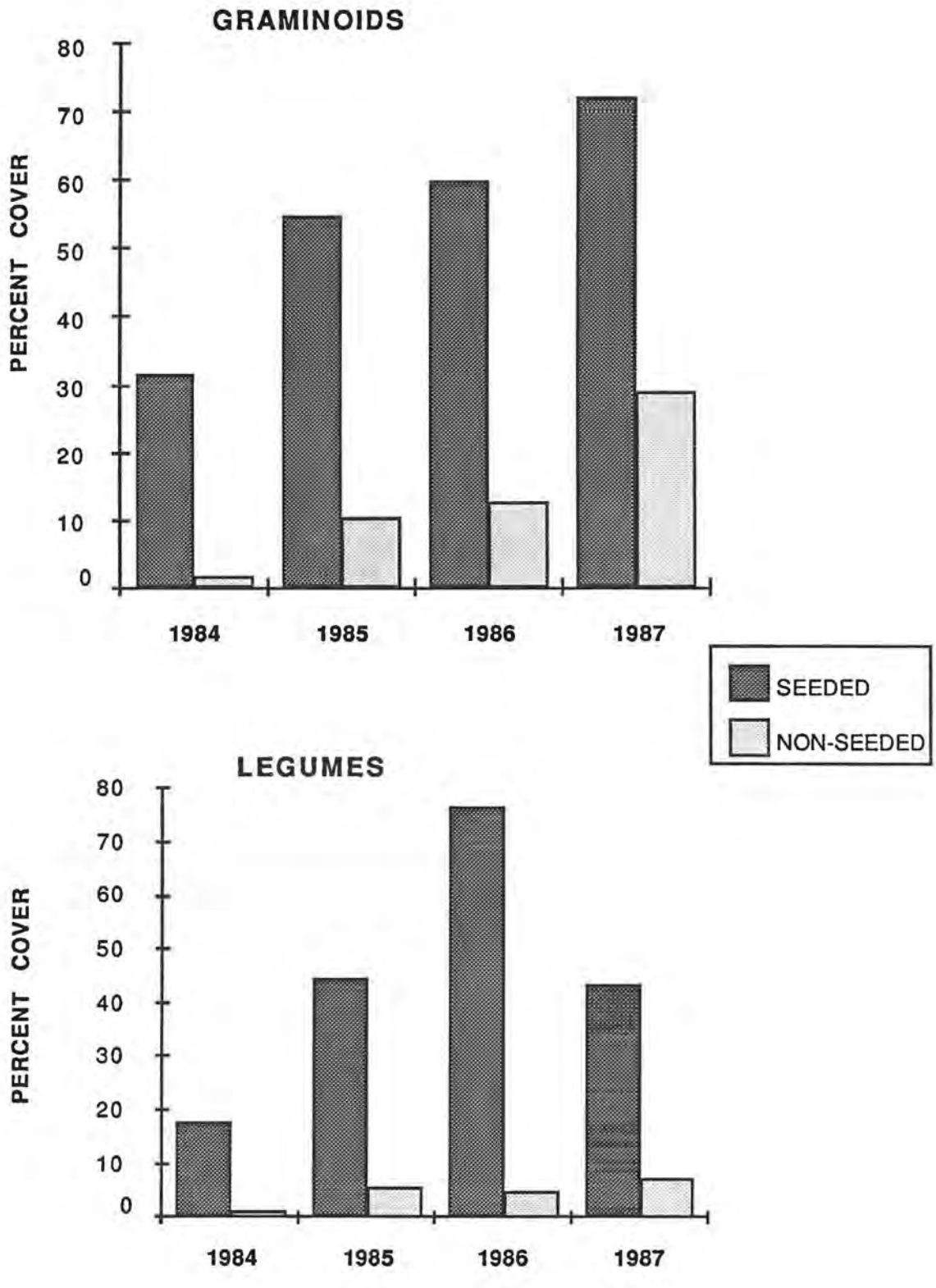

Figure 2: Comparison of graminoid and legume cover on the seeded and non-seeded portions of the pipeline right-of-way.

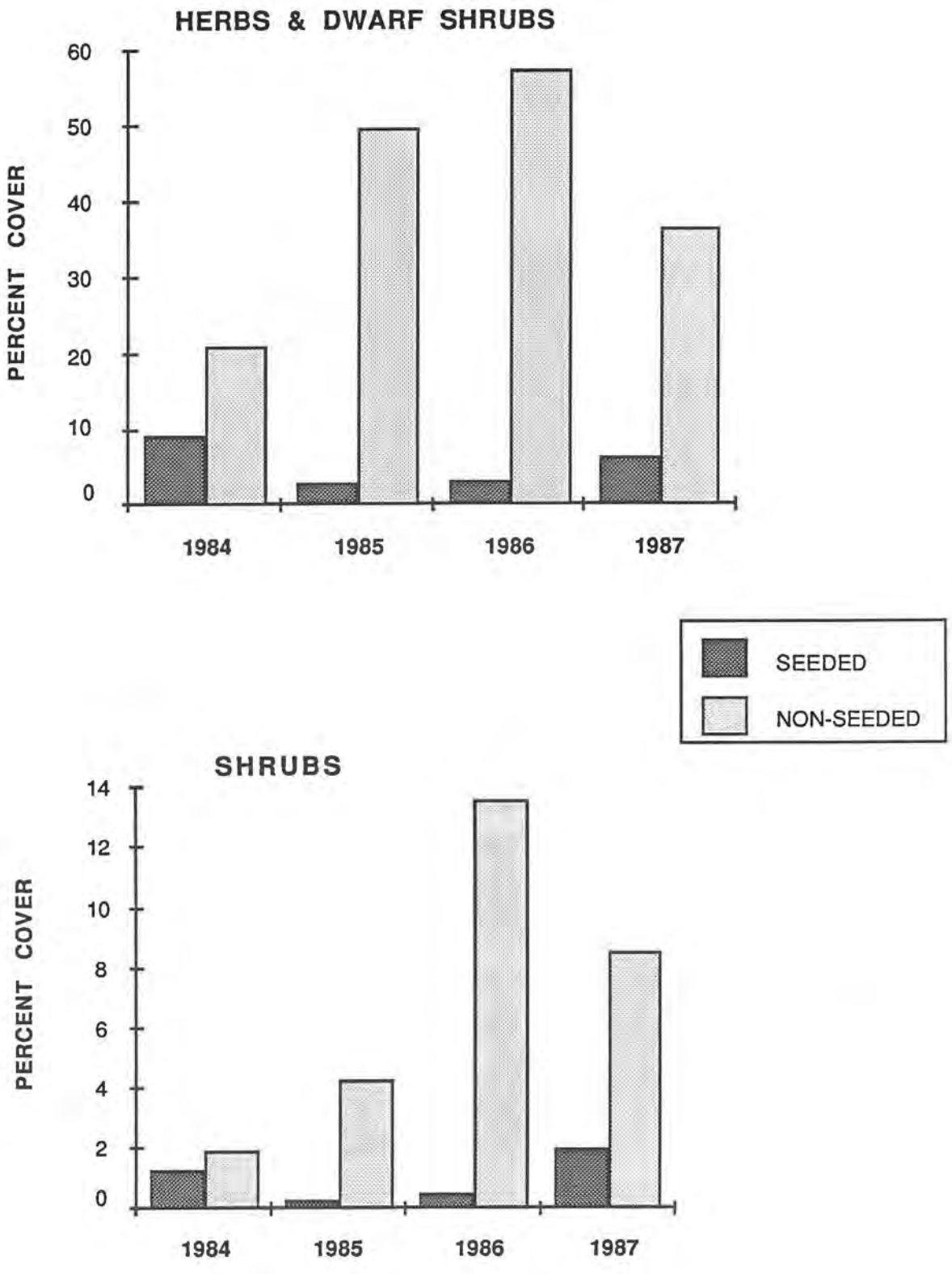

Figure 3: Comparison of herb and shrub cover on the seeded and non-seeded portions of the pipeline right-of-way.

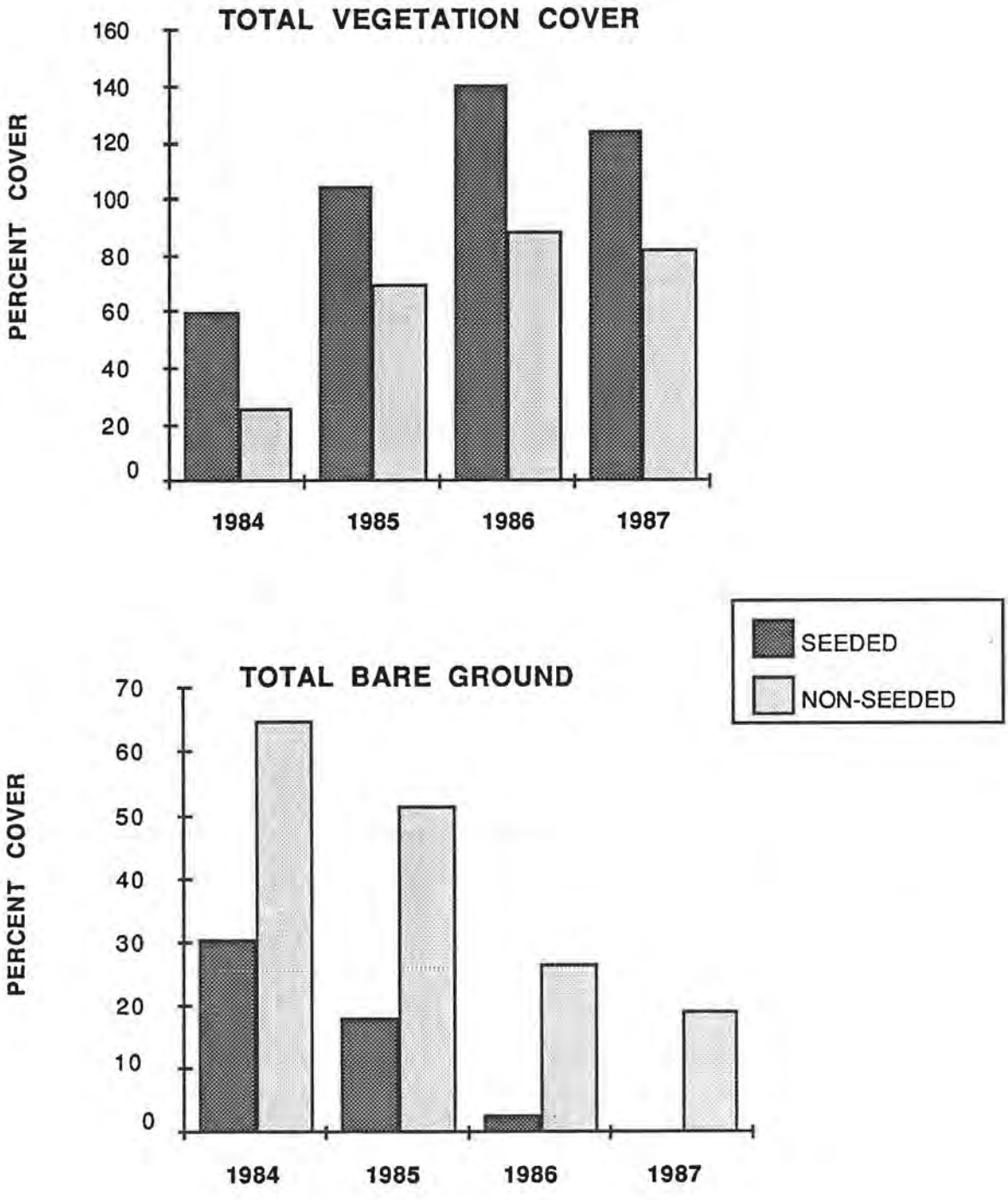

Figure 4: Comparison of total vegetative cover and bare ground on the seeded and non-seeded portions of the pipeline right-of-way.

Bare ground was observed at only 3% during 1986. The 1987 cover estimate (125%) represented a 15% decrease in total cover from 1986. Most of this decrease was due to a much reduced legume cover in 1987. Bare ground was observed at only a trace during 1987.

Non-Seeded Treatment

The non-seeded treatment was observed to have a much higher species diversity of vegetation species , particularly herb and shrub species, but lower total vegetation covers than the seeded treatment.

Total living cover on this treatment during 1984 was 26%, with bare ground observed at 65%. During 1985, the total living cover was observed at 70%, which reflects a two times increase in cover from herbaceous invading species than those recorded for 1984. Bare ground was observed at 51% during 1985. The total cover during 1986 was estimated at 89% and bare ground estimated at 27%. The 1986 cover estimates reflect an 18% increase in herbaceous cover from 1985. The 1987 cover estimate (82%) represented a 7% decrease in the cover of herbaceous invading native species compared to those recorded for 1986. This slight decrease was observed in herb and dwarf shrub covers. A small decrease in plant diversity was also observed (29 species during 1986 to 21 species during 1987). Bare ground was observed at 20% during 1987.

Vegetation Biomass

The results of the biomass evaluations during 1986 and 1987 are given in Table 4. Mean biomass for the seeded treatment was two times higher than the non-seeded treatment during 1987. These data compare to the 1986 numbers for biomass on the treatments.

Vegetation Encroachment

An estimate of the distance from the forest edge that vegetation has become established was conducted in 1986 and 1987 and the results are provided in Table 4. On the average, the non-seeded treatment had vegetation established 2.9m further from the forest edge than the seeded treatment. Encroachment had changed little from 1986.

Table 4: Estimates of biomass and vegetation encroachment on the seeded and non-seeded treatments during the revegetation surveys.

TREATMENT	MEAN BIOMASS (g/m^2)		ENCROACHMENT + S.D. (m)	
	1986	1987	1986	1987
Seeded	89.1	55.1	9.0 ± 2.70	8.5 ± 3.65
Non-Seeded	34.4	27.2	12.9 ± 2.15	11.4 ± 2.58

CONCLUSIONS

Following four growing seasons revegetation along the water pipeline right-of-way has progressed well on both treatments.

Differences in percentage cover and types of vegetation were observed during all revegetation surveys between the seeded and non-seeded portions of the right-of-way. The non-seeded portion was observed to have less vegetation cover and more bare ground than the seeded portion. However, the species diversity, particularly of herbaceous plants, was much higher on the non-seeded segment (Table 5).

As native invasion on to reclaimed areas is known to take considerably longer to establish than cover from agronomic seeding techniques, it was assumed that cover would again increase on the non-seeded treatment over the 1987 growing season. However, cover was observed to be slightly reduced in 1987. A comparison of plant community development indicates that in terms of abundance (cover) and diversity (number of species) the seeded and non-seeded treatments are stable. It is unlikely that a major increase or decrease in plant cover will be observed on either treatment over the next growing season.

The seeded treatment on the pipeline right-of-way achieved 100% vegetation cover within 2 years. The non-seeded treatment did not have the capability to achieve 100% cover within 5 years. This lack of capability to establish vegetative cover is an important consideration on sites that may have an erosion potential.

Species diversity on the non-seeded treatment was substantially higher each year of study and resembled the species composition of adjacent natural plant communities. The aspen and white spruce communities generally have high understory diversity due to their open canopies which provide a good residual source of native invaders. Additionally, the spreading of noxious weeds such as dandelion (maximum 3% cover), lambs quarters (max. 1%), and scentless chamomile (max. 1%) was very low on the non-seeded treatment.

Based on the data collected to date it is concluded that non-seeding of buried pipeline rights-of-way may be an acceptable reclamation technique provided that a) some fertilizer is applied initially, b) areas of high erosion risk are identified and not included, and c) monitoring is planned for 2 years at a minimum. The major benefits to non-seeding are economic savings and contribution to ecological diversity.

Further study is planned for these sites to monitor and evaluate the success of native invading shrubs and trees.

Table 5: Summary of percentage vegetation cover by type.

	SEEDED TREATMENT				NON-SEEDED TREATMENT			
GROUP	1984	1985	1986	1987	1984	1985	1986	1987
Graminoids	31.65	55.01	60.01	72.43	1.72	10.34	12.79	29.12
Legumes	18.01	44.95	76.74	43.41	1.51	5.87	4.90	7.54
Herbs & Dwarf Shrubs	9.10	2.79	3.20	6.42	21.21	49.67	57.69	36.53
Shrubs	1.31	0.30	0.53	2.03	1.97	4.31	13.58	8.58
Moss		1.77				6.02		0.24
Total Living Cover	60.07	104.82	140.48	124.29	26.41	70.18	88.96	82.05
Total Bare Ground	30.57	18.31	2.96		65.03	51.52	26.67	19.20
Total Litter				0.13				

Note: Covers greater than 100% due to the formation of strata.

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APPENDIX 1: Common and Botanical Names of Agronomic and Native Vegetation Species

COMMON NAME	BOTANICAL NAME
Graminoids	
Bluegrass	*Poa* sp.
Brome	*Bromus* sp.
Fescue	*Festuca rubra*
Foxtail barley	*Hierchloe jubatum*
Hairgrass	*Agrostis* sp.
Hairy Wild Rye	*Lolium* sp.
Northern Reed Grass	*Calamagrostis inexpansa*
Sedge	*Carex* sp.
Wheatgrass	*Agropyron* sp.
Legumes	
Alfalfa	*Medicago sativa*
Alsike Clover	*Trifolium hybridum*
White Sweet Clover	*Melilotus alba*
Herbs & Dwarf Shrubs	
Aster	*Aster* sp.
Baby's Breath	*Gysophilia paniculatra*
Bearberry	*Arctostaphylos uva-ursi*
Bishop's Cap	*Mitella nuda*
Bluebells	*Mertensia paniculata*
Bunchberry	*Cornus canadensis*
Buttercup	*Ranunculus* sp.
Canada Thistle	*Cirsium arvense*
Cattails	*Typha latifolia*
Cinquefoil	*Potentilla* sp.
Colt's Foot	*Petasites* sp.
Dandelion	*Taraxacum officinale*
Fireweed	*Epilobium angustifolium*
Fleabane	*Erigeron* sp.
Goatsbeard	*Tragopogon dubius*
Goldenrod	*Solidago gigantea*
Goosefoot	*Chenopodium* sp.

APPENDIX 1: continued.

COMMON NAME	BOTANICAL NAME
Hawk's Beard	*Crepis tectorum*
Hawkweed	*Hieracium* sp.
Horsetails	*Equisetum* sp.
Labrador Tea	*Ledum groenlandicum*
Lamb's Quarter	*Chenopodium album*
Mint	*Mentha* sp.
Mitrewart	*Mitella* sp.
Northern Bedstraw	*Galium boreale*
Pineapple Weed	*Matricaria matricarioides*
Plantain	*Plantago* sp.
Ragwort	*Senecio congestus*
Raspberry	*Rubus* sp.
Rose	*Rosa acicularis*
Russian Thistle	*Salsola kali*
Scentless Chamomile	*Matricaria maritima*
Shooting Star	*Dodecatheon radicatum*
Sow Thistle	*Sonchus* sp.
Strawberry	*Fragaria virginiana*
Twin Flower	*Linnaea borealis*
Vetch	*Vicia americana*
Western Dock	*Rumex occidentalis*
Wintergreen	*Pyrola* sp.
Yarrow	*Achillea millefolium*
Shrubs	
Alder	*Alnus* sp.
Aspen	*Populus tremuloides*
Balsam Poplar	*Populus balsamifera*
Birch	*Betula* sp.
Choke Cherry	*Prunus virginiana*
High-bush Cranberry	*Viburnum opulus*
Low-bush Cranberry	*Viburnum edule*
Spruce	*Picea* sp.
Willow	*Salix* sp.

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1989

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