Environmental Services

PIPELINE REVEGETATION RESEARCH: HAINES JUNCTION TEST SITE PROGRESS REPORT - 1979

Foothills Pipe Lines (South Yukon) Ltd.

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THE ALASKA HIGHWAY GAS PIPELINE PROJECT

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PIPELINE REVEGETATION RESEARCH:
HAINES JUNCTION TEST SITE
PROGRESS REPORT - 1979

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SUMMARY

In May, 1977 a revegetation research program was initiated proximal to Haines Junction, Yukon Territory in order to obtain information useful for successful revegetation of areas disturbed by construction of the proposed Alaska Highway Gas Pipeline. Four test sites were established to investigate various factors which can affect the success of a northern revegetation program. The factors studied were:

a) Plant adaptability to northern conditions
b) The effect of competition
c) The effect of aspect and slope and
d) The applicability of the shredding technique of revegetation.

Timing for optimal revegetation was also studied as the first and fourth of these tests were duplicated in the spring and fall.

The program was designed as a long term study with preliminary conclusions to be stated after three growing seasons. This report contains a summary of three years' results and contains conclusions valid in relation to the data obtained to date. Major findings include the following:

a) Native species regeneration will occur more rapidly on areas which have the rhizosphere retained during construction activity than on substrates subject to removal of all soil overlying the parent material.

b) On southern aspect slopes requiring revegetation the use of a mulch for microenvironment amelioration appears essential.

c) The shredding technique of vegetative revegetation can be used successfully in areas inundated by water during prime seeding time.

d) No conclusions can be drawn from this program regarding the optimal timing for revegetation.

e) Desirable components of a seed mixture for similar regions include three wheatgrasses (*Agropyron cristatum*, *A. pauciflorum* and *A. riparium*), hairgrass (*Deschampsia caespitosa*), hairy wild rye (*Elymus innovatus*), fescue (*Festuca* sp.) and three bluegrasses (*Poa compressa*, *P. glauca* and *P. pratensis*).

f) Little plant overwintering mortality has occurred to date but delayed germination of species such as the bluegrasses (*Poa* spp.) has greatly increased their emergence, thereby suggesting that these will provide a substantial portion of the permanent ground cover.

This program has now progressed to the point that final recommendations based on longer term results can be made with high expectations of success.

1.0 INTRODUCTION

Construction of the proposed Alaska Highway Natural Gas Pipeline, which will cross southern Yukon Territory from Beaver Creek to Watson Lake, will result in some environmental perturbation. Right-of-way clearing and construction of ancillary facilities will result in removal of vegetal cover and some disturbance to the terrain. Upon termination of construction a revegetation program will be implemented to aid in minimization of potential long term impacts such as sedimentation of waterways caused by erosion of exposed soil.

The program described herein was initiated in May 1977 with the establishment of four revegetation test sites near Haines Junction (Lat. 60°45', Long. 137°35'). At that time little definitive information was available regarding optimal techniques or candidate plant species for restoration of ground cover to disturbed land in southern Yukon Territory. Consequently, the Haines Junction Revegetation Research Program was initiated to obtain information pertinent to revegetation of disturbed areas in this xeric region.

Previous years' results have been reported in the progress reports entitled "Pipeline Revegetation Research - Haines Junction Test Site - 1977 Progress Report" (Foothills 1978) and "Pipeline Revegetation Research - Haines Junction Test Site - Progress Report - 1978" (Foothills 1979a). Field plans for the test sites are not included in this report as they were included in the 1978 report cited above.

The location of this program at Haines Junction (Figure 1) was dictated by two major factors:

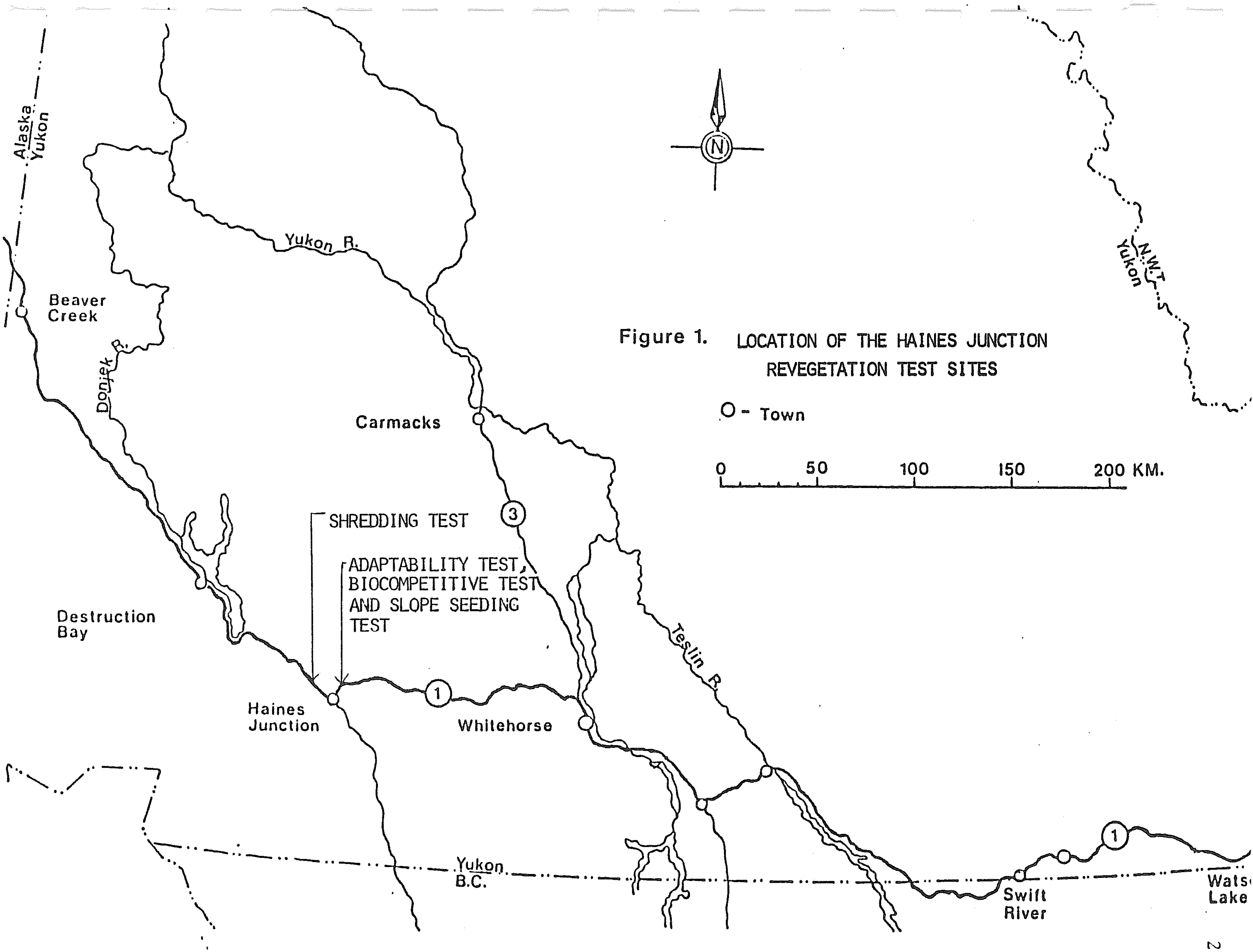

Figure 1. LOCATION OF THE HAINES JUNCTION REVEGETATION TEST SITES

(a) Precipitation at Haines Junction is very limited during the growing season (Table 1). If revegetation problems were to occur in southern Yukon Territory, it is likely that the major problem would occur in similar dry regions. Therefore, ecotype adaptability is more critical in such regions than in areas receiving greater amounts of precipitation.

(b) The soil at the Haines Junction Airstrip had been disturbed in a manner somewhat analogous to that which may be expected from pipeline right-of-way clearing.

Four test sites were established in 1977. The major site was designed as a long term adaptability test wherein ecotypes of grasses, shrubs and legumes could be evaluated for emergence, vigour, survival and reproductive ability for several years in order to assess their long term adaptability to climatic and edaphic conditions at Haines Junction. Two smaller sites were established to assess the bio-competitive ability of individual ecotypes when seeded in mixtures and to ascertain the effect of slope and aspect on success of seeding. A fourth site was established to test and demonstrate the applicability of the shredding technique of vegetative propagation in areas where seeding may be impossible because of standing water.

TABLE 1

CLIMATE OF YUKON TERRITORY

(reproduced from Oswald and Senyk 1977)

				TEMP (°C)				PRECIP. (mm)	
	Lat.	Long.	Elev.(m)	Annual	May-Sept.	Jan.	July	Annual	June-Aug.
Haines Rd. M75	59°47'	136°36'	884	-3	6	-20	9	761	143
Watson Lake*	60°07'	128°49'	685	-3	11	-25	15	434	147
Carcross	60°11'	134°41'	661	-1	9	-19	13	226	69
Tuchita	60°55'	129°15'	759	-5	9	-31	13	605	155
Teslin*	60°10'	132°45'	701	-1	10	-20	13	326	99
Johnsons x	60°29'	133°20'	690	-3	9	-26	13	346	132
Whitehorse*	60°43'	135°04'	698	-1	11	-19	14	260	98
Haines Jct.*	60°45'	137°35'	599	-3	9	-21	12	281	90
Tungsten	61°57'	128°15'	1143	-6	7	-27	11	605	214
Ross River	61°59'	132°27'	698	-7	9	-35	13	253	102
Burwash	61°22'	139°03'	801	-5	8	-30	12	283	144
Anvil	62°22'	133°23'	1173	-4	7	-25	11	368	135
Carmacks	62°06'	136°18'	521	-5	10	-34	14	247	107
Ft. Selkirk*	62°49'	137°22'	437	-5	11	-30	15	276	113
Beaver Ck.	62°23'	140°53'	663	-7	9	-34	13	412	229
Mayo*	63°36'	135°53'	495	-4	11	-27	15	293	117
Dempster	64°27'	138°13'	991	-7	7	-28	11	453	157
Dawson City*	64°04'	139°26'	324	-5	11	-29	16	325	140
Old Crow	67°34'	137°13'	55	-10	4	-25	11	173	99
Komokuk B.*	69°35'	140°11'	9	-11	2	-24	7	125	71

*Based on 25-year or more data.

2.0 GENERAL OBJECTIVES

The general purpose of this program was to obtain information regarding emergence, establishment and survival of various native species and naturalized landraces of grasses, legumes and shrubs within a self-supporting ecosystem.

As discussed above, the Haines Junction test sites were established in 1977 and have been evaluated each year. The primary objective was the monitoring of the long term performance of the test plants. Long term evaluation is necessary because one and two year results are frequently misleading since many plants thrive for a short time and then succumb to winter injury (Thirgood and Ziemkiewicz 1978). This is of particular importance in northern regions such as Yukon Territory which are subject to long, cold winters.

In 1979 the general objectives were to continue the evaluation of the test plants and subsequently assess the performance to date of each ecotype (See Table 11). Based on this assessment the preliminary recommendations for ecotype selection for revegetation of xeric regions of Yukon Territory were formulated (See Table 12).

The specific objectives and methods differed among the four sites and will be discussed in the appropriate sections.

3.0 ECOTYPE ADAPTABILITY TESTS

3.1 OBJECTIVES

Two major difficulties encountered in northern revegetation efforts are limited seedling emergence and high plant mortality during harsh northern winters. Seedling emergence can be reduced by abiotic factors such as temperature (McCown 1973) and moisture (Foothills 1979c) while northern diseases such as snowmold (*Sclerotinia borealis*) contribute to plant overwintering mortality (Vaartnou and Elliott 1969). The candidate species in many northern vegetation studies (Mitchell and McKendrick 1974 and 1975, Younkin 1976) have had initial success but suffered high mortality in following years. This has been attributed to physiological and morphological differences between native northern ecotypes and commercial cultivars developed for more southerly agronomic purposes (Mitchell and McKendrick 1974). Many northern ecotypes have adapted to the severe climatic conditions they encounter (Billings 1974, Billings and Mooney 1968) through the development of characteristics such as low growth form (Savile 1972). Thus, the ability to withstand northern conditions, brought about by adaptations in northern ecotypes is a prime consideration in choosing seed stock for revegetation in the north.

The adaptability tests were designed to monitor the emergence, survival and reproductive ability of individual ecotypes of grasses, legumes and shrubs over a period of several years. Extended monitoring is recommended by all researchers because long-term success is probably determined by extreme winter or summer temperatures which occur only infrequently (Klebesadel 1974).

3.2 MATERIALS

All ecotypes which were seeded are from the collection of Vaartnou and Sons Enterprises Ltd. The original seeds or plants of these ecotypes were collected from northern Alberta, northern British Columbia, Yukon Territory or the Northwest Territories. Subsequently, the seed stock was multiplied in northern Alberta.

Those ecotypes which were transplanted as rooted plants are native to Yukon Territory as all but one were collected from native vegetation within one kilometer of the test site. The one exception, sweetgrass (*Hierochloe odorata*), is also native to Yukon Territory. The ecotype used in the tests was collected from Whitehorse in 1973 and subsequently multiplied vegetatively in Alberta.

3.3 LOCATION AND DESCRIPTION

The adaptability test sites are located on Ministry of Transport property, 15 meters north of the Haines Junction airstrip (137°15' longitude and 60°45' latitude). The land had been disturbed by airstrip construction and maintenance which resulted in removal of much of the top soil. Therefore most of the soil available for a growth medium was C horizon or parent material.

When the site was selected in early May, 1977, pioneer species such as poplar (*Populus balsamifera*), hedysarum (*Hedysarum* spp.) and milk vetch (*Astragalus* spp.) were encroaching on the airstrip from all sides. Ministry of Transport personnel removed this surface vegetation by blading it off in mid-May, 1977, just prior to the spring planting. Thus, at the time of spring planting, the site was nearly void of surface vegetation but roots of many plants were still alive.
By the time of the fall planting considerable regeneration of species such as poplar (*Populus balsamifera*) and willow (*Salix* spp.) had occurred.

3.4 METHODS

3.4.1 Establishment

Spring planting occurred on May 25, 1977. Fifty ecotypes of northern grasses, legumes and shrubs were hand planted in rows with each ecotype planted to fifteen microsites per row. The microsites in each row were spaced one meter apart with rows also one meter apart.

Thirty-four ecotypes were hand seeded to a depth of one cm, fifteen were planted as rooted plants and one, willow (*Salix* sp.) was planted in the form of stem cuttings.

There was no seed bed preparation at the time of establishment but the site was fertilized with 16-20-0 commercial fertilizer at the rate of 80 kg/ha. On August 27, 1977, the site was again fertilized with the same fertilizer at an identical rate.

Fall planting occurred on October 1, 1977. Thirty-four ecotypes were hand seeded and sweetgrass (*Hierochloe odorata*) was transplanted from Edmonton. Thirty-three of the seeded ecotypes were identical to those of the spring planting while the other, hairgrass (*Deschampsia caespitosa*), was the same species but a different ecotype from that planted in the spring. Methods were identical to those used in the spring. No transplanting of local material was possible in the fall because the frozen ground was too hard for successful removal of native plants. There was no fertilization at this time but this site was fertilized in May, 1978 with 16-20-0 at 160 kg/ha.

Both spring and fall planting were replicated three times.

3.4.2 Evaluation

The sites were evaluated on July 20 and 21, 1979. The specific methods used are described below.

(a) Survival

The survival figures for each ecotype are based upon an exact count of all possible microsites which had a live plant. These totals were then converted to percentages.

(b) Vigour

The vigour ratings are subjective assessments of each ecotype's development in relation to it's optimum development under ideal conditions. They are based upon the gross morphology and phenology of each ecotype. Plant characters considered in this visual rating include leaf colour, leaf width and length, tillers, signs of disease and rhizomatous development if applicable. The numerical values 1, 2, 3 and 4 should generally be interpreted as corresponding to the words poor, fair, average and strong respectively.

The 5 rating denotes successful phenological development of the ecotype. This was only used for ecotypes which were rated 4 for gross morphology and which had produced seed on a minimum of 50% of surviving plants.

(c) Seed Production

The seed production figures are based on an exact count of plants which produced seed. These totals have been converted to two percentage values. The first is the percentage of plants having reproductive potential in relation to all possible microsites and the second is the percentage of extant plants which produced sexual reproduction organs.

3.5 RESULTS

3.5.1 May 25, 1977 Planting

(a) Seeded Ecotypes

Survival percentages of the seeded ecotypes did not change substantially from 1978 to 1979. The eight most successful ecotypes were five wheatgrasses (*Agropyron* spp.), two wild ryes (*Elymus* spp.) and a fescue (*Festuca* sp.). All had over 60% survival with streambank wheatgrass (*Agropyron riparium*) and slender wheatgrass (*A. pauciflorum*) the most successful at 95.6 and 91.1% respectively.

Three grasses; red top (*Agrostis gigantea*), meadow foxtail (*Alopecurus pratensis*) and alkaligrass (*Puccinellia distans*) and three legumes; yellow lucerne (*Medicago falcata*), Mackenzie's hedysarum (*Hedysarum Mackenzii*) and zig-zag clover (*Trifolium medium*) suffered at least 25% mortality as their small seedlings were unable to survive the winter. In contrast four bluegrasses; (*Poa alpina*, *P. glauca*, *P. palustris* 89 and *P. pratensis* 92) had at least a 25% increase resulting from delayed germination.

Vigour improved considerably over 1978 as, of thirty ecotypes having some survival, five were rated at 5, twelve were rated 4 and only three were rated at less than 3. The five ecotypes rated at 5 were slender wheatgrass (*Agropyron pauciflorum*), native fescue (*Festuca saximontana*), Canada bluegrass (*Poa compressa*), alkaligrass (*Puccinellia distans*) and one of the fowl bluegrass ecotypes (*Poa palustris* 93).

Seed production percentages of those ecotypes which had some surviving plants ranged from 100% for native fescue (*Festuca saximontana*) to 0% for nine ecotypes. All grass ecotypes except one Kentucky bluegrass (*Poa pratensis* 39) developed seed stalks on at least 16% of surviving plants. In contrast, of the legumes and shrubs which were seeded only Mackenzie's hedysarum (*Hedysarum Mackenzii*) had any floral development and that was limited to 10% of extant plants.

(b) Rooted Plants

1979 survival percentages for the rooted plants were nearly identical to those of 1978. Slender wheatgrass (*Agropyron pauciflorum*) had 93.3% survival while three other grasses; hairgrass (*Deschampsia caespitosa*), sweetgrass (*Hierochloe odorata*) and glaucous bluegrass (*Poa glauca*), had at least 75% survival after three growing seasons. The most successful shrubs were gooseberry (*Ribes oxyacanthoides*), and willow (*Salix glauca*) which had 68.9 and 62.2% survival respectively. The two legumes, milk vetch (*Astragalus eucosmus*) and Mackenzie's hedysarum (*Hedysarum Mackenzii*), had no surviving plants.

Vigour was excellent as no surviving ecotype was rated less than 3 and four grasses were rated 5. The latter four were hairgrass (*Deschampsia caespitosa*), glaucous bluegrass (*Poa glauca*), slender wheatgrass (*Agropyron pauciflorum*) and reed grass (*Calamagrostis neglecta*). Seed production percentages for these four grasses were 83.8, 79.4, 76.2 and 55.0% respectively. The other grasses, native fescue (*Festuca saximontana*) and sweetgrass (*Hierochloe odorata*) had 33.3 and 13.5% of plants with seed respectively while the only shrub to develop flowers was buffaloberry (*Shepherdia canadensis*). Survival of this latter ecotype was only 13.3% but of these, 33.3% produced flowers.

Stem Cuttings

(c) No stem cuttings rooted successfully in 1977.

The complete three year evaluation results of the May, 1977 planting trial are found in Table 2.

TABLE 2

SURVIVAL, VIGOUR AND SEED PRODUCTION OF ECOTYPES PLANTED ON MAY 25, 1977 AFTER THREE GROWING SEASONS

Species	Stock No.*	Survival (%)			Vigour (1-5)			Seed Production	
								Total Microsites (%)	Surviving Plants (%)
		1977	1978	1979	1977	1978	1979	1979	1979
SEEDED ECOTYPES									
Agropyron cristatum	244	51.1	86.7	77.8	3	4	3	17.8	22.9
Agropyron pauciflorum	8	80.0	93.3	91.1	3	4	5	66.7	73.2
Agropyron repens	466	80.0	82.2	82.2	3	4	4	40.0	49.1
Agropyron riparium	247	91.1	93.3	95.6	4	4	4	20.0	20.9
Agropyron Smithii	47	82.2	91.1	84.4	3	4	4	24.4	28.9
Agrostis gigantea	327	35.6	46.7	17.8	2	3	3	8.9	50.0
Alopecurus pratensis	280	24.4	33.3	26.7	3	2	4	4.4	16.3
Astragalus americanus	376	20.0	13.3	11.1	2	1	1	0.0	0.0
Astragalus eucosmus	380	0.0	0.0	0.0	-	-	-	---	---
Astragalus flexuosus	724	20.0	0.0	0.0	1	-	-	---	---
Bromus Pumpellianus	64	0.0	0.0	0.0	-	-	-	---	---
Deschampsia caespitosa	68	35.6	20.0	20.0	1	2	4	4.4	22.2
Dryas Drummondii	575	6.7	2.2	2.2	2	4	3	0.0	0.0
Elaeagnus commutata	166	33.3	37.8	31.1	3	3	4	0.0	0.0
Elymus canadensis	20	71.1	80.0	71.1	3	3	3	13.3	18.8
Elymus innovatus	331	22.2	62.2	64.4	3	4	4	13.3	20.7

TABLE 2 (continued)

SURVIVAL, VIGOUR AND SEED PRODUCTION OF ECOTYPES PLANTED ON MAY 25, 1977 AFTER THREE GROWING SEASONS

Species	Stock No.*	Survival (%) 1977	Survival (%) 1978	Survival (%) 1979	Vigour (1-5) 1977	Vigour (1-5) 1978	Vigour (1-5) 1979	Seed Production Total Microsites (%) 1979	Seed Production Surviving Plants (%) 1979
Festuca saximontana	526	15.6	15.6	15.6	1	2	5	15.6	100.0
Festuca sp.	524	82.2	88.9	77.8	3	4	4	37.8	48.6
Hedysarum alpinum	409	6.7	8.9	6.7	2	2	4	0.0	0.0
Hedysarum Mackenzii	413	28.9	37.8	22.2	3	3	4	2.2	10.0
Medicago falcata	110	40.0	22.2	2.2	1	1	1	0.0	0.0
Oxytropis campestris	643	28.9	24.4	24.4	3	1	3	0.0	0.0
Oxytropis splendens	745	13.3	13.3	13.3	2	1	3	0.0	0.0
Poa alpina	82	8.9	17.8	24.4	1	2	2	0.0	0.0
Poa ampla	84	33.3	44.4	48.9	1	3	4	15.6	31.8
Poa compressa	94	15.6	22.2	24.4	1	2	5	15.6	63.6
Poa glauca	95	6.7	17.8	35.6	1	2	3	15.6	43.8
Poa glaucantha	202	15.6	42.2	37.8	3	3	3	17.8	47.1
Poa palustris	89	11.1	37.8	48.9	3	3	3	33.3	68.2
Poa palustris	93	26.7	51.1	60.0	2	3	5	35.6	59.4
Poa pratensis	39	15.6	22.2	17.8	2	3	3	0.0	0.0
Poa pratensis	92	6.7	26.7	33.3	3	3	4	13.3	40.0

TABLE 2 (continued)

SURVIVAL, VIGOUR AND SEED PRODUCTION OF ECOTYPES PLANTED ON MAY 25, 1977 AFTER THREE GROWING SEASONS

Species	Stock No.*	Survival (%) 1977	1978	1979	Vigour (1-5) 1977	1978	1979	Seed Production: Total Microsites (%) 1979	Surviving Plants (%) 1979
Puccinellia distans	43	53.3	42.2	28.9	2	3	5	20.0	69.2
Trifolium medium	119	48.9	4.4	0.0	1	1	-	---	---
ROOTED PLANTS									
Agropyron pauciflorum	--	84.4	86.7	93.3	3	4	5	71.1	76.2
Arctostaphylos uva-ursi	--	4.4	4.4	6.7	2	2	4	0.0	0.0
Astragalus eucosmus	--	24.4	0.0	0.0	2	-	-	---	---
Calamagrostis neglecta	--	44.4	40.0	44.4	2	3	5	24.4	55.0
Deschampsia caespitosa	--	88.9	80.0	82.2	3	5	5	68.9	83.8
Festuca saximontana	--	42.2	42.2	26.7	1	3	3	8.9	33.3
Hedysarum Mackenzii	--	0.0	0.0	0.0	-	-	-	---	---
Hierochloe odorata	--	84.4	80.0	82.2	3	4	3	11.1	13.5
Picea glauca	--	24.4	26.7	24.4	3	3	3	0.0	0.0
Poa glauca	--	73.3	75.6	75.6	2	4	5	60.0	79.4
Populus balsamifera	--	31.1	4.4	4.4	1	1	3	0.0	0.0
Ribes oxyacanthoides	--	66.7	66.7	68.9	2	3	4	0.0	0.0

TABLE 2 (continued)

SURVIVAL, VIGOUR AND SEED PRODUCTION OF ECOTYPES PLANTED ON MAY 25, 1977 AFTER THREE GROWING SEASONS

Species	Stock No.*	Survival (%) 1977	Survival (%) 1978	Survival (%) 1979	Vigour (1-5) 1977	Vigour (1-5) 1978	Vigour (1-5) 1979	Seed Production: Total Microsites (%) 1979	Seed Production: Surviving Plants (%) 1979
Rosa acicularis	--	15.6	20.0	24.4	2	3	3	0.0	0.0
Salix glauca	--	80.0	68.9	62.2	3	3	3	0.0	0.0
Shepherdia canadensis	--	17.8	15.6	13.3	2	3	4	4.4	33.3
STEM CUTTINGS									
Salix sp.	--	0.0	0.0	0.0	-	-	-	---	---

*Stock Nos. refer to Vaartnou & Sons Enterprises Ltd. Botany Collection Number

3.5.2 October 1, 1977 Planting

(a) Seeded Ecotypes

Survival percentages increased substantially in 1979 as eighteen grass and one legume ecotype increased at least 20% due to delayed germination. Hairy wild rye (*Elymus innovatus*) had the highest survival percentage of 95.6% while seven other ecotypes had at least 80% survival. These were four wheatgrasses (*Agropyron cristatum*, *A. pauciflorum*, *A. repens* and *A. riparium*), northern brome (*Bromus Pumpellianus*), a fescue (*Festuca* sp.) and one ecotype of fowl bluegrass (*Poa palustris* 89). Legume emergence and survival was much weaker as only zig-zag clover (*Trifolium medium*) had over 10% survival and these seedlings were only rated at 1 for vigour.

The largest increase in emergence and survival took place in the bluegrass genus (*Poa* spp.) as extensive delayed germination occurred in 1979. Collectively, these nine ecotypes increased from 7.8 to 46.9%. Individually the largest increases occurred in alpine bluegrass (*Poa alpina*) - 4.4 to 71.1%; glaucous bluegrass (*Poa glauca*) - 0.0 to 42.2%; one ecotype of fowl bluegrass (*Poa palustris* 89) - 8.9 to 82.2%; and one ecotype of Kentucky bluegrass (*Poa pratensis* 39) - 4.4 to 62.2%.

Plant vigour also increased from 1978 to 1979 but these increases were less dramatic than the survival percentage increases. Of the twenty-nine ecotypes having some survival, five were rated at 1, seven were rated at 2, fifteen were rated at 3 and two; streambank wheatgrass (*Agropyron riparium*) and Sherman bluegrass (*Poa ampla*), were rated at 4. In 1978 only twenty-five ecotypes had any emergence and seventeen of these had been rated at less than 3.

Seed production percentages were low as only three bluegrasses (*Poa ampla*, *P. compressa* and *P. glauca*) produced seed stalks on more than 10% of surviving plants. Three wheatgrasses (*Agropyron cristatum*, *A. pauciflorum* and *A. repens*) and one other bluegrass (*Poa palustris* 93) also had some seed stalk development but no legumes had floral development in 1979.

(b) Rooted Plants

The only transplanted ecotype, sweetgrass (*Hierochloe odorata*), improved slightly from 1978 to 1979. Survival of 33.3% was similar to that of 1978 but vigour increased from 2 to 3. No seed production occurred in 1979.

The complete results from the October, 1977 seeding trial are found in Table 3.

3.6 DISCUSSION

Several inferences are now possible from the results found in Tables 2 and 3. If rapid ground cover is required for erosion control then the use of ecotypes which have relatively large seeds appears desireable. In both trials the wheatgrasses (*Agropyron* spp.), wild rye grasses (*Elymus* spp.) and a northern fesuce (*Festuca* sp.) had the highest first year emergence and survival percentages. These are also the ecotypes having the largest seeds. This correlation probably occurred because seemingly insignificant differences in seed shape and size can profoundly influence germination by altering such factors as seed-soil moisture relations (Harper et al 1970). This is particularly significant for xeric regions similar to Haines Junction which may be frequently subject to a shortage of moisture during the growing season.

TABLE 3

SURVIVAL, VIGOUR AND SEED PRODUCTION OF ECOTYPES PLANTED ON OCTOBER 1, 1977 AFTER TWO GROWING SEASONS

Species	Stock No.*	Survival (%) 1978	Survival (%) 1979	Vigour (1-5) 1978	Vigour (1-5) 1979	Seed Production Total Microsites (%) 1979	Seed Production Surviving Plants (%) 1979
ROOTED PLANTS							
Hierochloe odorata	--	35.6	33.3	2	3	0.0	0.0
SEEDED ECOTYPES							
Agropyron cristatum	244	68.9	88.9	2	3	2.2	2.5
Agropyron pauciflorum	8	91.1	88.9	3	3	2.2	2.5
Agropyron repens	466	75.6	91.1	3	3	6.7	7.3
Agropyron riparium	247	88.9	93.3	4	4	0.0	0.0
Agropyron Smithii	47	75.6	55.6	2	2	0.0	0.0
Agrostis gigantea	327	8.9	0.0	1	-	---	---
Alopecurus pratensis	280	28.9	53.3	3	3	0.0	0.0
Astragalus americanus	376	0.0	0.0	-	-	---	---
Astragalus eucosmus	380	0.0	0.0	-	-	---	---
Astragalus flexuosus	724	0.0	6.7	-	1	0.0	0.0
Bromus Pumpellianus	64	75.6	91.1	3	3	0.0	0.0
Deschampsia caespitosa	67	4.4	17.8	2	2	0.0	0.0
Dryas Drummondii	575	0.0	0.0	-	-	---	---

TABLE 3 (continued)

SURVIVAL, VIGOUR AND SEED PRODUCTION OF ECOTYPES PLANTED ON OCTOBER 1, 1977 AFTER TWO GROWING SEASONS

Species	Stock No.*	Survival (%)		Vigour (1-5)		Seed Production Total Microsites (%)	Seed Production Surviving Plants (%)
		1978	1979	1978	1979	1979	1979
Elaeagnus commutata	166	0.0	0.0	-	-	---	---
Elymus canadensis	20	55.6	55.6	2	2	0.0	0.0
Elymus innovatus	331	77.8	95.6	3	3	0.0	0.0
Festuca saximontana	526	0.0	51.1	-	2	0.0	0.0
Festuca sp.	524	73.3	91.1	3	3	0.0	0.0
Hedysarum alpinum	409	0.0	2.2	-	3	0.0	0.0
Hedysarum Mackenzii	413	8.9	4.4	3	2	0.0	0.0
Medicago falcata	110	4.4	8.9	1	1	0.0	0.0
Oxytropis campestris	643	6.7	6.7	1	1	0.0	0.0
Oxytropis splendens	745	2.2	2.2	1	1	0.0	0.0
Poa alpina	82	4.4	71.1	1	3	0.0	0.0
Poa ampla	84	35.6	53.3	2	4	13.3	25.0
Poa compressa	94	8.9	28.9	1	3	8.9	30.8
Poa glauca	95	0.0	42.2	-	3	11.1	26.3
Poa glaucantha	202	0.0	20.0	-	2	0.0	0.0
Poa palustris	89	8.9	82.2	2	3	0.0	0.0

TABLE 3 (continued)

SURVIVAL, VIGOUR AND SEED PRODUCTION OF ECOTYPES PLANTED ON OCTOBER 1, 1977 AFTER TWO GROWING SEASONS

Species	Stock No.*	Survival (%)		Vigour (1-5)		Seed Production	
						Total Microsites (%)	Surviving Plants (%)
		1978	1979	1978	1979	1979	1979
Poa palustris	93	4.4	33.3	2	2	4.4	9.5
Poa pratensis	39	4.4	62.2	1	3	0.0	0.0
Poa pratensis	92	2.2	28.9	1	3	0.0	0.0
Puccinellia distans	43	26.7	48.9	1	3	0.0	0.0
Trifolium medium	119	15.6	35.6	1	1	0.0	0.0

* Stock Nos. refer to Vaartnou & Sons Enterprises Ltd. Botany Collection Number

Another consideration relates to the delayed germination and emergence of smaller seeded ecotypes such as the bluegrasses (*Poa* spp.) and native fescue (*Festuca saximontana*). Most of these ecotypes had very low first year emergence but increased greatly in the second and third years after seeding. Such "bottom" species should be included in revegetation seed mixtures as they can usually provide the long term cover for permanent rehabilitation of an area. However, in such xeric regions, initial cover must be obtained from the larger seeded "top" species discussed above.

At the present time the longevity of any of the ecotypes is uncertain as winterkill has not been a problem and obvious signs of plant diseases have not appeared. This is fortunate as the development of sexual reproductive organs has been slow in comparison to that expected in more temperate regions. Bliss (1958) states that native northern ecotypes often set considerably less seed than plants in other regions; thus increases in cover from natural reseeding may be minimal in the north.

The nine legume ecotypes have not been successful to date as in the spring seeded trial only Mackenzie's hedysarum (*Hedysarum Mackenzii*) and late yellow loco weed (*Oxytropis campetris*) had more than 20% survival and vigour of at least 3. In the fall seeded trial no legumes had yet achieved these values. While this is unfortunate because the soil improvement possible from the nitrogen fixing association of legumes and *Rhizobium* spp. bacteria would be beneficial for revegetation success, it is not unusual as Klebesadel (1971) found poor seedling vigour and slow establishment with native legumes while the author (unpublished data) has consistently found extended dormancy resulting in emergence several years after seeding. Consequently it must be realized that establishment of extensive ground cover by seeding of native legumes should not be anticipated for several years and immediate erosion control assistance must be obtained from other species.

The high survival rate of the transplanted grass ecotypes is very encouraging as this indicates that, if required, sprigging of local material is viable. However, the generally low survival rates of the wildling shrubs indicates that modifications in technique may be necessary. The shrubs were removed with a shovel and immediately transplanted. This technique has been very successful on more favourable substrates (Foothills 1979b) but on the gravelly substrate at Haines Junction it may have resulted in excessive root and root hair damage. Consequently water and nutrient absorption may have been retarded to the extent that the shrubs could not reestablish. Therefore, if shrubs are required, they should be obtained from substrates where root damage can be minimized or they should be pregrown under controlled conditions. The former alternative is preferable from a cost standpoint but, depending upon the presence of local material, may not always be feasible.

Finally, the effect of seeding time must be considered. In these trials, results are inconclusive as first year emergence was collectively higher on the spring seeded trial (33% to 25%) but second year survival was higher on the fall seeded trial (37% to 42%). This occurred because of the much higher delayed germination in the fall seeded trial. However, if only the seven most successful ecotypes on each site are considered then the percentage on the fall seeded site is higher for both years (80% to 77% for the first year and 91% to 88% for the second year). Since an actual revegetation seed mixture should be composed of those ecotypes deemed to have the greatest chance of success the second calculation is more appropriate. These figures are very similar so no conclusions regarding time of seeding can be drawn from these trials. Theoretically the added moisture from snow melt should enhance germination and emergence but this was not the case at Haines Junction in 1977 and 1978.

4.0 BIOCOMPETITIVE ABILITY TESTS

4.1 OBJECTIVES

Water, nutrients and sunlight are necessary for plant growth. However, as these are limited, there is competition among plants to obtain sufficient quantities of each to sustain life. Consequently, for a plant to be useful in a revegetation program it must successfully compete with surrounding plants - both those which naturally re-establish and also other species in the revegetation mixture.

This test was designed to study the effect of this competition upon ecotype survival. Emergence of each ecotype when seeded in a mix and its ability to survive as part of a diverse plant community over a period of years are critical for revegetation success. The influence of native vegetation on the success of a revegetation seed mixture is also important since natural recolonization by vagile invader species will occur on disturbed areas such as pipeline rights-of-way.

4.2 MATERIALS

The seed mixes used in the biocompetitive ability test are composed of Vaartnou and Sons Enterprises Ltd. seed stock. The original seed or plant stock of each ecotype was collected from northern British Columbia, northern Alberta, Yukon Territory or the Northwest Territories and has since been multiplied in northern Alberta. Each of the three mixes contains five northern grasses and three legumes (Table 4).

4.3 LOCATION AND DESCRIPTION

These test sites are also located next to the Haines Junction airstrip. They are approximately 1.1 km west of the adaptability test site and are also on the north side of the airstrip.

TABLE 4

COMPOSITION OF SEED MIXES USED IN BIOCOMPETITIVE ABILITY AND SLOPE SEEDING TESTS

Mix A	Mix B	Mix C
GRASSES	GRASSES	GRASSES
Agropyron cristatum 244*	*Agropyron Smithii* 47	*Agropyron pauciflorum* 8
Agrostis gigantea 327	*Alopecurus arundinaceus* 17	*Bromus inermis* 80
Deschampsia caespitosa 68	*Elymus canadensis* 20	*Elymus innovatus* 331
Festuca sp. 524	*Festuca rubra* 22	*Festuca* sp. 524
Poa alpina 82	*Poa ampla* 84	*Poa pratensis* 92
LEGUMES	LEGUMES	LEGUMES
Hedysarum Mackenzii 413	*Hedysarum Mackenzii* 413	*Hedysarum Mackenzii* 413
Medicago falcata 110	*Medicago falcata* 110	*Medicago falcata* 110
Trifolium medium 119	*Trifolium medium* 119	*Trifolium medium* 119

* Numbers refer to stock number within the Vaartnou and Sons Enterprises Ltd. Botany collection.

Two test sites were established on disturbed soil at this location. Soil at both sites had been disturbed by airstrip maintenance operations but the amount of disturbance varied considerably. One location had all the top soil removed and consisted of parent material ("C" horizon) for a growth medium. Very little native vegetative growth had reestablished here. In contrast, the second location had only top vegetation bladed off with the organic layer retained. A substantial amount of living cover was present as species such as bearberry (*Arctostaphylos uva-ursi*) had not been disturbed while others such as willows (*Salix* spp.), poplar (*Populus balsamifera*), arctic lupine (*Lupinus arcticus*) and Mackenzie's hedysarum (*Hedysarum Mackenzii*) had regenerated from their roots.

4.4 METHODS

4.4.1 Establishment

Each test site was divided into twelve one by three meter plots with each seed mix (Table 4) hand scatter-seeded into four plots per test site. The four plots seeded to each mix were then treated with different surface manipulation techniques. On one plot the seed was raked into the soil and the soil was then compacted; on a second plot the seed was just raked into the soil; on a third plot the soil was compacted without raking and the fourth plot was left as an untreated control. All plots were fertilized with 16-20-0 commercial fertilizer at the rate of 80 kg/ha.

4.4.2 Evaluation

The biocompetitive tests were evaluated for per cent total live ground cover on each plot and for per cent live ground cover provided by the seeded species. Both figures are ocular estimates by the investigator. The most successful seeded species on each plot were also recorded.

4.5 RESULTS

4.5.1 Organic Soil Test

The presence of the existing vascular species resulted in limited seedling emergence in 1977. After the 1979 growing season seeded cover had increased but was still low as the maximum value attained by any plot was 25%. In contrast native cover now ranged from 25 to 75%, depending upon the specific plot.

Differences among the soil manipulation treatments were inconsistent but all three treatments provided more cover than the untreated controls. Differences among seed mixtures were also inconclusive but Mixtures B and C produced more cover than Mixture A.

The most successful ecotypes in each mixture were the wheatgrasses; (crested wheatgrass (*Agropyron cristatum*) in Mixture A, western wheatgrass (*Agropyron Smithii*) in Mixture B, and slender wheatgrass (*Agropyron pauciflorum*) in Mixture C). Other successful ecotypes included Sherman bluegrass (*Poa ampla*) in Mixture B and a fescue (*Festuca* sp.) in Mixture C. Complete three year evaluation results are found in Table 5.

4.5.2 "C" Horizon Soil Test

Seedling emergence was very low in 1977 and no substantial increase had occurred after the 1979 growing season. The only plots which had 10% seeded ground cover in 1979 were the "B" seed mixture/compacted soil treatment and the "C" seed mixture/raked soil treatment. Native reinvasion was also low as only the "A" seed mixture/control plot and "C" seed mixture/compacted soil plot had over 15% cover from native species.

TABLE 5

PER CENT GROUND COVER ON ORGANIC SOIL BIOCOMPETITIVE ABILITY TEST SITE AFTER ONE, TWO AND THREE GROWING SEASONS

SEED MIXTURE* AND TREATMENT	SEEDED GROUND COVER (%)			TOTAL GROUND COVER (%) July 22 1979	MOST SUCCESSFUL SEEDED SPECIES
	August 23 1977	August 19 1978	July 22 1979		
A: Raked and Compacted	<1	15	5	55	*Agropyron cristatum* *Poa alpina*
A: Raked	1	5	5	55	*Agropyron cristatum* *Festuca* sp.
A: Compacted	<1	5	<1	75	*Agropyron cristatum*
A: No Incorporation	<1	<1	<1	60	*Agropyron cristatum*
B: Raked and Compacted	<1	20	10	70	*Poa ampla* *Agropyron Smithii*
B: Raked	<1	10	25	55	*Poa ampla* *Elymus canadensis*
B: Compacted	1	10	10	70	*Poa ampla* *Agropyron Smithii*
B: No Incorporation	<1	<1	<1	50	*Agropyron Smithii*
C: Raked and Compacted	5	18	15	25	*Festuca* sp. *Agropyron pauciflorum*
C: Raked	3	15	25	60	*Agropyron pauciflorum* *Festuca* sp.

(continued)

TABLE 5 (continued)

PER CENT GROUND COVER ON ORGANIC SOIL BIOCOMPETITIVE ABILITY TEST SITE AFTER ONE, TWO AND THREE GROWING SEASONS

SEED MIXTURE* AND TREATMENT	SEEDED GROUND COVER (%)			TOTAL GROUND COVER (%) July 22 1979	MOST SUCCESSFUL SEEDED SPECIES
	August 23 1977	August 19 1978	July 22 1979		
C: Compacted	1	15	25	70	*Agropyron pauciflorum* *Festuca* sp.
C: No Incorporation	<1	1	<1	75	*Agropyron pauciflorum*

* Composition of each mixture is found in Table 4.

Ground cover was so low that differences among treatments and seed mixtures were inconsequential. Individually the most successful ecotypes were the three wheatgrasses (*Agropyron cristatum*, *A. Smithii* and *A. pauciflorum*), but three bluegrasses (*Poa alpina*, *P. ampla* and *P. pratensis*), two fescues (*Festuca* sp. and *F. rubra*) and Canada wild rye (*Elymus canadensis*) were present in some plots. Three year evaluation results are found in Table 6.

4.6 DISCUSSION

The biocompetitive tests have been inconclusive to date regarding the objectives for which they were established. This has occurred because plant emergence has been insufficient to place any real competitive pressure on those seedlings which have emerged. On the "C" horizon soil test site total ground cover values are so low that the effects of competition can be eliminated as limiting factors in individual ecotype survival. On the organic soil test site competitive pressure may now become important as total ground cover of 50% has been attained on 11 of 12 plots (Table 5). This pressure may later appear as a decline in native species or seeded ecotype ground cover as any component of the present cover may be excluded or reduced in future years.

However, other factors important for pipeline revegetation have been established at these sites. Foremost is the influence that retention of material from the rhizosphere can have upon native species regeneration. The 12 organic soil plots averaged 50% ground cover from native regeneration while the 12 "C" horizon soil plots averaged 10% cover from native regeneration. This indicates that if native regeneration is desired then retention of the rhizosphere will greatly facilitate this process.

TABLE 6

PER CENT GROUND COVER ON "C" HORIZON SOIL BIOCOMPETITIVE ABILITY TEST SITE AFTER ONE, TWO AND THREE GROWING SEASONS

SEED MIXTURE* AND TREATMENT	SEEDED GROUND COVER (%)			TOTAL GROUND COVER (%) July 22 1979	MOST SUCCESSFUL SEEDED SPECIES
	August 23 1977	August 19 1978	July 22 1979		
A: Raked and compacted	1	1	5	15	*Agropyron cristatum* *Poa alpina*
A: Raked	1	1	5	10	*Agropyron cristatum* *Poa alpina*
A: Compacted	<1	1	5	5	*Agropyron cristatum* *Poa alpina*
A: No Incorporation	<1	<1	1	45	*Agropyron cristatum* *Poa alpina*
B: Raked and Compacted	2	1	<1	<1	*Agropyron Smithii* *Poa ampla*
B: Raked	1	1	5	10	*Agropyron Smithii* *Poa ampla* *Elymus canadensis*
B: Compacted	1	1	10	15	*Festuca rubra* *Elymus canadensis*
B: No Incorporation	<1	<1	<1	5	*Festuca rubra* *Elymus canadensis*
C: Raked and Compacted	<1	<1	<1	5	*Agropyron pauciflorum* *Poa pratensis*

(continued)

TABLE 6 (continued)

PER CENT GROUND COVER ON "C" HORIZON SOIL BIOCOMPETITIVE ABILITY TEST SITE AFTER ONE, TWO AND THREE GROWING SEASONS

SEED MIXTURE* AND TREATMENT	SEEDED GROUND COVER (%)			TOTAL GROUND COVER (%) July 22 1979	MOST SUCCESSFUL SEEDED SPECIES
	August 23 1977	August 19 1978	July 22 1979		
C: Raked	<1	<1	10	15	*Agropyron pauciflorum* *Poa pratensis* *Festuca* sp.
C: Compacted	<1	<1	5	35	*Agropyron pauciflorum* *Festuca* sp.
C: No Incorporation	<1	<1	<1	5	*Agropyron pauciflorum*

*Composition of each mixture is found in Table 4.

A second consideration relates to emergence of the seeded ecotypes from these two substrates. While emergence was low on both soil types, superior results were obtained on the organic soil. This occurred despite the presence of more vascular cover on these plots at the time of seeding. The organic layer has acted as a mulch, improving the microclimate through improved moisture retention and a reduction in soil temperature fluctuation. Also it is probable that there are more available plant nutrients in the organic layer than in the sparsely weathered "C" horizon soil. Therefore, retention of a thin organic horizon can be beneficial for seedling development in micro-environments such as this. However, it must remembered that the presence of a thick dead organic mat can be a barrier to seedling development and survival. The combination of limited precipitation and lengthy photoperiod can combine to desiccate the organic mat, thereby resulting in a water deficiency for the young seedlings (Deneke et al 1975). Consequently caution is required and site-specific decisions may be necessary.

A final point relates to surface manipulation. It is generally accepted that incorporation of seed into the soil will increase germination and emergence of seedlings, regardless of edaphic or climatic conditions. It is also generally accepted that on lengthy linear projects such as pipelines this is impractical and often unfeasible because of difficulties encountered with machinery in rugged terrain. However, at these two sites the only treatment which has failed to produce more than 1% cover, regardless of seed mix, is the unincorporated control. Consequently in xeric environments such as that of Haines Junction either the use of mulches or surface manipulation techniques may be required for successful revegetation.

5.0 SLOPE SEEDING TEST

5.1 OBJECTIVES

Frequently the prime reason for revegetation of drastically disturbed lands is soil erosion control. Erosion, if permitted, will alter the physical environment and may contribute to problems such as sedimentation of waterways.

Revegetation alone is not sufficient to ensure erosion control as construction techniques must be such that slopes are not left inherently unstable (Johnson and Van Cleve 1976). However, in the long term, the restoration of vegetative cover can be of great assistance in prevention of erosion by wind and water, especially on slopes. The success of revegetation efforts on slopes can be affected by aspect and elevation as slight differences can maintain important gradients in soil moisture or other properties (Billings 1974).

Also of interest is the distribution of introduced plant growth on slopes. Loss of seed from the top of the slope is possible through the action of wind and water. Consequently, attempts to revegetate the upper portions of slopes may be hampered (Plate 23, Johnson et al 1977). If this were to happen, then the success of the erosion control program could be greatly reduced.

The objectives of this test are to consider the effect of aspect on seed germination and plant establishment and to obtain information regarding plant distribution resulting from equally scatter-seeding all parts of a slope.

5.2 MATERIALS

The composition of the seed mixtures used in this test is identical to that of the biocompetitive ability test mixtures (Table 4).

5.3 LOCATION AND DESCRIPTION

This test site is located in an abandoned borrow pit about 100 meters north of the Haines Junction airstrip. Pit depth is approximately three meters, the soil is sandy and slope angle is 45°. Living ground cover was less than 5% at the time of establishment.

5.4 METHODS

5.4.1 Establishment

Six plots, two by six meters each, were staked out on May 26, 1977. Three of these, on the north side of the pit, have a southern aspect while the other three, on the south side, have a northern aspect. Each seed mix was then hand scatter-seeded into one plot on each side of the pit. The seed was then lightly raked into the soil and all plots were fertilized with 16-20-0 commercial fertilizer at 80 kg/ha.

5.4.2 Evaluation

A visual estimate of per cent live seeded ground cover on each plot was made by the investigator and the most successful of the seeded species were recorded.

5.5 RESULTS

First year results indicated weak growth on plots of both aspects as no plot had more than 5% seeded ground cover. 1978 results showed an increase in cover on the northern aspect plots as cover ranged from 8 to 13%. However, cover on the southern aspect plots was still below 1%. The 1979 evaluation confirmed this trend as the northern aspect plots now had from 15 to 30% cover while the southern aspect plots still had less than 1% cover.

1979 was the first year in which substantial differences in cover occurred among the seed mixes. On the northern aspect plots, seed Mix "B" now provided twice the cover of Mix "A" or "C". This was attributable to the development of three species; red fescue (*Festuca rubra*), Sherman bluegrass (*Poa ampla*) and reed foxtail (*Alopecurus arundinaceus*). The species most successful in the other mixtures were crested wheatgrass (*Agropyron cristatum*) and alpine bluegrass (*Poa alpina*) in Mix A and slender wheatgrass (*Agropyron pauciflorum*) and a fescue (*Festuca* sp.) in Mix C. Complete results of three years evaluation of this site are found in Table 7.

5.6 DISCUSSION

The major inference which can be made from the results at this site relates to the importance of aspect in revegetation success. Even with such short (3 M) slopes, virtually no ground cover had established on the warmer southern aspect plots while the shaded northern aspect plots had considerable ground cover. This suggests that, especially in such xeric regions, moisture conservation and soil temperature amelioration are required for successful plant establishment. Consequently the use of mulch appears to be a prerequisite for revegetation success.

The use of rhizomatous species in seed mixtures appears beneficial in light of the low initial emergence. Mix B, which had the highest ground cover percentage, has three such species while Mixes A and C have one and two respectively. Specifically, two of the three species most successful in Mix B are rhizomatous. If initial emergence from seed is low then adequate ground cover can still be achieved if vegetative development can occur from rhizomes.

Plant distribution on the northern aspect plots was relatively uniform. This suggests that the same xeric conditions which mitigate against plant establishment on the southern aspect also result in little slope wash and consequent movement of seed from tops to toes of slopes.

TABLE 7

PER CENT GROUND COVER AT SLOPE SEEDING TEST SITE AFTER ONE, TWO AND THREE GROWING SEASONS

SEED MIXTURE*	GROUND COVER (%)			MOST SUCCESSFUL SPECIES IN EACH MIXTURE
	August 23 1977	August 19 1978	July 21 1979	
Northern Aspect				
A	3	8	15	*Agropyron cristatum* *Poa alpina*
B	5	8	30	*Festuca rubra* *Poa ampla* *Alopecurus arundinaceus*
C	3	13	15	*Agropyron pauciflorum* *Festuca* sp.
Southern Aspect				
A	<1	0	<1	*Agropyron cristatum*
B	<1	<1	<1	*Agropyron Smithii* *Poa ampla*
C	<1	<1	<1	*Festuca* sp.

* Composition of seed mixtures is found in Table 4.

6.0 SHREDDING TEST

6.1 OBJECTIVES

Revegetation using methods other than reseeding and transplanting will be necessary in some sections of the pipeline right-of-way. Examples include sedge fens and bog areas which support few grasses and legumes. Also, regions subject to standing water during prime seeding times will be difficult to reseed.

In such areas, a return of vegetal cover can be aided by the use of a shredding technique. This involves storage and subsequent return of the preexisting rhizosphere material to the disturbed area upon completion of construction. Thus, revegetation will occur through regeneration from the roots and rhizomes returned to the disturbed region.

This technique has been successfully used in more temperate climates, but had not been tested in northern conditions. Thus, the objective of this test was to ascertain whether the technique can be useful for northern pipeline revegetation. Various modifications, such as raking and/or compacting the rhizosphere, were also studied so that the optimal technique could be determined.

6.2 LOCATION AND DESCRIPTION

The site is located 1.7 km west of Kluane Park headquarters. It is approximately 240 meters south of the Alaska Highway just north of the northern border of Kluane Park.

Prior to shredding, vascular cover on the site was greater than 99% but there was little species diversity. The major species were hair-grass (*Deschampsia caespitosa*), silverweed (*Potentilla anserina*), sedges (*Carex* spp.) and rushes (*Juncus* spp.). Species growing on the site and species found in the immediate vicinity are listed in Table 8. When the site was chosen on May 7, 1977, it was covered with water but at the times of shredding on June 25, 1977 and September 18, 1978, no water remained.

TABLE 8

LIST OF PROMINENT SPECIES FOUND ON AND NEAR SHREDDING SITE AT TIME OF SHREDDING

SPECIES ON SHREDDING SITE

Calamagrostis canadensis
Carex spp.
Deschampsia caespitosa
Juncus spp.
Populus tremuloides (seedlings)
Potentilla anserina
Salix sp. (three small shrubs)

PROMINENT ADJACENT VEGETATION

Achillea borealis	*Hordeum jubatum*
Agropyron pauciflorum	*Oxytropis campestris*
Agrostis scabra	*Picea glauca*
Anemone multifida	*Poa ampla*
Arctostaphylos uva-ursi	*Poa glauca*
Astragalus flexuosus	*Populus balsamifera*
Elymus innovatus	*Potentilla fruticosa*
Festuca altaica	*Salix* spp.
Fragaria virginiana	*Shepherdia canadensis*
Hedysarum Mackenzii	*Solidago decumbens*
Hierochloe odorata	*Zygadenus elegans*

6.3 METHODS

6.3.1 Establishment

On June 25, 1977, an area six by twenty meters was staked and subdivided into four three by ten meter plots. Two passes with a hand rototiller at a depth of ten centimeters were required tc reduce live vascular cover to less than one per cent.

After elimination of this cover the four sub-plots were treated with different mechanical techniques. On one the soil was raked level, on a second, the soil was compacted, and on a third, the soil was both raked and compacted. The fourth plot was left as a control, with no treatment. No seeding or fertilization was done.

On September 18, 1978 an adjacent plot of identical dimensions was treated in a similar manner. This was done to study the rate of regeneration if the rhizosphere was exposed for a winter of dormancy prior to reinitiation of growth.

6.3.2 Evaluation

Total live ground cover on each sub-plot was visually estimated by the investigator. The approximate species composition of this cover was also visually estimated.

6.4 RESULTS

6.4.1 June 25, 1977 Shredding

After the 1977 and 1978 growing seasons, results indicated a substantial return of vascular species to all plots. The plot which had been raked and compacted had the highest cover percentage while the control plot had the lowest.

This trend continued in 1979 as ground cover increased on all plots. The raked and compacted plot now had 80% live vascular cover while the untreated control increased to 65%. The other two plots had intermediate values of 75% each.

Species composition of the cover was similar to that of 1978 as silverweed (*Potentilla anserina*) provided from 60 to 80%, depending upon treatment. Other cover was provided by three grasses; hairgrass (*Deschampsia caespitosa*), bluejoint (*Calamagrostis canadensis*) and foxtail barley (*Hordeum jubatum*), and by sedges (*Carex* spp.) and rushes (*Juncus* spp.). Complete three year results are found in Table 9.

6.4.2 September 18, 1978 Shredding

First year results at this site were very promising as cover provided by vascular species ranged from a high of 65% on the plot which had been both raked and compacted to a low of 25% on the untreated control. Intermediate values of 40 and 35% were recorded on the plots which had only been raked or compacted respectively.

Silverweed (*Potentilla anserina*) dominated the ground cover as it provided from 55 to 90%, depending upon treatment. On all plots at least 5% ground cover was provided by hairgrass (*Deschampsia caespitosa*) and rushes (*Juncus* spp.) while trace amounts of bluejoint (*Calamagrostis canadensis*), foxtail barley (*Hordeum jubatum*) and sedge (*Carex* spp.) were also present. Complete results are found in Table 10.

6.5 DISCUSSION

The high rate of return of vascular species clearly indicates that both spring and fall shredding can be successful in restoring cover to such sedge meadows which are flooded during the prime seeding time.
Of particular interest is the species composition of the new ground cover. Prior to rototilling two grasses; hairgrass (*Deschampsia caespitosa*) and bluejoint (*Calamagrostis canadensis*); two other graminoids; sedges (*Carex* spp.) and rushes (*Juncus* spp.); and one forb; silverweed (*Potentilla anserina*) provided the vast majority of

TABLE 9

PER CENT GROUND COVER AT SPRING SHREDDING SITE
AFTER ONE, TWO AND THREE GROWING SEASONS

TREATMENT*	GROUND COVER (%)			APPROXIMATE COMPOSITION OF REGENERATED GROUND COVER
	August 23 1977	August 19 1978	July 21 1979	
Raked and Compacted	25	55	80	60% *Potentilla anserina* 25% *Deschampsia caespitosa* 5% *Hordeum jubatum* 5% *Calamagrostis canadensis* 5% *Juncus* sp.
Raked	15	40	75	80% *Potentilla anserina* 5% *Deschampsia caespitosa* 5% *Hordeum jubatum* 5% *Juncus* sp. 5% *Carex* sp. Trace-*Calamagrostis canadensis*
Compacted	20	45	75	70% *Potentilla anserina* 10% *Deschampsia caespitosa* 5% *Hordeum jubatum* 5% *Calamagrostis canadensis* 5% *Juncus* sp. 5% *Carex* sp.
No Treatment	10	30	65	75% *Potentilla anserina* 10% *Deschampsia caespitosa* 10% *Hordeum jubatum* 5% *Juncus* sp. Trace-*Carex* sp. and *Calamagrostis canadensis*.

*All treatments had >99% vascular cover prior to rototilling. This was reduced to <1% vascular cover after completion of rototilling on June 27, 1977.

TABLE 10

PER CENT GROUND COVER AT FALL SHREDDING SITE AFTER ONE GROWING SEASON

TREATMENT*	GROUND COVER (%) JULY 21, 1979	APPROXIMATE COMPOSITION OF REGENERATED GROUND COVER
Raked and Compacted	65	85% *Potentilla anserina* ; 10% *Deschampsia caespitosa* ; 5% *Juncus* sp. Trace - *Hordeum jubatum*, *Calamagrostis canadensis* and *Carex* sp.
Raked	40	55% *Potentilla anserina*; 35% *Juncus* sp.; 10% *Deschampsia caespitosa*; Trace - *Hordeum jubatum*, *Calamagrostis canadensis* and *Carex* sp.
Compacted	35	90% *Potentilla anserina*; 5% *Deschampsia caespitosa*; 5% *Juncus* sp.; Trace - *Hordeum jubatum*, *Calamagrostis canadensis* and *Carex* sp.
No Treatment	25	75% *Potentilla anserina* ; 20% *Juncus* sp.; 5% *Deschampsia caespitosa*; Trace - *Hordeum jubatum*, *Calamagrostis canadensis* and *Carex* sp.

* All treatments had >99% vascular cover prior to rototilling. This was reduced to <1% vascular cover after completion of rototilling on September 18, 1978.

the ground cover (Table 8). These are the identical species which now provide at least 90% of the new ground cover on all plots (Tables 9 and 10). Of the 22 species commonly found adjacent to the site (Table 8), only the ubiquitous invader foxtail barley (*Hordeum jubatum*) had colonized either plot. This leads to the conclusion that the return of vascular species has been the result of regeneration from the roots and rhizomes of the species which were rototilled and not from peregrinations of seed from sources outside the plot.

The effect of the treatments appears to be relatively ephemeral. In the initial year after disturbance the combination of raking and compaction substantially increased the return of ground cover in relation to that obtained from other treatments (Tables 9 and 10). This probably occurred because the roots and soil were more closely bound, thereby facilitating the absorption of plant nutrients and water. However, by the third year the difference in ground cover had become minimal (Table 9). Thus it may be inferred that the maximum benefits from raking and compaction can be obtained in areas suspected of having high susceptibility to erosion.

A final consideration relates to time of shredding. First year cover was substantially higher on plots of all treatments in the fall shredding trial (Tables 9 and 10). On this plot, shredded in mid-September, winter dormancy and freezing occurred soon after shredding. In contrast, on the plot shredded in June, desiccation of roots probably occurred to some degree. Consequently it appears that shredding just prior to winter dormancy may provide optimal results.

7.0 CONCLUSIONS

Three years of field observation have been completed and a number of conclusions can be inferred. These conclusions are only valid for xeric areas similar to the Haines Junctions region and are only applicable in similar gravelly substrates. Also, it must be recognized that future field results may cause modification of these conclusions, especially regarding the usefulness of specific ecotypes for long term plant community development. The conclusions can be divided into general revegetation considerations and specific seed mixture recommendations and are discussed in this manner below.

7.1 GENERAL REVEGETATION CONSIDERATIONS

a) The retention of the rhizosphere material during construction procedures will greatly aid in natural revegetation through regeneration of plants from roots and rhizomes (Section 4.6).

b) A thin organic layer can be a superior medium for seedling establishment compared to the exposed soil parent material (Section 4.6).

c) Northern aspect slopes can be successfully revegetated but even short southern aspect slopes may require mulching for water conservation and general micro-climate amelioration (Section 5.6).

d) Slope wash and resultant revegetation difficulties on the tops of slopes are unlikely to be a problem in such xeric regions (Section 5.6).

e) Shredding can be a successful revegetation technique. Additional surface manipulation effects are transitory as all treatments were successful after three years (Section 6.5).

f) Fall shredding can provide a more rapid return of vegetal cover than spring shredding because root desiccation is less pronounced after fall shredding (Section 6.5).

g) Sprigging of grasses can be very successful as survival rates were high with all ecotypes tested (Section 6.5).

h) Transplanting success with wildling shrubs is dependent upon species chosen and the amount of damage to roots which occurs during excavation of the wildlings (Section 3.6).

i) The wheatgrasses (*Agropyron* spp.) had the highest first year emergence while bluegrasses (*Poa* spp.) had low first year emergence but subsequently developed into equally sturdy plants (Section 3.6).

7.2 SEED MIXTURE RECOMMENDATIONS

Seed mixture recommendations which follow are based upon the candidate ecotypes performance in the adaptability test (Section 3.0). The revegetation potential of each ecotype has been rated for initial and delayed emergence, initial and subsequent vegetative development (vigour), reproductive capacity and survival (Table 11). The classes poor, fair, good and excellent used for each of these attributes were delimited as follows:

a) Initial emergence values were obtained by averaging first year emergence percentages in the spring and fall seeded trials. The delimiting values for each rating were: poor - <25%, fair - 25-50%, good - 51-75%, excellent - >75%.

b) Delayed emergence values were obtained by averaging the seedling emergence which occurred in both trials after the first growing season. Values for each ecotype were calculated from

TABLE 11

REVEGETATION POTENTIAL OF ECOTYPES TESTED IN THE ADAPTABILITY TEST

SPECIES	STOCK NO.*	EMERGENCE		VEGETATIVE DEVELOPMENT		REPRODUCTIVE CAPACITY AFTER 3 YR	SURVIVAL	REVEGETATION POTENTIAL
		INITIAL	DELAYED	INITIAL	SUBSEQUENT			
Agropyron cristatum	244	good	excellent	fair	good	poor	excellent	Useful for initial ground cover. Poor reproductive capacity may limit long term effectiveness.
Agropyron pauciflorum	8	excellent	fair	good	excellent	good	excellent	Excellent revegetation ecotype. Sustains vigour and has good reproductive capacity. Best of ecotypes tested at this site.
Agropyron repens	466	excellent	fair	good	good	fair	excellent	Strong but not superior to other wheatgrasses. Consequently should be omitted because of "weedy" reputation.
Agropyron riparium	247	excellent	fair	excellent	excellent	poor	excellent	Provides excellent ground cover in first year. May be included to provide first year erosion control.
Agropyron Smithii	47	excellent	poor	fair	good	fair	good	Better adapted further south. Not recommended as other wheatgrasses are more suitable in this environment.
Agrostis gigantea	327	poor	poor	poor	fair	fair	poor	Not adapted to xeric, gravelly environments. Needs more moisture and prefers clay soils.

TABLE 11 (continued)

REVEGETATION POTENTIAL OF ECOTYPES TESTED IN THE ADAPTABILITY TEST

SPECIES	STOCK NO.*	EMERGENCE		VEGETATIVE DEVELOPMENT		REPRODUCTIVE CAPACITY AFTER 3 YR	SURVIVAL	REVEGETATION POTENTIAL
		INITIAL	DELAYED	INITIAL	SUBSEQUENT			
Alopecurus pratensis	280	poor	fair	good	good	poor	good	Poor emergence and reproductive capacity. Only recommended for mesic environments.
Astragalus americanus	376	poor	nil	fair	poor	nil	fair	Poor emergence and development. Not recommended.
Astragalus eucosmus	380	nil	nil	--	--	--	--	No emergence. Not recommended.
Astragalus flexuosus	724	poor	poor	poor	poor	nil	poor	Poor emergence and development. Not recommended.
Bromus Pumpellianus	64	fair	nil	good	good	nil	excellent	Fall trial much superior to spring trial. Not recommended as it prefers heavier soils.
Deschampsia caespitosa	68**	poor	nil	poor	good	poor	fair	Poor emergence but vigour subsequently improves. Possibly useful for long term cover.
Deschampsia caespitosa	67***	poor	fair	fair	fair	--	excellent	

TABLE 11

REVEGETATION POTENTIAL OF ECOTYPES TESTED IN THE ADAPTABILITY TEST

SPECIES	STOCK NO.*	EMERGENCE		VEGETATIVE DEVELOPMENT		REPRODUCTIVE CAPACITY AFTER 3 YR	SURVIVAL	REVEGETATION POTENTIAL
		INITIAL	DELAYED	INITIAL	SUBSEQUENT			
Dryas Drummondii	575	poor	nil	fair	good	nil	poor	Poor emergence. Not recommended.
Elaeagnus commutata	166	fair	poor	good	excellent	nil	good	Fair emergence but good development. One of very few shrubs which may be established from seed.
Elymus canadensis	20	good	fair	good	fair	poor	good	Good establishment but little improvement. Not recommended as other rapidly establishing ecotypes have better long term cover.
Elymus innovatus	331	fair	excellent	good	excellent	poor	excellent	Fair establishment but excellent development. May be very useful as long term cover.
Festuca saximontana	526	poor	fair	poor	excellent	excellent	excellent	Poor establishment but excellent development and reproductive capacity. May be useful in very xeric regions where other ecotypes can not establish.
Festuca sp.	524	good	good	good	good	fair	excellent	Good emergence and development. Recommended to provide initial cover which will sustain itself for several years.

TABLE 11 (continued)

REVEGETATION POTENTIAL OF ECOTYPES TESTED IN THE ADAPTABILITY TEST

SPECIES	STOCK NO.*	EMERGENCE		VEGETATIVE DEVELOPMENT		REPRODUCTIVE CAPACITY AFTER 3 YR	SURVIVAL	REVEGETATION POTENTIAL
		INITIAL	DELAYED	INITIAL	SUBSEQUENT			
Hedysarum alpinum	409	poor	poor	fair	good	nil	good	Poor establishment. Only useful for long term cover. Not recommended as it prefers more moisture.
Hedysarum Mackenzii	413	poor	poor	good	good	poor	fair	Limited emergence but good development. Possibly the most useful native legume in this region.
Medicago falcata	110	poor	poor	poor	poor	nil	poor	Poor development and survival. Not recommended as it prefers other edaphic conditions.
Oxytropis campestris	643	poor	nil	fair	fair	nil	good	Poor emergence and limited development. Only useful for long term community development.
Oxytropis splendens	745	poor	nil	poor	fair	nil	excellent	Identical to *O. campestris*.
Poa alpina	82	poor	fair	poor	good	nil	excellent	After poor emergence has developed well. Only recommended for higher elevations.

TABLE 11 (continued)

REVEGETATION POTENTIAL OF ECOTYPES TESTED IN THE ADAPTABILITY TEST

SPECIES	STOCK NO.*	EMERGENCE		VEGETATIVE DEVELOPMENT		REPRODUCTIVE CAPACITY AFTER 3 YR	SURVIVAL	REVEGETATION POTENTIAL
		INITIAL	DELAYED	INITIAL	SUBSEQUENT			
Poa ampla	84	fair	fair	poor	excellent	fair	excellent	Limited initial emergence but good development. Recommended for alkaline regions in this environment.
Poa compressa	94	poor	fair	poor	good	good	excellent	Limited initial emergence but strong development. Recommended to provide long term ground cover.
Poa glauca	95	poor	good	poor	good	fair	excellent	Limited initial emergence but strong development. Recommended for long term ground cover.
Poa glaucantha	202	poor	fair	good	good	fair	good	Reasonably successful but not recommended as other bluegrasses are superior in performance.
Poa palustris	89	poor	excellent	fair	good	good	excellent	Good development after poor emergence. Only recommended for moister conditions as other bluegrasses are better in xeric regions.
Poa palustris	93	poor	good	fair	good	good	excellent	Identical to *P. palustris* 89.

TABLE 11 (continued)

REVEGETATION POTENTIAL OF ECOTYPES TESTED IN THE ADAPTABILITY TEST

SPECIES	STOCK NO.*	EMERGENCE		VEGETATIVE DEVELOPMENT		REPRODUCTIVE CAPACITY AFTER 3 YR	SURVIVAL	REVEGETATION POTENTIAL
		INITIAL	DELAYED	INITIAL	SUBSEQUENT			
Poa pratensis	39	poor	fair	poor	good	nil	good	Poor establishment. Not recommended as it develops too slowly in this region for use in revegetation.
Poa pratensis	92	poor	good	fair	good	fair	excellent	Limited initial emergence but good development. Possibly excellent for long term cover because of its rhizomatous nature.
Puccinellia distans	43	fair	fair	poor	good	good	fair	Reasonable development but requires good seed production to sustain itself. Recommended for alkaline areas.
Trifolium medium	119	poor	fair	poor	poor	nil	poor	Poor emergence and survival. Not recommended in this environment.

* Stock numbers refer to ecotype number in the Vaartnou and Sons Enterprises Ltd. Botany Collection.

** Only seeded in May, 1977.

*** Only seeded in October, 1977.

emergence which occurred in those microsites which had none in the first year. Classes were then delimited according to the following intervals: poor - <10%, fair - 10-25%, good - 26-50%, excellent - >50%.

c) Initial vegetative development classes were based on the average of first year vigour ratings in the spring and fall seeded trials. Subsequent vegetative development classes were based on the average of the 1979 vigour ratings for each ecotype (average of third year for spring seeded trial and second year for fall seeded trial). In cases where the average was not an integer the conservative value was used. The classes correspond to the following vigour ratings: poor = 1, fair = 2, good = 3, excellent = 4 and 5.

d) Reproductive capability classes were based on the percentage of extant plants in the spring seeded trial which produced seed or flowers in 1979. Classes were delimited as follows: poor - <25%, fair - 25-50%, good - 51-75%, excellent - >75%.

e) Survival classes were based on the percentage of microsites which had surviving plants at the time of the 1979 evaluation in relation to the number of survivors in the year of maximum survival for each ecotype. Classes were delimited as follows: poor - <50%, fair - 50-75%, good - 76-90%, excellent - >90%.

The ecotypes recommended in Table 12 were chosen to provide both a rapid, though perhaps temporary, ground cover and also a slower developing long term ground cover. The ecotypes recommended for site-specific purposes should be added to the basic mixture wherever environmental conditions are appropriate. Seed production capability has not been considered in these recommendations but if seed production of any ecotype may prove difficult an asterisk has been used to denote this.

TABLE 12

PRELIMINARY SEED MIXTURE RECOMMENDATIONS FOR THE HAINES JUNCTION REGION

BASIC SEED MIXTURE**

Agropyron cristatum	244
Agropyron pauciflorum	8
Agropyron riparium	247*
Deschampsia caespitosa	68*
Elymus innovatus	331*
Festuca sp.	524
Poa compressa	94
Poa glauca	95
Poa pratensis	92

SITE-SPECIFIC ADDITIONS

ALKALINE SOILS

Poa ampla	84
Puccinellia distans	43*

XERIC AREAS

Festuca saximontana	526
Hedysarum Mackenzii	413*
Oxytropis campestris	643*

MESIC AREAS

Alopecurus pratensis	280
Poa palustris	93

* Dependent upon successful seed production.

** The nitrogen fixing shrub, wolfwillow (*Elaeagnus commutata*), may also be included in the basic seed mixture if seed incorporation into the soil is feasible.

Finally, it should be recognized that these preliminary recommendations are based completely on results from this program. Final recommendations may differ because other ecotypes not included in this program will be included if they continue to thrive at test sites in other revegetation programs. Specifically, purple wheatgrass (*Agropyron violaceum*) and red top (*Agrostis gigantea*) have been successful in the Alaska Highway Revegetation Program (Foothills 1979c) and will probably be major components of most mixtures for the entire length of the right-of-way.

8.0 LITERATURE CITED

Billings, W.D. 1974. Arctic and alpine vegetation: Plant adaptations to cold summer climates. p. 400-443 in Arctic and Alpine Environments (J.D. Ives and R.G. Barry Eds). London: Methuen and Co. Ltd.

Billings, W.D. and H.A. Mooney 1968. The Ecology of Arctic and Alpine Plants. Biological Review, Vol. 43, p. 481-529.

Bliss, L.C. 1958. Seed Germination in Arctic and Alpine Plant Species. Arctic, Vol.11, p. 180-188.

Deneke, F.J., B.H. McCown, P.I. Coyne, W. Rickard and J. Brown 1975. Biological Aspects of Terrestrial Oil Spills - U.S.A. CRREL Oil Research in Alaska 1970-74, U.S.A. CRREL Research Report 346. 66 pp.

Foothills Pipe Lines (Yukon) Ltd. 1978. Pipeline Revegetation Research - Haines Junction Test Site, 1977 Progress Report. Prepared by Vaartnou and Sons Enterprises Ltd. 42 pp.

Foothills Pipe Lines (South Yukon) Ltd. 1979a. Pipeline Revegetation Research - Haines Junction Test Site, Progress Report 1978. Prepared by Vaartnou and Sons Enterprises Ltd. 54 pp.

Foothills Pipe Lines (South Yukon) Ltd. 1979b. Pipeline Revegetation Research - Northern British Columbia Test Sites, Progress Report 1978. Prepared by Vaartnou and Sons Enterprises Ltd. 44 pp.

Foothills Pipe Lines (South Yukon) Ltd. 1979c. Pipeline Revegetation Research: Alaska Highway Test Sites Progress Report 1978. Prepared by Vaartnou and Sons Enterprises Ltd. 135 pp.

Harper, J.L., P.H. Lovell and K.G. Moore 1970. The Shapes and Sizes of Seeds. Annual Review of Ecology and Systematics. Vol. 1, p. 327-356.

Johnson, L., W. Quinn and J. Brown 1977. Revegetation and Erosion Control Observations Along the Trans-Alaska Pipeline. U.S.A. CRREL Special Report 77-8. 36 pp.

Johnson, L. and K. Van Cleve 1976. Revegetation in Arctic and Subarctic North America - A Literature Review. U.S.A. CRREL Report 76-15, 32 pp.

Klebesadel, L.J. 1971. Native Alaskan Legumes Studied. Agroborealis, Vol 3(1), p. 9-11.

Klebesadel, L.J. 1974. Winter Stresses Affecting Overwintering Crops in the Matanuska Valley. Agroborealis, Vol 6(1), p. 17-20.

McCown, B.H. 1973. Growth and Survival of Northern Plants at Low Soil Temperatures. U.S.A. CRREL Special Report 186. 15 pp.

Mitchell, W.W. and J.D. McKendrick 1974. Tundra Rehabilitation Research: Prudhoe Bay and Palmer Research Centre. 1973 Progress Report to Alyeska Pipeline Service Co., Arco, Canadian Arctic Gas Study Ltd., Exxon, Shell Oil and Union Oil. Institute of Agricultural Science, University of Alaska, Fairbanks. 84 pp.

Mitchell, W.W. and J.D. McKendrick 1975. Tundra Rehabilitation Research: Prudhoe Bay and Palmer Research Centre, 1973-4 Summary Report to Alyeska Pipeline Service Co., Arco, Canadian Arctic Gas Study Ltd., Exxon, Shell Oil and Union Oil. Institute of Agricultural Science, University of Alaska, Fairbanks. 14 pp.

Oswald, E.T. and J.P. Senyk 1977. Ecoregions of Yukon Territory. Fisheries and Environment Canada, Canadian Forest Service. 115 pp.

Savile, D.B. 1972. Arctic Adaptations in Plants. Monograph No. 6, Research Branch, Canada Department of Agriculture.

Thirgood, J.V. and P.F. Ziemkiewicz 1978. Reclamation of Coal Surface-Mined Land in Western Canada. p. 537-551 in Reclamation of Drastically Disturbed Lands. (F.W. Schaller and P. Sutton Eds). ASA, CSSA and SSA, Madison, Wisconsin, 742 pp.

Vaartnou, H. and C.R. Elliott 1969. Snowmolds in Lawns and Lawn Grasses in Northwest Canada. Plant Disease Reporter. Vol. 53(11).

Younkin, W.E. (Ed.) 1976. Revegetation Studies in the Northern Mackenzie Valley Region. Prepared by Northern Engineering Services Limited for Canadian Arctic Gas Study Limited. Biological Report Series, Vol. 38. 57 pp.

APPENDIX

BOTANICAL AND COMMON NAMES USED IN THIS REPORT

APPENDIX

BOTANICAL AND COMMON NAMES USED IN THIS REPORT

BOTANICAL NAME*	COMMON NAME
Achillea borealis Bong.	Northern yarrow
Agropyron cristatum (L.) Gaertn.	Crested wheatgrass
Agropyron pauciflorum (Schwein.) Hitchc.	Slender wheatgrass
Agropyron repens (L.) Beauv.	Couchgrass
Agropyron riparium Scribn. & Smith	Streambank wheatgrass
Agropyron Smithii Rydb.	Western wheatgrass
Agropyron violaceum (Hornem.) Lange	Purple wheatgrass
Agrostis gigantea Roth	Red top
Agrostis scabra Willd.	Ticklegrass
Alopecurus arundinaceus Poir.	Reed foxtail
Alopecurus pratensis L.	Meadow foxtail
Anemone multifida Poir.	Anemone
Arctostaphylos uva-ursi (L.) Spreng	Bearberry
Astragalus americanus (Hook.) M.E. Jones	American milk vetch
Astragalus eucosmus Robins.	Milk vetch
Astragalus flexuosus (Dougl.) Don	Milk vetch
Bromus inermis Leyss.	Smooth brome
Bromus Pumpellianus Scribn.	Northern brome
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint
Calamagrostis neglecta (Ehrh.) Gaertn., Mey. & Schreb.	Reed grass
Carex L.	Sedge
Deschampsia caespitosa (L.) Beauv.	Hairgrass
Dryas Drummondii Richards.	Drummond's dryas
Elaeagnus commutata Bernh.	Wolfwillow
Elymus canadensis L.	Canada wild rye
Elymus innovatus Beal	Hairy wild rye
Festuca altaica Trin.	Fescue
Festuca rubra L.	Red fescue

BOTANICAL NAME	COMMON NAME
Festuca saximontana Rydb.	Native fescue
Festuca L.	Fescue
Fragaria virginiana Duchesne.	Wild strawberry
Hedysarum alpinum L.	American hedysarum
Hedysarum Mackenzii Richards.	Mackenzie's hedysarum
Hierochloe odorata (L.) Wahlenb.	Sweetgrass
Hordeum jubatum L.	Foxtail barley
Juncus L.	Rush
Lupinus arcticus S. Wats.	Arctic lupine
Medicago falcata L.	Yellow lucerne
Oxytropis campestris (L.) DC.	Late yellow loco-weed
Oxytropis splendens Dougl.	Showy loco-weed
Picea glauca (Moench) Voss	White spruce
Poa alpina L.	Alpine bluegrass
Poa ampla Merrill	Sherman bluegrass
Poa compressa L.	Canada bluegrass
Poa glauca M. Vahl	Glaucous bluegrass
Poa glaucantha	Uplander bluegrass
Poa palustris L.	Fowl bluegrass
Poa pratensis L.	Kentucky bluegrass
Polygonum aviculare L.	Knotweed
Populus balsamifera L.	Poplar
Populus tremuloides Michx.	Aspen
Potentilla anserina L.	Silverweed
Potentilla fruticosa L.	Shrubby cinquefoil
Puccinellia distans (L.) Parl.	Alkaligrass
Ribes oxyacanthoides L.	Gooseberry
Rosa acicularis Lindl.	Prickly rose
Salix glauca L.	Willow
Salix L.	Willows
Shepherdia canadensis (L.) Nutt.	Buffaloberry
Solidago decumbens Greene	Goldenrod
Trifolium medium L.	Zig-zag clover
Zygadenus elegans Pursh.	Death camas

*Botanical nomenclature follows E. Hultén, Flora of Alaska and Neighbouring Territories, Stanford University Press, Stanford, California, 1968.