EVALUATION OF TREES AND SHRUBS FOR OIL SANDS RECLAMATION: FIELD TRIAL RESULTS

1987
Edmonton

Alberta
FORESTRY,
LANDS AND WILDLIFE
Forest Service

Publication Number: T/149
International Standard Book Number: 86499-462-1

READER INFORMATION

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ABSTRACT

The Alberta Oil Sands Environmental Research Program (AOSERP) Subproject VE 7.1 was initiated to select suitable tree and shrub species for use in revegetating spoils and tailings resulting from oil sand mining operations in northeastern Alberta. As part of this program three field trials were established near the Mildred Lake field camp, approximately 38 km north of Fort McMurray, in 1980 and 1981. The purpose was to test one or more provenances (seed sources) of promising native and exotic woody species.

The trial site was prepared to simulate an oil sands reclamation situation. Overburden and peat were hauled to the site from Syncrude Canada Ltd.'s mining lease and incorporated in native sand. The resulting reconstructed soil was alkaline (pH 7.5), non-saline, and low in available N, P, and K. No fertilizers were added. A fine-mesh fence was erected around the trial site to exclude small mammals.

All species were outplanted as one- or two-year-old container stock. All seed used to rear the native species was collected from local populations in the oil sands region.

In August 1986 the trials were assessed. Survival rates were high for most species. Girdling damage by small mammals was almost non-existent, probably because of the fine-mesh fencing.

Populus Northwest and *P.* Tristis #1 were the tallest and fastest growing species. Among the native species, *Pinus banksiana* was the tallest and fastest growing. Several other species also performed well and may be suitable for oil sands reclamation: *Caragana arborescens*, *Cornus stolonifera*, *Elaeagnus commutata*, *Empetrum nigrum*, *Picea glauca*, *Picea mariana*, and *Populus* Brooks #6. Some species gave mediocre or inconsistent performances, including *Betula glandulosa*, *Betula papyrifera*, *Populus* Walker, and *Vaccinium vitis-idaea*. The remaining species were failures and may not be adapted to the test site environment: *Acer negundo*, *Alnus tenuifolia/crispa*, *Elaeagnus angustifolia*, *Fraxinus pennsylvanica*, *Lonicera tartarica*, *Populus tremuloides*, *Rosa woodsii*, *Salix acutifolia*, *Salix fragilis* var. *basfordiana*, *Salix pentandra*, and *Ulmus pumila*.

There were few significant differences among provenances for any of the native species. This suggests that genotypic differences were small among the populations tested.

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ACKNOWLEGEMENTS

These field studies were designed principally by Glen Dunsworth and Jim Sherstabetoff of the Alberta Forest Service. The native species seed collections were supervised by Dunsworth and Sherstabetoff. Paul King and Sam Takyi, also of Alberta Forest Service, established and maintained the plots and made the early assessments. Bill Russell and Rick Baker carried out the assessments in 1986. The planting stock was reared at the Provincial Tree Nursery, Alberta Agriculture, and the Pine Ridge Forest Nursery, Alberta Forest Service.

The project was initially administered under the Alberta Oil Sands Environmental Research Program (AOSERP), a joint Alberta-Canada research program established to fund, direct, and co-ordinate environmental research in the Athabasca Oil Sands area of northeastern Alberta. When the AOSERP funding expired around 1980, the project reverted to the Reforestation and Reclamation Branch of Alberta Forest Service.

This report was written by Bill Russell of Russell Ecological Consultants, Edmonton, Alberta.

1. INTRODUCTION

The field trials in this report are part of the Alberta Oil Sands Environmental Research Program (AOSERP) Subproject VE 7.1. This project was begun in 1975 primarily to evaluate selected native and exotic trees and shrubs for use in reclaiming areas mined for oil sands deposits. The first field tests were demonstration plots established on the Suncor Inc. mining lease. Results of these are in Sherstabetoff et al. (1979) and Russell (1985).

In 1977 the direction of the project was changed, primarily to establish a more rigorous study design. Five field trials were set up in 1977 on the Suncor lease. The objectives were to evaluate the adaptability of selected woody species and to examine methods of enhancing their survival and growth rates. The results are reported in Dunsworth et al. (1979), Sherstabetoff et al. (1979), and Russell (1985).

The results from these early studies were disheartening. By 1985 the overall seedling survival rate in the demonstration plots was 11.6% and in the 1977 trials was 1.7% (Russell 1985). Girdling damage by small mammals was a major cause of seedling mortality.

At the time of project redirection in 1977, it was generally agreed that trees and shrubs native to the AOSERP study area may have greater potential as revegetation material than exotic species. Thus, a project was initiated to test native ecotypes from local populations. Seeds of promising native species were collected from populations in the oil sands region and reared at the Pine Ridge Forest Nursey and Provincial Tree Nursery. The seedlings were outplanted in 1981 in a specially prepared reconstructed soil near the Mildred Lake field camp. The soil was designed to simulate an oil sands reclamation situation. Overburden and peat from the Syncrude lease were incorporated in native sand.

In conjunction with the native species trial, two separate field trials of promising exotic woody species were established in 1980 and 1981 at Mildred Lake. This report presents the first long-term results from these three trials.

2. STUDY AREA DESCRIPTION

The trial site is near the AOSERP Mildred Lake field camp approximately 38 km north of Fort McMurray (NE 18-93-10-W4M; Figure 1). The site is in the Dry Subregion of the Boreal Mixedwood Ecoregion (Strong and Leggat 1981) at an elevation of 314 m. The trials are in a small forest clearing, relatively protected from winds. The surrounding forest is dominated by jack pine (Pinus banksiana).

Detailed descriptions of the area's climate, geology, physiography, soils and vegetation are available in Longley and Janz (1978), McPherson and Kathol (1977), Stringer (1976), and Turchenek and Lindsay (1982).

The trial site was prepared in 1979 to simulate a reclamation situation on tailings sand. The upper soil horizon (A) was stripped to expose the sandy B and C horizons. Overburden and peat were hauled to the site from stockpiles at Syncrude's mining lease. They were spread on the native sand in two 15 cm layers and mixed by tilling with a Rome plow to a depth of 15 cm. A low, fine-mesh fence was erected around the site to exclude small mammals.

The reconstructed soil was alkaline and non-saline (Table 1). It had good water and nutrient holding capacities but was low in available nitrogen, phosphorous, and potassium. Since no fertilizers were added, the reconstructed soil was low in fertility.

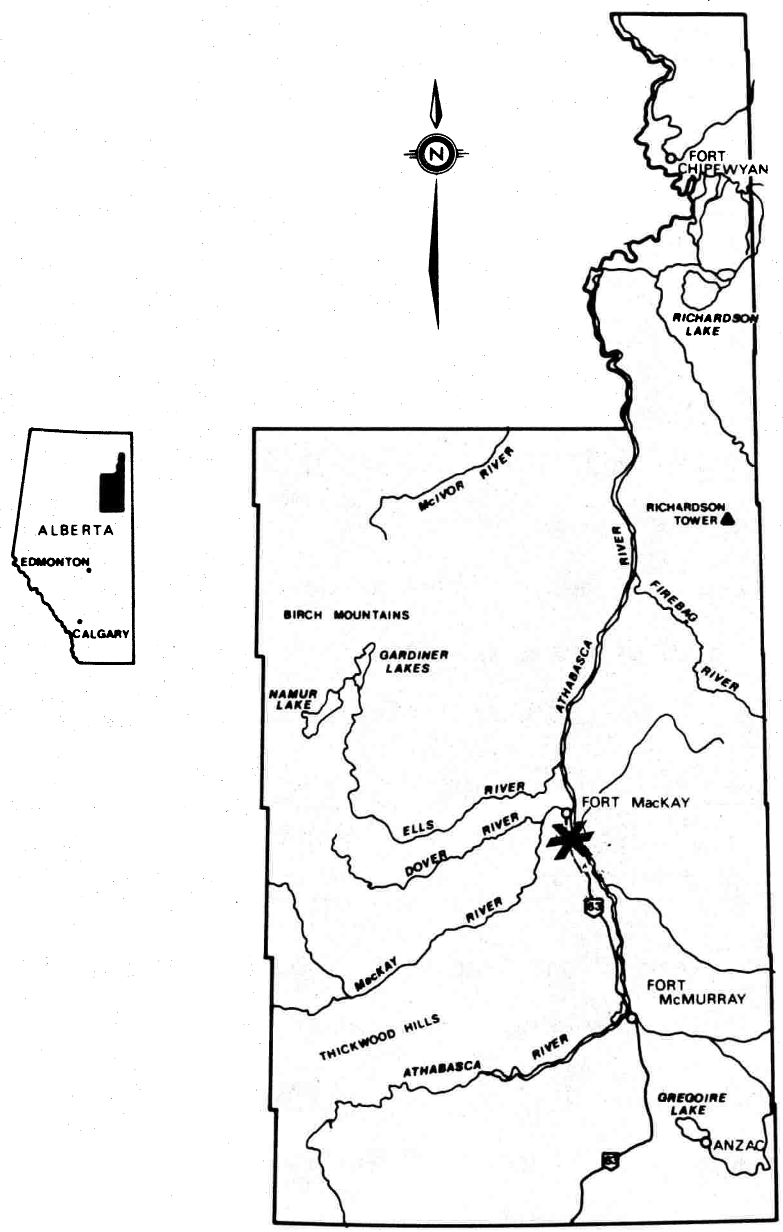

Figure 1. Location of the study site.

TABLE 1

SOME CHEMICAL AND PHYSICAL PROPERTIES OF THE MATERIALS USED IN CONSTRUCTING THE SOIL

Property	Native Sand	Overburden	Peat	Reconstructed Soil
pH	5.7	7.4	6.9	7.5
Electrical Conductivity (mS/cm)	0.1	0.5	0.5	1.3
Organic Matter (%)	0.8	4.1	37.4	11.6
NO_3-N (ppm)	0.5	2.0	20.5	6.5
Available P (ppm)	17.0	0.0	0.5	0.5
Available K (ppm)	28.5	38.0	21.0	50.5
SO_4-S (ppm)	1.0	10.8	12.8	12.6
Total N (%)	0.008	0.027	1.074	0.269
Particle Size (less than 2 mm)				
Sand (%)	86	72	-	68
Silt (%)	10	24	-	20
Clay (%)	4	4	-	12
Texture Class	LS	SL,LS	0	SL
Total Exchange Capacity (mequiv./100 g)	3.55	5.03	57.51	18.25
Exchangeable Cations (mequiv./100 g)				
Na	0.72	0.73	0.71	1.07
K	0.32	0.23	0.24	0.33
Ca	0.81	7.83	63.42	37.57
Mg	0.38	0.90	9.95	4.34

The underlying native sand was acidic and non-saline (Table 1). It had poor water and nutrient holding capacities. It too was low in available nitrogen and potassium, but apparently had adequate levels of available phosphorus.

3. METHODS

3.1 Establishment of the Trials

Three trials were established. The first was set up on May 1, 1980 to test nine exotic tree and shrub species (Table 2). It was a 9 x 3 x 2 complete, randomized block experiment with three blocks and two replicates of each treatment (species) per block.

The second trial was established in May 1981 to test 10 exotic woody species (Table 3). It was designed as a 10 x 3 x 2 complete, randomized block experiment with three blocks and two replicates of each treatment (species) per block. Because of a shortage of planting stock, however, not every species was replicated in every block.

The last trial was set up in May 1981 to examine 11 native trees and shrubs (Table 4). It was a 11 x 3 x 3 complete, randomized block experiment with three blocks and, for six of the species, three provenances (seed sources). For the other five species three replicates of the same provenance were established in each block (Table 3). All seed was collected from populations in the oil sands region.

All species were planted as containerized seedlings. The seedlings were planted by hand using a Swedish tree planting mattock. Each plot consisted of nine seedlings of a given species spaced at 1 m intervals. No fertilizer or grass seed was used. The plots were groomed by hand in the first and second years to keep them weed free.

TABLE 2

SPECIES AND PLANTING STOCK USED IN THE
1980 EXOTIC SPECIES TRIAL

Species	Source[1]	Container[2]	Age (years)
Acer negundo	ATN	H	1
Caragana arborescens	ATN	H	1
Populus Northwest	ATN	T	1
Populus Walker	ATN	3.8 L. pots	1
Populus Brooks #6	ATN	T	1
Salix acutifolia	ATN	T	1
Salix fragilis var. basfordiana	ATN	T	1
Salix pentandra	ATN	T	1
Ulmus pumila	ATN	H	1

1 ATN = Alberta Tree Nursery, Edmonton

2 H = Hillson (160 cm^3)
T = Tinus (500 cm^3)

TABLE 3

SPECIES AND PLANTING STOCK USED IN THE
1981 EXOTIC SPECIES TRIAL

Species	Source[1]	Container[2]	Age (years)
Elaeagnus angustifolia	ATN	H	2
Elaeagnus commutata	ARP	H	2
Fraxinus pennsylvanica	ATN	H	2
Lonicera tartarica	ATN	H	1
Populus Brooks #6-162	AFS/Suncor	T	1
Populus Northwest 359	AFS/Suncor	T	2
Populus Northwest 375	AFS/Suncor	T	2
Populus Walker 352	AFS/Suncor	3.8 L. pots	2
Populus Walker 374	AFS/Suncor	3.8 L. pots	2
Populus Tristis #1	PFRA	T	1

1 ATN = Alberta Tree Nursery, Edmonton
ARP = Alberta Recreation and Parks
AFS/Suncor = Cuttings were taken from Alberta Forest Service research plots on the Suncor lease and reared at ATN. Original plants were from PFRA or ATN.
PFRA = Prairie Farm Rehabilitation Administration Tree Nursery, Indian Head, Saskatchewan

2 H = Hillson (160 cm^3)
T = Tinus (500 cm^3)

TABLE 4

SPECIES AND PLANTING STOCK USED IN THE
1981 NATIVE SPECIES TRIAL

Species	Seedlot[1]	Container[2]	Age (years)
Alnus tenuifolia/crispa	ALD 4-77	T	2
	ALD 3-78	T	2
	ALD 1-77	T	2
Betula glandulosa	Dwarf 1-79	H	2
Betula papyrifera	PAP 1-78	H	1
	PAP 2-78	H	1
	PAP 3-78	H	1
Cornus stolonifera	DOG 1-78	T	2
	DOG 3-78	T	2
	DOG 4-78	T	2
Empetrum nigrum	CROW 1-78	H	2
Picea glauca	DA 94-11-4-75	H	2
	DA 86-8-4-75	H	2
	DA 90-12-4-76	H	2
Picea mariana	RB DA 94-11-4-78	H	2
Pinus banksiana	JAC 1-78	H	2
	JAC 2-78	H	2
	JAC 3-78	H	2
Populus tremuloides	ASP 5-78	T	2
Rosa woodsii	WIL 1-76	H	2
	WIL 2-78	H	2
	WIL 3-78	H	2
Vaccinium vitis-idaea	BOG 2-79	H	2
	BOG 4-79	H	2
	BOG 5-79	H	2

1 Seedlot numbers were assigned by the Provincial Tree Nursery, where all planting stock was reared.

2 H = Hillson (160 cm^3)
T = Tinus (500 cm^3)

Because seedling mortality was unacceptably high in some plots, dead seedlings were dug up and replaced during the first and second growing seasons. The purpose was to minimize the importance of planting stock condition as a cause of mortality.

3.2 Assessment of the Trials

The seedlings were assessed from August 28 to 31, 1986 for the following variables:

(1) Survival Rate: by counting the number of living seedlings in each plot and expressing it as a percentage of the total number planted (nine).

(2) Vigor: by rating each seedling using a subjective four-point scale: (1) poor; (2) fair; (3) good; and (4) excellent.

(3) Height: by placing a metre stick or surveying rod at the base of the plant and bending the tallest stem to the vertical stick. The height of the tallest living woody tissue was measured to the nearest centimetre.

(4) Annual Height Increment: by taking the difference in seedling heights at planting time and assessment time (1986) and dividing the result by the number of intervening growing seasons (six or seven).

(5) Stem Diameter: by measuring the diameter of each seedling at approximately 1 cm above the root collar using calipers. Two measurements were taken and the average used. The first

measurement was at the widest point and the second was perpendicular to the first.

(6) Annual Stem Diameter Increment: by taking the difference in stem diameter at planting time and assessment time (1986) and dividing the result by the number of intervening growing seasons (six or seven).

(7) Crown Diameter: by placing a metre stick or surveying rod horizontally through the plant at its broadest point and measuring the width of the crown to the nearest centimetre. A second measurement was taken perpendicular to the first and the average of the two measurements used.

(8) Number of Stems per Plant: by counting the number of stems on or arising from each planted seedling.

(9) Cover: by visually estimating the total cover provided by the seedlings in each plot. Cover was taken as the percentage of the ground area in each plot covered by a vertical projection of all above ground living plant parts to the ground surface. Cover was estimated using a five-point scale: (1) less than 5%; (2) 6-25%; (3) 26-50%; (4) 51-75%; and (5) 76-100%. Cover class mid-points were used in the analyses of variance.

(10) Flowering Rate: by counting the number of seedlings in each plot bearing flowers at assessment time. Flowering rate was expressed as a percentage of the number of living seedlings in the plot.

(11) Fruiting Rate: by counting the number of seedlings in each plot bearing fruit at assessment time. Fruiting rate was

expressed as a percentage of the number of living seedlings in the plot.

(12) Dieback Rate-Current Year: by counting the number of seedlings with dieback that occurred during the current growing season (1986). Dieback was expressed as a percentage of the number of living seedlings in the plot.

(13) Dieback Rate-Previous Years: by counting the number of seedlings with dieback that occurred during previous years. Dieback was expressed as a percentage of the number of living seedlings in the plot.

(14) Insect Damage Rate: by counting the number of seedlings in each plot showing any of the following types of insect damage: (1) defoliation; (2) gall making; (3) leaf mining; (4) sap-sucking; and (5) boring or girdling. Insect damage was expressed as a percentage of the number of living seedlings in the plot.

(15) Girdling Rate: by counting the number of seedlings in each plot with small mammal girdling damage on their stems. Girdling rate was expressed as a percentage of the number of living seedlings in the plot.

(16) Girdling/Plant Rate: by estimating the percentage of the circumference of each damaged stem that was girdled. The average amount of damage among those plants showing damage was calculated for each plot.

(17) Rhizome Sprouting Rate: by counting the number of seedlings reproducing by sprouting from rhizomes in each plot. Rhizome

sprouting rate was expressed as a percentage of the number of living seedlings in the plot.

(18) Suckering Rate: by counting the number of seedlings in each plot with sprouts arising on or near the root collar. Suckering rate was expressed as a percentage of the number of living seedings in the plot.

3.3 Data Analyses

Analyses of variance were conducted to determine the main effects of the treatments (species and/or provenances) on each of the dependent variables. Duncan's New Multiple Range tests were used to determine the significance of differences among treatment means. All statistics were computed using the SPSSx program package (SPSS 1983).

4. RESULTS AND DISCUSSION

4.1 1980 Exotic Species Trial

The three hybrid poplars performed well in this trial, as they have in other trials in this region (see Russell 1985). They were taller and had larger stem and crown diameters than the other species tested (Table 5). Their vigor was rated good to excellent.

The only negative result for the poplars was the high incidence of seedlings showing insect defoliation. However, the damage was usually light, often consisting of just a few partially consumed leaves per seedling.

Northwest was the best of the poplars. It was tallest, had the largest stem diameters, the highest vigor rating, and the lowest dieback rate.

Introduced as a male clone by the Northwest Nursery of Valley City, North Dakota, Northwest poplar is a natural hybrid between *Populus deltoides* Marsh. and *P. balsamifera* L. Under favorable conditions it is reportedly fast growing and winter hardy. However, like many poplars it is susceptible to insects and diseases and will perform poorly under very dry conditions (PFRA n.d.).

Walker poplar performed nearly as well as Northwest. Walker is a female clone selected from open-pollinated seedlings of *Populus*

TABLE 5

EFFECTS OF SPECIES ON 17 DEPENDENT VARIABLES IN
THE 1980 EXOTIC SPECIES TRIAL

Species	Survival Rate (%)	Vigor (1-4)	Height (cm)	Annual Height Increment (1980-86) (cm/yr)	Stem Diameter (mm)	Crown Diameter (cm)
Acer negundo	92.5 a[1]	1.6 b	79.2 c	8.1 c	12.7 cd	32.9 d
Caragana arborescens	100.0 a	3.8 a	165.1	21.3	25.4 b	121.0 b
Populus Northwest	100.0 a	3.8 a	398.5 a	51.8 a	52.9 a	163.4 a
Populus Walker	96.3 a	3.3 a	363.4 ab	48.2 ab	49.4 a	135.4 b
Populus Brooks #6	100.0 a	3.3 a	334.4 b	43.2 b	45.7 a	166.4 a
Salix acutifolia	83.3 ab	1.6 b	48.0 c	3.8 cd	13.2 cd	41.7 cd
Salix fragilis var. basfordiana	66.6 b	1.4 b	49.9 c	0.4 d	8.2 d	30.7 d
Salix pentandra	85.2 ab	1.7 b	47.7 c	1.9 cd	13.7 cd	48.9 cd
Ulmus pumila	100.0 a	1.8 b	85.4 c	9.3 c	19.4 bc	66.9 c

1 Means followed by the same letter within a column are not significantly different at the 5% level (N = 6).

TABLE 5 (CONTINUED)

Species	No. of Stems/ Plant	Cover (%)	Flowering Rate (%)	Fruiting Rate (%)	Dieback Rate Current Yr. (%)	Dieback Rate Previous Yr. (%)
Acer negundo	2.4 ab	11.2 b	0.0 a	0.0 a	5.6 a	92.6 ab
Caragana arborescens	4.5 a	79.7 a	0.0 a	98.0	0.0 a	1.9 e
Populus Northwest	2.9 ab	88.0 a	0.0 a	0.0 a	0.0 a	1.9 e
Populus Walker	2.0 b	79.7 a	0.0 a	0.0 a	13.0 a	38.9 d
Populus Brooks #6	1.2 b	84.0 a	0.0 a	0.0 a	0.0 a	14.8 de
Salix acutifolia	2.3 ab	20.8 b	0.0 a	0.0 a	0.0 a	81.5 abc
Salix fragilis var. basfordiana	1.9 b	9.0 b	0.0 a	0.0 a	0.0 a	64.8 c
Salix petandra	2.4 ab	15.5 b	0.0 a	0.0 a	0.0 a	68.5 bc
Ulmus pumila	2.9 ab	20.8 b	0.0 a	0.0 a	0.0 a	100.0 a

TABLE 5 (CONTINUED)

Species	Insect Damage Rate (%)	Girdling Rate (%)	Girdling/ Plant Rate (%)	Rhizome Sprouting Rate (%)	Suckering Rate (%)
Acer negundo	0.0 b	0.0 a	0.0 a	0.0 b	55.4 ab
Caragana arborescens	0.0 b	1.9 a	6.3 a	0.0 b	88.9 a
Populus Northwest	72.2 a	1.9 a	2.2 a	5.6 a	3.7 c
Populus Walker	64.8 a	0.0 a	0.0 a	0.0 b	44.4 b
Populus Brooks #6	81.5 a	0.0 a	0.0 a	1.9 ab	7.4 c
Salix acutifolia	0.0 b	0.0 a	0.0 a	0.0 b	81.5 ab
Salix fragilis var. basfordiana	0.0 b	0.0 a	0.0 a	0.0 b	50.0 ab
Salix petandra	1.9 b	0.0 a	0.0 a	0.0 b	81.5 ab
Ulmus pumila	0.0 b	0.0 a	0.0 a	0.0 b	81.5 ab

deltoides at the PFRA Tree Nursery in Indian Head, Saskatchewan. It is generally faster growing but less winter hardy than Northwest (PFRA n.d.). In this trial its annual height increment was not significantly different from Northwest's but it did have a higher incidence of dieback (Table 5).

Caragana (Caragana arborescens Lam.) also performed well. It had a 100% survival rate and tied with Northwest poplar for having the highest vigor rating (Table 5). It had very little dieback and was the only species in this trial bearing fruit when the assessments were made.

Caragana was introduced to the Canadian prairies from the steppes of Siberia. It is exceptionally drought and cold hardy. It will grow in a wide range of soils, including dry sands, but is sensitive to repeated flooding (PFRA n.d.). Caragana has also performed well in other reclamation field trials in this region (see Russell 1985).

The willows did not perform well in this trial. Although their survival rates were generally high, they had low vigor ratings and high dieback rates (Table 5).

Laurel willow (Salix pentandra L.) was introduced from Europe and is used for shelterbelts in Alberta. It is more susceptible to dieback than other willows used for shelterbelts in Alberta and generally is not recommended for use on dry sites or infertile soils (PFRA n.d.).

Acuteleaf willow (Salix acutifolia Willd.) is a fast growing, multiple-stemmed tree introduced for shelterbelt planting in Alberta. It also does not perform well in dry or infertile soils (PFRA n.d.).

Bassford willow (Salix fragilis var. basfordiana Reher) was introduced for use in farmstead shelterbelts. It proved to be susceptible to winterkill in the Canadian prairies and is no longer produced at PFRA. Incomplete winter hardiness may explain its poor performance in this trial.

Manitoba maple (Acer negundo L.) had a high survival rate but suffered from heavy dieback (Table 5). After seven growing seasons its mean height was only 80 cm. Its vigor was rated poor to fair.

Manitoba maple is a native of southeastern Alberta where it occurs along streams, river valleys, and ravines. It is winter hardy but not drought tolerant (PFRA). It can suffer complete or partial dieback under dry conditions, which may explain its poor performance in this trial.

Siberian elm (Ulmus pumila L.) also had a high survival rate but low vigor and heavy dieback (Table 5). A native of southern Siberia and northern Manchuria, this species is fast growing, drought tolerant and well suited for shelterbelt planting, especially in southwestern Saskatchewan (PFRA n.d.). It is winter hardy under normal prairie conditions, but may topkill during severe winters. Its poor performance in this trial may be the result of inadequate winter hardiness in northern Alberta.

4.2 1981 Exotic Species Trial

Of the species in this trial, Tristis #1 poplar appeared the best adapted to the test site environment. It had a 100% survival rate

(Table 6). It was the tallest species and had the largest stem and crown diameters. It had the highest vigor rating and lowest rate of dieback of the species tested. Although almost every seedling of Tristis #1 showed some defoliation from insects, the amount of damage was slight.

The two sources of Northwest poplar cuttings performed well (Table 6). Both had high survival rates and good height and stem diameter growth rates. Their vigor ratings were good. Both had low amounts of dieback. Similar to Tristis #1, Northwest had a high percentage of seedlings showing insect defoliation, but the amount of damage was usually slight.

Brooks #6 poplar is a female clone selected from open-pollinated seedlings of Populus deltoides at the Brooks Nursery in Alberta. It did well in this trial. It had a high survival rate and fair to good vigor. Its height and stem diameter growth rates were high in comparison with most other species (Table 6).

Wolfwillow (Elaeagnus commutata Bernh.) had a 100% survival rate and fair vigor (Table 6). Dieback was common but the amount of damage was usually slight. Wolfwillow is native throughout Alberta, but is most common on lighter soils of the parkland region. In this trial it reproduced prolifically by sprouting from rhizomes.

Russian olive (Elaeagnus angustifolia L.) had a relatively low survival rate and high incidence of dieback (Table 6). It is a Eurasian introduction that occasionally escapes from cultivation in western Canada. It is considered drought hardy but susceptible to winterkill. Incomplete winter hardiness and/or poor planting stock quality may explain its poor performance in this trial.

TABLE 6

EFFECTS OF SPECIES ON 18 DEPENDENT VARIABLES IN THE 1981 EXOTIC SPECIES TRIAL

Species	Survival Rate (%)	Vigor (1-4)	Height (cm)	Annual Height Increment (1981-86) (cm/yr)	Stem Diameter (mm)	Annual Stem Diameter Increment (1981-86) (mm/yr)
Elaeagnus angustifolia	55.3 b[1]	2.6 ab	47.8 d	16.4 c	24.7 abc	2.1 b
Elaeagnus commutata	100.0 a	2.2 bc	124.9 cd	21.7 bc	16.3 bc	1.7 b
Fraxinus pennsylvanica	0.0 c	-	-	-	-	-
Lonicera tartarica	0.0 c	-	-	-	-	-
Populus Brooks #6-162	96.3 a	2.8 ab	181.7 bc	23.5 bc	26.5 ab	3.1 ab
Populus Northwest 359	98.0 a	2.9 ab	204.4 bc	29.5 bc	28.2 a	3.2 ab
Populus Northwest 375	100.0 a	3.4 ab	230.3 ab	31.2 ab	30.5 a	3.2 ab
Populus Walker 352	0.0 c	-	-	-	-	-
Populus Walker 374	46.3 b	1.3 c	99.4 d	24.8 bc	14.5 c	2.3 b
Populus Tristis #1	100.0 a	3.7 a	302.6 a	43.1 a	43.0	4.6 a

1 Means followed by the same letter within a column are not significantly different at the 5% level (N = 3-6).

TABLE 6 (CONTINUED)

Species	Crown Diameter (cm)	No. of Stems/ Plant	Cover (%)	Flowering Rate (%)	Fruiting Rate (%)	Dieback Rate Current Yr. (%)
Elaeagnus angustifolia	75.0 bc	2.8 a	15.5 d	0.0 a	0.0 a	0.0 a
Elaeagnus commutata	56.7 c	2.7 a	38.0 bc	0.0 a	46.3	0.0 a
Fraxinus pennsylvanica	-	-	-	-	-	-
Lonicera tartarica	-	-	-	-	-	-
Populus Brooks #6-162	102.8 ab	1.5 b	50.5 b	0.0 a	0.0 a	1.9 a
Populus Northwest 359	108.1 ab	1.2 b	50.5 b	0.0 a	0.0 a	0.0 a
Populus Northwest 375	116.6 a	1.1 b	71.3 a	0.0 a	0.0 a	0.0 a
Populus Walker 352	-	-	-	-	-	-
Populus Walker 374	47.5 c	1.1 b	19.8 cd	0.0 a	0.0 a	4.2 a
Populus Tristis #1	159.9	1.3 b	88.0 a	0.0 a	0.0 a	0.0 a

TABLE 6 (CONTINUED)

Species	Dieback Rate Previous Yr. (%)	Insect Damage Rate (%)	Girdling Rate (%)	Girdling/ Plant Rate (%)	Rhizome Sprouting Rate (%)	Suckering Rate (%)
Elaeagnus angustifolia	94.4 a	55.6 bc	0.0 a	0.0 a	0.0 b	77.8 a
Elaeagnus commutata	66.7 ab	22.2 d	0.0 a	0.0 a	96.3	83.2 a
Fraxinus pennsylvanica	-	-	-	-	-	-
Lonicera tartarica	-	-	-	-	-	-
Populus Brooks #6-162	7.4 cd	57.4 b	5.6 a	6.4 a	0.0 b	31.5 bc
Populus Northwest 359	7.4 cd	87.0 ab	1.9 a	2.2 a	0.0 b	18.5 bc
Populus Northwest 375	3.7 cd	94.4 a	5.6 a	4.3 a	5.6 a	7.4 c
Populus Walker 352	-	-	-	-	-	-
Populus Walker 374	49.5 bc	25.2 cd	0.0 a	0.0 a	6.3 a	41.2 b
Populus Tristis #1	1.9 d	96.3 a	1.9 a	2.2 a	3.7 ab	14.8 bc

Walker poplar did very well in the 1980 exotic trial (see Section 4.1), thus demonstrating its adaptation to the test site environment. However, in this trial it did poorly. One of the sources of cuttings (352) failed completely and the other (374) had a survival rate of only 46% (Table 6). Its vigor rating was the lowest of any species (1.3). It had the highest incidence of dieback of the poplars. Poor quality of planting stock may account for its poor performance in this trial.

Green ash (Fraxinus pennsylvanica Marsh. var. subintegerrima (Vahl) Fern.) had no surviving seedlings. It is a native tree in southern Canada, where it ranges from Saskatchewan eastward. In Alberta it is commonly planted along city streets as an ornamental or shade tree. The planting stock of green ash was in poor condition at planting time, which could explain its poor performance in this trial.

Tartarian honeysuckle (Lonicera tartarica L.) also failed in this trial. This introduced shrub is grown as an ornamental and for shelterbelts. It is moderately hardy and grows well in moist or poorly drained soils (PFRA n.d.). In northern Alberta it may not be completely winter hardy, which may explain its failure in this trial. Also, the planting stock was of poor quality.

4.3 1981 Native Species Trial

The trial site was located in a clearing in a forest dominated by jack pine (Pinus banksiana Lamb.). Thus, jack pine was expected to, and did, perform well on this site. It had the highest vigor rating and a high survival rate (Table 7). It was the tallest species in this

TABLE 7

EFFECTS OF SPECIES ON 17 DEPENDENT VARIABLES IN
THE 1981 NATIVE SPECIES TRIAL

Species	Survival Rate (%)	Vigor (1-4)	Height (cm)	Annual Height Increment (1981-86) (cm/yr)	Stem Diameter (mm)	Crown Diameter (cm)
Alnus tenuifolia/crispa	11.8	1.9 e	49.4 c	5.1 d	8.4 d	43.9 c
Betula glandulosa	98.5 a[1]	2.4 cd	110.8 b	9.7 c	19.5 ab	78.0 b
Betula papyrifera	94.8 a	2.2 de	105.7 b	13.9 b	22.9 a	64.2 b
Cornus stolonifera	97.8 a	3.2 b	105.7 b	10.4 bc	15.5 bc	105.5 a
Empetrum nigrum	89.6 a	3.9 a	6.2 d	-	-	21.6 de
Picea glauca	91.1 a	3.7 a	51.0 c	6.6 cd	14.6 c	29.7 cd
Picea mariana	88.9 a	2.9 bc	35.0 c	3.3 d	8.6 d	22.5 de
Pinus banksiana	94.1 a	3.9 a	159.8 a	23.6 a	31.9	101.9 a
Populus tremuloides	40.0	2.1 de	141.8 a	21.5 a	21.3 a	76.4 b
Rosa woodsii	98.5 a	1.7 e	51.7 c	7.0 cd	-	40.2 c
Vaccinium vitis-idaea	65.9	2.6 cd	2.8 d	-	-	9.5 e

1 Means followed by the same letter within a column are not significantly different at the 5% level (N = 15).

TABLE 7 (CONTINUED)

Species	No. of Stems/ Plant	Cover (%)	Flowering Rate (%)	Fruiting Rate (%)	Dieback Rate Current Yr. (%)	Dieback Rate Previous Yr. (%)
Alnus tenuifolia/crispa	4.8 a	6.0 f	0.0 a	26.7	0.0 b	21.1 c
Betula glandulosa	5.5 a	48.2 bc	5.3	68.4 a	0.7 b	85.7 a
Betula papyrifera	1.8 b	36.7 c	0.0 a	0.0 b	0.8 b	79.9 ab
Cornus stolonifera	8.7	69.7 a	0.0 a	74.1 a	1.5 b	67.0 b
Empetrum nigrum	-	7.1 ef	0.0 a	0.0 b	0.0 b	0.0 d
Picea glauca	1.0 b	14.6 def	0.0 a	0.0 b	1.5 b	0.7 d
Picea mariana	1.0 b	14.6 def	0.0 a	0.0 b	0.0 b	13.8 cd
Pinus banksiana	1.0 b	58.4 ab	0.0 a	78.8 a	4.4 ab	5.4 d
Populus tremuloides	1.1 b	19.6 de	0.0 a	0.0 b	9.5 a	0.0 d
Rosa woodsii	6.0 a	22.3 d	0.0 a	1.5 b	0.0 b	84.2 a
Vaccinium vitis-idaea	-	2.5 f	0.0 a	0.0 b	0.0 b	0.0 d

TABLE 7 (CONTINUED)

Species	Insect Damage Rate (%)	Girdling Rate (%)	Girdling/ Plant Rate (%)	Rhizome Sprouting Rate (%)	Suckering Rate (%)
Alnus tenuifolia/crispa	42.2 bc	6.7 a	0.9 a	0.0 b	53.3 b
Betula glandulosa	61.2 b	0.7 b	0.9 a	0.0 b	83.3 a
Betula papyrifera	96.7 a	0.7 b	0.9 a	0.0 b	39.6 b
Cornus stolonifera	35.9 c	0.7 b	0.9 a	0.0 b	100.0 a
Empetrum nigrum	0.0 d	0.0 b	0.0 a	84.6 a	9.2 c
Picea glauca	21.2 cd	0.0 b	0.0 a	0.0 b	0.0 c
Picea mariana	9.1 d	0.0 b	0.0 a	0.0 b	0.0 c
Pinus banksiana	0.0 d	0.0 b	0.0 a	0.0 b	0.0 c
Populus tremuloides	88.1 a	3.2 a	1.7 a	5.3 b	14.6 c
Rosa woodsii	82.7 a	0.0 b	0.0 a	91.5 a	98.4 a
Vaccinium vitis-idaea	1.1 d	0.0 b	0.0 a	35.8	90.2 a

trial and had the largest mean stem diameter. Jack pine showed very little dieback. Furthermore, a large proportion of its seedlings (79%) bore fruit (cones) at assessment time.

White spruce (Picea glauca (Moench) Voss.) also performed well. Although its annual height increment was only one third that of jack pine, white spruce had a high survival rate and high vigor rating (Table 7). Furthermore, it had almost no dieback.

Crowberry (Empetrum nigrum L.) performed well. It had a high survival rate and tied with jack pine for having the highest vigor rating (Table 7). It had no visible dieback. However, crowberry is a small, prostrate shrub. It provided an average of only 7% ground cover per plot (with plants spaced 1 m apart), indicating it would be of little use for erosion control purposes unless planted at much higher densities.

Black spruce (Picea mariana (Mill) BSP.) had a high survival rate and good vigor rating (Table 7). It appeared generally well adapted to the test site, although it did exhibit some dieback. Its annual height increment was half that of white spruce and one seventh that of jack pine. Black spruce would be a poor choice if rapid growth was desired.

Dogwood (Cornus stolonifera Michx.) is a native shrub of woodlands, coulees, and water courses throughout the prairie provinces. It is adapted to wet and dry sites and a wide range of soil types (PFRA n.d.). In this trial it had a high survival rate and good vigor rating (Table 7). Although it had a high incidence of dieback, the dieback was generally light. A high proportion of dogwood seedlings bore fruit at assessment time. Dogwood gave the appearance of being well adapted to the test site environment.

Bog cranberry (*Vaccinium vitis-idaea* L.) appeared adapted to the test site. Although its survival rate was only 66% it had fair to good vigor and no dieback (Table 7). However, like crowberry, bog cranberry is a low, prostrate shrub that produced little ground cover.

Both native birches, *Betula glandulosa* Michx. and *B. papyrifera* Marsh., had high survival rates and fair to good vigor ratings (Table 7). However, both species had high incidences of dieback and damage by defoliating insects, suggesting they are not fully adapted to the test site environment.

Rose (*Rosa woodsii* Lindl.) performed poorly. Although its survival rate was high its vigor was low (Table 7). There were dieback and insect defoliation on most seedlings. It reproduced prolifically by sprouting from rhizomes but few seedlings produced fruit. Rose appeared stressed on this site, perhaps because of the low fertility of the soil.

Aspen (*Populus tremuloides* Michx.) had a low rate of survival (40%) and only fair vigor (Table 7). Most surviving seedlings had some damage from defoliating insects, suggesting insect damage contributed to the poor survival rate. Although aspen can grow in a wide range of soils, including sand, it grows best in well-drained loams. The sandy, nutrient-poor soils in this trial may have contributed to its poor performance. Also, the quality of the planting stock was poor.

Alder (*Alnus tenuifolia* Nutt. and/or *A. crispa* (Ait.) Pursh) had the lowest survival rate of any of the native species (12%; Table 7). The quality of the planting stock was poor for this species also.

For six of the 11 species in this trial more than one provenance was tested. For most of these species the dependent variables did not vary significantly among provenances; i.e. provenance had little effect on the variables measured (Tables 8-13). This suggests that genetic variability among the provenances was not great enough to influence the variables measured. It may also indicate that the sample size (5) was too small to establish statistically significant differences. While it is probably true that if the sample size had been larger more of the differences among the provenances would have been statistically significant, for the most part the differences were small and probably inconsequential. The results indicate that none of the provenances for a given species outperformed any other.

TABLE 8

ALNUS TENUIFOLIA/CRISPA

EFFECTS OF PROVENANCE ON 17 DEPENDENT VARIABLES IN THE 1981 NATIVE SPECIES TRIAL

	Seedlot[1]		
Variable	ALD 4-77	ALD 3-78	ALD 1-77
Survival Rate (%)	20.0 a[2]	8.9 a	6.7 a
Vigor (1-4)	2.1 a	1.6 a	2.0 a
Height (cm)	49.5 a	49.1 a	49.6 a
Annual Height Increment (cm)	2.3 a	7.6 a	5.5 a
Stem Diameter (mm)	9.5 a	6.1 a	9.6 a
Crown Diameter (cm)	43.6 a	48.3 a	40.0 a
No. Stems/Plant	4.4 a	4.7 a	5.2 a
Cover (%)	9.8 a	4.1 a	0.0 a
Flowering Rate (%)	0.0 a	0.0 a	4.1 a
Fruiting Rate (%)	30.0 a	30.0 a	20.0 a
Dieback Rate - Current Year (%)	0.0 a	0.0 a	0.0 a
Dieback Rate - Previous Years (%)	33.3 a	10.0 a	20.0 a
Insect Damage Rate (%)	66.7 a	20.0 b	40.0 ab
Girdling Rate (%)	0.0 b	0.0 b	20.0 a
Girdling/Plant Rate (%)	0.0 a	0.0 a	2.6 a
Rhizome Sprouting Rate (%)	0.0 a	0.0 a	0.0 a
Suckering Rate (%)	60.0 a	40.0 a	60.0 a

1 Seedlot numbers at the Alberta Tree Nursery.

2 Means followed by the same letter within a row are not significantly different at the 5% level (N = 5).

TABLE 9

BETULA PAPYRIFERA

EFFECTS OF PROVENANCE ON 17 DEPENDENT VARIABLES
IN THE 1981 NATIVE SPECIES TRIAL

	Seedlot[1]		
Variable	PAP 1-78	PAP 2-78	PAP 3-78
Survival Rate (%)	97.8 a[2]	91.1 a	95.6 a
Vigor (1-4)	2.1 a	2.2 a	2.2 a
Height (cm)	97.7 a	105.7 a	113.7 a
Annual Height Increment (cm)	12.6 a	14.0 a	14.9 a
Stem Diameter (mm)	21.4 a	22.6 a	24.7 a
Crown Diameter (cm)	61.7 a	61.8 a	69.2 a
No. Stems/Plant	2.0 a	1.9 a	1.6 a
Cover (%)	38.5 a	38.0 a	33.5 a
Flowering Rate (%)	0.0 a	0.0 a	0.0 a
Fruiting Rate (%)	0.0 a	0.0 a	0.0 a
Dieback Rate - Current Year (%)	2.5 a	0.0 a	0.0 a
Dieback Rate - Previous Years (%)	79.7 a	80.4 a	79.7 a
Insect Damage Rate (%)	95.6 a	94.6 a	100.0 a
Girdling Rate (%)	0.0 a	0.0 a	2.2 a
Girdling/Plant Rate (%)	0.0 a	0.0 a	2.6 a
Rhizome Sprouting Rate (%)	0.0 a	0.0 a	0.0 a
Suckering Rate (%)	53.1 a	48.6 a	17.2 a

1 Seedlot numbers at the Alberta Tree Nursery.

2 Means followed by the same letter within a row are not significantly different at the 5% level (N = 5).

TABLE 10

CORNUS STOLONIFERA

EFFECTS OF PROVENANCE ON 17 DEPENDENT VARIABLES IN THE 1981 NATIVE SPECIES TRIAL

	Seedlot[1]		
Variable	DOG 1-78	DOG 3-78	DOG 4-78
Survival Rate (%)	93.3 a[2]	100.0 a	100.0 a
Vigor (1-4)	3.2 a	3.1 a	3.1 a
Height (cm)	107.6 a	97.9 a	111.6 a
Annual Height Increment (cm)	10.2 a	9.0 a	12.1 a
Stem Diameter (mm)	15.8 a	15.3 a	15.5 a
Crown Diameter (cm)	108.6 a	99.0 a	108.8 a
No. Stems/Plant	8.7 a	8.5 a	8.8 a
Cover (%)	68.0 a	68.0 a	73.0 a
Flowering Rate (%)	0.0 a	0.0 a	0.0 a
Fruiting Rate (%)	57.8 a	82.2 a	82.2 a
Dieback Rate - Current Year (%)	0.0 a	4.4 a	0.0 a
Dieback Rate - Previous Years (%)	83.3 a	71.1 ab	46.7 b
Insect Damage Rate (%)	38.9 a	33.3 a	35.6 a
Girdling Rate (%)	2.2 a	0.0 a	0.0 a
Girdling/Plant Rate (%)	2.6 a	0.0 a	0.0 a
Rhizome Sprouting Rate (%)	0.0 a	0.0 a	0.0 a
Suckering Rate (%)	100.0 a	100.0 a	100.0 a

1 Seedlot numbers at the Alberta Tree Nursery.

2 Means followed by the same letter within a row are not significantly different at the 5% level (N = 5).

TABLE 11

ROSA WOODSII

EFFECTS OF PROVENANCE ON 17 DEPENDENT VARIABLES
IN THE 1981 NATIVE SPECIES TRIAL

	Seedlot[1]		
Variable	WIL 1-76	WIL 2-78	WIL 3-78
Survival Rate (%)	97.8 a[2]	97.8 a	100.0 a
Vigor (1-4)	1.7 a	1.7 a	1.7 a
Height (cm)	54.3 a	53.5 a	47.4 a
Annual Height Increment (cm)	7.5 a	7.2 a	6.2 a
Stem Diameter (mm)	-	-	-
Crown Diameter (cm)	41.4 a	40.7 a	38.5 a
No. Stems/Plant	6.5 a	5.9 a	5.6 a
Cover (%)	24.5 a	22.4 a	20.0 a
Flowering Rate (%)	0.0 a	0.0 a	0.0 a
Fruiting Rate (%)	2.2 a	0.0 a	2.2 a
Dieback Rate - Current Year (%)	0.0 a	0.0 a	0.0 a
Dieback Rate - Previous Years (%)	93.3 a	81.4 a	77.8 a
Insect Damage Rate (%)	77.8 a	76.9 a	93.3 a
Girdling Rate (%)	0.0 a	0.0 a	0.0 a
Girdling/Plant Rate (%)	0.0 a	0.0 a	0.0 a
Rhizome Sprouting Rate (%)	93.3 a	87.8 a	93.3 a
Suckering Rate (%)	97.5 a	97.8 a	100.0 a

1 Seedlot numbers at the Alberta Tree Nursery.

2 Means followed by the same letter within a row are not significantly different at the 5% level (N = 5).

TABLE 12

PINUS BANKSIANA

EFFECTS OF PROVENANCE ON 17 DEPENDENT VARIABLES IN THE 1981 NATIVE SPECIES TRIAL

Variable	Seedlot[1]		
	JAC 1-78	JAC 2-78	JAC 3-78
Survival Rate (%)	95.6 a[2]	88.9 a	97.8 a
Vigor (1-4)	3.8 a	3.9 a	3.9 a
Height (cm)	158.4 a	166.8 a	154.3 a
Annual Height Increment (cm)	22.6 a	25.0 a	23.4 a
Stem Diameter (mm)	31.9 a	32.7 a	31.3 a
Crown Diameter (cm)	103.0 a	104.1 a	98.5 a
No. Stems/Plant	1.0 a	1.0 a	1.0 a
Cover (%)	64.3 a	53.0 a	58.0 a
Flowering Rate (%)	0.0 a	0.0 a	0.0 a
Fruiting Rate (%)	68.6 a	83.9 a	83.9 a
Dieback Rate - Current Year (%)	8.9 a	0.0 a	4.4 a
Dieback Rate - Previous Years (%)	16.2 a	0.0 a	0.0 a
Insect Damage Rate (%)	0.0 a	0.0 a	0.0 a
Girdling Rate (%)	0.0 a	0.0 a	0.0 a
Girdling/Plant Rate (%)	0.0 a	0.0 a	0.0 a
Rhizome Sprouting Rate (%)	0.0 a	0.0 a	0.0 a
Suckering Rate (%)	0.0 a	0.0 a	0.0 a

1 Seedlot numbers at the Alberta Tree Nursery.

2 Means followed by the same letter within a row are not significantly different at the 5% level (N = 5).

TABLE 13

VACCINIUM VITIS-IDAEA

EFFECTS OF PROVENANCE ON 17 DEPENDENT VARIABLES IN THE 1981 NATIVE SPECIES TRIAL

	Seedlot[1]		
Variable	BOG 2-79	BOG 4-79	BOG 5-79
Survival Rate (%)	62.2 a[2]	75.5 a	60.0 a
Vigor (1-4)	2.4 a	2.7 a	2.7 a
Height (cm)	2.7 a	3.3 a	2.3 a
Annual Height Increment (cm)	-	-	-
Stem Diameter (mm)	-	-	-
Crown Diameter (cm)	9.6 a	9.4 a	9.7 a
No. Stems/Plant	-	-	-
Cover (%)	2.5 a	2.5 a	2.5 a
Flowering Rate (%)	0.0 a	0.0 a	0.0 a
Fruiting Rate (%)	0.0 a	0.0 a	0.0 a
Dieback Rate - Current Year (%)	0.0 a	0.0 a	0.0 a
Dieback Rate - Previous Years (%)	0.0 a	0.0 a	0.0 a
Insect Damage Rate (%)	0.0 a	3.3 a	0.0 a
Girdling Rate (%)	0.0 a	0.0 a	0.0 a
Girdling/Plant Rate (%)	0.0 a	0.0 a	0.0 a
Rhizome Sprouting Rate (%)	16.2 b	35.2 b	56.0 a
Suckering Rate (%)	96.7 a	100.0 a	74.0 a

1 Seedlot numbers at the Alberta Tree Nursery.

2 Means followed by the same letter within a row are not significantly different at the 5% level (N = 5).

5. CONCLUSIONS AND RECOMMENDATIONS

1. The hybrid poplars, especially Northwest, Tristis #1, and Brooks #6 were the largest, fastest growing species. They appeared well adapted to the test site environment and may be useful in oil sands reclamation where rapidly growing trees are needed. Walker poplar had inconsistent results, performing well in one trial but poorly in another.
2. Of the native species, jack pine (Pinus banksiana) was the largest and fastest growing. It too appeared well adapted to the test site and can be recommended for oil sands reclamation.
3. Caragana (Caragana arborescens) performed very well and can be recommended for oil sands reclamation. Although not as tall and fast growing as some species, caragana produced a high ground cover and was free of dieback and insect damage.
4. White spruce (Picea glauca) and black spruce (Picea mariana) were adapted to the test site. However, they were much slower growing than jack pine or the poplars and would be less useful for rapid soil stabilization or cover development. Because they are relatively long-lived they would be more appropriate for longer-term reclamation objectives.
5. Crowberry (Empetrum nigrum) performed well in these trials. However, crowberry is a small, prostrate shrub that produced

very little ground cover. It would be of little use for erosion control unless planted at very high densities.

6. Dogwood (Cornus stolonifera) appeared well adapted to the test site and can be recommended for oil sands reclamation.

7. Elaeagnus commutata reproduced vigorously by rhizomes and appeared adapted to the test site.

8. Several species performed poorly and may not be adapted to the test site. These are: Acer negundo, Alnus tenuifolia/crispa, Elaeagnus angustifolia, Fraxinus pennsylvanica, Lonicera tartarica, Populus tremuloides, Rosa woodsii, Salix acutifolia, S. fragilis var. basfordiana, S. pentandra, and Ulmus pumila. Poor quality planting stock probably contributed to the poor performances of Elaeagnus angustifolia, Fraxinus pennsylvanica, Lonicera tartarica, and Populus tremuloides.

9. The remaining species had only mediocre performances and cannot at the present time be recommended for use in oil sands reclamation. They are: Betula glandulosa, B. papyrifera, and Vaccinium vitis-idaea. With the exception of V. vitis-idaea, these species survived well but suffered from low vigor and high rates of dieback. V. vitis-idaea had fair to good vigor and no dieback, but its survival rate was comparatively poor.

10. Girdling damage by small mammals was almost non-existent in these trials, probably because of the fine-mesh fencing erected around the trial site.

11. The test site is located in a small forest clearing and is relatively protected from winds. Many of the species planted

have survived and grown well. However, in more exposed areas species survival and growth rates may suffer.

12. Provenance had little effect on the measured variables in the native species trial. No superior or inferior provenances could be identified for any of the species. This suggests that genotypic differences among the provenances were small (all provenances were in northeastern Alberta).

13. The test site was designed to simulate an oil sands reclamation situation. However, because of logistical problems native sand rather than tailings sand (a waste by-product of the bitumen extraction process) was used in constructing the soil. The performance of trees and shrubs planted in native sand may not be indicative of their performance in tailings sand.

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