ESTABLISHMENT AND SURVIVAL OF GROUND COVER PLANTINGS ON DISTURBED AREAS IN ALBERTA

REPORT NO. 1

Revegetation Of Disturbed Sites Such As
Pipelines, Cutlines And Stripmining Areas

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DISTURBED AREAS REVEGETATION STUDIES

Report #1

Objectives:

To determine which native plant species might be useful in the revegetation of disturbed sites such as pipelines, cutlines and strip mining areas.

To make recommendations of which plants to include in further studies and to collect seed of these plants for future study.

Methods (Fort McMurray):

To get a general idea of the vegetation types and access possibilities, a preliminary survey was done from the air[1] and, to a limited extent, from the ground.

To determine which native species were likely to be important in revegetation of disturbed areas, the plant communities of cleared areas were compared to those of undisturbed areas nearby. This was done by randomly locating ten plots of one square metre each in the community being surveyed. The area covered at ground level by each plant species was then estimated and expressed as a percentage of one square metre. Plants covering less than one percent of the area were listed as present only. While the plots were being sampled those species seen in the area but not included in any of the plots were noted and given a frequency of zero. However, no attempt was made to produce a complete species list because the rare species are not likely to be important in revegetation projects.

At least one series of ten plots was located in each vegetation type, giving a minimum total of 20 plots for an area including a cleared and uncleared section.

1. A note of appreciation to Syncrude and Shell for providing the opportunity.

The vegetation types used in this study are basically the same as the habitat types given in Syncrude Canada Ltd.[2]. The ones used are the:

Pure aspen (Populus tremuloides) community
Jackpine (Pinus banksiana) community
Pure white spruce (Picea glauca) community
White spruce-aspen boreal mixed wood community
Black spruce (Picea mariana) treed muskeg community
Riverine community

The recent burn and old burn habitat types of Syncrude Canada Ltd. were not included as such in this study because they are composed of mosaics of several of the other communities having only recent fire disturbance in common. The fen muskeg habitat type was left out because it is unlikely that plants adapted to the wet organic soils of this community would be useful in the revegetation of strip mining sites or tailings deposits.

Results were then compared to determine which species increased in abundance on cleared sites. Species which occur in significant numbers in cleared areas and are present in uncleared areas (i.e. are not "weedy" species) are most likely to be useful in establishing ground cover in revegetation projects.

Methods (Pipelines throughout Alberta):

Pipeline sites were surveyed at randomly selected locations throughout the province. Only those areas which appeared to have been naturally revegetated were studied -- i.e. parts of a line running through alfalfa fields were not considered.

At each site, a series of ten plots of one square metre each was

2. Syncrude Canada Ltd. The Habitat of Syncrude Tar Sands Lease #17, Environmental Research Monograph 1973 - 1.

surveyed. As in Fort McMurray, all major species within the plots were given ground level cover ratings.

The approach differed in two respects from the previously described work. First, the placing of the plots was not random -- they were deliberately located directly on top of the line as well as both ways toward the uncleared area. If there were topographical variations, as many of these as possible were included.

The second difference was inlisting species present only. As well as those within the plot area rating less than 1% cover, those in the immediate vicinity were noted.

For analysis purposes, the field date was divided into six groups according to soil zone - brown, dark brown, thin black, black, degraded black and grey wooded. Species were selected for future studies on the basis of their potential for providing ground cover within each soil zone and, where possible, on different soil textures within each soil zone.

Results and Discussion (Fort McMurray):

One fact which became apparent from the initial surveys was that cutlines and other small areas used only during the winter presented no problems of revegetation so long as surface litter and topsoil were not removed during the clearing of trees and shrubs. Areas in cutlines which retained surface litter showed good regrowth while areas where the mineral soil was exposed had fewer plants. It is probable that small cleared areas with intact topsoil can be safely left to revegetate themselves.

However, pipelines, roadsides and clearings which have had litter and topsoil removed present a different problem. Since natural revegetation on such sites is too slow to prevent erosion, some type of seeding programme is required. In some areas, it would be possible to eliminate

the need for artificial revegetation by being careful not to disturb the topsoil and litter.

Areas presenting special problems include strip mines in general because large areas are involved and tar sand mines in particular due to the physical and chemical nature of the mine tailings.

In general, the diversity and density of herb and shrub strata increase when the tree canopy is removed. This is due to more light, less precipitation interception, and higher soil and air temperatures.

A clear example of this change is shown in a comparison of the cleared and uncleared sites in the white spruce forest.

The effective increase in lower strata may be diminished for several reasons. The original canopy may have been quite open and thus not have intercepted enough light or precipitation to make these factors limiting to the understory. An example of this is found in the pine forests on sand.

The soil under the pine forest was dry. This is a major controlling factor on understory development. There are relatively few shrubs and herbs in either cleared or uncleared sites. Arctostaphylos uva-ursi (Bearberry) was the only species which appeared to increase significantly when trees were removed (Table 1).

In an area where all topsoil and litter was removed, colonization of the bare sand was slow. Weedy species were present.

The pine-aspen forest was in a moister location. This is reflected in the composition of the understory which includes such drought intolerant species as Equisetum sylvaticum (Woodland Horsetail), Ledum groenlandicum (Labrador Tea) and Cornus canadensis (Bunchberry) (Table 1).

Since Arcostaphylos uva-ursi was the only species which increased

with clearing, several others which tolerated clearing were selected.

These include Vaccinium myrtilloides, (Blueberry), Oryzopsis pungens (Rice Grass), and V. vitis-idea (Bog Cranberry, Cow-Berry). Several species not present at high levels were included in the list of recommended species since they are able to colonize bare sand. They include Potentilla tridentata (Three-toothed Cinquefoil), Elymus innovatus (Hairy Wild Rye) and Rosa spp. (Wild Rose includes R. acicularis and R. woodsii).

Three types of boreal forest communities growing on glacial till were studied. These included a mature pure aspen stand, a white spruce-aspen boreal mixedwood stand and a pure white spruce stand. The tills ranged in texture from clayloam to sandy loam and none of the three communities was restricted to any one texture of till.

In the pure aspen community (Table 2) ground cover and species diversity increased with clearing. The species which increased with clearing included Fragaria virginiana (Wild Strawberry), Achillea millefolium (common Yarrow), Galium boreale (Northern Bedstraw), Equisetum arvense (Field Horsetail), and Vicia americana (Wild Vetch). Species which were present in large numbers but which did not change much with clearing included Elymus innovatus, Cornus canadensis, Rosa spp. and Rubus pubescens (Dewberry).

The increase in species diversity with clearing is even more noticeable in the spruce-aspen mixedwoods, where there were almost twice as many species in the cleared area as in the uncleared area (Table 3). In this particular site the only large increase in ground cover was by Populus tremuloides seedlings. Species which showed little change in ground cover include Elymus innovatus, Ledum groenlandicum, Vaccinium vitis-idea and Epilobium angustifolium (Fireweed).

The large number of species present in the pure white spruce stand which were not present in the cleared area (Table 4) shows how much the dense spruce canopy affects the ground cover. Ground cover under the mature spruce stand is dominated by feather mosses, with only a few scattered herbs and low shrubs. Once the tree cover is removed, increased light, higher temperatures, and a decrease in the acidity of the soil facilitates the development of a more complex herb and shrub strata. Epilobium angustifolium, Petasites palmatus (Palmate-leaved Coltsfoot), Rubus strigosus (Wild Raspberry), Fragaria virginiana and Agrostis scabra (Hair grass) are the species which increased after clearing the white spruce stand.

In the treed muskeg stands (Table 5), which occur on organic soils, the two species showing major increases with clearing were Betula sp. (Birch) and Salix sp. (Willow). Equisetum arvense was the only herb which increased in cover.

The stand of the Riverine community sampled (Table 7) was on the alluvial soil in the Athabasca River valley. Calamagrostis canadensis (Marsh Reed Grass), Poa sp. (Bluegrass), Melilotus sp. (sweet clover) and Rosa sp. all increased with clearing of this community. Rubus strigosus was about equally prominent in both the cleared and uncleared stands.

Table 6 lists the data for three stands in a recent burn. Judging from the age of the trees this burn occurred 12 - 18 years ago. These stands were included to get some idea of the important ground cover species after a natural disturbance such as fire. The major ground cover species in the black spruce-willow-birch stand were Calamagrostis canadensis, Salix sp., and Petasites sagittatus (Arrow-leaved Coltsfoot). Mosses, a dwarf creeping Salix sp., Arctostaphylos rubra (Alpine Bearberry), and young spruce trees were the major ground cover species in the spruce-

balsam poplar stand on the organic soil. The third stand, also a spruce-balsam poplar stand, was on a clay-loam till. The major ground cover species were Sheperdia canadensis (Buffalo-berry), Linnaea borealis (Twin Flower), the dwarf-creeping Salix sp., and Aster spp.

In a clearing in the white spruce-aspen mixedwoods south of Gregoire Lake, Lathyrus venosus (Pea Vine), Populus tremuloides and Equisetum arvense were the main increasers. The lack of plants growing in the clearing is apparently due to the almost complete removal of litter and topsoil and the lack of time for plants to colonize the subsoil. This is indicated by the fact that most of the plants in the clearing were growing on small patches of remaining topsoil with only a few scattered plants on the exposed mineral soil.

Three series of 10 plots were done in a test site used by Amoco from 1958 to 1962. This site was on the north facing slopes of the hills south of Gregoire Lake. The three series of plots were done in the upper, middle and lower thirds of the test site (Table 9). The soil in upper and middle thirds was a sandy loam, while in the lower third it was a shallow organic soil. The major species providing ground cover in the upper two thirds of the clearing were Poa pratensis (Kentucky Bluegrass), Poa palustris (Fowl Bluegrass), Agropyron trachycaulum (Slender Wheat Grass), Calamagrostis canadensis, Epilobium angustifolium, Trifolium hybridum (Alsike clover) and Melilotus sp.. In the lower third of the clearing ground cover was provided mainly by mosses, Equisetum arvense and Trifolium hybridum.

The species selected for future study are given in the following list:

Vaccinium myrtilloides
V. vitis-idea
Arctostaphylos uva-ursi
*A. rubra
*Oryzopsis pungens
*Potentilla tridentata

*Rosa spp.
*Elymus innovatus
Vicia americana
Agrostis scabra
*Amelanchier alnifolia (Saskatoon-berry)
*Cornus stolonifera (Red Osier, Dogwood)
Agropyron trachycaulum
Poa pratensis
*Festuca (native ovina type) (Fescue)
*Symphoricarpos occidentalis (Buckbrush)
*S. albus (Snowberry)

* Indicates species included for study because they formed good stands in areas not studied in detail or because they were found to be able to grow in bare sand exposed in borrow pits and other areas where the vegetation had been removed from the sand.

Several species were not considered for future studies because of seed handling difficulties. Examples are Calamagrostis spp., Equisetum spp., Fragaria virginiana, Epilobium angustifolium, and Rubus strigosus.

Results and Discussion - Pipelines

The seeding of pipeline right-of-way to assist revegetation is important not only to control erosion but also to keep them from acting as weed seed reservoirs. A community composed of several species is more stable and therefore better able to control erosion and weeds than a community composed of one or two species. Thus seed mixtures used on pipeline rights-of-way should consist of a relatively large number of native and naturalized species.

In order to identifiy those species most suitable for use in the various soil zones, a survey of pipeline right-of-way vegetation was conducted throught the province. Those species which form a good ground cover and are not classified as weeds are most likely to be useful for revegetating new pipeline rights-of-way.

Tables 10 to 15 include only those species likely to be useful in revegetation projects. Most weeds and minor native species have been left out in order to simplify the tables.

In the grey wooded soil zone (see the Soil Group Map of Alberta for location of soil zones) clay loam and loam were the main soil textures encountered. The difference in vegetation between the two soil types was not enough to require separating them in the discussion. The most important introduced species were Trifolium hybridum, Phleum pratense (Timothy), Festuca rubra (Creeping Red Fescue), Trifolium pratense (Red Clover), and to a lesser extent Bromus inermis (Smooth Brome). Poa spp. (Bluegrass. Mainly Poa pratensis - Kentucky Bluegrass - but including undetermined amounts of other Poa spp.), Vicia americana, Rosa spp. and Agropyron trachycaulum are the most important native species on pipeline rights-of-way in the grey wooded soil zone.

In the degraded black soil zone (Dark Grey and Dark Grey Wooded soils on map) the soil texture of the plots studied falls into two groups: clay loam and loam. Important introduced species include Bromus inermis, Trifolium pratense, T. hybridum and Phleum pratense. Important native species are Poa spp. and Vicia americana. Trifolium repens and Vicia americana occur more often on clay loam soils while the Poa spp. are more common on loam soils. (Table 11)

The major introduced species found on pipeline rights-of-way in the black soil zone are Phleum pratese, Bromus inermis and Festuca rubra. Natives include Poa spp., Festuca idahoensis (Bluebunch Fescue, Idaho Fescue), Rosa spp., Danthonia parryi (Parry's Oat Grass), and Vicia americana. Poa spp., Phleum pratense and Vicia americana occured more commonly on clayey soils while Festuca idahoensis, F. rubra and Danthonia parryi were more common on sandy soils. (Table 12)

The thin black soil zone forms the southern and eastern half of the black soil zone as shown on the map. Except for the apparent exclusion of Vicia americana from the sandy loam soils, table 13 does not show any great difference between the sandy loam and clay loam soils. The important native species are Poa spp., Agropyron spp. (Wheat Grasses), Elaeagnus commutata (Silver Willow, Wolf Willow), Koeleria cristata (June Grass), Rosa spp., and Vicia americana. The most important introduced species are Bromus inermis and Phleum pratense.

South and east of the thin black soil zone lies the dark brown soil zone. Within this zone Bromus inermis is the only important introduced species. Koeleria cristata, Symphoricarpos occidentalis (Buckbrush), Agropyron spp. and Rosa spp. are the important native species. The Agropyron spp. tend to occur on the loam soils more than the sandy loam soils. However, in this sample there is little difference between the two soil types. (Table 14)

Within the brown soil zone the most important native plants are Stipa spp. including S. comata (Needle and Thread, Spear Grass), S. spartea var curtiseta (Western Porcupine Grass), and S. viridula (Green Needle Grass); Bouteloua gracilis (Blue Grama Grass); and Agropyron spp. including A. trachycaulum, A. smithii (Western Wheat Grass), and A. subsecundum (Bearded Wheat Grass). The only introduced species of much importance was A. cristatum (Crested Wheat Grass). (Table 15).

By comparing the lists of species for each soil zone one can see that different combinations of species will be needed for use in the different soil zones. The following list of species is recommended for future study. The soil zones in which each species is expected to be useful are indicated by the following code.

Grey wooded soil zone	GW
Degraded black soil zone	DBl
Black soil zone	Bl
Thin Black soil zone	TBl
Dark Brown soil zone	DBr
Brown soil zone	Br
Arctostaphylos rubra	GW
A. uva-ursi	GW DBl Bl
Vaccinium vitis-idaea	GW DBl
V. myrtilloides	GW DBl Bl
Viburnum edule	GW DBl
Rosa acicularis	GW DBl Bl TBl DBr Br
Ledum groenlandicum	GW
Cornus stolonifera	GW DBl
Amelanchier alnifolia	GW DBl Bl TBl DBr Br
Symphoricarpos occidentalis	GW DBl
S. albus	GW DBl Bl TBl
Potentilla fruticosa	GW DBl Bl TBl
Elaeagnus commutata	Bl TBl DBr
Corylus cornuta	GW DBl Bl TBl
Lonicera involucrata	GW DBl Bl
Prunus virginiana	GW Bl TBl DBr
Vicia americana	GW DBl Bl TBl
V. cracca	GW DBl Bl TBl
Lupinus argenteus	GW DBl
Lathyrus ochroleucus	GW DBl Bl TBl
Trifolium medium	GW DBl
Medicago falcata	GW DBl
M. sativa	GW DBl Bl TBl
Oxytropis sericea	DBl Bl TBl DBr Br
O. splendens	TBl DBr Br
Astragalus canadensis	GW DBl Bl TBl
Hedysarum alpinum	GW DBl Bl TBl
Agropyron trachycaulum	GW DBl Bl TBl DBr Br
A. smithii	GW DBl Bl DBr Br
Agrostis borealis	GW
A. gigantea	GW DBl Bl
A. scabra	GW

Bromus pumpellianus	GW DBl
Deschampsia caespitosa	GW DBl Bl TBl DBr Br
Elymus innovatus	GW DBl Bl
Festuca brachyphylla	GW
F. ovina	GW DBl
F. scabrella	DBl Bl TBl DBr
Glyceria pulchella	GW DBl
Hierochloe odorata	GW DBl Bl TBl
Koeleria cristata	TBl DBr BR
Oryzopsis pungens	GW DBl Bl
O. hymenoides	GW DBr Br
Phleum alpinum	GW DBl Bl TBl
Poa alpina	Foothills & Mtns.
Poa compressa	GW DBl
Poa palustris	GW DBl
Poa ampla	GW DBr Br
Poa pratensis	GW DBl Bl TBl DBr Br
Puccinellia distans	GW DBl Bl TBl DBr Br

This list does not include naturalized species such as Agropyron cristatum or Trifolium hybridum because the information on seed handling, seeding, disease resistance and usefulness within the various soil zones is readily available.

Recommended Study Areas:

1. Production of seed
2. Storage and preparation of the seed for planting
3. Seed bed preparation and seeding methods
4. Early maintenance of the plantings
5. Disease resistance

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TABLE 1

Vegetation on Sands - Athabasca Tar Sands Area

Species	Dry Sand						Moist Sand			
	uncleared		cleared		cleared to bare sand		uncleared		cleared	
	20 plots		10 plots		10 plots		10 plots		10 plots	
	Cover	Freq	Cover	Freq	Cover	Freq	Cover	Freq	Cover	Freq
Lycopodium	0.7[1]	3.5[2]								
Amelanchier alnifolia	P	2.5								
Actea rubra	P	1								
Pyrola sp.	P	0.5								
Cerastium sp.	P	0.5								
Alnus sp.	P	0								
Geocaulon lividum	P	0								
Lilium philadelphicum	P	0								
Selaginella densa			P	0						
Paronychia sessilifolora			P	0						
Anemone multifida	P	1			P	1				
Galium boreale	P	0.5			P	0				
Commandra pallida	P	9	P	3	P	0				
Solidago gigantea	P	2.5	P	0	P	2				
Prunus pensylvanica	P	0	P	2	P	1				
Apocynum androsaemifolium	P	1.5	P	2	0.1	2				
Potentilla tridentata	P	2			P	0	P	3	P	2
Cladonia sp.	15.6	10	10	6			P	6		
Solanum nigrum			P	0	P	1				
Rubus strigosus			P	0	P	0				
Agrostis scabra			0.1	1	P	0				
Peltigera	P	2					P	6		
Linnaea borealis	P	3					0.3	1		
Smilacina trifolia	0.6	10	P	7			P	1	0.5	3
Melampyrum lineare	P	1	P	1			P	6	P	2
Arctostaphylos uva-ursi	3.8	10	7.3	9	0.2	1	0.4	3		
Pinus banksiana	P	0	P	0	P	0	P	0		
Oryzopsis pungens	P	7	0.2	6	0.1	3	P	1	P	0

1 Cover values are given in percent and are the mean cover for each species in all plots studied within each vegetation unit.

2 Frequency is given as the number of occurences per 10 plots.

TABLE 1 Continued

Species	Dry Sand						Moist Sand			
	uncleared		cleared		cleared to bare sand		uncleared		cleared	
	20 plots		10 plots		10 plots		10 plots		10 plots	
	Cover	Freq	Cover	Freq	Cover	Freq	Cover	Freq	Cover	Freq
Epilobium angustifolium	P	1	P	0	P	0	P	2	P	4
Populus tremuloides	P	1	P	2	P	1	P	7	0.5	8
Campanula rotundifolia	P	1.5	P	2	P	0	P	2	P	0
Vaccinium myrtilloides	1.7	8	0.4	8	0.4	6	1.1	9	0.8	7
V. vitis-idea	1.1	5.5	P	5	0.1	1	2.3	9	0.3	4
Corydalis aurea					P	0				
Chenopodium alba					P	1				
C. capitatum					P	0				
Aster sp.	P	0.5					P	4	P	2
Fragaria virginiana			P	1			P	2	P	0
Rosa sp.					P	1	P	1	P	1
Geranium sp.					P	1			P	1
Picea glauca							P	0		
Calamagrostis inexpansa							P	1		
Agropyron sp.							P	1		
Solidago sp.							P	1		
Populus balsamifera							P	4		
Potentilla fruiticosa							P	1	P	0
Elymus innovatus							P	4	0.3	2
Achillea millefolium							P	3	P	0
Betula sp.							P	1	P	1
Cornus canadensis							0.6	9	0.2	5
Equisetum arvense							P	5	P	3
Ledum groenlandicum							0.1	3	P	3
Equisetum sylvaticum							P	1	P	2
Sheperdia canadensis									0.1	1
Salix sp.									P	3
Potentilla rivalis									P	0
Petasites palmatus									P	1

TABLE 2

Mature Aspen Community - Athabasca Tar Sands Area

Species	uncleared 10 plots		cleared 10 plots	
	Cover	Freq.	Cover	Freq.
Rubus pubescens	0.1	6	0.8	9
Rosa sp.	0.3	9	0.4	10
Fragaria virginiana	P	3	0.6	7
Cornus canadensis	0.1	5	0.6	6
Achillea millefolium	P	3	0.1	8
Galium boreale	P	3	0.2	7
Elymus innovatus	0.2	5	0.5	6
Populus tremuloides	0.2	4	0.1	7
Linnaea borealis	0.3	5	0.2	3
Aster	P	5	P	9
Equisetum palustre	P	1	P	6
Lathyrus ochroleucus	P	1	P	3
Smilacina trifolia	P	4	P	3
Pyrola sp.	P	2	P	3
Amelanchier alnifolia	P	1	P	2
Epilobium angustifolium	P	1	P	1
Lathyrus venosus	P	1	P	1
Alnus crispa	P	1	P	1
Sheperdia canadensis	P	3	P	1
Actea rubra	P	4	P	1
Petasites palmatus	P	2	P	1
Mertensia paniculata	P	1	P	0
Viburnum edule	P	5	P	0
Viola sp.	P	3		
Picea sp.	P	2		
Peltigera sp.	P	1		
Calamagrostis neglecta	P	1		
Mosses	P	1		
Equisetum arvense			P	6
Vicia americana			P	5
Salix sp.			P	2

TABLE 2 Continued

Species	uncleared 10 plots		cleared 10 plots	
	Cover	Freq.	Cover	Freq.
Solidago sp.			P	2
Populus balsamifera			P	1
Rubus strigosus			P	1
Agropyron dasystachum			P	1
Galium aparine			P	1
Moneses uniflora			P	1
Geranium bicknellii			P	1
Potentilla norvegica			P	1
Cornus stolonifera			P	1
Bromus ciliatus			P	1
Calamagrostis canadensis			P	0

TABLE 3

Spruce - Aspen Mixedwoods - Athabasca Tar Sands Area

Species	Uncleared 10 plots		Cleared 20 Plots	
	Cover	Freq.	Cover	Freq.
Elymus innovatus	2.2	4	2.5	6.5
Ledum groenlandicum	1.4	6	1.0	4
Linnaea borealis	0.2	6	0.1	2.5
Cornus canadensis	0.1	7	0.3	4.5
Equisetum arvense	0.6	4	1.0	3
Vaccinium vitis-idea	0.2	4	P	3.5
V. myrtilloides	0.9	3	0.5	2
Salix sp.	0.2	3	0.5	1.5
Mosses	13.5	3	P	2
Epilobium angustifolium	P	7	1.0	7.5
Lathyrus venosus	P	4	P	2
Fragaria virginiana	P	2	0.2	2
Cladonia sp.	P	2	P	2.5
Sheperdia canadensis	P	1	P	1
Galium boreale	P	1	P	1.5
Viburnum edule	P	1	P	0.5
Symphoricarpos sp.	P	1	P	2.5
Picea sp.	P	1	P	1
Mertensia paniculata	P	1	P	1
Thalictrum venulosum	P	1	P	0.5
Achillea millefolium	P	1	P	2
Potentilla fruiticosa	P	1	0.5	2
Rosa sp.	P	7	P	1.5
Populus tremuloides	P	1	0.1	6.5
Petasites palmatus	P	2	0.1	3.5
P. sagittatus	P	1		
Peltigera apthosa	P	2		
P. canina	P	1		
Betula papyrifera	P	1		
Aster sp.	P	1		
Goecaulon lividum	P	1		
Arcostaphylos uva-ursi	P	1	P	0.5
Solidago sp.			0.5	1

TABLE 3 - continued

Species	Uncleared 10 plots Cover	Uncleared 10 plots Freq.	Cleared 20 plots Cover	Cleared 20 plots Freq.
Calamagrostis canadensis			0.5	0.5
Betula gladulosa			0.2	0.5
Oryzopsis pungens			0.5	0.5
Lilium philadelphicum			P	1
Juncus sp.			P	1
Poa sp.			P	1
Rubus acaulis			P	0.5
Kalmia polifolia			P	0.5
Scirpus sp.			P	0.5
Actea rubra			P	0.5
Lathyrus ochroleucus			P	0.5
Vicia americana			P	3
Geum allepicum			P	0.5
Calamagrostis inexpansa			P	0.5
Geranium bicknelli			0.5	1.5
Galeopsis tetrahit			P	1.5
Potentilla norvegica			P	0.5
Gentiana sp.			P	0.5
Parnassia palustris			P	0
Senecio sp.			P	0
Luzula multiflora			P	0
Aquelegia brevistyla			P	0
Cerastium arvense			P	0
Populus balsamifera			P	0
Salix sp.			P	0

TABLE 4

Mature White Spruce Community - Athabasca Tar Sands Area

Species	uncleared 10 plots		cleared 10 plots	
	Cover	Freq.	Cover	Freq.
Equisetum pratense	P	2	1.3	5
E. palustre	P	2	0.6	5
E. arvense	0.9	9	0.6	4
Rosa sp.	P	3	0.2	3
Epilobium angustifolium	P	1	P	8
Petasites palmatus	P	1	P	6
Elymus innovatus	P	1	P	3
Salix sp.	P	0	P	2
Ranunculus sp.	P	1	P	2
Picea sp.	0.1	5	P	2
Cornus canadensis	0.2	3	P	2
Rubus acaulis	P	2	P	1
Calamagrostis canadensis	0.1	2	P	1
Populus tremuloides	P	2	P	1
Ribes oxyacanthoides	P	0	P	0
Mosses	70.5	9		
Vaccinium vitis-idea	0.4	5		
Geocaulon lividum	0.1	1		
Smilacina sp.	P	3		
Pyrola sp.	P	3		
Peltigera sp.	P	3		
Linnaea borealis	P	2		
Ledum groenlandicum	P	1		
Petasites sagittatus	P	1		
Equisetum scirpoides	P	1		
Larix laricina	P	0		
Bromus (ciliatus?)	P	0		
Monesis uniflora	P	0		
Viburnum trilobum	P	0		
Betula sp.	P	0		
Rubus strigosus			0.7	5

TABLE 4 Continued

Species	uncleared 10 plots		cleared 10 plots	
	Cover	Freq.	Cover	Freq.
Fragaria virginiana			0.2	5
Alopecurus aequilis			0.5	2
Aster conspicuus			0.2	3
Gentiana sp.			0.2	1
Alnus sp.			0.1	1
Mertensia paniculata			0.5	3
Agrostis scabra			P	4
Vicia americana			P	3
Achillea millefolium			P	3
Potentilla norvegica			P	3
Aster sp.			P	3
Lathyrus venosus			P	2
Mitella nuda			P	2
Geranium bicknellii			P	2
Thalictrum venulosum			P	2
Cornus stolonifera			P	2
Galium boreale			P	2
Calamagrostis sp.			P	1
Poa sp.			P	1
Taraxacum sp.			P	1
Populus balsamifera			P	1
Rubus pubescens			P	1
Agropyron subsecundum			P	1

TABLE 5

Black Spruce (Treed Muskeg) Community -
Athabasca Tar Sands Area

Species	uncleared 30 plots		cleared 30 plots	
	Cover	Freq.	Cover	Freq.
Mosses	40.	9.6	5.8	6.3
Cladonia sp.	1.5	5	1.2	1
Equisetum arvense	0.6	5	1.6	9.6
Betula sp.	0.9	1.6	0.1	3.3
Deschampsia caespitosa	0.2	1.3	0.1	1.3
Salix sp.	0.3	1.6	0.1	3.3
Salix sp. (dwarf creeping)	P	0.3	0.8	1.6
Smilacina sp.	0.1	2.3	0.1	3
Ledum groenlandicum	0.6	7.6	0.2	5
Vaccinium vitis-idea	0.1	8	0.5	4.3
Oxycoccus sp.	0.1	3.6	P	1.6
Picea sp.	0.1	7	P	1.6
Arctostaphylos rubra	0.6	0.6	0.3	0.6
Potentilla fruiticosa	0.2	1	P	0.6
Agropyron sp.	0.2	0.3	P	1
Fragaria virginiana	0.1	0.6	P	0.3
Rubus acaulis	P	1.6	P	2.6
Achillea millefolium	P	3	P	1.6
Peltigera apthosa	P	2	P	0.6
P. canina	P	0.3	P	0.3
Parnassia sp.	P	0.6	P	1
Larix laricina	P	1	P	0.6
Equisetum palustre	P	2.6	0.1	3
Epilobium angustifolium	P	2	P	0.3
Equisetum scirpoides	P	0.3	P	0.6
Aster sp.	P	0.6	P	1.3
Populus tremuloides	P	0.6	P	0.3
Symphoricarpos occidentalis	P	0.6	0.1	1.6
Galium boreale	P	0.6	P	1.3
Calamagrostis inexpansa	P	0.3	P	1
Juncus balticus	P	0	0.1	1
Arctostaphylos uva-ursi	P	0	P	0.3

TABLE 5 Continued

Species	uncleared 30 plots		cleared 30 plots	
	Cover	Freq.	Cover	Freq.
Linnaea borealis	P	0.6		
Melampyrum lineare	P	0.6		
Viburnum trilobum	P	0.3		
Pyrola sp.	P	0.3		
Petasites palmatus	P	1.3		
Equisetum sylvaticum	P	0.6		
Rosa sp.	P	0.6		
Vaccinium myrtilloides	P	0.6		
Petasites vitifolius	P	0.3		
Luzula sp.	P	0.3		
Calamagrostis canadensis	P	0.3		
Lathyrus ochroleucus	P	0.3		
Lilium philadelphicum	P	0.3		
Geocaulon lividum	P	0		
Vicia americana	P	0		
Eriophorum sp.	P	0		
Rubus chamaemorus	P	1		
Petasites sagittatus			0.1	2
Spiranthes romanzoffiana			P	0.6
Elymus innovatus			P	0.6
Urtica gracilis			P	0.6
Actea rubra			P	0.3
Stellaria sp.			P	0.6
Poa sp.			P	0.6
Epilobium glandulosum			P	0
Caltha palustris			P	0

TABLE 6

15 - 20 Year Old Burn - Athabasca Tar Sands Area

Species	Black Spruce Willow Birch 10 plots		Spruce Balsam Poplar[1] 10 plots		Spruce Balsam Poplar[2] 10 plots	
	Cover	Freq.	Cover	Freq.	Cover	Freq.
Petasites sagittatus	0.5	6				
Caltha palustris	0.3	3				
Ribes oxyacanthoides	P	5				
Liliaceae	P	5				
Rubus pubescens	P	4				
Potentilla palustris	P	3				
Cornus stolonifera	P	1				
Liverworts	P	1				
Betula glandulosa	P	0				
B. occidentalis	P	0				
Rubus acaulis	P	1	P	2		
Calamagrostis canadensis	3.1	9			P	1
Viburnum edule	P	2			P	1
Salix sp.	0.5	6	0.1	2	P	4
Galium boreale	P	6	P	4	P	5
Rosa sp.	P	6	P	7	P	5
Epilobium angustifolium	P	4	P	5	P	7
Mosses	P	1	15.0	10	P	1
Arctostaphylos rubra			2.5	5		
Symphoricarpos occidentalis			P	3		
Equisetum pratense			P	3		
Ranunculus sp.			P	2		
Vaccinium vitis-idea			P	2		
Parnasia palustris			P	1		
Salix (dwarf)			2.4	6	0.4	5
Picea sp.			0.5	9	P	8
Linnaea borealis			0.4	5	0.7	6
Equisetum arvense			0.3	5	P	1
Sheperdia canadensis			0.2	3	0.7	8
Petasites palmatus			P	9	P	8
Achillea millefolium			P	9	P	4
Aster sp.			P	7	0.1	9

TABLE 6 Continued

Species	Black Spruce Willow Birch 10 plots		Spruce Balsam Poplar 10 plots		Spruce Balsam Poplar 10 plots	
	Cover	Freq.	Cover	Freq.	Cover	Freq.
Vaccinium myrtilloides			P	4	P	2
Ledum groenlandicum			P	3	0.1	3
Peltigera apthosa			P	2	0.5	4
Fragaria virginiana			P	2	P	8
Populus balsamifera			P	1	P	3
Elymus sp.			P	1	0.1	1
Vicia americana			P	1	P	2
Lilium philadelphicum			P	1	P	2
Equisetum scirpoides			P	1	P	2
Cornus canadensis			P	0	P	8
Habenaria sp.			P	0	P	1
Potentilla fruticosa			P	0	0.1	2
Arctostaphylos uva-ursi					1.0	2
Cladonia sp.					P	3
Castilleja raupii					P	3
Lathyrus venosus					P	2
Peltigera canina					P	1
Populus tremuloides					P	1
Smilacina sp.					P	1
Alnus sp.					P	1
Solidago sp.					P	0

1. This stand was on an organic soil.

2. This stand was on a sandy loam glacial till.

TABLE 7

Spruce-Aspen Mixed Wood on Alluvial Soil (Riverine Community)

Athabasca Tar Sands Area

Species	Uncleared 20 Plots		Cleared 10 Plots	
	Cover	Freq.	Cover	Freq.
Equisetum pratense	6.5	10	1.8	9
Cornus stolonifera	0.3	6	P	2
Rubus strigosus	0.5	8.5	P	9
Cornus canadensis	0.1	1	0.4	2
Populus balsamifera	0.5	2	P	2
Vicia americana	P	1.5	P	1
Rosa sp.	P	1	0.1	6
Galium boreale	P	1	P	1
Mentha arvensis	P	0.5	P	1
Viburnum edule	0.1	2		
V. trilobum	0.1	2.5		
Mertensia paniculata	P	3.5		
Actea rubra	P	1		
Calamagrostis inexpansa	P	0.5		
Picea sp.	P	0		
Ribes oxyacanthoides	P	0.5		
Erigeron philadelphicus	P	0.5		
Galium aparine	P	0.5		
Mosses	P	0.5	P	1
Calamagrostis canadensis	P	1.0	6.3	10
Poa sp.			0.4	4
Solidago sp.			0.1	3
Melilotus sp.			P	4
Sonchus sp.			P	3
Anemone canadensis			P	3
Matricaria matricariodies			P	2
Erigeron sp.			P	2

TABLE 7 - continued

Species	Uncleared 20 Plots Cover	Uncleared 20 Plots Freq.	Cleared 10 Plots Cover	Cleared 10 Plots Freq.
Equisetum arvense			P	1
Chenopodium album			P	1
Taraxacum sp.			P	2
Epilobium angustifolium			P	1
Plantago major			P	1
Achillea millefolium			P	1
Aster sp.			P	1
Rubus chamaemorus			P	1
Stachys palustris			P	1
Impatiens sp.			P	0
Achillea sibirica			P	0
Lepidium sp.			P	0
Capsella bursa-pastoris			P	0
Erigeron canadensis			P	0

TABLE 8

Spruce Aspen Mixedwoods on North Facing Slope South of Gregoire Lake - Athabasca Tar Sands Area

Species	uncleared 10 plots		cleared 10 plots	
	Cover	Freq.	Cover	Freq.
Cornus canadensis	0.2	9	0.1	6
Ranunculus sp.	0.1	4	P	1
Populus tremuloides	0.2	2	P	6
Viburnum sp.	P	5	P	3
Calamagrostis inexpansa	P	5	P	1
Equisetum palustre	P	5	P	2
Aster sp.	P	5	P	1
Petasites palmatus	P	4	P	1
Actea rubra	P	3	P	2
Lathyrus venosus	P	2	P	6
Rosa sp.	P	1	P	2
Equisetum pratense	P	1	P	1
Lycopodium complanatum	0.2	4		
Lonicera sp.	0.1	1		
Mosses	1.0	2		
Linnaea borealis	P	6		
Rubus pubescens	P	5		
Viola sp.	P	4		
Epilobium angustifolium	P	4		
Smilacina trifolia	P	3		
Habenaria orbiculata	P	2		
Polypodium vulgare	P	2		
Lathyrus ochroleucus	P	2		
Betula occidentalis	P	1		
Galium triflorum	P	1		
Pyrola secunda	P	1		
Mertensia paniculata	P	1		
Trientalis borealis	P	1		
Pyrola virens	P	1		
Lycopodium annotinum	P	0		
Picea sp.	P	0		
Alnus crispa	P	0		
Betula papyrifera	P	0		
Equisetum arvense			P	4
Rubus strigosus			P	3
Geranium sp.			P	3

TABLE 9

Vegetation In Old Amoco Test Site South of Gregoire Lake

Athabasca Tar Sands Area

Species	Upper 1/3 of clearing 10 plots		Middle 1/3 of clearing 10 plots		Lower 1/3 of clearing 10 plots	
	Cover	Freq.	Cover	Freq.	Cover	Freq.
Plantago major	P	3				
Calamagrostis canadensis	2.2	7	1.1	3		
Poa sp.	2.1	6	5.6	7		
Agropyron trachycaulum	0.2	4	0.7	5		
Crepis sp.	P	5	P	2		
Hordeum jubatum	P	2	P	2		
Populus tremuloides	P	0	P	1		
Trifolium hybridum	1.3	9	P	9	0.4	7
Fragaria virginiana	0.1	3	P	3	P	6
Melilotus sp.	0.8	6	P	2	0.5	2
Epilobium angustifolium	P	10	0.2	8	P	3
Achillea millefolium	P	9	P	5	P	8
Taraxacum sp.	P	5	P	5	P	2
Aster sp.	P	5	P	5	P	3
Equisetum arvense	P	1	0.1	2	0.4	10
Mosses	2.5	3			3.5	7
Populus balsamifera	P	0			P	7
Phleum pratense			0.1	2		
Elymus innovatus			P	3		
Prunus sp.			P	1		
Equisetum pratense			P	1		
Solidago sp.			P	1		
Vicia americana			P	1		
Cornus canadensis			P	1		
Rubus strigosus			P	0		
Salix sp.			P	0		
Betula sp.			P	0	P	1
Alnus crispa			P	0	0.5	1
Achillea sibirica					P	3
Parnassia palustris					P	2
Sonchus sp.					P	2
Picea glauca					P	1
Lathyrus venosus					P	1

TABLE 10

Pipeline Vegetation Grey Wooded Soil Zone

Species	Clay Loam 76 plots	Clay Loam x 2/3[1]	Silty Loam 54 plots
Trifolium hybridum	18 - 23[2]	12 - 15	16 - 15
Phleum pratense	15 - 26	10 - 18	10 - 26
Poa spp.	8 - 32	6 - 22	5 - 27
Trifolium pratense	10 - 22	6 - 14	5 - 14
Festuca rubra	4 - 6	3 - 4	11 - 9
Trifolium repens	3 - 6	2 - 4	6 - 0
Agropyron trachycaulum	2 - 19	2 - 12	5 - 8
Medicago sativa	2 - 5	2 - 4	5 - 4
Vicia americana	6 - 32	4 - 22	0 - 22
Bromus inermis	4 - 22	3 - 14	1 - 6
Agropyron dasystachum	4 - 4	3 - 3	1 - 3
Rosa spp.	1 - 31	1 - 20	3 - 14
Arctostophylos uva-ursi	1 - 5	1 - 4	2 - 6
Agropyron repens	1 - 1	1 - 1	1 - 0
Melilotus alba	1 - 5	1 - 4	0 - 2
Dactylis glomerata	0 - 0	0 - 0	1 - 4
Elymus innovatus	1 - 3	1 - 2	0 - 0
Agrostis scabra	1 - 1	1 - 1	0 - 0
Glyceria grandis	1 - 0	1 - 0	0 - 1
Trisetum spicatum	1 - 0	1 - 0	0 - 0
Lathyrus ochroleucus	0 - 13	0 - 8	0 - 5
Agropyron cristatum	0 - 2	0 - 2	0 - 3
Bromus ciliatus	0 - 4	0 - 3	0 - 1
Bromus pumpellianus	0 - 2	0 - 2	0 - 0
Agropyron latiglume	0 - 0	0 - 0	0 - 1

1. A conversion factor used so direct comparison can be made between the two soil types.

2 The first number indicates the number of plots in which the species had more than 1% ground cover. The second number shows the number of plots in which the species was listed as being present. The total number of occurrences is found by adding the two numbers. This also applies to tables 11 - 15.

TABLE 11

Pipeline Vegetation Degraded Black Soil Zone

Species	Clay Loam 29 Plots	Loam 36 Plots
Poa spp.	9-5	14-11
Trifolium hybridum	7-8	7-8
Bromus inermis	10-5	3-12
Phleum pratense	2-15	7-9
Trifolium pratense	8-10	0-4
T. repens	3-2	5-3
Agropyron repens	1-6	4-2
A.trachycaulum	3-2	0-2
Vicia americana	2-17	1-9
Lathyrus ochroleucus	0-5	3-1
Bromus ciliatus	1-2	1-3
Artostaphylos uva-ursi	0-0	2-1
Melilotus alba	0-0	1-1
Festuca rubra	0-1	1-3
F. scabrella	0-0	1-0
Medicago sativa	0-0	0-7
Elymus innovatus	0-4	0-0
Amelanchier alnifolia	0-0	0-2
Agropyron dasystachum	2-0	0-0
Symphoricarpos occidentalis	0-1	0-1
S. albus	0-1	0-0
Agrostis scabra	0-1	0-1

TABLE 12

Pipeline Vegetation Black Soil Zone

Species	Clay-Clay Loam 56 Plots	Clay-Clay Loam x 1/2	Sandy-Loam Sandy 22 Plots
Poa spp.	20-11	10-5	5-4
Phleum pratense	10-11	5-5	0-3
Bromus inermis	9-4	4-2	2-5
Festuca idahoensis	3-3	1-1	6-1
F. rubra	4-3	2-1	5-2
Danthonia parryi	2-7	1-3	4-2
Trifolium hybridum	6-5	3-2	0-0
Agrostis gigantea	4-2	2-1	1-3
Agropyron subsecundum	0-6	0-3	2-1
Symphoricarpos albus	2-9	1-4	0-0
Trifolium pratense	3-6	1-3	0-2
Rosa spp.	0-12	0-6	1-7
Koeleria cristata	1-2	1-1	1-4
Agropyron trachycaulum	2-8	1-4	0-2
Symphoricarpos occidentalis	2-5	1-2	0-1
Amelanchier alnifolia	0-1	0-1	0-5
Elymus glauca	0-1	0-1	0-3
Stipa spartea var. curtiseta	1-2	1-1	0-0
Agropyron dasystachum	0-1	0-1	1-1
Dactylis glomerata	1-0	1-0	0-0
Muhlenbergia richardsonis	1-0	1-0	0-0
Vicia americana	1-13	1-7	0-4
Festuca rubra	3-1	1-1	1-0
Hedysarum sp.	0-3	0-1	0-1
Medicago sativa	1-0	1-0	0-5
Agropyron cristatum	0-3	0-1	0-0
Sporobolus cryptandrus	0-0	0-0	1-1
Lathyrus sp.	0-4	0-2	0-2
Agropyron sp.	0-0	0-0	0-1
Festuca scabrella	0-1	0-1	0-0
Agropyron smithii	0-1	0-1	0-0
Oryzopsis pungens	0-0	0-0	0-1
Arctostaphylos uva-ursi	0-1	0-1	0-1
Trifolium repens	1-1	1-1	0-0

TABLE 13

Pipeline Vegetation Thin Black Soil Zone

Species	Clay Loam 51 Plots	Sandy Loam 42 Plots
Poa spp.	19-12	30-3
Bromus inermis	10-.4	5-1
Koeleria cristata	3-4	4-6
Agropyron smithii	4-6	2-15
Symphoricarpos albus	2-7	4-3
Melilotus alba	5-6	0-0
Phleum pratense	1-10	2-2
Muhlenbergia sp.	3-3	0-0
Dactylis glomerata	3-2	0-0
Symphoricarpos occidentalis	2-5	0-8
Agropyron sp.	1-1	0-0
Bromus sp.	1-1	1-2
Elaeagnus commutata	1-5	0-10
Agropyron cristatum	0-7	5-3
Trifolium repens	1-5	0-0
Stipa spartea var. curtiseta	1-2	1-2
Agrostis sp.	1-5	0-0
Trifolium hybridum	1-1	0-0
Festuca idahoensis	1-0	1-0
Danthonia sp.	0-0	1-0
Amelanchier alnifolia	1-0	0-0
Rosa acicularis	0-8	0-13
Vicia americana	0-10	0-0
Agropyron subsecundum	0-8	0-0
Festuca scabrella	1-0	3-0
Agropyron trachycaulum	0-3	0-1
Hedysarum sp.	0-1	0-2
Medicago sativa	0-0	0-3
Agropyron dasystachum	1-0	0-0
Festuca rubra	0-1	0-0

TABLE 14

Pipeline Vegetation Dark Brown Soil Zone

Species	Sandy Loam 28 plots	Loam X ¼	Loam 102 plots
Bromus inermis	7 - 6	4 - 5	17 - 20
Koeleria cristata	2 - 3	3 - 4	14 - 15
Agropyron smithii	0 - 1	4 - 3	15 - 11
A. trachycaulum	2 - 2	2 - 5	9 - 22
Symphoricarpos occidentalis	1 - 5	1 - 4	4 - 15
S. albus	0 - 0	1 - 1	5 - 2
Agropyron cristatum	0 - 2	2 - 4	10 - 18
Stipa viridula	1 - 1	1 - 1	3 - 1
Melilotus alba	2 - 2	2 - 3	7 - 12
Poa spp.	3 - 6	4 - 7	12 - 29
Rosa spp.	0 -10	2 - 5	6 - 19
Medicago sativa	0 - 2	1 - 2	4 - 7
Festuca rubra	1 - 0	1 - 1	5 - 5
Bouteloua gracilis	0 - 0	1 - 1	3 - 2
Amelanchier alnifolia	0 - 0	1 - 1	3 - 4
Poa compressa	0 - 0	1 - 1	3 - 2
Agrostis sp.	1 - 2	1 - 1	1 - 2
Festuca scabrella	2 - 1	1 - 1	5 - 2
Stipa spartea var. curtiseta	0 - 3	4 - 2	16 - 7
Vicia americana	0 - 0	1 - 2	1 - 9
Agropyron subsecundum	0 - 3	1 - 1	1 - 5
Phleum pratense	0 - 0	1 - 1	1 - 3
Hedysarum sp.	0 - 0	0 - 1	0 - 3
Agropyron repens	0 - 2	0 - 0	0 - 0
Poa secunda	0 - 0	0 - 1	0 - 2
Trifolium hybridum	0 - 2	0 - 0	0 - 0
Elaeagnus commutata	0 - 3	1 - 1	2 - 3
Dactylis glomerata	0 - 0	0 - 1	0 - 1
Sheperdia canadensis	0 - 0	0 - 1	0 - 1
Agropyron dasystachum	0 - 1	1 - 1	1 - 5

TABLE 15

Pipeline Vegetation Brown Soil Zone

Species	Loam 218 plots	Loam x 1/10	Sandy Loam 22 plots
Stipa sp.	44 - 83	4.4 - 8	10 - 6
Bouteloua gracilis	37 - 42	4 - 4	4 - 8
Agropyron trachycaulum	33 -102	3 -10	1 -14
A. smithii	25 - 29	2.5 - 3	2 - 7
A. cristatum	23 - 55	2 - 5.5	1 - 2
Poa spp.	19 - 22	2 - 2	3 - 3
Koeleria cristata	15 - 72	1.5 - 7	0 - 4
Rosa acicularis	11 - 21	1 - 2	1 - 6
Melilotus alba	9 - 22	1 - 2	1 - 3
Bromus inermis	12 - 15	1 - 1.5	4 - 2
Medicago sativa	3 - 4	.5 - .4	1 - 1
Stipa spartea var. curtiseta	4 - 0	.4 - 0	0 - 0
Vicia americana	1 - 0	.1 - 0	2 - 1
Agropyron subsecundum	1 - 6	.1 - .6	0 - 0
Symphoricarpos occidentalis	8 - 18	1 - 2	0 - 2
Agrostis scabra	0 - 4	0 - .4	0 - 2
Oryzopsis sp.	0 - 3	0 - .3	0 - 0
Trifolium hybridum	0 - 3	0 - .3	0 - 0
Dactylis glomerata	0 - 2	0 - .2	0 - 1
Elymus innovatus	0 - 1	0 - .1	0 - 0
Festuca rubra	1 - 3	.1 - .3	0 - 1

SOIL GROUP MAP OF ALBERTA

MAJOR GROUPS

BROWN SOILS

The Brown Soils occur in the semi-arid short grass prairie section of the province. Orthic Brown Soils have an average of five inches of surface horizon that is brown in colour and contains about two per cent organic matter. The horizon of lime accumulation is at about 15 to 20 inches; this represents the average depth of rainfall penetration. The average annual precipitation in the area is about 12 inches; the yearly total varying from 6 to 26 inches. Moisture is a limiting factor to crop growth and only a few soil types are considered arable. There are about two and one-half million acres cultivated under a dry land agriculture. It is mainly under a wheat-fallow rotation. Half a million acres are irrigated. The irrigation projects lie west and northwest of Medicine Hat and are in the area having the longest growing season in the province. The remainder of the area, nine million acres, is used as native pasture.

DARK BROWN SOILS

The Dark Brown Soils occur in an area that is slightly less arid than the Brown Soil area. Precipitation averages about 14 inches, but varies widely from year to year. Orthic Dark Brown Soils have an average of seven inches of surface horizon that contains about four per cent organic matter. The horizon of lime concentration is at about 24 inches. As in the Brown Soil area moisture is the main limiting factor to crop production and here also a wheat-fallow rotation is almost universal. There are about nine million acres of Dark Brown Soils with about four million cultivated. There are 200,000 acres of Dark Brown Soils irrigated.

BLACK SOILS

The Black Soils occur in areas with a dry-subhumid climate; in general the parkland portion of the province. Rainfall in the area varies from an annual average of 15 inches along the southeastern side to 18 inches on the north and west sides. Some frost hazard occurs in the eastern portion of the area and along the western side. The soils in the southeastern half of the area are Thin Black and have an average of five inches of a black surface horizon; the northwestern half are Orthic Black and the black surface horizon averages about 10 inches. The lime concentration horizon varies from about 30 inches in the Thin Black Soils to 48 inches in the Orthic Black Soils. The organic matter in the black surface horizon averages about eight per cent. There are 15 million acres of Black Soils, with 9 million cultivated. There are approximately 50,000 acres of Black Soils irrigated; these are in the southwest corner of the province. A wide range of crops can be grown in the Black Soil areas and the soil's productivity is generally high.

DARK GREY AND DARK GREY WOODED SOILS

The Dark Grey and Dark Grey Wooded Soils occur in areas with a dry-subhumid to subhumid climate and where there is fairly continuous tree cover. The average annual rainfall in the areas varies from 16 to 19 inches and the average frost free period averages less than in the Black Soil zone. These soils usually have a thin leaf mat on the surface. Under the leaf mat is a black to dark grey surface horizon from 3 to 10 inches thick. Under this there is often a very light grey leached horizon. The lime concentration horizon, if present, is generally at 40 to 60 inches below the surface. There are about 10 million acres of Dark Grey and Dark Grey Wooded Soils, a little over four million of which are cultivated. A fairly wide range of crops can be grown and their productivity is generally fairly high.

GREY WOODED SOILS

The Grey Wooded Soils occur in areas with a subhumid climate and where there usually is continuous tree cover. Rainfall in the areas varies from 19 to 22 inches in the southwestern portion of the area to 12 to 14 inches in the northern portion. In most of the areas frost is a hazard to crop production. An Orthic Grey Wooded Soil is characterized by a leaf mat, a thin dark surface horizon of less than two inches in thickness, a light grey platy structured subsurface horizon, and a strongly structured subsoil horizon. These soils are low in natural fertility and respond to the application of mineral fertilizers and additions of organic matter. There are upwards of 50 million acres of Grey Wooded Soil of which about 5 million are cultivated. Coarse grains and hays are the principal crops grown on these soils. Careful soil management is required to achieve good productivity.

BROWN WOODED AND ACID BROWN WOODED SOILS

Brown Wooded and Acid Brown Wooded Soils occur in areas with a subhumid climate and where there is tree cover. In general they are young soils with weak profile development. They are brown to dark brown in colour and there is no clear demarcation between the surface and subsoil. The subsoil is friable and lacks well defined structure. The Brown Wooded Soils are neutral to mildly alkaline in reaction; the Acid Brown Wooded Soils are mildly to moderately acid in reaction. In addition to the area indicated on the map small areas occur throughout the northern and western portion of the province. Very few acres are presently cultivated. However, some areas have arable possibilities.

INDIFFERENTIATED MOUNTAIN COMPLEX

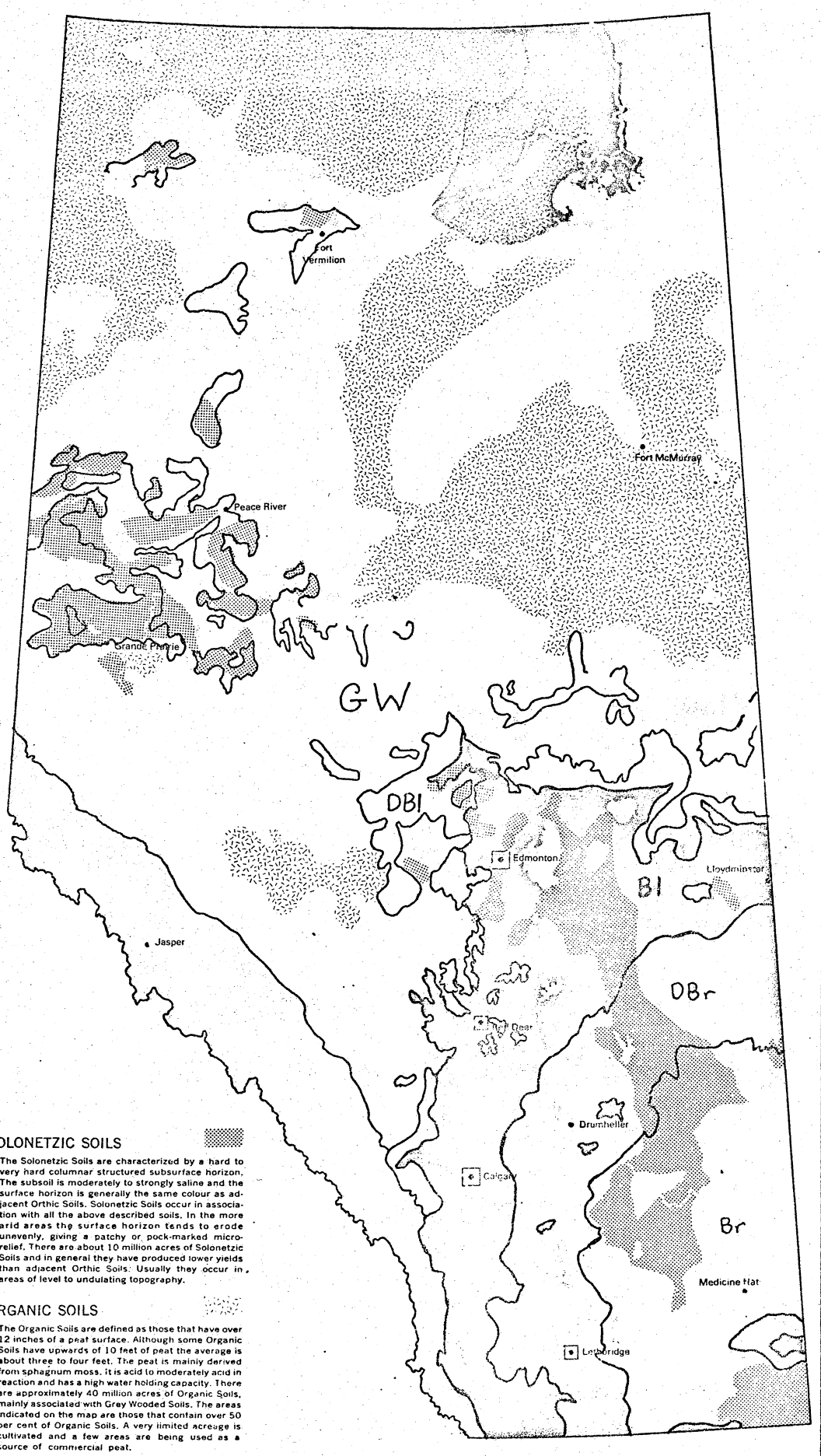
Limited survey data suggest three divisions: (a) bare rock, mostly steeply sloping; (b) relatively shallow soils on the lower slopes that are mainly Grey Wooded, Podzol, or Brown Wooded; and (c) the bottom lands containing Gleysolic, Organic, and/or Regosolic Soils.

SOLONETZIC SOILS

The Solonetzic Soils are characterized by a hard to very hard columnar structured subsurface horizon. The subsoil is moderately to strongly saline and the surface horizon is generally the same colour as adjacent Orthic Soils. Solonetzic Soils occur in association with all the above described soils. In the more arid areas the surface horizon tends to erode unevenly, giving a patchy or pock-marked micro-relief. There are about 10 million acres of Solonetzic Soils and in general they have produced lower yields than adjacent Orthic Soils. Usually they occur in areas of level to undulating topography.

ORGANIC SOILS

The Organic Soils are defined as those that have over 12 inches of a peat surface. Although some Organic Soils have upwards of 10 feet of peat the average is about three to four feet. The peat is mainly derived from sphagnum moss, it is acid to moderately acid in reaction and has a high water holding capacity. There are approximately 40 million acres of Organic Soils, mainly associated with Grey Wooded Soils. The areas indicated on the map are those that contain over 50 per cent of Organic Soils. A very limited acreage is cultivated and a few areas are being used as a source of commercial peat.



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