# REVEGETATION

## SPECIES SELECTION — AN INITIAL REPORT

ENVIRONMENTAL RESEARCH MONOGRAPH 1974-3
Published as a public service by
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Through a comprehensive program of surveillance of the effects of our technology and careful application of that technology, we aim to prevent accidental damage to the environment. Total effects will be examined by professional ecologists and study results provided to public representatives.

# FOREWARD

This monograph is the first formal public report of the Syncrude revegetation program. The revegetation program itself is part of a long term (up to 30 years) effort directed towards reclaiming and rehabilitating the disturbed land areas. The goal is to return these land areas to a state inhabitable by the plant and animal organisms that were originally present, or by organisms similar to these. For this reason the revegetation program has been designed to use native species as far as possible.

The study was conducted for Syncrude Canada Ltd. under the direction of H. Vaartnou, Ph.D., P.Ag. Dr. Vaartnou is presently Head of the Botany Section, Plant Industry Laboratory of the Alberta Department of Agriculture. His main interests lie in the fields of grass ecology and taxonomy, plant pathology and landscape design and planning. The work reported in this monograph was done in cooperation with the Plant Industry Laboratory, Botany Section of the Alberta Department of Agriculture. The survey of naturally and artificially vegetated areas, reported here as Chapter 3 was supported financially by Alberta Environment, Calgary Power and the Oil Sands Environmental Group (OSESG), of which Syncrude is a member.

The Management of Syncrude Canada Ltd. feel that scientific information which results from its studies should be made available to the public. Industry has a responsibility to contribute to the body of knowledge necessary for orderly development of the tar sands in order to minimize damage and maintain the ecological integrity of the area. It is hoped that the research information will be helpful to the scientific community and to the citizens of Alberta who are concerned with the management of resources on a sound ecological basis.

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FIGURE 13 Ecotypic Differences in Response to Soil Types. Each picture shows a clone of *Agropyron smithii*.

ABSTRACT

This monograph reports the selection of native and naturalized species suitable for use in revegetation of disturbed sites in the Athabasca Tar Sands Area. The criteria used for the selection of species to be studied included climatic adaptability, root system, growth habit, soil type adaptability, disease resistance and competitive ability. Information useful in the initial selection of species was gathered from a general survey of the plant communities in the area and from a survey of naturally and artificially disturbed sites in the Athabasca Tar Sands Area. Growth chamber tests using twenty-five species of grasses and legumes were used to compare the early development of these species on five different soil types, including tailing sand. These tests also showed the importance, in selection, of ecotypic differences within a species. For species to be used in revegetation, methods for economical production and handling of seed must be established.



KEYWORDS: Revegetation, Reclamation, Native Species, Surface mining, Biocompetitive, Tar Sands, Northern.

# 1. INTRODUCTION

## 1.1 Study Description

Development of the energy resources within Syncrude Canada Ltd.'s Tar Sands Lease #17 will have major impact on other natural resources of the area. Returning the disturbed areas to a useful, reasonably aesthetic condition is a legal requirement for which Syncrude accepts full responsibility. Syncrude states as an unconditional objective in the Site Development and Reclamation Plan that "the area left as land must be biotically productive" (Syncrude 1973 (a), p. 7.1). The first step towards this goal is the establishment of a permanent self-supporting and maintenance-free plant community. Such development will permit subsequent habitation by wildlife.

It is felt that to successfully establish a stable plant community it is best to imitate the natural sequence of succession as much as possible. The need to produce a permanent community as rapidly as possible will permit only an approximation of this sequence. Plants associated with earlier stages of community development such as grasses, legumes and herbs will be introduced prior to establishing woody species such as trees and shrubs. It is also felt that use of native species as far as possible will ensure the greatest success.

The immediate concern and the main theme of this report is the selection of the plant species to be used for revegetation.[1] The success of the revegetation program hinges on the selection of the most appropriate species. In some cases, selection must go further than the species level if ecotypic differences exist within a species.



1. For definition, see Glossary

There are two information sources available for use in initial selection of plant species. The first is the community of plants already growing in the area to be revegetated, or in environments similar to this area. These native plant communities are obviously suited to the environmental conditions of the area under study and so are logical choices for re-seeding on disturbed land. A second useful source is species identified from surveys of naturally or artificially revegetated areas such as cutlines, pipeline rights-of-way, roadsides and surface-mined sites. Species which have already proven successful on these disturbed areas may show promise for this particular application.

Initial testing of selected species and ecotypes, for comparison of their properties and their suitability to specific environments, can be done under controlled conditions in greenhouses and growth chambers. Final studies, of course, must place the plant communities in the actual environment for evaluation of performance under natural conditions. However, species and ecotype selection in itself is not an adequate solution to the revegetation problem. Methods for handling and growing the material must be established, and, if a species proves suitable, seed production must be studied to provide a reliable and economical seed source.

Selecting species to revegetate a particular area requires defined guidelines. While agricultural crops may be selected for economically favourable qualities such as yield or ease of harvesting, species for reclamation work are selected on a somewhat different basis. The primary concerns are defined here as:

(a) Climatic considerations -- Climatic characteristics of the area to which the plant is adapted must be considered in an initial selection for particular environments.

(b) Root system -- A variety of root systems in an area will help optimize use of nutrients at different levels in the soil, since the depth to which roots penetrate in a particular soil type often varies among species. Fibrous, rhizomatus, or taproot root systems may be advantageous in erosion control.

(c) Growth habit -- In reclamation work the amount of ground cover provided by a species is important for soil erosion control and water conservation (from both an immediate and a long-term view point).

(d) Suitability to soil type -- Plants must be suited to the qualities of the soil in which they are seeded. Nutrient levels are, of course, important, but other factors to be considered include pH, salt content, conductivity, and texture. Ideally, plants would be selected to suit the range of these conditions for an area such as the tar sands. Because of the great expected variation among the sites, it is unlikely that a single species can be selected to suit more than a limited number of these soils.

(e) Disease resistance -- One of the most important requirements will be resistance to *Sclerotinia borealis*, snow mold. Other diseases may also be identified that are important to certain species.

(f) Biocompetitive requirements -- A single plant species may seem well suited for use in a particular environment, but in selection of a mixture of species each must be considered for its competitive ability. A plant will be of little use in revegetation work unless it can survive on a particular site in competition with other plants. It may not be able to exist on a site as part of a community in spite of the fact that it could survive on its own. Exceptions to this will be short lived species used to provide rapid ground cover for erosion control. Competition between species for water and nutrients, as well as the effects of shading by other plants, must be considered before a final species selection is made. In many ways, this aspect is a cumulation of all other selection factors, for the plant must be able to survive and reproduce within the plant community.

## 1.2 Environmental Limitations

Several environmental characteristics of an area will limit the species that can survive in that area. These characteristics, the most important of which are climate, soils, and hydrology, are basic concerns in a revegetation program.

## Climate[2]

The tar sands area lies in the northern cool temperate zone. It is generally characterized by light precipitation year-round with high temperatures and unstable atmospheric conditions in summer, and very low temperatures and stable atmospheric conditions in winter.

January average temperatures range from -13.0° F to -3.0° F, with extremes as low as -50° F. Summer temperatures reach the seventies, with extremes to 90° F.

Precipitation is heaviest in the summer months of June, July and August, with about 3.0 to 4.0 inches monthly during this period. Spring and fall generally experience a monthly average of 1.0 to 2.0 inches of rainfall. Winter snows average 3 to 4 feet.

The growing season lasts 60 to 80 days with the last spring frost generally occurring towards the end of May and the first fall frost prior to mid-September. Sunshine averages about 240 hours per month during the growing season, with day length increasing to a maximum of eighteen hours during the summer. Conditions of instability during the summer are reflected in the frequent occurrence of thunderstorms and hail; Fort McMurray has recorded 27 thunderstorms in a single month.

## Soils

Soils in the tar sands region are basically a grey-wooded type, supporting mixed deciduous and evergreen woods,



2. This information has been derived from Department of Transport monthly meteorological data collected at Ft. McMurray over the past nine year period, and from "An Environmental Study of the Athabasca Tar Sands", Intercontinental Engineering of Alberta Ltd. (1973).

but interspersed with frequent muskegs and sedge bogs. In most areas, the surface is covered by a thin layer of semi-decomposed leaf litter. The soil below this has been severely leached and so is infertile.

However, because the revegetation program will be applied to a set of soil types new to the area, the characteristics of these soils must be defined. Soil studies have been initiated to identify the chemical, biological and physical soil properties suitable to the plants and environment and how to achieve and maintain these parameters.

One of the new materials that will need to be revegetated will be tailing sand. This substance contains little organic matter and will require modification to improve its water holding ability, texture, structure and fertility before it is able to maintain a plant community.

## Hydrology

Moisture conditions of surface soils, water table characteristics, and area hydrology are fundamental knowledge to a revegetation program. Plant species and soil amendments can be chosen to suit the various hydrologic conditions found in reclaimed areas. In addition, the whole process of reclamation and revegetation can be modified to reduce undesirable changes in water table levels or water quality.

# 2. GENERAL PLANT COMMUNITY DESCRIPTIONS

The naturally occurring vegetation of Lease 17 can be divided into eight main plant communities. These communities are similar to the habitat types given in "The Habitat of Syncrude Tar Sands Lease #17: An Initial Evaluation" (Syncrude 1973 (c)). The Recent Burn and Old Burn habitat types were not included as such in this study because they were identified as mosaics of several of the other communities, with the only common element being recent fire disturbance.

The eight community types studied were:

1) Jackpine *(Pinus banksiana)*
2) Jackpine-Aspen *(Pinus banksiana-Populus tremuloides)*
3) Aspen *(Populus tremuloides)*
4) White Spruce-Aspen *(Picea glauca-Populus tremuloides)*
5) White Spruce *(Picea glauca)*
6) Riverine *(Populus balsamifera-Picea glauca)*
7) Black Spruce *(Picea mariana)*
8) Sedge *(Carex)* Fen

## 2.1 Jackpine Community

Stands of the Jackpine community on Lease 17 are primarily found on dry sand ridges, located northeast of Mildred Lake and in the southeast corner of the lease.

The soil in the study area, a podzol (Figure 1), was dry. Although phosphorus levels (21-33 ppm) were adequate, nitrogen (7 ppm) and potassium (75 lbs per acre) were low. These measurements are summarized in Table 1.

TABLE 1

SUMMARY OF SOILS AND AVAILABLE NUTRIENTS ASSOCIATED WITH DIFFERENT COMMUNITY TYPES

| COMMUNITY | ASSOCIATED SOIL(S) | AVAILABLE NUTRIENTS Phosphorous (ppm) | Potassium (lbs/acre) | Nitrogen (ppm) |
|---|---|---|---|---|
| Jackpine | podzol | 21-33 | 75 | 7 |
| Aspen | bisequa-grey-wooded | 15 | 100 | 4 |
| White Spruce-Aspen | podzol | | | |
| White Spruce | greywooded | | | |
| Riverine | alluvial | 8 | 700 | 12 |
| Black Spruce | peat | 4 | 1000 | 8 |

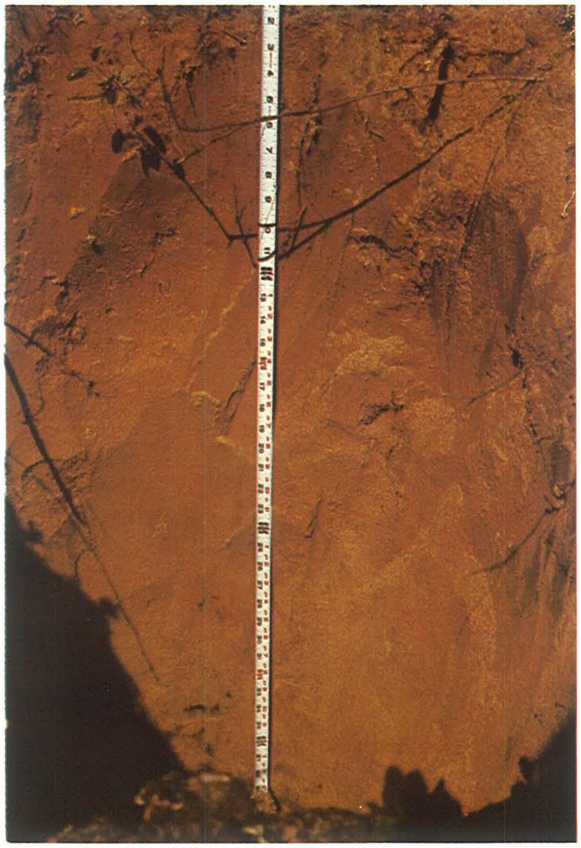

Figure 1
PODZOL SOIL OF A JACKPINE STAND

Figure 2
A STAND OF THE JACKPINE COMMUNITY

The typical open canopy and sparse ground cover of this community are visible in Figure 2. Jackpine is the only important tree species. The important ground cover species include bearberry *(Arctostaphylos uva-ursi)*, reindeer lichens *(Cladonia spp)*, and blueberries *(Vaccinium myrtilloides)*. Other less important ground cover species were bog cranberries *(Vaccinium vitis-idaea)*, three leaved solomon's seal *(Smilacina trifolia)*, club mosses *(Lycopodium annotinum* and *L. clavatum)* and shorthorn rice grass *(Oryzopsis pungens)*. On a sand site cleared of trees (Figure 3) the ground cover consisted of more grass including shorthorn rice grass, saximontana fescue *(Festuca saximontana)*, tickle grass *(Agrostis scabra)* and some slender wheatgrass *(Agropyron trachycaulum)*.

With increasing soil moisture the Jackpine community grades into the Aspen and White Spruce-Aspen communities.

## 2.2 Jackpine-Aspen Community

Aspen and white spruce are able to grow with jackpine in those sand areas with a higher water table. A more varied ground cover is able to develop, including species such as hairy wild rye *(Elymus innovatus)*, willows *(Salix spp)*, field horsetail *(Equisetum arvense)*, bunchberry *(Cornus canadansis)*, buffalo berry *(Shepherdia canadensis)*, and green alder *(Alnus crispa)*.

## 2.3 Aspen, White Spruce-Aspen and White Spruce Communities

These three communities compose the majority of the upland forests on Lease 17. Forming a successional series from Aspen to White Spruce-Aspen to White Spruce stands, (Hardy 1967) they occur on a similar range of soil types. Stands are

Figure 3
SAND SITE CLEARED OF TREES

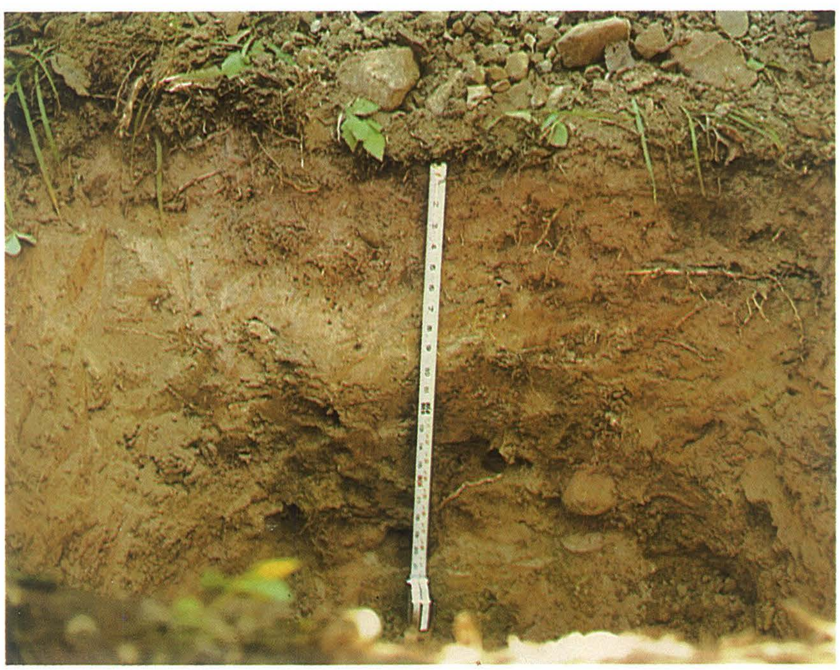

Figure 4
GREYWOODED SOIL OF A WHITE SPRUCE-ASPEN MIXEDWOOD COMMUNITY

found on virtually all soils in the area, with the exceptions of the dry land ridges and the organic soils of the muskeg. Bisequa greywooded, podzols and greywooded (Figure 4) are soils typical of these communities.

In the soils analysed, nitrogen (4 ppm) and potassium (less than 100 lbs/acre) contents were low while phosphorus (15 ppm) content was marginally adequate.

Aspen stands are found on the eastern portion of the lease. The shrub and herb layers in the Aspen stands are prominent, containing several species. The major shrubs include willows, red osier dogwood *(Cornus stolonifera)*, saskatoon berry *(Amelanchier alnifolia)*, chokecherry *(Prunus virginiana)*, buffalo-berry, wild rose *(Rosa spp)* and shrubby cinquefoil *(Potentilla fruticosa)*. Herbs include hairy wild rye, Kentucky bluegrass *(Poa pratensis)*, fowl bluegrass *(Poa palustris)*, strawberry *(Fragaria virginiana)*, bunchberry, dewberry *(Rubus pubescens)*, yarrow *(Achillea millefolium)*, wild vetch *(Vicia americana)*, pea vine *(Lathyrus ochroleucus* and *L. venosus)*, and northern bedstraw *(Galium boreale)*.

Pure aspen stands are not common because white spruce will invade them as quickly as the available seed supply will permit. Once the spruce have established and affected the ground cover the stand is classified as a White Spruce-Aspen community. The division between the two groups is arbitrary, depending on the density as well as the size of the white spruce trees.

The majority of upland forest on Lease 17, including much of the forest in the western part of the lease designated as Old Burn and Recent Burn in "The Habitat of the Syncrude Tar Sands Lease #17"(Syncrude 1973 (c)), belongs to the White Spruce-Aspen mixedwood community. Figure 5 shows a view of a White Spruce-Aspen stand which has a predominance of aspen.

Figure 5

A STAND OF THE WHITE SPRUCE-ASPEN MIXEDWOOD COMMUNITY

Figure 6

GROUND COVER IN A WHITE SPRUCE-ASPEN
MIXED WOOD STAND

The diversity of the ground cover in the White Spruce-Aspen mixedwoods is apparent in Figure 6. In the foreground the understory is typical of areas where aspen is dominant. It is basically the same as the understory of the pure Aspen community and is composed of the same plant species. The effect of spruce on the ground cover vegetation can be seen in the middle of the picture. Under the patches of spruce the majority of ground cover is provided by the feather mosses *(Hylocomiun splendens, Pleurozium schreberi* and *Ptilium crista-castrensis).* Other species occasionally found under spruce are woodland horsetail *(Equisetum sylvaticum)*, meadow horsetail *(E. pratense)*, field horsetail, twin flower *(Linnaea borealis)*, mooseberry *(Viburnum spp)*, bunchberry and labrador tea *(Ledum groen landicum).*

Pure White Spruce stands cover only a small part of Lease #17. These stands develop in the absence of fire when the white spruce crowds out the aspen in a mixedwood community. The areas history of frequent fires is the explanation for the limited occurrence of pure White Spruce stands. Fire tends to favor the growth of aspen rather than spruce for two reasons:

1. Aspen is able to regenerate more quickly after a fire than spruce due to more rapid regeneration by root suckers than seed.
2. Fires tend to be hotter and more destructive in spruce stands because of the dense canopy of highly flammable branches.

The ground cover in a pure White Spruce stand can be seen in Figure 7. On this site the ground cover was basically the same as that under the spruce in the White Spruce-Aspen stands. The major differences were a much thicker feather moss carpet and generally smaller and weaker shrubs and herbs.

Figure 7
GROUND COVER IN A WHITE SPRUCE STAND

Figure 8
RIVERINE COMMUNITY SOIL PROFILE SHOWING DARK BANDS OF LITTER BURIED BY FLOODING

## 2.4 Riverine Community

Stands of the Riverine community are most often found on the alluvial soils along the Athabasca and MacKay Rivers, with some stands appearing along Beaver Creek. These soils provide an excellent growth medium, having high nutrient levels, good soil moisture and aeration, and support boreal mixed-wood stands with large numbers of balsam poplar *(Populus balsamifera)*.

The soil profile from a pit between Horseshoe Lake and the Athabasca River is shown in Figure 8. Dark bands of litter buried by floods are visible at various depths throughout the profile. The pit is approximately 3 feet deep. Potassium was found to be adequate (700 lbs/acre) and phosphorus (8 ppm) nearly so; however, nitrogen (12 ppm) was low at this site.

Most of these stands have been logged in the past and have a good shrub cover of red osier dogwood, willows, roses, raspberries *(Rubus strigosus)*, saskatoon berries and mooseberries. Figure 9 shows the growth of shrubs in a stand of the Riverine community. Ground cover species include slender wheatgrass, hairy wild rye, marsh reed grass *(Calamagrostis inexpansa)*, bluejoint *(C. canadensis)*, kentucky bluegrass, fowl bluegrass, field horsetail, meadow horsetail, bluebells *(Mertiensia paniculata)* and wild vetch.

## 2.5 Black Spruce Community

Figure 10 shows a typical Black Spruce stand. This well-treed stand was on a shallow peat, about 2 feet thick, with a pH of about 7. With increasing depth of peat and increasing acidity the tree cover in these communities becomes more open. Willow, birch *(Betula spp)*, tamarack *(Larix laricina)* and

Figure 9

SHRUB GROWTH IN THE RIVERINE COMMUNITY. THE RED OSIER DOGWOOD IS 8' - 10' TALL.

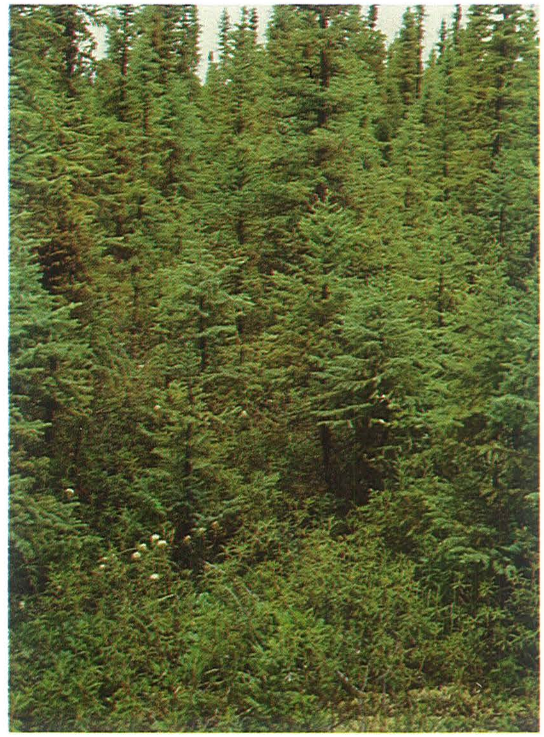

Figure 10

A STAND OF THE BLACK SPRUCE COMMUNITY

Figure 11

THE AREA ON THE LEFT SHOWS VOLUNTEER GROWTH FROM MUSKEG PEAT SPREAD OVER, AND NOT MIXED INTO, THE TAILING SAND SURFACE.

occasional aspen and balsam poplar are found in addition to black spruce in stands of this community. Important ground cover species include several species of mosses, alpine bearberry *(Arctostaphylos rubra)*, creeping willow *(Salix repens)*, bog cranberry, labrador tea, bog birch *(Betula glandulosa)*, marsh horsetail *(Equisetum arvense)*, field horsetail and lichens *(Peltigera spp.* and *Cladonia spp.)*.

Nitrogen (less than 8 ppm) and phosphorous (less than 4 ppm) were low at the site sampled while potassium was high (more than 1000 lbs/acre).

## 2.6 Sedge Fen Community

Stands of this community consist of wet meadows dominated by sedges and reed grasses *(Calamogrostis spp)*. Patches of bog birch and willows are usually found scattered throughout the sedge fens.

This community was not studied in any detail because it is unlikely that plants adapted to the wet organic soils of this community would be useful in the revegetation of sites with very different drainage characteristics, such as surface mining areas and tailing deposits.

## 3. SURVEY OF NATURALLY AND ARTIFICIALLY REVEGETATED AREAS

A survey of the vegetation existing on cutlines, pipeline rights-of-way, roadsides and surface mined areas was carried out in the Athabasca Tar Sands area during the summer of 1973. This was part of a larger survey conducted as the first step in a project designed to find native species suitable for use in the revegetation of disturbed areas in Alberta. The survey was based on a series of 10 $m^2$ plots located on disturbed and undisturbed sites in each of the tar sands communities discussed in Chapter 2. Cutlines formed the majority of the disturbed sites and so were most often used; the remaining sites were located along roadsides and pipeline rights-of-way.

### 3.1 Cutlines

The cutlines studied had all been left to revegetate naturally; no reseeding had been done. Most of the disturbance on the cutlines was restricted to removal of trees with little or no disturbance to the topsoil, although in some cases the topsoil and litter had also been removed.

The major effect of tree removal along cutlines with little or no disturbance to the litter and topsoil was an increase in the density and diversity of the shrub and herb vegetation. This is due to better light conditions, less interception of precipitation and higher soil and air temperatures at ground level after removal of the trees. As an example, Figure 7 shows the impoverished vegetation under the white spruce trees. Its depletion is due, in part, to the higher light and precipitation interception of the spruce trees relative to the aspen. An increase in the acidity of the soil under the spruce trees is also partially responsible. In stands where the original tree canopy was quite open, such as the Jackpine Community (Figure 2), clearing of the trees does not have as much effect on the ground cover, as can be seen by comparing Figures 2 and 3. The Jackpine and Black Spruce communities showed the least change in ground cover. The other five communities showed much larger changes in ground cover after tree removal, with the White Spruce community showing the greatest alteration.

Natural revegetation was much slower on sites where the topsoil and litter were removed. In some cases it was not fast enough to prevent erosion; this indicated the need for a reseeding program on these sites. Vegetation on these sites consisted of a few introduced weeds and native pioneer species such as fireweed *(Epilobium angustifolium)* and wild strawberry.

Since rapid natural revegetation of sites occurs where the topsoil has not been disturbed, minimizing topsoil disturbance wherever possible should reduce the need for reseeding.

## 3.2 Pipeline Rights-of-Way

Pipeline rights-of-way have two types of habitat. Over the trench, the severe disturbance of the soil usually leaves relatively infertile parent material at the surface. Beside the trench, the topsoil, although left in place, is heavily disturbed by the use of heavy equipment in pipeline construction. Disturbance to the top soil retards the rate of natural revegetation allowing undesirable perennial weeds such as Canada thistle *(Cirsium arvense)* to become established. This is especially a problem on the backfilled trench where the pipeline is buried. Unless reseeding is done to insure a good plant cover in a relatively short period of time erosion may also become a problem.

All pipeline rights-of-way studied in the tar sands area had been left to revegetate naturally. The most common grasses found were bluejoint, slender wheatgrass and bluegrasses *(Poa spp)*. Fireweed, wild rose, wild strawberry, wild raspberry, field horsetail, marsh horsetail and common yarrow *(Achillea millefolium)* were also common. The major legumes present were wild vetch and, occasionally, pea vine. Important weeds present included dandelions *(Taraxacum officinale)* sow thistle *((Sonchus arvensis)* and Canada thistle.

The weeds were more common at a site next to secondary highway 963 than they were on a site south of Fort McMurray several miles from any well travelled road.

## 3.3 Roadsides

The habitat along roadsides is similar to the habitat of the backfilled pipeline trench. The disturbance along roadsides tends to be greater because of the cuts and fills used to reduce grades on roads. The original surface contour is usually retained along pipelines.

Roadside vegetation falls into two categories:

1. areas where the roadside has been seeded by the Department of Highways and Transport, and
2. areas where the roadside has been left to vegetate naturally.

On roadsides where seeding has been done, smooth brome *(Bromus inermis)*, red fescue *(Festuca rubra)* and timothy *(Phleum pratense)* were the most important grasses. Sweet clover *(Melilotus alba* and *M. officinale)*, alsike clover *(Trifolium hybridum)*, white clover *(T. repens)* and red clover *(T. pratense)* were the most important legumes. Along roadsides north of Fort McMurray where no seeding was done the most common ground cover species were field horsetail, willows, fireweed, sedges, reed grasses, wild strawberries, wild vetch and sweet clover.

### 3.4 Surface Mined Areas

Surface mined areas present special problems for revegetation because of the large areas involved and, in the tar sands area, because of the chemical and physical nature of the tailing sand. The tailing sands are low in plant nutrients and have a low water holding capacity (Massey 1972). Its loose, single grained structure means it is susceptible to erosion by both wind and water. A good plant cover is essential to prevent this erosion. Low fertility can be overcome relatively easily by the application of fertilizers. However, a plant community capable of recycling the nutrients is essential to prevent leaching of them from the soil. Otherwise continuous application of fertilizer will be necessary to maintain the ground cover in a healthy enough condition to prevent erosion.

Field trials by Great Canadian Oil Sands Ltd. (GCOS) (Massey 1972) and by Environment Canada (Lesko 1974) have shown that seeding the commercial forage species presently used in revegetation work directly onto untreated tailing sand was not successful in providing an effective ground cover, even with application of fertilizer. Some treatment to increase the water holding capacity of the sand was required. GCOS used peat from the muskeg overburden to mix into the top six inches of the tailing sand to improve water holding capacity. The Environment Canada study indicated that contour trenching before seeding was effective in enabling grasses to become established. However, some native species such as sweet grass *(Hierochloe odorata)* or houghton sedge *(Carex houghtonii)* may be able to establish themselves on the tailing sand without the need for such treatment.

Grass species which successfully established themselves included crested wheatgrass *(Agropyron cristatum)*, pubescent wheatgrass *(A. tricophorum)*, latiglume wheatgrass *(A. latiglume*, streambank wheatgrass *(A. riparium)*, smooth brome, red top *(Agrostis alba)* and timothy (Lesko 1974). Since these results were published after only two growing seasons it is not known how long any of these species will be able to maintain themselves in this area. Species like crested wheatgrass are not likely to provide permanent ground cover in this area. GCOS was able to establish good stands of introduced forage grasses and legumes using a Brillion grass seeder and mixing peat in with the tailing sand (Massey 1972). GCOS also had some success using a Hydroseeder but the Brillion grass seeder provided more consistent results (Massey 1972).

# 4. GROWTH CHAMBER STUDIES

For initial species evaluation, tests were carried out in the winter of 1973-74 to examine species response to various soil types and time to germination (but not percentage germination).

## 4.1 Methods

All soil response tests were carried out in Plant Industry Laboratory growth chambers. Diurnal temperature variation was $10^{o}$F., between $65^{o}$ and $55^{o}$; day length was 15 hours; relative humidity was maintained between 65% and 80%. Plants were watered daily.

A test consisted of 50 seeds per species planted in a six inch pot. Each test was replicated three times.

Seed used in the testing was collected manually from native plants throughout the province.

Soils were used as collected. The first two tests were carried out on five soil types - organic (peat), clay-loam, sand, tar sand and tailing sand. In the third group of tests, a standard greenhouse or garden soil mix was used for comparison with tailing sand. For this test, an initial evaluation was made 17 days after germination. At 19 days and 33 days after germination, 20-20-20 fertilizer was added to the pots, and a second evaluation was made at day 41 to determine effects of fertilization.

Evaluation of the plants was based on a scale of 0 to 5. Plants were evaluated through visual observations only. Death of the plant was represented on the scale by 0, with higher numbers indicating increasing healthiness of the plant, 5 being the healthiest.

## 4.2 Results

The results indicated that in some cases soil type affected the time required for germination (but in no case did it affect the number of plant germinations).

The first trials, to test response to five different soil types, used 25 different species of grasses and legumes. The effects of soil type on time of germination are presented in Table 2. Growth was evaluated at days 17 and 44 after germination, as recorded in Table 3.

The second tests were similar to the first, with growth evaluation at 16 and 39 days after germination. Table 4 shows the number of days to germination, and Table 5 the growth evaluations.

The third set of experiments was designed with two goals in mind. To determine if there were ecotypic differences in response within a species, seeds from several clones of a single species were tested. As well, fertilizer effects could be studied by adding fertilizer after an initial growth evaluation. In this way, changes caused by the fertilizer could be noted at the second evaluation. These results are given in Table 5.

## 4.3 Conclusions

As expected, some species were far more sensitive to soil type than others were. This is illustrated clearly in Figure 12. Such results give a good indication of the species which may be useful for revegetation. Species, such as the

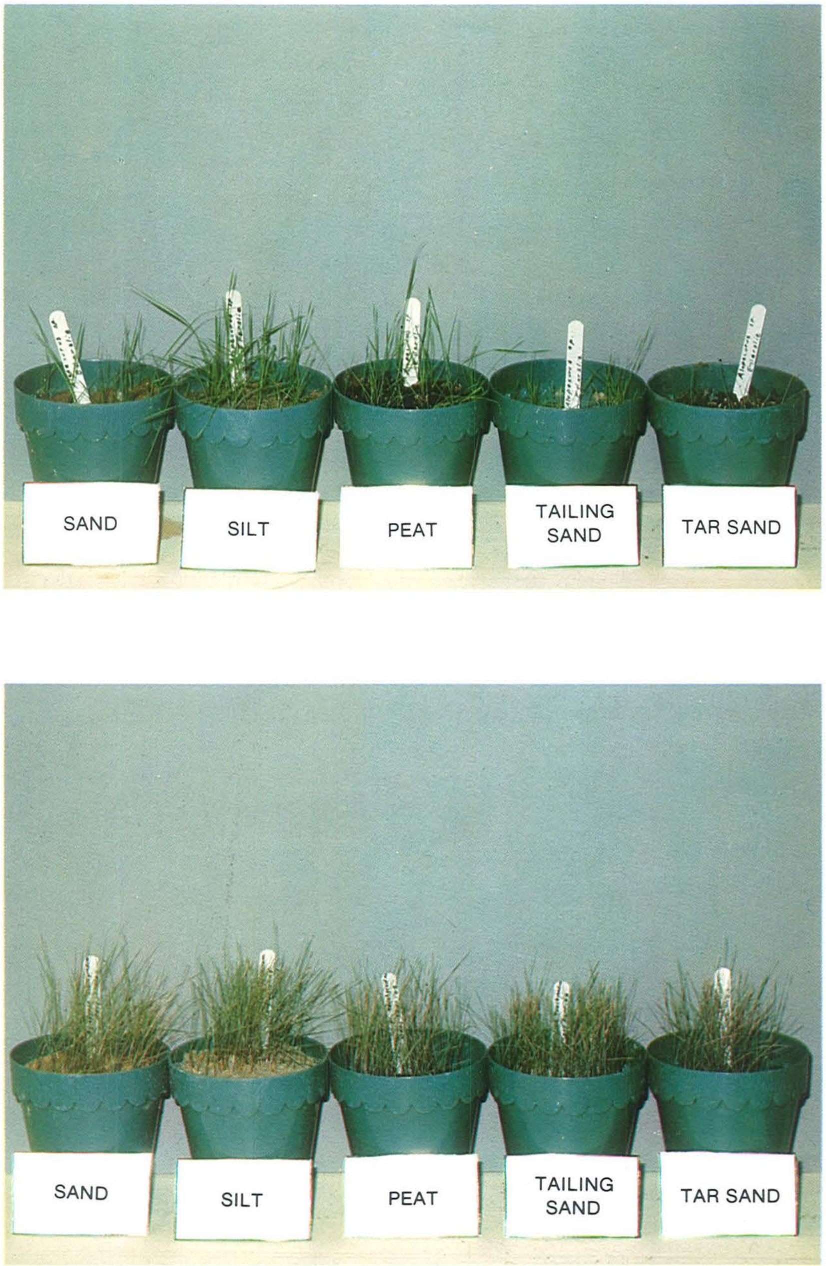


Figure 12
SPECIES DIFFERENCES IN RESPONSE TO SOIL TYPES

UPPER: *ALOPECURUS SPP.* WHICH DOES NOT GROW WELL IN SAND.

LOWER: *AGROPYRON TRACHYCAULUM* WHICH GROWS EQUALLY WELL IN ALL TESTED SOIL TYPES.


Figure 13

ECOTYPIC DIFFERENCES IN RESPONSE TO SOIL TYPES. EACH PICTURE SHOWS A CLONE OF *AGROPYRON SMITHII.*

*Agropyron* species, which grew well on the sandy soils in the test, may be of great value in the tar sands area. Preliminary selection can therefore be made for species for subsequent study.

However, the problem is not simply one of *species* selection, as can be seen in Figure 13. This demonstration of ecotypic differences within a species gives a further basis for seed selection. It becomes important not only to select the correct species for reclamation work, but also to select the best lines within that species for the particular area of concern.

TABLE 2

DAYS TO SEED GERMINATION IN FIVE SOIL TYPES

| | SPECIES | SOIL TYPE | | | | |
|---|---|---|---|---|---|---|
| | | Organic | Clay Loam | Sand | Oil Sand | Tailing Sand |
| 1. | *Agropyron cristatum* | 10 | 14 | 10 | 10 | 10 |
| 2. | *Agropyron smithii* | 6 | 7 | 7 | 7 | 7 |
| 3. | *Agropyron trachycaulum* | 6 | 7 | 6 | 8 | 7 |
| 4. | *Agrostis gigantea* | 5 | 5 | 5 | 6 | 5 |
| 5. | *Bromus pumpellianus* | 8 | 10 | 10 | 10 | 10 |
| 6. | *Festuca altiaca* | 6 | 10 | 10 | 10 | 10 |
| 7. | *Festuca ovina* | 5 | 5 | 5 | 5 | 5 |
| 8. | *Festuca scabrella* | 8 | 10 | 10 | 10 | 10 |
| 9. | *Festuca saximontana* | 10 | 10 | 10 | 10 | 10 |
| 10. | *Phleum pratense* | 5 | 6 | 6 | 6 | 6 |
| 11. | *Poa ampla* | 5 | 5 | 5 | 6 | 6 |
| 12. | *Poa compressa* | 10 | 10 | 10 | 10 | 10 |
| 13. | *Poa palustris* | 7 | 13 | 10 | 13 | 12 |
| 14. | *Poa alpina* | 5 | 10 | 10 | 10 | 10 |
| 15. | *Poa pratensis* | 10 | 10 | 10 | 10 | 11 |
| 16. | *Puccinellia distans* | 8 | 10 | 10 | 11 | 10 |
| 17. | *Hedysarum alpinum* | 8 | 8 | 8 | 9 | 8 |
| 18. | *Medicago sativa* | 3 | 3 | 3 | 3 | 3 |
| 19. | *Medicago falcata* | 3 | 3 | 3 | 5 | 3 |
| 20. | *Oxytropis sp.* | 3 | 3 | 3 | 3 | 3 |
| 21. | *Trifolium hybridum* | 3 | 3 | 3 | 3 | 3 |
| 22. | *Trifolium medium* | 3 | 3 | 3 | 3 | 3 |
| 23. | *Trifolium pratense* | 3 | 3 | 3 | 3 | 3 |
| 24. | *Trifolium repens* | 3 | 3 | 3 | 3 | 3 |
| 25. | *Vicia cracca* | 33 | 18 | 13 | 21 | 24 |

TABLE 3

EVALUATION* OF EARLY PLANT DEVELOPMENT IN FIVE SOIL TYPES

| SPECIES | 17 DAYS AFTER GERMINATION | | | | |
|---|---|---|---|---|---|
| | Organic | Clay Loam | Sand | Oil Sand | Tailing Sand |
| 1. *Agropyron cristatum* | 5 | 5 | 5 | 5 | 5 |
| 2. *Agropyron smithii* | 5 | 5 | 5 | 4 | 5 |
| 3. *Agropyron trachycaulum* | 5 | 5 | 5 | 4 | 4 |
| 4. *Agrostis gigantea* | 5 | 4 | 5 | 4 | 4 |
| 5. *Bromus pumpellianus* | 5 | 5 | 5 | 3 | 4 |
| 6. *Festuca altiaca* | 5 | 5 | 5 | 5 | 5 |
| 7. *Festuca ovina* | 5 | 5 | 5 | 4 | 5 |
| 8. *Festuca scabrella* | 5 | 4 | 5 | 2 | 3 |
| 9. *Festuca saximontana* | 5 | 4 | 5 | 3 | 3 |
| 10. *Phleum pratense* | 5 | 4 | 5 | 4 | 4 |
| 11. *Poa ampla* | 5 | 5 | 4 | 4 | 3 |
| 12. *Poa compressa* | 5 | 3 | 4 | 2 | 2 |
| 13. *Poa palustris* | 5 | 4 | 5 | 3 | 4 |
| 14. *Poa alpina* | 5 | 4 | 5 | 4 | 4 |
| 15. *Poa pratensis* | 5 | 5 | 5 | 4 | 4 |
| 16. *Puccinellia distans* | 5 | 5 | 4 | 3 | 3 |
| 17. *Hedysarum alpinum* | 5 | 5 | 5 | 4 | 3 |
| 18. *Medicago sativa* | 3 | 5 | 4 | 2 | 3 |
| 19. *Medicago falcata* | 3 | 5 | 2 | 2 | 3 |
| 20. *Oxytropis sp.* | 3 | 4 | 5 | 3 | 3 |
| 21. *Trifolium hybridum* | 5 | 4 | 4 | 2 | 3 |
| 22. *Trifolium medium* | 5 | 4 | 4 | 2 | 3 |
| 23. *Trifolium pratense* | 5 | 5 | 5 | 4 | 4 |
| 24. *Trifolium repens* | 5 | 5 | 5 | 4 | 3 |
| 25. *Vicia cracca* | 4 | 5 | 5 | 5 | 5 |

* Evaluation based on 0-5 scale; 0 indicating death of the plant, 5 indicating healthiest plants.

Table 3 continued

EVALUATION OF EARLY DEVELOPMENT IN FIVE SOIL TYPES

| SPECIES | | 44 DAYS AFTER GERMINATION | | | | |
|---|---|---|---|---|---|---|
| | | Organic | Clay Loam | Sand | Oil Sand | Tailing Sand |
| 1. | *Agropyron cristatum* | 4 | 4 | 5 | 3 | 3 |
| 2. | *Agropyron smithii* | 5 | 5 | 5 | 4 | 4 |
| 3. | *Agropyron trachycaulum* | 5 | 5 | 5 | 5 | 5 |
| 4. | *Agrostis gigantea* | 5 | 4 | 5 | 3 | 3 |
| 5. | *Bromus pumpellianus* | 5 | 5 | 5 | 3 | 4 |
| 6. | *Festuca altiaca* | 5 | 5 | 4 | 3 | 3 |
| 7. | *Festuca ovina* | 5 | 5 | 4 | 3 | 3 |
| 8. | *Festuca scabrella* | 5 | 5 | 5 | 4 | 4 |
| 9. | *Festuca saximontana* | 5 | 5 | 5 | 4 | 4 |
| 10. | *Phleum pratense* | 4 | 5 | 3 | 2 | 2 |
| 11. | *Poa ampla* | 5 | 4 | 4 | 3 | 2 |
| 12. | *Poa compressa* | 4 | 5 | 4 | 3 | 3 |
| 13. | *Poa palustris* | 4 | 3 | 5 | 2 | 2 |
| 14. | *Poa alpina* | 5 | 5 | 5 | 4 | 3 |
| 15. | *Poa pratensis* | 4 | 5 | 5 | 0 | 3 |
| 16. | *Puccinellia distans* | 4 | 5 | 4 | 3 | 3 |
| 17. | *Hedysarum alpinum* | 5 | 5 | 4 | 3 | 3 |
| 18. | *Medicago sativa* | 4 | 5 | 4 | 3 | 3 |
| 19. | *Medicago falcata* | 4 | 5 | 2 | 2 | 3 |
| 20. | *Oxytropis sp.* | 4 | 5 | 5 | 0 | 3 |
| 21. | *Trifolium hybridum* | 5 | 4 | 4 | 3 | 3 |
| 22. | *Trifolium medium* | 5 | 4 | 5 | 3 | 4 |
| 23. | *Trifolium pratense* | 5 | 5 | 5 | 4 | 4 |
| 24. | *Trifolium repens* | 4 | 4 | 5 | 3 | 3 |
| 25. | *Vicia cracca* | 5 | 5 | 5 | 5 | 5 |

TABLE 4

DAYS TO SEED GERMINATION IN FIVE SOIL TYPES

| SPECIES | SOIL TYPE | | | | |
|---|---|---|---|---|---|
| | Organic | Clay Loam | Sand | Oil Sand | Tailing Sand |
| 1. *Agropyron trachycaulum a** | 7 | 8 | 7 | 8 | 8 |
| 2. *Agropyron trachycaulum b* | 7 | 8 | 7 | 8 | 8 |
| 3. *Agrostis scabra* | 7 | 7 | 10 | 10 | 10 |
| 4. *Agrostis tenuis* | 5 | 5 | 5 | 6 | 6 |
| 5. *Alopecurus ventricosus* | 6 | 6 | 6 | 9 | 6 |
| 6. *Alopecurus pratensis* | 13 | 13 | 13 | 13 | 13 |
| 7. *Elymus innovatus* | 9 | 9 | 9 | 9 | 9 |
| 8. *Festuca elatior a* | 5 | 6 | 6 | 6 | 6 |
| 9. *Festuca elatior b* | 8 | 8 | 8 | 8 | 8 |
| 10. *Festuca ovina* | 5 | 6 | 6 | 6 | 6 |
| 11. *Festuca rubra* | 6 | 7 | 7 | 7 | 7 |
| 12. *Festuca scabrella* | 6 | 8 | 6 | 8 | 8 |
| 13. *Glyceria sp.* | 13 | 20 | 13 | 20 | 13 |
| 14. *Koeleria cristata* | 8 | 8 | 8 | 8 | 8 |
| 15. *Phleum pratense* | 6 | 8 | 8 | 9 | 8 |
| 16. *Poa pratensis a* | 8 | 8 | 8 | 9 | 9 |
| 17. *Poa pratensis b* | 13 | 13 | 13 | 15 | 13 |
| 18. *Stipa spartea* | 27 | 20 | 20 | 27 | 27 |
| 19. *Astragalus cicer* | 6 | 6 | 6 | 8 | 6 |
| 20. *Lotus corniculatus* | 5 | 5 | 5 | 5 | 5 |
| 21. *Oxytropis splendens* | 7 | 6 | 7 | 7 | 7 |
| 22. *Oxytropis campestris or sericea* | 6 | 6 | 6 | 7 | 6 |

* Letters following a species name indicate different ecotypes of that species.

TABLE 5

EVALUATION* OF EARLY PLANT DEVELOPMENT IN FIVE SOIL TYPES

| SPECIES | 16 DAYS AFTER GERMINATION | | | | |
|---|---|---|---|---|---|
| | Organic | Clay Loam | Sand | Oil Sand | Tailing Sand |
| 1. *Agropyron trachycaulum* a | 5 | 5 | 5 | 5 | 5 |
| 2. *Agropyron trachycaulum* b | 4 | 4 | 4 | 4 | 4 |
| 3. *Agrostis scabra* | 3 | 3 | 2 | 2 | 2 |
| 4. *Agrostis tenuis* | 5 | 4 | 5 | 4 | 4 |
| 5. *Alopecurus ventricosus* | 4 | 4 | 3 | 2 | 3 |
| 6. *Alopecurus pratensis* | 3 | 3 | 2 | 2 | 3 |
| 7. *Elymus innovatus* | 4 | 4 | 4 | 4 | 4 |
| 8. *Festuca elatior* a | 5 | 5 | 5 | 5 | 5 |
| 9. *Festuca elatior* b | 5 | 4 | 4 | 4 | 4 |
| 10. *Festuca ovina* | 5 | 4 | 4 | 5 | 5 |
| 11. *Festuca rubra* | 5 | 5 | 5 | 5 | 5 |
| 12. *Festuca scabrella* | 5 | 4 | 5 | 5 | 5 |
| 13. *Glyceria sp.* | 4 | 0 | 4 | 0 | 3 |
| 14. *Koeleria cristata* | 5 | 5 | 5 | 5 | 5 |
| 15. *Phleum pratense* | 5 | 3 | 4 | 3 | 4 |
| 16. *Poa pratensis* a | 5 | 3 | 5 | 2 | 5 |
| 17. *Poa pratensis* b | 3 | 3 | 2 | 2 | 2 |
| 18. *Stipa spartea* | 0 | 0 | 0 | 0 | 0 |
| 19. *Astragalus cicer* | 1 | 5 | 5 | 3 | 4 |
| 20. *Lotus corniculatus* | 4 | 5 | 5 | 5 | 5 |
| 21. *Oxytropis splendens* | 1 | 4 | 4 | 4 | 4 |
| 22. *Oxytropis campestris or sericea* | 1 | 4 | 3 | 1 | 3 |

* Evaluation based on 0-5 scale; 0 indicating death of the plant, 5 indicating healthiest plants.

Table 5 continued

EVALUATION OF EARLY PLANT DEVELOPMENT IN FIVE SOIL TYPES

| SPECIES | 39 DAYS AFTER GERMINATION | | | | |
|---|---|---|---|---|---|
| | Organic | Clay Loam | Sand | Oil Sand | Tailing Sand |
| 1. *Agropyron trachycaulum* a | 4 | 4 | 4 | 4 | 4 |
| 2. *Agropyron trachycaulum* b | 5 | 5 | 5 | 5 | 5 |
| 3. *Agrostis scabra* | 4 | 3 | 2 | 2 | 2 |
| 4. *Agrostis tenuis* | 5 | 4 | 5 | 4 | 4 |
| 5. *Alopecurus ventricosus* | 5 | 4 | 5 | 4 | 4 |
| 6. *Alopecurus pratensis* | 4 | 5 | 3 | 3 | 4 |
| 7. *Elymus innovatus* | 5 | 5 | 5 | 5 | 5 |
| 8. *Festuca elatior* a | 5 | 5 | 5 | 5 | 5 |
| 9. *Festuca elatior* b | 5 | 5 | 5 | 5 | 5 |
| 10. *Festuca ovina* | 5 | 5 | 5 | 5 | 5 |
| 11. *Festuca rubra* | 5 | 5 | 5 | 5 | 5 |
| 12. *Festuca scabrella* | 5 | 5 | 5 | 5 | 5 |
| 13. *Glyceria sp.* | 3 | 2 | 4 | 1 | 2 |
| 14. *Koeleria cristata* | 4 | 4 | 4 | 3 | 4 |
| 15. *Phleum pratense* | 5 | 3 | 4 | 2 | 3 |
| 16. *Poa pratensis* a | 4 | 3 | 4 | 3 | 4 |
| 17. *Poa pratensis* b | 4 | 4 | 2 | 2 | 3 |
| 18. *Stipa spartea* | 3 | 3 | 4 | 1 | 2 |
| 19. *Astragalus cicer* | 2 | 5 | 4 | 3 | 4 |
| 20. *Lotus corniculatus* | 4 | 4 | 5 | 5 | 5 |
| 21. *Oxytropis splendens* | 1 | 3 | 2 | 1 | 1 |
| 22. *Oxytropis campestris or sericea* | 2 | 4 | 3 | 1 | 1 |

TABLE 6

DAYS TO SEED GERMINATION AND EVAUATION* OF EARLY PLANT DEVELOPMENT IN TWO SOIL TYPES

20-20-20 FERTILIZER WAS APPLIED AFTER DAY 17 EVALUATION

| | | Days to Germination | | 17 Days After Planting | | 41 Days After Planting | |
|---|---|---|---|---|---|---|---|
| | | Garden Soil | Tailing Sand | Garden Soil | Tailing Sand | Garden Soil | Tailing Sand |
| 1. | *Agropyron repens* | 6 | 8 | 5 | 3 | 5 | 2 |
| 2. | *Agropyron smithii a* | 8 | 17 | 2 | 1 | 4 | 1 |
| 3. | *Agropyron smithii b* | 10 | 15 | 2 | 1 | 3 | 1 |
| 4. | *Agropyron smithii c* | 5 | 6 | 4 | 3 | 5 | 3 |
| 5. | *Agropyron smithii d* | 5 | 8 | 4 | 3 | 5 | 3 |
| 6. | *Agropyron smithii e* | 6 | 10 | 3 | 2 | 5 | 2 |
| 7. | *Agropyron smithii f* | 7 | 10 | 5 | 4 | 5 | 5 |
| 8. | *Agropyron smithii g* | 10 | 10 | 3 | 2 | 5 | 3 |
| 9. | *Agropyron trachycaulum* | 6 | 6 | 5 | 1 | 5 | 3 |
| 10. | *Agropyron sp. a* | 10 | 11 | 3 | 3 | 5 | 1 |
| 11. | *Agropyron sp. b* | 11 | 11 | 1 | 1 | 3 | 1 |
| 12. | *Agropyron sp. c* | 6 | 7 | 5 | 3 | 5 | 2 |
| 13. | *Agropyron sp. d* | 6 | 7 | 5 | 4 | 5 | 3 |
| 14. | *Agropyron sp. e* | 6 | 7 | 5 | 4 | 5 | 3 |
| 15. | *Agropyron sp. f* | 10 | 13 | 3 | 2 | 5 | 2 |
| 16. | *Agrostis sp. a* | 5 | 6 | 3 | 2 | 5 | 2 |
| 17. | *Agrostis sp. b* | 9 | 10 | 3 | 1 | 5 | 1 |
| 18. | *Agrostis gigantea a* | 5 | 6 | 5 | 3 | 5 | 3 |
| 19. | *Agrostis gigantea b* | 4 | 5 | 5 | 2 | 5 | 4 |
| 20. | *Alopecurus sp.* | 7 | 10 | 3 | 1 | 5 | 1 |
| 21. | *Bromus inermis a* | 6 | 7 | 5 | 3 | 5 | 4 |
| 22. | *Bromus inermis b* | 4 | 5 | 5 | 3 | 5 | 3 |

* Evaluation based on 0-5 scale; 0 indicating death of the plant; 5 indicating the healthiest plants.

Table 6 continued

| | Days to Germination | | 17 Days After Planting | | 41 Days After Planting | |
|---|---|---|---|---|---|---|
| | Garden Soil | Tailing Sand | Garden Soil | Tailing Sand | Garden Soil | Tailing Sand |
| 23. *Bromus inermis c* | 5 | 6 | 5 | 3 | 5 | 3 |
| 24. *Calamagrostis sp.* | 11 | 12 | 2 | 1 | 4 | 1 |
| 25. *Deschampsia sp. a* | 5 | 7 | 4 | 2 | 5 | 3 |
| 26. *Deschampsia sp. b* | 4 | 5 | 5 | 3 | 5 | 5 |
| 27. *Elymus canadensis* | 6 | 7 | 5 | 5 | 5 | 5 |
| 28. *Elymus innovatus a* | 10 | 11 | 5 | 3 | 5 | 4 |
| 29. *Elymus innovatus b* | 10 | 11 | 3 | 2 | 5 | 3 |
| 30. *Elymus innovatus c* | 10 | 10 | 5 | 3 | 5 | 4 |
| 31. *Elymus innovatus d* | 10 | 11 | 3 | 2 | 5 | 2 |
| 32. *Elymus innovatus e* | 9 | 10 | 4 | 3 | 5 | 3 |
| 33. *Festuca rubra a* | 6 | 7 | 5 | 3 | 5 | 4 |
| 34. *Festuca rubra b* | 6 | 8 | 5 | 4 | 5 | 5 |
| 35. *Festuca rubra c* | 9 | 10 | 5 | 3 | 5 | 3 |
| 36. *Festuca scabrella a* | 7 | 10 | 3 | 2 | 4 | 2 |
| 37. *Festuca scabrella b* | 7 | 11 | 2 | 2 | 4 | 2 |
| 38. *Koeleria cristata* | 10 | 11 | 2 | 1 | 4 | 1 |
| 39. *Phalaris sp.* | 11 | 12 | 2 | 1 | 3 | 1 |
| 40. *Phleum sp.* | 6 | 7 | 5 | 3 | 5 | 3 |
| 41. *Poa ampla a* | 6 | 7 | 4 | 3 | 5 | 5 |
| 42. *Poa ampla b* | 11 | 12 | 1 | 1 | 2 | 1 |
| 43. *Poa compressa a* | 11 | 11 | 2 | 2 | 5 | 4 |
| 44. *Poa compressa b* | 11 | 15 | 2 | 1 | 5 | 4 |
| 45. *Poa palustris* | 10 | 12 | 3 | 2 | 5 | 4 |
| 46. *Poa pratensis a* | 11 | 18 | 2 | 1 | 5 | 4 |
| 47. *Poa pratensis b* | 11 | 12 | 1 | 1 | 5 | 4 |
| 48. *Poa pratensis c* | 10 | 11 | 4 | 2 | 5 | 4 |

Table 6 continued

| | | Days to Germination | | 17 Days After Planting | | 41 Days After Planting | |
|---|---|---|---|---|---|---|---|
| | | Garden Soil | Tailing Sand | Garden Soil | Tailing Sand | Garden Soil | Tailing Sand |
| 49. | *Poa pratensis d* | 12 | 15 | 1 | 1 | 3 | 1 |
| 50. | *Poa sp. a* | 10 | 11 | 5 | 3 | 5 | 5 |
| 51. | *Poa sp. b* | 10 | 11 | 5 | 3 | 5 | 4 |
| 52. | *Poa sp. c* | 7 | 10 | 5 | 3 | 5 | 3 |
| 53. | *Puccinellia sp.* | 9 | 10 | 3 | 1 | 5 | 1 |
| 54. | *Hedysarum alpinum a* | 9 | 10 | 4 | 2 | 5 | 1 |
| 55. | *Hedysarum alpinum b* | 12 | 12 | 3 | 1 | 5 | 1 |
| 56. | *Hedysarum alpinum c* | 13 | 13 | 3 | 1 | 5 | 1 |
| 57. | *Oxytropis splendens* | 5 | 5 | 5 | 1 | 5 | 1 |
| 58. | *Trifolium hybridum a* | 5 | 10 | 5 | 1 | 5 | 1 |
| 59. | *Trifolium hybridum b* | 11 | 11 | 2 | 1 | 4 | 1 |
| 60. | *Trifolium hybridum c* | 11 | 11 | 2 | 1 | 3 | 1 |
| 61. | *Trifolium pratense a* | 4 | 5 | 4 | 2 | 5 | 2 |
| 62. | *Trifolium pratense b* | 4 | 5 | 5 | 2 | 5 | 4 |

## 5. SEED PRODUCTION

Because it is difficult to predict a plant's response in a specific environment, recommendations for establishing economical, large-scale seed production can be made only after comprehensive testing programs have been completed. At present there is little available information on seed production of native and naturalized species. A program to obtain some of this knowledge is presently in progress.

Plant species vary widely in their requirements for optimum seed production, so testing of selected ecotypes in several environments is necessary to determine suitable conditions. Test nurseries are being established in five distinct environments differing in factors such as soil type, temperature, precipitation and day length:

1. High Level
2. Grande Prairie
3. Waskatenau
4. Edson
5. Edmonton

The response of selected ecotypes to these environments is being studied. Plant response and suitability will be determined by evaluating the effects of a particular environment on disease resistance and quality and quantity of seed produced.

Appropriate methods for handling seed are to be determined. Storage temperature and humidity conditions may be important in some species to maintain seed viability. In addition, some seeds may require a pretreatment such as chemical or mechanical scarification or stratification.

The Appendix lists the species of greatest applicability to the seed production program.

# 6. SUMMARY

The extraction of bitumen from the Syncrude Lease #17 will disturb large areas of land and require the revegetation of over 5000 acres. Before these areas can be reclaimed, research to determine plant species suitable for use in revegetation must be completed.

Selection criteria for plant species include climatic and soil suitability, erosion control potential (root systems and ground cover), disease resistance and competitive ability within a plant community.

A survey of native or naturalized species growing in the area or in similar areas, as well as a survey of plant material now growing on disturbed areas, gives a logical starting point for species selection.

Species variation in response to soil type has already been demonstrated in tests carried out under controlled environments. Such tests should prove valuable in making preliminary selections, but further selection for ecotypic differences may also be required.

Soils vary throughout the area, so soil analysis is an integral part of the program. Presently investigations are directed toward developing the most appropriate growing medium to support any particular assemblage of plants, sown or naturally occurring, in disturbed areas. Further information is essential to accomplish satisfactory establishment on "created" soils, followed by self-maintainence of an ecosystem. Other aspects, such as drainage properties, and availability of moisture, also vary from site to site. Such diversity of local environments further complicates plant selections. Species and ecotypes must be selected, not only for a general region, but also for specific sites within that region.

Reliable methods for handling and growing the material must be determined, and seed production programs should be established for selected species.

Careful analysis of conditions, and species selection to suit those conditions, are essential in land reclamation. A revegetation program can be considered successful only when the material used has established itself as a permanent, stable plant community.

# GLOSSARY

bisequa grey wooded soil -- grey wooded soils with a podzolic soil profile developing in the leached layer

clone -- a group of plants produced by vegetative reproduction from a single plant

ecosystem -- energy-driven complex of a community of organisms and its controlling environment

ecotype -- individuals of a species adapted to a particular environment

grey wooded soil -- soils with a leached topsoil and an accumulation of clay in the subsoil

habitat -- the place where an organism or community of organisms is found, that is the place one would go to look for an organism or community of organisms

muskeg -- a general term for areas with wet organic soils

naturalized -- an introduced species which is so well adapted to the environment of the area it was introduced to that it has become established and reproduces without further intervention by man

pH -- a measure of the acidity or alkalinity of a soil. A pH of 7 indicates a neutral soil - one that is neither acid nor alkaline; a pH greater than 7 indicates an alkaline soil while a pH less than 7 indicates an acid soil.

pioneer species -- plant species which are usually the first plants to colonize a bare area

plant community -- all of the plant species growing together in a given habitat - usually they are thought of as being interdependent. A general term referring to all similar stands of vegetation in an area. (see stand also)

podzols -- soils with an accumulation of organic matter and iron or aluminum in the subsoil and usually with an ashy grey topsoil that has been leached of most plant nutrients ppm -- parts per million, for soil nutrients. ppm x 2 roughly equals lbs/acre in the top six inches of soil

reclamation -- returning a disturbed site to a condition where the original organisms or similar organisms can inhabit the site

rehabilitation -- the land is returned to a stable ecological state according to a land use plan that does not contribute to further environmental deterioration

restoration -- the site conditions, including topography, will be returned to essentially the same state they were in prior to the disturbance

revegetation -- provision of a vegetative cover on a disturbed site

rhizomatus -- with a rhizome, that is, a horizontal underground stem which gives rise to new roots and shoots

species -- a convenient grouping of similar organisms (plants), usually freely interbreeding amongst themselves and not so with other groups of organisms

stand -- a concrete example of a plant community, refers to a group of plants in a specific geographic location (see plant community also)

tailing sand -- the residue of sand left after the oil has been extracted from the tar sand

weed -- a plant growing in an area where it is not wanted

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## APPENDIX

## SPECIES SELECTED FOR FURTHER STUDY

Species to be Studied With Regard to Management and Seed Production

| | |
|---|---|
| *Agropyron dasystachyum* | Northern Wheatgrass |
| *A. riparium* | Streambank Wheatgrass |
| *A. smithii* | Western Wheatgrass |
| *A. spicatum* | Bluebunch Wheatgrass |
| *A. subsecundum* | Bearded Wheatgrass |
| *A. trachycaulum* | Slender Wheatgrass |
| *Agrostis scabra* | Tickle Grass |
| *Arctagrostis arundinaceae* | Arctagrostis |
| *Astragalus agrestis* | Purple Milk Vetch |
| *A. americanus* | |
| *A. canadensis* | Canada Milk Vetch |
| *A. cicer* | Cicer Milk Vetch |
| *A. flexuosus* | Flexile Milk Vetch |
| *Bromus pumpellianus* | Northern Awnless Brome |
| *Calamagrostis canadensis* | Marsh Reed Grass |
| *C. inexpansa* | Northern Reed Grass |
| *Calamovilfa longifolia* | Sand Grass |
| *Deschampsia caespitosa* | Tufted Hair Grass |
| *Elymus canadensis* | Canada Wild Rye |
| *E. innovatus* | Hairy Wild Rye |
| *Festuca brachyphylla* | Alpine Fescue |
| *F. saximontana* | |
| *F. scabrella* | Rough Fescue |
| *Glyceria pulchella* | Manna Grass |
| *Hedysarum alpinum* | Alpine Hedysarum |

| | |
|---|---|
| *Hierochloe odorata* | Sweet Grass |
| *Koeleria cristata* | June Grass |
| *Lathyrus ochroleucus* | Pea Vine |
| *L. venosus* | Pea Vine |
| *Lupinus argenteus* | Silvery Lupine |
| *Medicago falcata* | Alfalfa |
| *Oxytropis sericea* | Early Yellow Loco-weed |
| *O. splendens* | Showy Loco-weed |
| *Phleum alpinum* | Alpine Timothy |
| *Pea alpina* | Alpine Bluegrass |
| *P. ampla* | Big Bluegrass |
| *P. compressa* | Canada Bluegrass |
| *P. interior* | Interior Bluegrass |
| *P. palustris* | Fowl Bluegrass |
| *Puccinellia airodes* | Nuttall Alkali Grass |
| *P. distans* | Weeping Alkali Grass |
| *T. medium* | Zig-zag Clover |
| *Vicia americana* | Wild Vetch |
| *V. cracca* | Bird Vetch |

Species to be Studied with Regard to Germination and Early Management

(Seed Production of these species will not be studied because they are naturally plentiful and easily collected from native stands)

| | |
|---|---|
| *Arctostaphylos rubra* | Alpine Bearberry |
| *A. uva-ursi* | Bearberry |
| *Elaeagnus Commutata* | Silverberry |
| *Prunus pensylvanica* | Pincherry |
| *Rosa acicularis* | Wild Rose |
| *R. Woodsii* | Wild Rose |
| *Symphoricarpos albus* | Snowberry |
| *Vaccinium myrtilloides* | Blueberry |
| *V. Vitis-idaea* | Bog Cranberry |