

SPECIES SUITABILITY FOR SAND DUNE RECLAMATION  
AT LESSER SLAVE LAKE, ALBERTA

By

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ABSTRACT

*Sand dunes in Lesser Slave Lake Provincial Park were severely disturbed by recreational overuse and sand excavation for highway construction. This study on the reclamation of sand dunes indicated that the species most successful in germinating and growing on the sand after hydromulching were Russian wild-rye (*Elymus junceus* Fisch.), Nordan wheatgrass (*Agropyron desertorum* (Fisch.)Schult.), pubescent wheatgrass (*A. trichophorum* (Link) Richt.), Alberta fescue (*Festuca arundinacea* Schreb.), fairway wheatgrass (*Agropyron cristatum* (L.) Gaertn.), perennial ryegrass (*Lolium perenna* L.), and sainfoin (*Onobrychis corniculatus* L.). Plantings of saskatoon wildings (*Amelanchier alnifolia* Nutt.), *Artemisia* cuttings (*Artemisia caudata*), and willow pole cuttings (*Salix* sp.) gave good results.*

RESUME

*Par suite d'usage excessif par les touristes et de l'exploitation de sablières, les dunes de sable dans le parc provincial de Lesser*

*Slave Lake* se trouvent dans un mauvais état. L'auteur, désirant régénérer la végétation sur ces dunes, trouva que les espèces qui réussirent le mieux à germer et pousser après hydropaillage sont l'*Elyme de Russie* (*Elymus junceus* Fisch.), l'*Agropyron Nordan* (*Agropyron desertorum* (Fisch.) Schult.), l'*Agropyron pubescent* (*A. trichophorum* Link), la *Fétuque de l'Alberta* (*Festuca arundinacea* Schreb.), l'*Agropyron cristatum* (L.) Gaertn., l'*Ivraie vivace* (*Lolium perenne* L.), et le *Sainfoin* (*Onobrychis corniculatus* L.). Il obtint aussi du succès avec la plantation de *sauvageons de Saskaton* (*Amelanchier alnifolia* Nutt.), des boutures d'*Armoise caudée* (*Artemisia caudata* Michx.) et des boutures de *perchis de Saules* (*Salix*).

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### *INTRODUCTION*

Sand dunes and other sand areas are widely distributed in Alberta, covering probably over a million acres of land. In spite of this wide distribution they cause little problem because they are protected by natural vegetation. However, sand dune vegetation is easily damaged by human activities, and the sand is then exposed to wind and water erosion. The subsequent damage is not restricted to the sand dunes, because the shifting sand may invade adjacent areas unless it is promptly revegetated.

Sand dunes in Lesser Slave Lake Provincial Park were severely disturbed by recreational overuse and sand excavation for highway construction. As a result, sections of the dune system were completely denuded of native vegetation, and sand began to shift away from Lesser Slave Lake.

Personnel of the Provincial Parks Branch stabilized the sand with snow fences parallel to the lakeshore. This produced three dunes about 3 meters (10 feet) high, with ridges about 30 meters (100 feet) apart. The dunes were hydroseeded by Western Canadian Erosion Control Ltd. in the first half of May, 1973. A mixture of species was used for seeding because there was little information on sand dune rehabilitation in Alberta.

This study identifies the most suitable species of commercially available seeds and local material for the stabilization of sand dunes in Alberta.

### STEPS IN RECLAMATION

Reclamation of sand areas usually begins with the checking of

sand movements with some mechanical barrier. Altpeter (1941) used both brush and lath fences and found the latter more effective. Sand movement can also be reduced by the application of chemicals and mulches. Zak and Wagner (1967) stopped sand shifting for 4.5 years by applying 2,000 liters/hectare (200 gallons/acre) fuel oil. However, the oil prevented the establishment of native vegetation around planted trees. Their experiments with asphalt mulch were not effective even at an application rate of 3,000 liters/hectare (300 gallons/acre). Mulching with manure, straw, and hay successfully stopped blows in Altpeter's experiments (1941).

The second step is to establish pioneer vegetation to stabilize the sand permanently and accumulate organic matter and nutrients in the sand. Grasses are most useful for this purpose. Legumes are mixed with the grasses for the nitrogen enrichment of the sand.

Wild rye (*Elymus arenarius* L.) and European beachgrass (*Ammophila arenaria* (L.) Link) were most successful in stabilizing sand in Vermont (Altpeter, 1941). Poverty grass (*Danthonia spicata* (L.) Beauv.) and hairy crabgrass (*Digitaria sanguinalis* (L.) Scop.) were used as complementary species. In the Midwest and Great Plains States switchgrass (*Panicum variegatum* Hort.), sand blue stem (*Andropogon halii* Hack.), giant sand reed (*Calamovilfa gigantea* (Mutt.) Scribn. and Merr.), Canadian wild rye (*Elymus canadensis* L.), western wheatgrass (*Agropyron smithii* Rydb.), and crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) were useful (U.S.D.A. 1948). Tall grasses generally were more effective sand binders than short grasses.

The third step is to establish woody vegetation or agricultural crop species. For the establishment of trees, direct seeding is not

recommended. Altpeter (1941) used 2+2 and 2+1 jack pine (*Pinus banksiana* Lamb.) and black locust (*Robinia pseudacacia* L.) seedlings with success in Vermont. In New Zealand, Gadgil (1971) planted Monterey pine (*Pinus radiata* D. Dor) 4.5 years after the establishment of a *Lupinus arboreus* stand on coastal sand dunes.

Sand dune reclamation procedures tested in the United States should be applied with caution in Alberta, primarily because of different climatic conditions. However, the main steps of the reclamation procedure can be followed and some of the grass species may be useful in central Alberta.

#### DESCRIPTION OF THE STUDY AREA

The study area is located in the Lesser Slave Lake Basin in central Alberta at approximately 55°20' north latitude and 114°46' longitude (Figure 1).

The area is part of the Lesser Slave Lake Lowland, at an elevation of approximately 576 meters (1,920 feet) above mean sea level. The topography is generally level, with sand dunes near the lakeshore.

The climate is humid continental with short, cool summers and long, cold winters. The average number of frost-free days is 80. The dominant wind directions are southwest and west, representing over 50% of wind frequency (Longley, 1968). The average potential evapotranspiration is 14-18 inches, somewhat less than the mean annual precipitation (Government and University of Alberta, 1969). Monthly temperature and precipitation data for Slave Lake are summarized in Table 1.

Soils of the study area have been described briefly by Wynnyk *et al.* (1963). About 80% of the area is covered with peat moss bogs, and

the other 20% is mostly sand with some gravelly outwash. Soils on the mineral parent material were classified as Bisequa Gray Wooded, Gray Wooded, or Podzols. Podzols occur mainly on stabilized sand dunes with mature vegetation.

The new sand dunes lack soil development and are classified as Regosols. They are almost free of organic matter or clay and have low moisture-holding capacity and nutrient content.

The climax vegetation of the sand dunes is jack pine or lodge-pole pine (*Pinus contorta* Loudon var. *latifolia* Engelm.) forest. Other tree species in the area are balsam poplar (*Populus balsamifera* L.), aspen (*P. tremuloides* Michx.), and paper birch (*Betula papyrifera* Marsh.). Most frequent shrubs are chokecherry (*Prunus virginiana* L.), saskatoon berry (*Amelanchier alnifolia* Nutt.), and wild rose species (*Rosa*). Common species in the ground cover are bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.), hairy wild rye (*Elymus innovatus* Beal), three-leaved Solomon's seal (*Smilacina trifolia* (L.) Desf.), and twin-flower (*Linnaea borealis* L.).

#### METHODS

The performance of 14 grass species, 5 legumes, and 5 woody species was tested in four different topographic positions on the sand dunes.

#### PLOT LAYOUT

Sample plots were laid out in four topographic positions: dune crest, low between two dunes, northwest dune side and southeast dune side. There were four sample plots in each topographic position. The plots were 4.5 by 5.4 meters or 9 by 2.7 meters (5 by 6 yards or 10 by 3 yards) in size, divided up into thirty 0.9 by 0.9 meter (1-square-yard) sub-plots.

The seeds of a grass species or the cuttings of a woody species were placed in the sub-plots (Figures 2 and 3).

#### SEEDING AND PLANTING METHODS

Grasses and legumes were hand-seeded, using 275 milliliters ( $\frac{1}{2}$  cup) of seed for each sub-plot. The species used in the experiment are listed in Table 2.

Cuttings of willow (*Salix* sp.), Artemisia, and balsam poplar were collected in the fall of 1972 and in May 1973, a few days before planting. Those collected in the fall were cold-stored until planting and all cuttings were coated with curasol for moisture retention.

Willow cuttings were planted vertically or obliquely, five in each sub-plot. Willow poles 2.5-5 centimeters ( $\frac{1}{2}$  inches) in diameter were planted vertically or obliquely, one in each sub-plot. Cuttings of balsam poplar and Artemisia (*Artemisia caudata*) were planted vertically, five in each sub-plot. Saskatoon berry wildings were transplanted into holes dug with a shovel, five into each sub-plot. Native sod clumps (hairy wild rye) were transplanted three to a sub-plot.

All seeding and planting was carried out between May 3 and 11, 1973, and seeds used in the experiment were rated Canada - 1.

#### SURFACE TREATMENT

The sample plots were sprayed with the following hydromulch after seeding and planting:

<u>Mulch Component</u>	<u>Rate of Application</u>
Fertilizer 10 - 30 - 10 40 - 0 - 0	225 kilograms/hectare (200 pounds/acre)
Milorganite (sludge)	225 kilograms/hectare (200 pounds/acre)

Curasol AK	75-150 liters (30-60 gallons/acre)
Curasol AH (water resistant)	75-162 liters (30-65 gallons/acre)
Tylose 666 (thickener)	79-140 kilograms (70-120 pounds/acre)

## EVALUATION

Performance of the different species was surveyed on October 10 and 11, 1973. Grasses and legumes were evaluated by their average height and by the area they covered in the sub-plots. In addition, the number of individual stems in the legumes was counted to estimate their relative germination capacity in the field.

An index was developed for comparative estimate of the produced biomass above ground by using the product of the area covered (A) and the average height (H).

$$\text{Biomass Index} = A(\text{cm}^2) H(\text{cm})$$

Cuttings and transplants were evaluated as the number of surviving individuals. The analysis of variance technique and Duncan's multiple range test were used for species performance evaluation.

## RESULTS

### PERFORMANCE OF GRASSES AND LEGUMES

#### Cover

The areas covered by all species are compared in Table 3. These data are overall means for each species in all topographic positions. Nordan wheatgrass covered a significantly larger area than other species after the first growing season. The best coverage among the legumes was achieved by sainfoin, which covered an area about six times as large as the next most successful legume.

The topographic position on the dunes influenced the performance of legumes and grasses. The area covered by vegetation was significantly smaller on the dune crest than in any other topographic position:

Topographic Position	Area Covered by Vegetation cm <sup>2</sup>
Northwest Side	1,168
Low Between Dunes	1,165
Southeast Side	1,009
Dune Crest	379

Standard Error ( $\bar{Sx}$ ) = 95; Any two means not connected by the same line are significantly different at the 95% probability level.

Species performance was compared separately in each topographic position to find the species best suited to a particular edaphic situation. On the dune crest only nordan wheatgrass covered a significantly larger area than most of the other species. The best performer among the legumes was sainfoin, but the differences were not statistically significant.

Alberta fescue, Russian wild rye, and perennial ryegrass were the most successful on the northwest dune side; sainfoin was the best legume in this topographic position too, but its lead was not statistically significant. Nordan wheatgrass, pubescent wheatgrass, fairway wheatgrass, and perennial rye grass had the greatest area cover on the southeast dune side; while nordan wheatgrass, sainfoin, and pubescent wheatgrass were the best in the lows between dunes (Table 7).

#### Height growth

The height growth of grasses and legumes was dominated by the

native sod clumps, Russian wild-rye, and Indian rice grass in all topographic positions (Table 4). Average heights on the dune crests were significantly lower than heights on the southeast and northwest dune sides or in the lows between dunes:

Topographic Position	Average Height cm
Low Between Dunes	14
Northwest Side	14
Southeast Side	13
Dune Crest	10

Standard Error ( $\bar{Sx}$ ) = 0.79; Any two means not connected by the same line are significantly different at the 95% probability level.

Sweet clover had the best height growth among the legumes in all topographic positions with the exception of dune crests, where sainfoin was the best.

#### Biomass index

The comparative biomass index was developed from vegetation height and area cover to estimate the volume of vegetable production without the destruction of the sample plots.

The highest values of biomass indices were attained by Russian wild-rye, native sod clumps, and nordan wheatgrass in all topographic positions (Table 5). Of the five legumes sainfoin showed the best results, although not always significantly better than the other legumes.

Topographic position had a significant effect on biomass production. Plants on the dune crest had a biomass index (5122) of about

only one-quarter that of the other positions (20176, 20666, and 22461).

Since the biomass index combines the heights with the area cover, it may be used as a measure of species suitability for sand dune reclamation in general or in a specific topographic position.

#### Germination of legumes

Germination of legumes was evaluated as the number of seedlings produced from approximately equal volumes of seeds on a 0.81-square-meter (1-square-yard) area. Germination capacity of all seeds was between 80% and 90%.

The best rate of germination for all species was obtained in the lows between dunes, and the poorest was on the dune crests:

Topographic Position	No. of Germinants/0.81 square meter (square yard)
Low Between Dunes	70
Northwest Dune Side	47
Southeast Dune Side	36
Dune Crest	31

$\bar{S}_x = 8.85$ : Any two means not connected by the same line are significantly different at the 95% probability level.

Sainfoin produced significantly more seedlings (142) from equal volume of seeds than any other legume in all topographic positions. Crown vetch, trefoil, milk vetch, and sweet clover produced only 29,22,18 and 17 seedlings per 0.81 square meter (1 square yard) respectively. The difference between the germination of sainfoin and the other legumes would have been even greater if an equal number of seeds had been planted

for each species, because the number of sainfoin seeds in an equal volume is only about one-quarter to one-tenth that of the other legume seeds used in the experiment.

#### SURVIVAL OF PLANTED WOODY SPECIES

Table 6 shows the survival rate of planted woody species. Transplanted saskatoon wildings had the best survival (17 per 20 planted), followed by *Artemisia* cuttings (10 per 20 planted). Poplar and willow cuttings performed poorly, with only 3 poplar and 2 willows surviving of the 20 of each planted.

Topographic position did not have a significant influence on survival, and neither did the method of planting the willow cuttings (vertical or oblique) have a significant effect on survival in any topographic position.

Willow pole cuttings had a survival rate of 3 per 5 planted, much better than the rate for the willow twig cuttings. The topographic position significantly affected the survival of willow pole cuttings (Table 7). The number of survivors was higher on the dune sides than on the dune crests or in the lows between the dunes. The method of planting (vertical or oblique) did not influence the survival of the willow poles in the overall results. However, vertical planting was more successful than the oblique on the dune crests, while the oblique planting was the better in the lows between the dunes.

Detailed data on the performance of all species in different topographic positions are available on request from the author.

*DISCUSSION*

The first step in the reclamation of sand dunes in Lesser Slave Lake Provincial Park was the mechanical control of the sand with the help of lath fences. These fences accumulated the sand in dunes but did not entirely stop the movement of the sand. Therefore, further stabilization of the sand was necessary with hydromulching, as described in *Methods*. The hydromulch formed a thin crust on the surface of the sand which was permeable to water but effectively bound the sand grains, preventing their movement. However, some sand accumulated along the fences on the dune crest from sources outside the mulched area. The hydromulch crust was effective at least during one growing season, because the sprayed area was protected from foot traffic. The crust has a tendency to break up under footsteps and the wind is then able to roll the crust up, exposing the sand to wind erosion.

Hydromulch improves the germination of seeds already in the ground by conserving moisture. Improved moisture conditions and stabilization probably assisted the establishment of Russian thistle (*Salsola Kali* var. *tenuifolia*), which invaded the dunes in 1972 before hydromulching. During the following growing season this annual plant germinated on the sand dunes in large numbers; however, most plants were lost during the first winter because they have a tendency to break at the base and be tumbled away by the wind. The establishment of a new stand in the 1974 growing season is not expected because the hydromulch crust will probably prevent the penetration of Russian thistle seeds into the sand. However, in the single growing season this weed provided valuable shelter for the young grass seedlings sown before hydromulching. The combined cover of

seeded and volunteer plants is compared to conditions before seeding in Figures 4 and 5.

### CONCLUSIONS

The most successful grasses in the species suitability experiment were Russian wild-rye, native sod clumps (*Elymus innovatus*), and nordan wheatgrass. These are tall perennial grasses similar to those found to be successful in the American Middle West (U.S.D.A., 1948). Prairie sandreed and Indian ricegrass, which are related to some of the most suitable sand-binding species in the U.S.A., showed inferior performance in central Alberta. The height growth of Indian ricegrass was satisfactory, but its germination fell much behind that of the most successful species. Canada bluegrass, rough fescue, bluegrass, prairie sandreed, red fescue, and hard fescue had both small cover and stunted height growth.

The overall results suggest that the number of grass species used in the area may be reduced to six: Russian wild-rye, nordan wheatgrass, pubescent wheatgrass, Alberta fescue, fairway wheatgrass, and perennial rye-grass. The transplanted native sod clumps were very successful but the high expense of transplanting would limit their large-scale use.

Of the five legumes only sainfoin seems suitable for sand dune reclamation. The other species, with the exception of sweet clover, exhibited both poor germination and stunted growth. The growth of sweet clover was poor on the dune crest, but was better than that of the sainfoin in all other topographic positions. However, its germination was low in all positions.

The superior germination of sainfoin may be due to its seed size, which is more than 10 times larger than seeds of the other tested legumes. The larger seeds can resist dessication better than small seeds.

Of the plantings of woody species, only saskatoons, *Artemisia* cuttings, and willow pole cuttings were successful. Poplar and willow twig cuttings had very poor survival. It is possible that their water supply was not sufficient because of the relatively shallow settings. Costin (1959) in Romania used 5-foot long poplar cuttings planted vertically and buried entirely by the sand. The success rate for these cuttings after two growing seasons was 85.4%, while all other cuttings and rooted seedlings failed, even with the addition of humus to the sand.

The results of this study may have application for sand stabilization at lower elevations in Alberta and Saskatchewan. The findings also may be useful in tar sands reclamation work, because the well-drained tar sands tailings are very similar to sand dunes in their physical properties and nutritional qualities.

*RECOMMENDED PROCEDURE FOR SAND STABILIZATION*

The following steps are recommended for the reclamation of shifting sand areas in north-central Alberta:

- 1) Preparation of topography by rounding of sharp ridges and reducing steep slopes.
- 2) Control of large-scale sand movement by fences more or less perpendicular to the dominant wind direction. The distance between fences should not be greater than 20 times the height of the fence.
- 3) Stabilization of the sand with pioneer grasses and forbs. Early spring seeding is recommended to utilize the water supplied by snow melt.
- 4) Hydromulching after seeding to prevent drifting of the seeds.
- 5) While cuttings or seedlings of drought-tolerant shrubs may be planted at the time of seeding, trees should be introduced only 2 or 3 years after the establishment of protective grass cover. Direct seeding of trees is not recommended. Trees should be planted as large cuttings or at least 2-year-old seedlings in the case of the conifers.

A good supply of fertilizers is also necessary in the first two or three years of the revegetation because the nutrient content of shifting sands is very low.

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Table 1. Mean daily temperatures in C° and F° and precipitation in millimeters and inches at Slave Lake.

Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Mean Daily	-16.8	-13.3	-6.8	2.7	9.5	12.9	15.9	14.2	9.5	3.6	-5.7	-13.4	1.0
Temperature	1.7	7.3	19.8	36.9	49.1	55.3	60.6	57.6	49.1	38.5	21.7	7.9	33.8
Mean Total	24	23	21	22	43	66	81	65	43	29	27	25	466
Precipitation	0.95	0.91	0.83	0.85	1.71	2.60	3.02	2.55	1.70	1.15	1.05	1.00	18.32

Table 2. Grass and legume species used in the experiment.

SPECIES	COMMON NAME
<i>Agropyron cristatum</i> (L.) Gaertn.	Fairway wheatgrass
<i>Agropyron dasystachyum</i> (Hook.) Scribn.	Thick spike wheatgrass
<i>Agropyron trichophorum</i> (Link) Richt.	Pubescent wheatgrass
<i>Agropyron desertorum</i> (Fisch.) Schult.	Nordan wheatgrass
<i>Festuca rubra</i> L.	Red fescue
<i>Festuca scabrella</i> Torr.	Rough fescue
<i>Festuca ovina</i> var. <i>duriuscula</i> A. Gray	Hard fescue (Durar)
<i>Festuca arundinacea</i> Schreb.	Alberta fescue
<i>Lolium perenne</i> L.	Perennial ryegrass
<i>Poa compressa</i> L.	Canada bluegrass
<i>Poa glaucantha</i> Gaudin	Bluegrass
<i>Calamovilfa longifolia</i> (Hook.) Scribn.	Prairie sandreed
<i>Orysopsis hymenoides</i> (Roem. and Schult.) Ricker	Indian ricegrass
<i>Elymus junceus</i> Fisch.	Russian wild-rye
<i>Melilotus</i> sp.	Sweet clover 1-7007
<i>Astragalus cicer</i> L.	Cirer milk vetch
<i>Coronilla varia</i> L.	Crown vetch
<i>Onobrychis sativa</i> Lam.	Sainfoin
<i>Lotus corniculatus</i> L.	Bird's Foot Trefoil

Table 3. Average cover of grasses and legumes in descending order in all topographic positions

SPECIES	AREA COVERED cm <sup>2</sup>
Nordan wheatgrass	2759
Pubescent wheatgrass	1949
Sainfoin	1948
Russian wild-rye	1767
Perennial ryegrass	1737
Alberta fescue	1631
Native sod clumps	1377
Fairway wheatgrass	1271
Hard fescue (Durar)	1019
Red fescue	757
Thick spiked wheatgrass	714
Sweetclover	350
Crown vetch	244
Prairie sandreed	236
Cicer milk vetch	188
Indian ricegrass	186
Trefoil	165
Rough fescue	157
Bluegrass	142
Canada bluegrass	111

Any two means not connected with the same line are significantly different at the 95% probability level.

$\bar{Sx} = 242.23$

Table 4 Average height growth of grasses and legumes in all topographic positions.

SPECIES	HEIGHT (cm)
Native sod clump	42
Russian wild-rye	40
Indian ricegrass	39
Nordan wheatgrass	18
Sweetclover	14
Bluegrass	12
Fairway wheatgrass	11
Alberta fescue	10
Pubescent wheatgrass	10
Thick spiked wheatgrass	10
Prairie sandreed	9
Sainfoin	9
Canada bluegrass	9
Perennial ryegrass	8
Crown vetch	7
Rough fescue	7
Trefoil	6
Cicer milk vetch	6
Hard fescue	6
Red fescue	5

Any two means not connected with the same line are significantly different at the 95% probability level.

$\bar{S}_x = 1.78$

Table 5      Average biomass index for grasses and legumes in all topographic positions.

SPECIES	BIOMASS INDEX
Russian wild-rye	78761
Native sod clumps	71280
Nordan wheatgrass	51739
Sainfoin	20428
Pubescent wheatgrass	20351
Alberta fescue	19264
Fairway wheatgrass	16609
Perennial ryegrass	16082
Thick spiked wheatgrass	8652
Indian ricegrass	8499
Sweetclover	7429
Hard fescue	6657
Red fescue	4771
Prairie sandreed	2591
Crown vetch	1900
Bluegrass	1732
Trefoil	1445
Cicer milk vetch	1439
Rough fescue	1306
Canada bluegrass	1189

Any two means not connected with the same line are significantly different at the 95% probability level.

$\bar{S}_x = 5393$

Table 6 Survival of cuttings and planted trees.

SPECIES	SURVIVED OUT OF 20
Saskatoon and cherry (seedlings)	17
Artemisia	10
Poplar cutting	3
Willow cutting (vertical)	2
Willow cutting (horizontal)	2

Any two means not connected by the same line are significantly different at the 99% probability level. Standard error of a varietal means

$$\bar{Sx} = 0.92$$

Table 7. Survival of willow pole cuttings as influences by topographic position and planting method. The total number of willow poles was 4 per treatment.

POSITION	M E T H O D		TOTAL
	VERTICAL	OBLIQUE	
N.W. Dune Side	3	3	6
S.E. Dune Side	3	3	6
Dune Crest	3	1	4
Low	1	3	4

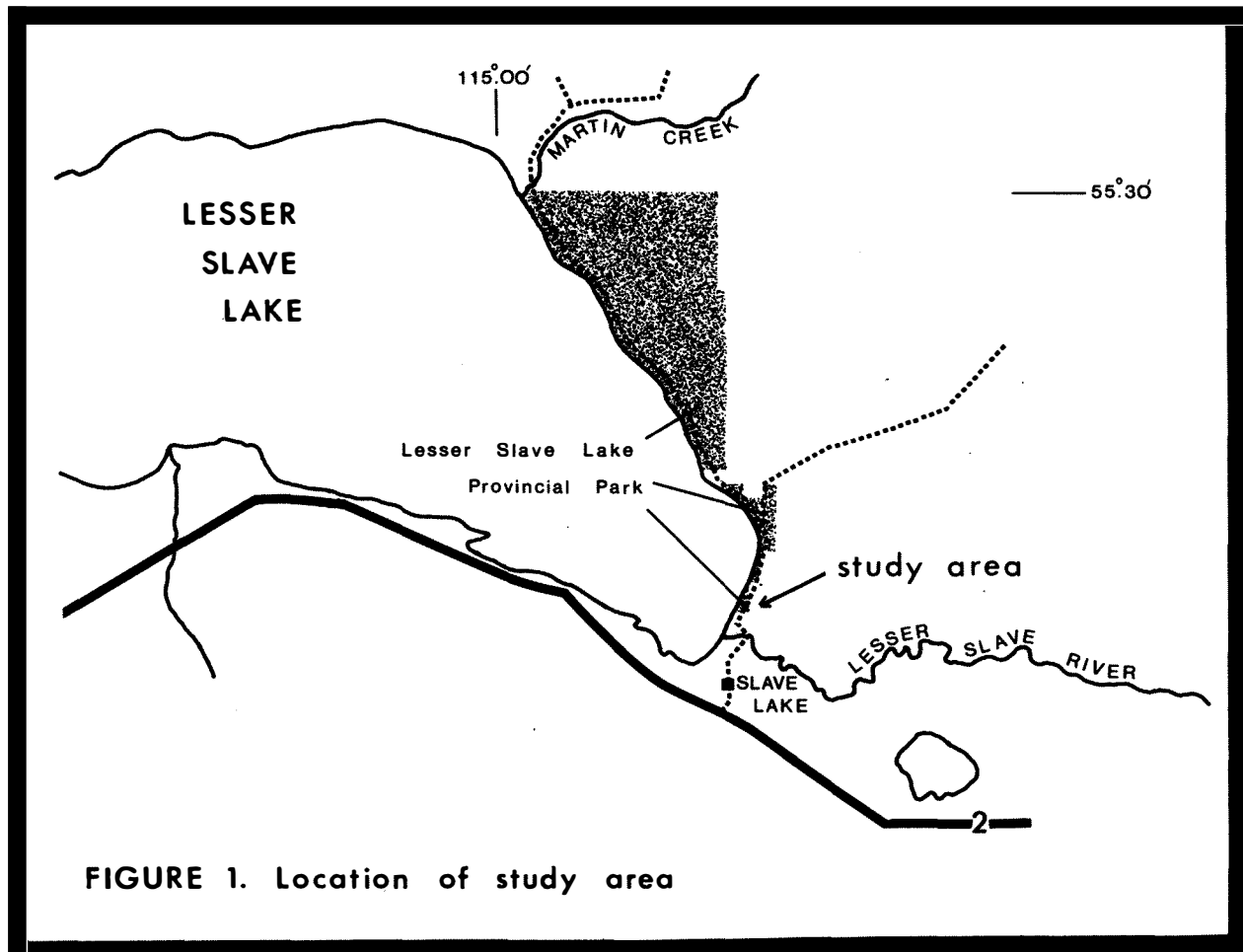




Figure 2. Hand seeding in the sample plots.



Figure 3. Plot lay-out on dune side and in the low between two dunes.



Figure 4. The study area before seeding.



Figure 5. The study area after one growing season.