FURTHER SITE INVESTIGATION FOR LOCATION OF ALBERTA FOREST SERVICE TREE NURSERY

by

I. K. Edwards and W. D. Holland

NORTHERN FOREST RESEARCH CENTRE
INFORMATION REPORT NOR-X-78
DECEMBER, 1973

CANADIAN FORESTRY SERVICE
DEPARTMENT OF THE ENVIRONMENT
5320 - 122 STREET
EDMONTON, ALBERTA, CANADA
T6H 3S5

TABLE OF CONTENTS

FURTHER SITE INVESTIGATION FOR LOCATION OF ALBERTA FOREST SERVICE TREE NURSERY

by

I. K. Edwards and W. D. Holland

ABSTRACT

In a previous investigation, 17 sites were examined; three were considered potential tree nursery sites and selected for more detailed study. They are located near Grande Prairie, Egremont and High Prairie. Soil profiles were examined at each site (eight at Grande Prairie, two at Egremont and six at High Prairie); the horizons were described, sampled and analysed physically and chemically. Water samples were also collected and analysed.

Grande Prairie has the longest frost-free period (108 days) compared to that near Egremont (79 days) and at High Prairie (84 days). The High Prairie site is unsuitable because it may be situated in a frost-pocket and also because of its gently undulating to rolling topography (up to 7% slope). Grande Prairie and Egremont are level to gently undulating (up to 3% and 2% slope, respectively). The incidence of disease at Grande Prairie and Egremont is negligible but High Prairie is severely infested with mistletoe and, to a lesser extent, spruce gall rust.

The soil is shallowest at Egremont (21 inches) and deepest at Grande Prairie (19-47 inches) therefore levelling would be most feasible at the latter site. The water table was highest at Egremont (47-72 inches). At Grande Prairie, it was at 58-126 inches and at High Prairie it was deeper than 111 inches.

All sites are acid (pH 5.4 - 5.8). Grande Prairie is loamy sand and more suitable for a nursery than either Egremont or High Prairie which are sands.

The soils are low in soluble salts. Carbonate is not present at Egremont and deep enough at the other sites to offer no soil management problem. Except for phosphorus, fertility is very low at all sites. Peat at 300-400 cu. yards/acre, nitrogen at 100 lbs./acre and potassium at 80 lbs./acre are recommended for any of the sites selected.

Water samples from High Prairie were of highest quality although other sources excluding the bog at Grande Prairie could be used after appropriate acidification.

The sites, as ranked in decreasing order of suitability, are, 1) Grande Prairie, 2) Egremont and 3) High Prairie.

INTRODUCTION

Our previous report (1) represented the first phase of a two-step approach to the selection of a suitable tree nursery site by the Alberta Forest Service (A.F.S.). Phase One consisted of the examination of 17 sites, nine of which were sampled and analysed in detail. The remainder were eliminated from further consideration because of obvious limitations such as climate, topography, location of labour and distance from service centres. Laboratory analysis indicated no suitable sites among those sampled although one prospect was identified. Aerial photographs and soil survey reports indicated two other sites that might be of the required texture and acreage and all three were sampled and analysed.

This report - Phase Two - presents the results of a more detailed examination of these sites (Grande Prairie, Egremont and High Prairie) shown in Figure 1.

METHODS

Site requirements and sampling techniques have been outlined previously (1). However, sampling of these three sites was more intensive. Eight soil pits were dug at the Grande Prairie site; two were at Egremont and six were at High Prairie. The Ae, Bm and C horizons were sampled but the L-H horizon was excluded because of shallow depth. In some cases the profiles were sampled to the depth of the water table. The soil distribution and location of the sampled pits are shown in Figures 2, 3 and 4. At Grande Prairie, peat from an adjacent sphagnum bog was also collected and analysed.

All soil samples were air-dried and crushed to pass through a 2 mm sieve. Besides texture, pH, electrical conductivity (E.C.) and organic matter (O.M.), the samples were analysed for nitrate nitrogen (NO_3-N), available phosphorus (P), exchangeable calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na).

Texture, electrical conductivity and organic matter were determined according to the methods mentioned earlier (1). The pH was determined in a soil-$CaCl_2$ mixture (2, p. 47). Nitrate nitrogen was extracted with copper sulphate and determined colorimetrically (2, p. 197). Available phosphorus was extracted with sodium bicarbonate and determined colorimetrically by the ascorbic acid method (10). Exchangeable bases were determined by a Perkin Elmer Model 303 atomic absorption spectrophotometer following extraction with ammonium acetate (2, p. 66). The presence of carbonate was determined with 10 percent hydrochloric acid. The sample of peat was analysed for pH and electrical conductivity.

Water samples were collected near the sites and analysed. At Grande Prairie, water was collected from a nearby pond and from three adjacent poorly-drained sites (water table: 24-30 inches deep) including a sphagnum-peat bog. At High Prairie, the samples were taken from the North Heart River near the site and from the South Heart River seven miles north of the townsite. At Egremont, a creek north of the site and the Redwater River (south of the site) were sampled.

The samples were analysed for pH, electrical conductivity (or soluble salt concentration), calcium, magnesium, sodium, potassium,

sulphate, chloride, carbonate and bicarbonate according to methods used at the United States Salinity Laboratory (8). In the course of the bicarbonate determination, data were obtained for computing the amount of sulphuric acid that would be required to lower the pH of the water to 6.0.

SITE DESCRIPTION

The three potential nursery locations are given in Figure 1 and Table 1. Mean elevations are given in Table 2. Comparison of the three sites is in Table 3. Each site is described separately.

Grande Prairie:

This site is located approximately 4 miles west and 7 miles south of Grande Prairie. Major vegetation cover consists of 80-85-year-old hybrids of lodgepole pine (Pinus contorta) and jack pine (P. banksiana). Aspen (Populus tremuloides) and white birch (Betula papyrifera) are less common. The understory include kinikinikk (Arctostaphylos uva-ursi), rose (Rosa acicularis), blueberry (Vaccinium spp.), reindeer moss (Cladonia spp.), saskatoon (Amelanchier alnifolia), sedge (Carex spp.) and alder (Alnus spp.) in depressions and several grasses. There is evidence of one severe fire about 120 years ago and at least three recent (within 20 years) ground fires.

The site has two well-drained soils: Leith and Heart series (5). Poorly drained, organic soils are represented by the Eaglesham and Kenzie series, thus providing two kinds of organic soils for amelioration of the mineral soils. The distribution of these soils is shown in Figure 2 and on a separate photo mosaic (scale 8" = 1 mile;

1 copy only to the A.F.S.). In the figure, only the well drained soils are suitable for a tree nursery.

A representative profile of the Heart series (GP-1) is described as follows:

Horizon	Average Depth in Inches	Coarse Fragments %	Dry Color	Texture	Consistence	pH $CaCl_2$
L-H	Approximately 1" of litter; too thin to sample					
Ae	0-5 Min. 3	0	Brown	Loamy sand	Loose	5.5
Bm_1	5-20 Min. 10	1%	Yellowish brown	Loamy sand	Loose	5.6
Bm_2	20-47 Min. 9	0	Yellowish brown	Loamy sand	Loose	5.7
C	47-101	0	Dark grayish brown	Sand	Loose	7.2
IIC	101-138	0	Light brownish gray	Silty clay loam at 102" gradually changing to sandy loam at 138"	Firm, becoming loose at 138"	7.5

Long, gentle slopes up to 3% were encountered. However, this should present no problem in the design and layout of a nursery. Some levelling could be done where the C horizon is 4 feet from the surface but this might produce a dangerously shallow solum in places where the C horizon is as close as 19 inches to the surface (Table 1).

This site has the soil qualities desirable for a coniferous tree nursery (9). However, it does have a severe wind-erosion hazard,

thus requiring shelterbelt protection. Addition of irrigation water is not expected to affect the water table significantly. One precaution would be a grid series of borings to establish the contour of the underlying silty clay loam IIC horizon. The site is free of disease except for a minor occurrence of spruce gall rust. A sphagnum bog is adjacent to the site and is a possible source of peat for soil amendment.

Egremont:

This site is located approximately 4 miles west of Egremont. The vegetation consists of an open stand of 20-year-old jack pine and aspen. Rose and blueberry are very common among the lower vegetation. No tree diseases are evident. The mineral soil is predominantly Nestow series (3). There are some adjacent Organic and Gleysolic soils. The distribution of these soils is given in Figure 3 and on a separate photo mosaic (8" = 1 mile; 1 copy to the A.F.S.). Only the well-drained soils are suitable for a tree nursery.

A Nestow profile (EG-9) description follows:

Horizon	Average Depth in Inches	Coarse Fragments	Dry Color	Texture	Consistence	pH $CaCl_2$
L-H	Less than 1 inch; not present in grassy areas; too thin to sample					
Aej	0-3 Min. 1 Max. 3	0	Brown	Sand	Loose	5.2
Bm_1	3-10 Min. 6 Max. 9	0	Yellowish brown	Sand	Loose	5.2
Bm_2	10-21 Min. 6 Max. 12	0	Reddish yellow (slightly mottled)	Sand	Loose	4.8
Cg_1	21-37 Min. 14 Max. 18	0	Light yellowish brown (strongly mottled)	Sand	Loose	5.0
Cg_2	37-41 Min. 10 Max. 12	0	Yellowish brown (strongly mottled)	Sand	Loose	4.9

Further information is available ((3), Table X and p. 72). The topography presents no site limitations. Minimum depth to the water table was 46 inches, the shallowest encountered at any of the three sites and mottling occurred less than 24 inches from the surface. Shelterbelts are necessary to prevent wind erosion. The frost-free period at Thorhild (8 miles north of the site) is 79 days and this suggests a definite climatic limitation to the use of the Egremont site for a tree nursery.

NW21, Tp58, R22, W4 has an established poultry farm on it and use of this portion of land for a tree nursery is not advisable because of probable high levels of nitrates in the soil. The south half of Section 29 has a number of gas wells and associated access roadways that may be awkward for planning field layout.

High Prairie:

This site is located approximately 9 miles north and 3 miles west of High Prairie. It supports multi-age, homogeneous stands of jack pine: some 30 years old and others 150 years old. Other vegetation consists mainly of kinikinikk and reindeer moss.

The mineral soil is predominantly Heart series (4). Organic soils, Kenzie series, are to the north. The distribution of these soils is given in Figure 4 and on a separate photo mosaic (8" = 1 mile; 1 copy to the A.F.S.). The soils designated as well-drained are the only areas suitable for a tree nursery.

A Heart soil profile (HP-11) is described below:

Horizon	Average Depth in Inches	Coarse Fragments	Dry Color	Texture	Consistence	pH $CaCl_2$
L-H	Usually less than 1"; not sampled					
Ae	0-4	0	Brown	Sand	Loose	5.4
Bm_1	4-22	0	Light yellowish brown	Sand	Loose	4.9
Bm_2	22-40	0	Brownish yellow	Sand	Loose	5.3
BC	40-51	0	Pale brown	Sand	Loose	5.4
C	51-111	0	Pale brown	Sand	Loose	7.1

While the described profile indicates lack of coarse fragments, it should be noted from Figure 4 and the accompanying photo mosaic that gravel pits occur to the west and gravel was found in four of the six profiles examined. The minimum depth at which gravel occurs is 9 inches (HP-13) and is found mostly in the BC and C horizons. Gravel does not appear to be a problem over most of the area and could help to maintain a low water table.

The pH values are acceptable. The main limitations to the use of this site for a tree nursery are undulating topography especially in a north-south direction (slopes up to 7%); low number of frost-free days (84), topographic position which indicates the possible existence of a frost pocket, and severe infestation of mistletoe. Spruce gall rust is common. On account of the mistletoe, proper sanitation would necessitate clearing of a buffer strip at least one-half mile beyond the perimeter of a nursery located at the site. Wind erosion is a potential hazard; shelterbelts and snow-fences would help to prevent this.

RESULTS AND DISCUSSION

Soil Analyses. The results of physical and chemical analyses of the soil samples are shown in Table 4.

pH. The Grande Prairie and High Prairie sites are strongly acid in the Ae (pH 5.5 - 6.2) and B horizons (pH 5.6 - 6.1) only while the C horizon is slightly to moderately alkaline (pH 7.1 - 7.7). Egremont, on the other hand, is strongly acid throughout the profile with pH ranging from 5.2 in the Ae horizon to 4.9 - 5.5 in the C horizon.

In most cases, the B horizon extends beyond 24 inches and there is no limitation of any of these areas on account of pH. On the contrary, a range of 5.0 - 6.0 is ideal for conifer production (6, 7, 11).

Electrical Conductivity. Although conductivity increased with depth on all sites (0.01 to 0.11) the values are sufficiently low to pose no salinity problem for plant growth.

Texture. At the Grande Prairie site, the Ae and Bm horizons are loamy sand. The C horizons are generally of coarser texture although some IIC horizons were clay loam, silty clay loam, sandy clay loam, and sandy loam. These finer textured horizons were at least 36 inches from the surface and there was no evidence of impeded drainage in any of the profiles examined. Soils from Egremont are entirely sand throughout the profiles. In all horizons at High Prairie, the <2mm fraction was classified as sand. However, gravel formed a substantial portion of the lower horizons in some pits, ranging from 14 percent to 81 percent in the Bm_2, BC and C horizons. At Pit #13, gravel was found at 9 inches but generally it was found below 18 inches.

Textural analyses indicate that the Grande Prairie site is most suitable. Loamy sand is the ideal texture for conifer nurseries (6, 7). There is also sufficient depth of loamy sand below the root zone to offer good but not excessive drainage following irrigation. Finer textured zones are too thin and deep to appreciably influence drainage within the root zone.

Carbonate. Reaction to hydrochloric acid was confined to the C, IIC and Ck horizons in all the pits examined at Grande Prairie

but was no closer to the surface than 19-20 inches. No carbonate was detected in any of the Egremont soils. With one exception, Pit #12, soils at High Prairie contained carbonate. It was confined to the C horizons (below 40 inches) except in Pit #16 where the BC horizon (30-37 inches) contained carbonate.

At both the Grande Prairie and High Prairie sites, carbonate was observed along root channels and as a coating on some stones. Highly calcareous Ck horizons were found at three of the Grande Prairie pits but these were much deeper than the root zone. Free carbonate should not be a limitation to growth on either of these sites especially since drainage appears to be good.

Organic Matter. Organic matter is very low at all three sites. An acceptable range is 5-8 percent. At Grande Prairie, surface soils range from 0.43 - 1.23 percent. It is only 0.68 - 0.74 percent at Egremont and 0.52 - 0.82 percent at High Prairie. Generally, organic matter decreased with an increase in depth but in a few instances, such as Pit #5, some sub-soils contained higher levels of organic matter than surface soils. This could result from accumulation along root channels following transport by water.

In the efficient use of any of these sites for conifer production, additional organic matter as peat, perhaps 2-3 inches (300-400 cu. yards/acre) would be required. This would improve soil structure and increase its capacity to retain moisture and nutrients. Therefore proximity to an adequate supply of peat and haulage costs should be considered in the selection of a site.

Nitrate Nitrogen (NO_3-N). No nitrate nitrogen was found in any of the samples analysed. The supply of NO_3-N is an indication of easily available nitrogen in the soil at the time of sampling. The absence of NO_3-N in these soils is probably related to their very low levels of organic matter, relatively coarse texture and well-drained profiles.

The application of commercial fertilizers is another prerequisite to seedling production on these sites. The nitrogen status could be improved by applying ammonium nitrate either at seeding as a top-dressing or as solution metered into the irrigation water. A minimum rate of 100 lbs. N/acre for each of the first three years should be considered.

Phosphorus. Levels of available phosphorus are adequate for seedling growth in the surface horizons of all sites. A minimum of 20 ppm P is required. Phosphorus decreases sharply in the lower horizons i.e. below the root zone, and should not affect seedling growth.

Exchangeable Bases. Exchangeable bases are generally low. Minimum levels of 3, 1 and 0.2 milliequivalents per 100 grams of calcium, magnesium and potassium, respectively, have been suggested for nursery soils (6). Four Grande Prairie soils had adequate calcium in the Ae horizon but both magnesium and potassium were insufficient. Exchangeable calcium was high in the C and IIC horizons of the Grande Prairie site probably due to dissolution of free calcium carbonate by ammonium acetate used in the extraction procedure. Egremont was low in all exchangeable bases throughout the profile. The High Prairie

sites were low in all exchangeable bases in the Ae and B horizons but certain C horizons, because of their calcareous characteristics, had unusually high calcium. Exchangeable sodium is very low on all sites but especially so at Egremont and High Prairie. No sodium-related problems of structure and drainage are foreseen. In order to increase potassium in these soils for the initial production of conifers, applications of 80-100 lbs. K/acre as potash should be plowed into the soil during seedbed preparation.

Exchangeable hydrogen was not determined but is not expected to contribute significantly to total cation exchange capacity (C.E.C.) among these soils on account of their pH. Summation of the exchangeable bases (i.e. Ca + Mg + K + Na) in the Ae and Bm horizons will approximate total C.E.C. The highest values obtained in this fashion for the root zone occurred on the Grande Prairie site and ranged from 4.69 to 4.89 milliequivalents per 100 grams. For nursery soils, a C.E.C. of 7-10 milliequivalents per 100 grams has been suggested by Wilde (11) and van den Driessche (9) has reported desirable C.E.C. for a Douglas Fir nursery to be 15 milliequivalents per 100 grams.

The C.E.C. status of any of the three sites could be improved through the addition of peat. Its effectiveness will depend on the degree of decomposition but an increase in C.E.C. of three units (15-18 me/100 gm) from the application of 100 cu. yards of peat per acre has been reported (9). Some calcium and magnesium would undoubtedly be supplied by the peat while an additional amount would be applied through irrigation.

Peat Analysis. The pH of the peat at Grande Prairie is 7.0. It is low in soluble salts (E.C. 0.225 mmhos/cm) and could be used to improve the soil.

Water Analyses. The results of analyses of water samples from the sites are shown in Table 5. Electrical conductivity is a measure of soluble salt concentration. The pH of all samples is between 7.0 and 8.0 and those from High Prairie are lowest in soluble salts. However, except for the bog source at Grande Prairie (high salinity), the waters could be used for nursery irrigation owing to their low salinity. Waters having an electrical conductivity of 0.250 millimhos/cm or less are considered suitable for all irrigation whereas those with conductivity in the 0.250 - 0.750 millimhos/cm range may be used on all but the most salt-sensitive plants (8).

The ratio of sodium to calcium-plus-magnesium is expressed by the Sodium Adsorption Ratio (S.A.R.). For the levels of salinity present, S.A.R. values of up to 6.0 would be acceptable. All samples are less than this and therefore the waters present no sodium hazard. Bicarbonate is the anion of highest concentration and since it can be neutralized by acid, sub-samples were titrated with sulphuric acid to determine the amount of acid required to lower the pH to 6.0. This indicates the buffering capacity of the samples and affords a guide to the acid requirement, should any of these supplies be required for irrigation. Samples from High Prairie required least acid, 162 and 136 ml/1000 gallons of water, to lower the pH to 6.0. At Grande Prairie, water of pH 7.00 from a peat bog required 1558 ml/1000 gallons in contrast to that from a pond, the pH of which was 8.00

and which required only 312 ml acid/1000 gallons. This illustrates a wide difference in buffering capacity of these waters. The data indicate that of all three sites, the High Prairie sources are of highest quality. At Grande Prairie, water from the adjacent pond is preferred for irrigation. The Egremont sources are lower in quality but could be used after appropriate treatment with acid. Use of the bog water at Grande Prairie for irrigation should be avoided. All water samples were taken from surface or near-surface sources; for stable supply and quality, the use of wells is recommended.

CONCLUSIONS

1. The Grande Prairie site was most suitable on account of soil texture (loamy sand) and length of frost-free period (108 days). Soil texture in Egremont and High Prairie was sand; the latter had some gravel as well. Both appeared to have similarly short frost-free periods, 79 days and 84 days, respectively, and this made them less suitable sites.

2. Soil depth at all sites was adequate but undulating topography will necessitate levelling. However, this might be impractical at High Prairie, with slopes up to 7 percent.

3. The water table is closest to the surface (46-72 inches) at Egremont and the presence of mottling within 24 inches of the surface renders this site unsuitable without installation of a tile-drainage system. At Grande Prairie, the water table was found at 58-126 inches probably on account of gravel in the C horizons. Either site would be better drained than Egremont in the event of irrigation.

4. The High Prairie site is undesirable because of severe mistletoe infestation in the present vegetation. Proper sanitation would require clearing of at least a one-half mile radius of land beyond the perimeter of a nursery situated there.

5. The soils at all sites are sufficiently acid (pH 5.4-5.8) and low in soluble salts to be suitable for the production of conifers. Free calcium carbonate was found only in the C horizons of the Grande Prairie and High Prairie soils but was deep enough to offer no danger to plant growth.

6. Soil fertility of the Grande Prairie site was highest but was far below the standards suggested for tree nurseries. Phosphorus was present in adequate amounts but organic matter, nitrogen and exchangeable bases were very low.

7. Water samples from the vicinity of the sites are, with one exception, alkaline but could be used for nursery irrigation following acidification. The High Prairie samples are of highest quality and require least acid. At Grande Prairie, the pond supply was best for irrigation whereas use of the bog source should be avoided on account of high salinity and buffering capacity.

8. The sites, in decreasing order of suitability, are 1) Grande Prairie, 2) Egremont and 3) High Prairie.

RECOMMENDATIONS

1. Wells may be considered as a permanent source of irrigation water for the nursery (page 14). Quantity and quality are likely to fluctuate much less than surface or near-surface supplies. Observation wells (piezometers) should be installed on the site to determine the effect of pumping and irrigation on the water table.

2. For long-term use, irrigation water of around pH 6.0 should be considered. Appropriate acidification of a water supply for the selected site is recommended (page 14).

3. Owing to the relatively coarse soil texture at all sites, wind erosion is a potential hazard. In addition to shelterbelts, snow-fences should be used (pages 6, 7 and 9).

4. To optimize seedling production on any site selected, the application of the following is recommended: peat at 300-400 cu. yards/acre, nitrogen at 100 lbs./acre as ammonium nitrate and potassium at 80 lbs./acre as potash (pages 11-13). Additional calcium and magnesium would be supplied in the irrigation water.

5. The Heart soil as described in this report is atypical of the series in that it lacks bands of clay and/or iron in the profile. Should other sites be examined, it is advisable to check for the presence of these bands as they could impede drainage, depending on their distance from the surface.

6. The nursery should be located close to an adequate labour supply and a major distribution centre. Grande Prairie is favoured on account

of its size (population: 16,000). High Prairie is much smaller (population: 1,600). The village of Egremont (population less than 250) is 40 miles from Edmonton. The nearest town, Redwater, is 8 miles away and has a population of only 1,200.

7. Three-phase electrical power should be available.

ACKNOWLEDGEMENTS

The authors were assisted by Dr. A. K. Hellum and Mr. E. Ritchie of the Alberta Forest Service during sampling of the sites. Assessment of disease and physical layout were done by Dr. L. W. Carlson and Mr. R. Huber, respectively. Dr. J. Powell contributed climatic data. Graphical work was done by Mr. D. Allan and Mr. Z. Nemeth. Laboratory analyses were carried out by Mr. J. van Dyk and the staff of the Soils Laboratory under the direction of Mr. V. Kalra.

REFERENCES

1. Holland, W.D. and I.K. Edwards. 1973. Site investigation for location of Alberta Forest Service tree nursery. Northern Forest Research Centre, Information Report NOR-X-68, Canadian Forestry Service, Edmonton.

2. Jackson, M.L. 1958. Soil Chemical Analysis. Prentice Hall Inc., Englewood Cliffs, N.J. 498 pp.

3. Kjearsgaard, A.A. 1972. Soil survey of the Tawatinaw map sheet (83-I). Alberta Institute of Pedology Report No. S-72-29.

4. Odynsky, W., A. Wynnyk and J.D. Newton. 1952. Reconnaissance soil survey of the High Prairie and McLennan sheets. Alberta Soil Survey Report No. 17.

5. Odynsky, W., A. Wynnyk and J.D. Newton. 1956. Reconnaissance soil survey of the Grande Prairie and Sturgeon Lake sheets. Alberta Soil Survey Report No. 18.

6. Stoeckler, J.H. and G.W. Jones. 1957. Forest nursery practice in the Lake States. U.S. Dept of Agriculture, Forest Service. Agriculture Handbook No. 110.

7. Stoeckler, J.H. and P.E. Slabaugh. 1965. Conifer nursery practice in the Prairie - Plains. U.S. Dept. of Agriculture, Forest Service. Agriculture Handbook No. 279.

8. United States Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. U.S. Dept. of Agriculture. Agriculture Handbook No. 60. Washington, D.C.

9. van den Driessche, R. 1969. Forest nursery handbook. British Columbia Forest Service, Research Notes No. 48.

10. Watanabe, F.S. and S.R. Olsen. 1965. Test of an Ascorbic Acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. Soil Sci. Soc. Amer. Proc. 29:677-678.

11. Wilde, S.A. 1958. Forest Soils. Their properties and relation to silviculture. The Ronald Press, New York. 537 pp.

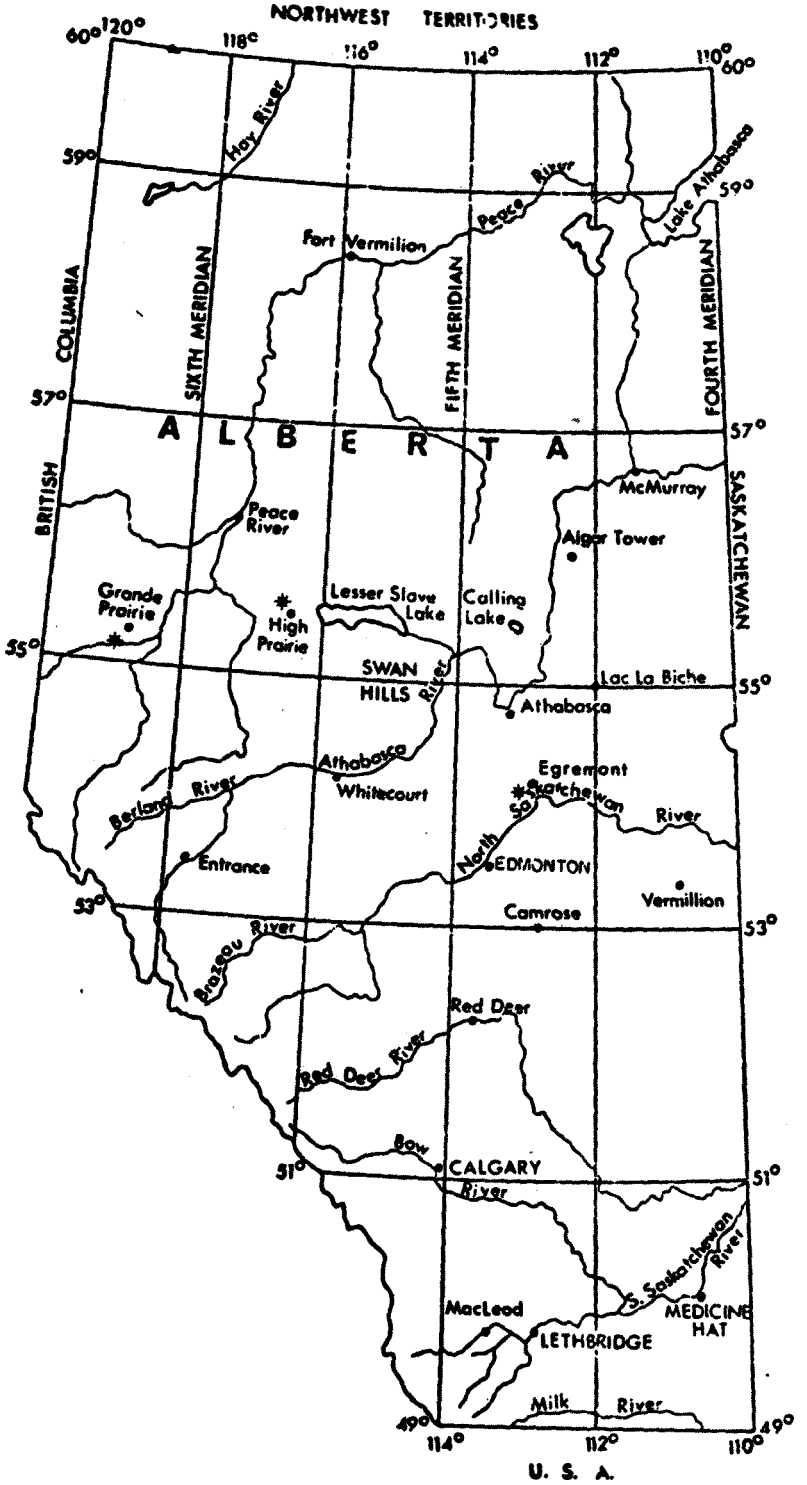

Figure 1. Location of Candidate Nursery Sites.

Table 1. Location of potential nursery sites

Area Name	General Location	Legal Description	Soil Pits Sampled	Laboratory Soil Sample Numbers
Grande Prairie	4 miles west and 7 miles south of Grande Prairie city	Sec. 18 and 19, Tp. 70, R. 6, W.6.	GP-1 GP-2 GP-3 GP-4 GP-5 GP-6 GP-7 GP-8	1 to 34 inclusive
Egremont	2 miles west of Egremont	Sec. 29, Tp. 58, R. 22, W.4.	EG-9 EG-10	35 to 43 inclusive
High Prairie	9 miles north and 3 miles west of town of High Prairie	Sec. 4 and 9, Tp. 76, R. 17, W.5.	HP-11 HP-12 HP-13 HP-14 HP-15 HP-16	44 to 63 inclusive

Table 2. Elevation of potential nursery sites

Area Name	Elevation (feet above mean sea level)
Grande Prairie (city)	2,153
(airport)	2,190
Grande Prairie (nursery site)	2,100 - 2,200
Egremont (town site)	2,111
(nursery site)	2,100 (approx)
High Prairie (town)	1,968
High Prairie (nursery site)	1,900 - 1,950

TABLE 3

COMPARISON OF POTENTIAL NURSERY SITES

		Grande Prairie	Egremont	High Prairie
Soil Series		Predominantly Heart; some Leith; considerable Eaglesham-Kenzie (organic); and some Gleysolic inclusions	Predominantly Nestow; some Nicot; Organic; and some Gleysolic inclusions	Predominantly Heart; considerable Kenzie (organic)
Topsoil (The layer of soil moved in cultivation)	1. Texture	Loamy sand (except for (Leith, GP-8	Sand	Sand
	2. Mean pH	5.8	5.4	5.4
Subsoil (Excludes the parent material)	1. Texture	Loamy sand (except for (Leith, GP-8	Sand	Sand
	2. Mean pH	5.8	5.2	5.4
Depth to parent material		(Min.19" (Max.47" Mean 27"	Min. 21" Max. 21" Mean 21"	Min. 17" Max 40" Mean 31"
Depth to water table during mid-August		Min. 58" Max. 126"	Min. 46" Max. 72"	Not found to 111"
Drainage in solum (System of Soil Classification for Canada, 1970)		Well drained	Well drained	Well drained
Topography		(Gently undulating (Min. 1%; Max. 3% Mean 2%	Gently undulating Min. 1%; Max. 2%	Undulating to gently rolling Min. 2%; Max. 7% Mean 3.5%
Cover	1. Main tree species	Jp-Lp hybrids	Jp	Jp-Lp hybrids
	2. Common members of ground flora	Kinikinikk, Reindeer moss Rose, Vaccinium	Veccinium, Rose	Kinikinikk, Reindeer moss
Climatic Data	1. Total annual precipitation	17.4	17.3	17.7
	2. Precipitation during growing season	10.7	11.5	11.4
	3. Number of frost-free days	108	79 (Thorhild)[1]	84
	4. Highest temperature recorded during growing season	94	93	97
Site Limitations	1. Soil profile	None	Mottling less than 2' from surface, too sandy	Too sandy
	2. Soil pattern	No problem	No problem	No problem
	3. Wind erosion	Requires shelterbelt	Requires shelterbelts	Requires shelterbelts
	4. Climatic		Short frost-free season	Possible frost pocket short frost-free season
	5. Economic (access, power, water)	Not assessed	Not assessed	Not assessed
	6. Disease	Spruce gallrust (negligible)	Nil	Severe mistletoe infection
Approximate Acreage of Useable Land		645.20 - Heart 257.71 - Leith	742.58 - Nestow	1259.86 - Heart

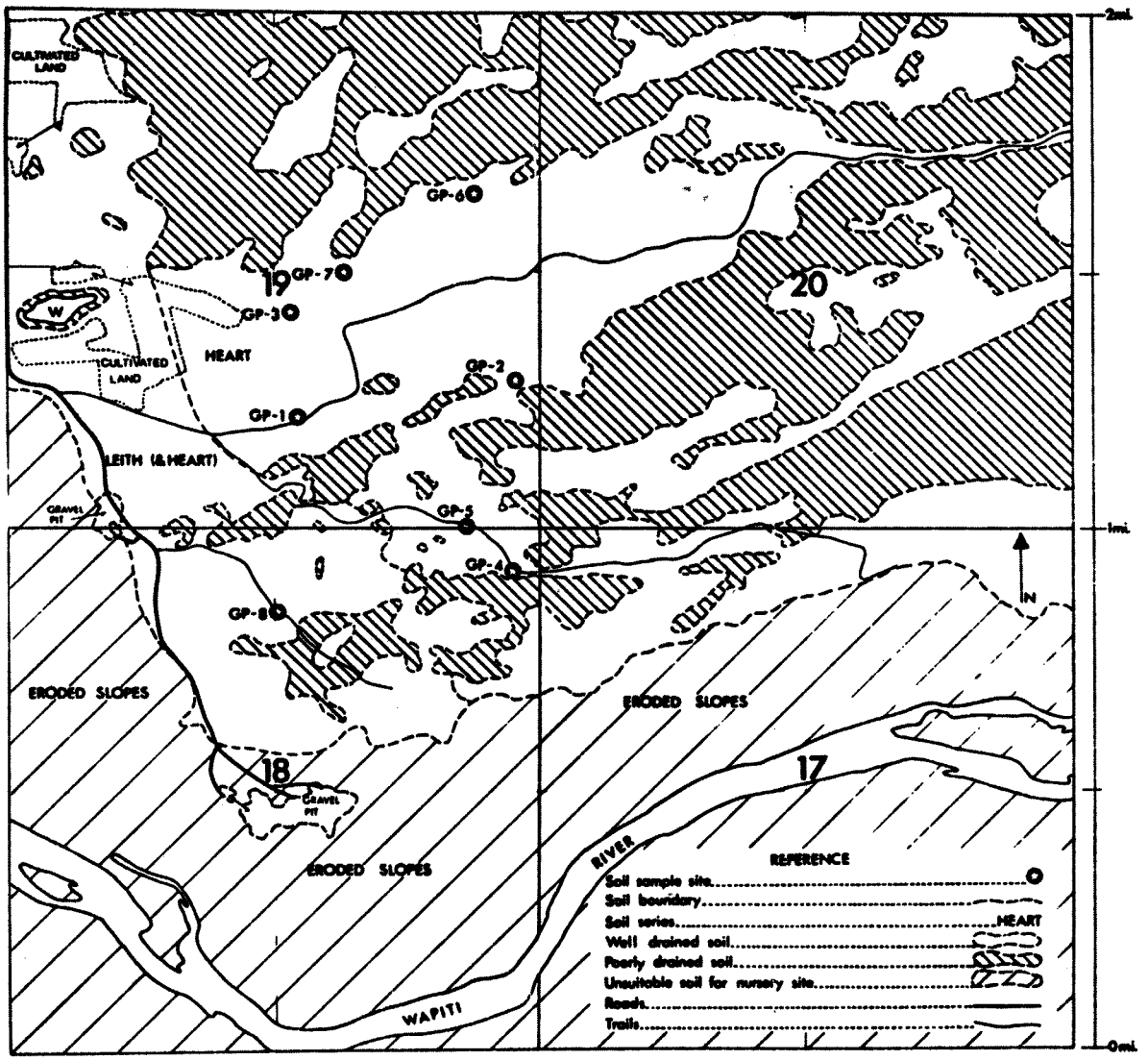

Figure 2. Distribution of soils on the Grande Prairie site. (1961 photos)

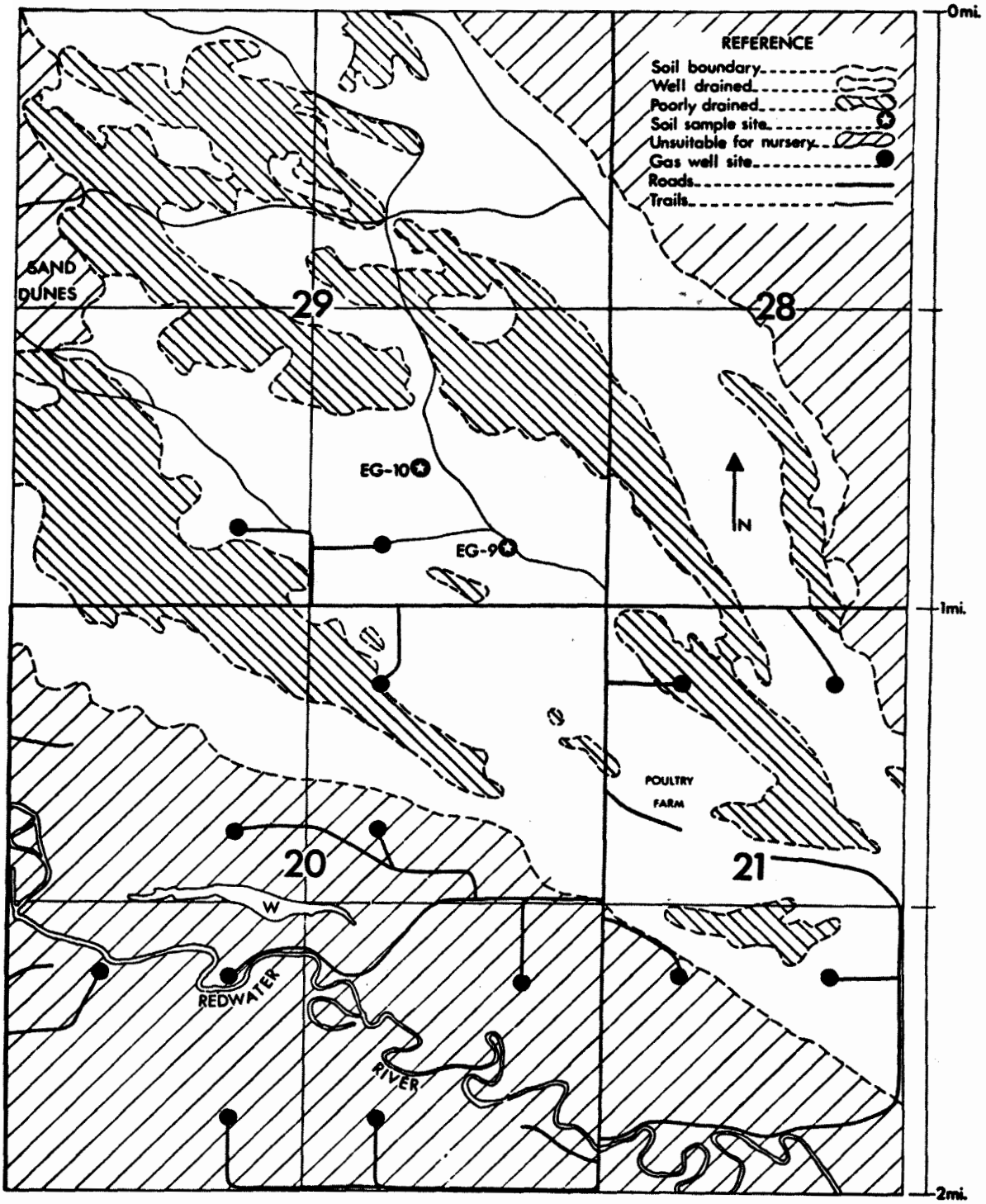

Figure 3. Distribution of soils on the Egremont site.

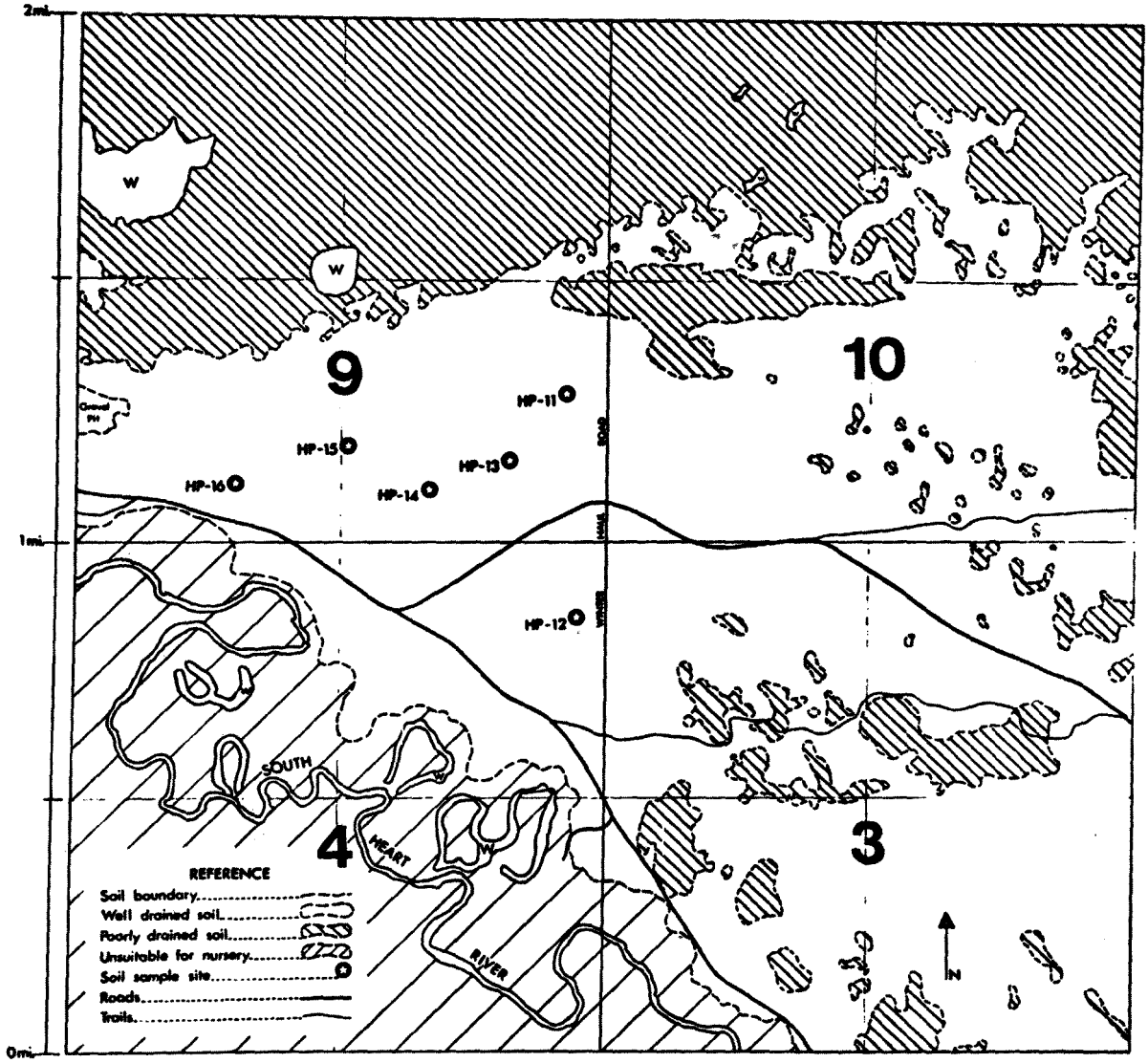

Figure 4. Distribution of soils on the High Prairie site.(1961 photos)

TABLE 4. Results of analysis of soils from prospective A.F.S. nursery sites.

Sample No.	Loc. - Pit#	Hor./Depth Ins.	pH	E.C. mmhos/cm	Sand %	Silt %	Clay %	Textural Class	Carbonate Present	O.M. %	SO3-S ppm	Avail. P ppm	Ca me/100 g	Mg me/100 g	K me/100 g	Na me/100 g
1	GP - 1	Ae 0-5	5.5	0.04	79.6	12.0	8.4	LS		1.23	0	42.0	3.80	0.46	0.14	0.03
2		Bm1 5-20	5.6	0.02	81.6	8.4	10.0	LS		0.19	0	34.0	3.80	0.50	0.16	0.02
3		Bm2 20-47	5.7	0.03	86.0	6.0	8.0	LS		0.20	0	22.0	4.96	0.46	0.11	0.06
4		C 47-101	7.2	0.07	92.0	6.0	2.0	S	+	0.14	0	0.5	20.75	0.44	0.04	0.03
5		IIC ac 102	7.5	0.10	5.6	66.4	28.0	SICL	+	1.26	0	0	28.70	1.99	0.19	0.04
5A		IIC ac 126	7.6	0.12	3.6	70.0	26.4	SiL	+	1.29	0	1.5	28.70	2.22	0.22	0.07
5A-X		IIC ac 138	7.4	0.09	70.0	24.0	6.0	SL	+	0.51	0	0	24.96	1.20	0.08	0.05
6	GP - 2	Ae 0-6	5.5	0.02	79.6	12.0	8.4	LS		0.63	0	26.5	2.35	0.48	0.14	0.03
7		Bm 6-19	5.6	0.02	84.0	8.0	8.0	LS		0.19	0	20.0	3.98	0.48	0.19	0.02
8		Ck 19-36	7.3	0.07	86.0	8.0	6.0	LS	+	0.32	0	0.5	22.52	0.55	0.07	0.03
9		IICk 36-76	7.7	0.11	21.6	46.0	32.4	CL	+	1.19	0	0	32.29	3.25	0.10	0.09
10	GP - 3	Ae 0-10	5.2	0.02	82.0	14.0	4.0	LS		0.99	0	23.0	2.27	0.33	0.14	0.01
11		Bm1 10-17	5.7	0.02	86.0	8.0	6.0	LS		0.23	0	6.5	2.39	0.52	0.15	0.06
12		Bm2 17-28	5.9	0.02	84.0	8.0	8.0	LS		0.30	0	4.0	4.92	0.50	0.18	0.05
13		C 28-44	7.2	0.08	88.0	8.0	4.0	S	+	0.26	0	0.5	21.71	0.38	0.07	0.04
14		IIC 44-80	7.4	0.09	60.0	32.0	8.0	SL	+	0.39	0	0	24.68	0.68	0.11	0.04
15	GP - 4	Ae 0-8	6.2	0.03	80.0	14.0	6.0	LS		0.50	0	24.0	3.64	0.49	0.16	0.08
16		Bm 8-28	6.0	0.02	86.0	8.0	6.0	LS		0.19	nd	15.5	3.62	0.41	0.19	0.03
17		C 28-55	7.2	0.08	88.0	8.0	4.0	S	+	0.33	0	1.5	22.56	0.52	0.07	0.04
18		Ck 55-58	7.6	0.13	66.0	24.0	30.0	SCL	+	1.86	0	1.0	27.76	0.81	0.04	0.06
19	GP - 5	Ae 0-4	6.1	0.08	82.0	12.0	6.0	LS		1.05	0	34.0	3.83	0.69	0.32	0.05
20		Bm 4-20	6.1	0.03	86.0	8.0	6.0	LS		0.19	0	9.0	3.83	0.49	0.25	0.01
21		C 20-36	7.3	0.08	93.6	4.4	2.0	S	+	0.23	0	0.5	20.50	0.42	0.07	0.01
22		Ck 36-70	7.5	0.13	72.0	13.6	14.4	SL	+	1.78	0	2.5	25.24	0.57	0.06	0.01
22-X		Ck > 72"	7.7	0.13	32.4	40.0	27.6	CL	+	0.66	nd	nd	28.00	2.00	0.18	0.05
23	GP - 6	Ae 0-7	6.3	0.02	84.8	9.6	5.6	LS		0.43	0	27.5	2.22	0.28	0.09	tr
24		Bm 7-27	6.1	0.04	84.4	6.0	9.6	LS		0.19	0	24.0	3.68	0.68	0.13	0.01
25		C 27-61	7.2	0.10	86.4	8.0	5.6	LS	+	0.42	0	3.0	22.23	0.71	0.05	0.01
26		IIC 61-72	7.2	0.10	90.4	8.0	1.6	S	+	0.23	0	1.0	21.07	0.64	0.04	tr
27	GP - 7	Ae 0-8	5.5	0.01	84.4	10.0	5.6	LS		0.69	0	29.0	2.16	0.35	0.15	0
28		Bm 8-20	5.9	0.01	86.4	8.0	5.6	LS		0.14	0	20.0	3.15	0.47	0.14	tr
29		C 20-41	7.0	0.09	94.4	4.0	1.6	S	+	0.26	0	4.5	20.94	0.36	0.04	0.01
30		IIC 41-56	7.3	0.11	92.4	4.0	3.6	S	+	0.70	0	3.0	21.97	0.50	0.04	0.01
31	GP - 8	Ae 0-4	5.6	0.02	60.0	32.0	8.0	SL		0.92	0	34.5	3.72	0.62	0.18	0.01
32		Bt 4-14	5.6	0.01	54.0	18.0	28.0	SCL		1.15	0	4.5	12.10	1.91	0.37	0.03
33		C 26-40	7.1	0.10	64.0	22.0	14.0	SL	+	0.77	0	8.5	20.63	1.42	0.17	0.02
34		IIC 40-50	7.2	0.10	88.4	8.0	3.6	S	+	0.24	0	0.5	21.84	0.53	0.05	0.01
35	EG - 9	Aej 0-3	5.2	0.01	86.4	10.0	3.6	S		0.74	0	15.5	1.10	0.23	0.04	0
36		Bm1 3-10	5.2	0.01	88.4	8.0	3.6	S		0.34	0	11.0	1.29	0.23	0.04	tr
37		Bm2 10-21	4.8	0.01	94.4	2.0	3.6	S		0.07	0	4.5	0.36	0.09	0.02	tr
38		Cg1 21-37	5.0	0.01	96.4	2.0	1.6	S		0.07	0	20.0	0.39	0.10	0.02	tr
39		Cg2 37-41	4.9	0.01	96.4	2.0	1.6	S		0.05	0	15.5	0.31	0.09	0.01	tr
40	EG - 10	Aej 0-2	5.2	0.01	92.4	6.0	1.6	S		0.68	0	50.5	1.16	0.23	0.11	tr
41		Bm1 2-9	5.7	0.08	96.4	3.6	0	S		0.05	0	11.5	0.35	0.12	0.05	0
42		Bm2 9-21	5.0	0.01	90.4	8.0	1.6	S		0.30	0	41.0	0.71	0.23	0.11	0
43		Cg 21-71	5.5	0.01	100.0	0	0	S		0.08	0	4.0	0.27	0.07	0.03	0
44	MP - 11	Ae 0-4	5.4	0.03	98.0	2.0	0	S		0.52	0	26.0	1.73	0.13	0.07	0.01
45		Bm1 4-22	4.9	0.01	98.0	2.0	0	S		0.18	0	28.0	0.41	0.10	0.03	tr
46		Bm2 22-40	5.3	0.01	100.0	0	0	S		0.01	0	9.0	0.57	0.10	0.01	tr
47		BC 40-51	5.4	0.01	100.0	0	0	S		0.04	0	7.0	0.66	0.12	0.02	tr
48		C 51-111	7.1	0.07	100.0	0	0	S	+	0.02	0	3.0	16.62	0.41	0.01	0.01
49	MP - 12	Ae 0-3	5.7	0.02	96.0	4.0	0	S		0.82	0	23.0	2.05	0.18	0.08	tr
50		Bm1 3-18	5.7	0.01	96.0	4.0	0	S		0.12	0	20.0	0.94	0.15	0.05	tr
51		Bm2 18-33	5.3	0.01	100.0	0	0	S		0.03	0	10.0	0.73	0.12	0.03	tr
52		C 33-94	5.4	0.01	100.0	0	0	S		0.01	0	11.0	0.53	0.10	0.02	0.01
53	MP - 13	Ae 0-3	5.6	0.02	96.0	4.0	0	S		0.93	0	16.0	2.18	0.26	0.10	0.01
54		Bm1 3-11	5.5	0.01	94.0	6.0	0	S		0.45	0	18.0	1.33	0.18	0.06	tr
55		Bm2 11-17	5.6	0.01	100.0	0	0	S		0.07	0	8.0	0.83	0.17	0.03	tr
56		C1 17-42	6.4	0.02	100.0	0	0	S		0.15	0	7.0	1.88	0.35	0.02	tr
57		C2 42-66	7.0	0.06	100.0	0	0	S	+	0.15	0	4.0	16.68	0.42	0.01	tr
58	MP - 14	Ae 0-4	5.6	0.02	96.0	4.0	0	S		0.82	0	23.0	2.08	0.30	0.10	tr
59		Bm1 4-10	5.4	0.01	94.0	6.0	0	S		0.27	0	29.0	1.35	0.19	0.12	tr
60		Bm2 10-17	5.5	0.01	96.0	4.0	0	S		0.17	0	30.0	1.59	0.23	0.06	0.01
61		BC 17-27	5.4	0.01	100.0	0	0	S		0.08	0	18.0	1.44	0.28	0.05	0.01
62		C1 27-41	5.8	0.01	100.0	0	0	S		0.04	0	9.0	0.75	0.13	0.02	tr
63		C2 41-97	6.6	0.02	100.0	0	0	S	tr	0.05	0	7.0	5.68	0.28	0.02	tr
64	MP - 15	Ae 0-4	5.3	0.01	100.0	0	0	S		0.80	0	24.0	1.97	0.27	0.13	0.01
65		Bm1 4-14	5.3	0.01	96.0	4.0	0	S		0.34	0	34.0	1.13	0.26	0.09	0.01
66		Bm2 14-27	5.2	0.01	100.0	0	0	S		0.05	0	12.0	1.81	0.25	0.04	0.01
67		BC 27-43	5.7	0.01	100.0	0	0	S		0.06	0	12.0	1.37	0.15	0.02	tr
68		C 40-90	7.0	0.06	100.0	0	0	S	+	0.02	0	4.0	17.44	0.50	0.01	0.01
69	MP - 16	Ae 0-4	5.5	0.01	94.8	3.2	0	S		0.58	0	29.0	1.37	0.28	0.07	0
70		Bm1 4-12	5.3	0.01	96.8	3.2	0	S		0.19	0	29.0	1.17	0.21	0.10	tr
71		Bm2 12-26	5.4	0.01	96.8	2.4	0	S		0.06	0	15.0	1.40	0.30	0.05	tr
72		Bm3 26-30	5.5	0.01	98.8	1.2	0	S		0.07	0	15.0	2.03	0.43	0.07	0.01
73		BC 30-37	7.1	0.07	98.8	1.2	0	S	+	0.33	0	7.0	19.71	0.76	0.04	0.02
74		C 37-50	7.3	0.09	98.8	1.2	0	S	+	0.19	0	3.0	21.13	0.68	0.03	0.02

nd not determined because of insufficient sample.
tr trace

Table 5. Analytical results of water samples collected near the prospective nursery sites

Sample No.	Location	pH	E.C.* mmhos/cm	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	S.A.R.**	H_2SO_4 to pH 6.0 (ml)***
				milli-equivalents per litre									
1	Grande Prairie, near Pit 732. W.T. at 24"	7.40	0.691	6.08	1.26	0.06	0.05	NIL	7.81	0.04	0.09	0.03	649
2	Grande Prairie, near Pit 737, W.T. at 24"	7.25	0.490	4.62	0.38	0.04	0.06	NIL	5.35	0.03	0.11	0.03	454
3	Grande Prairie, peat bog S. of site, W.T. at 30"	7.00	1.364	15.73	2.94	0.39	0.01	NIL	16.35	0.02	NIL	0.13	1558
4	Grande Prairie, pond N. of potato field	8.00	0.308	1.16	1.88	0.22	0.20	NIL	3.34	0.08	0.07	0.18	312
5	Egremont, creek ½ mile N. of site	7.90	0.638	4.32	1.77	0.82	0.16	NIL	6.07	0.04	0.68	0.47	639
6	Egremont, Redwater River, S. of Opal	7.95	0.576	3.12	1.63	0.97	0.12	NIL	4.20	0.08	1.23	0.63	383
7	High Prairie, North Heart River, S.E. of site	7.65	0.274	1.63	0.73	0.22	0.08	NIL	2.11	0.04	0.46	0.20	162
8	High Prairie, South Heart River, N of town	7.55	0.245	1.42	0.60	0.23	0.08	NIL	1.88	0.05	0.34	0.23	136

* Electrical conductivity is a measure of salinity.

** Sodium adsorption ratio = $\frac{Na}{\sqrt{\frac{Ca+Mg}{2}}}$ is a measure of sodium hazard. For the salinity present, S.A.R. could be as high as 6.00 without being a sodium hazard.

*** Amount of sulphuric acid required to lower the pH of 1000 gallons of water to 6.0.

ANNEX: Additional Investigations

After completing the report concerning the Grande Prairie, High Prairie and Egremont sites, the Alberta Forest Service (A.F.S.) requested that three additional sites be assessed for their suitability as tree nurseries. These are located at Watino, Reno and Clyde. The Watino and Reno sites were sampled by A.F.S. personnel; the Clyde site was sampled by the Canadian Forestry Service (C.F.S.). An assessment of these three sites is presented here as an addendum to the foregoing report.

With few exceptions, the methodology is similar to that used in the report. Sampling was done after freeze-up in November and was not as intensive as before. Because of the freeze-up, no water samples were collected. Two horizons were sampled at both Watino and Reno whereas five horizons were sampled at each of two profiles examined at Clyde. We determined pH on a soil-water paste rather than the soil-$CaCl_2$ mixture used before, since soluble salt concentration is uniformly very low.

Brief Site Description

Additional studies were conducted late in the fall at Watino, Reno and Clyde. Two soil samples were taken by the A.F.S. at the Watino and Reno (Twp. 80, Sec. 11, R. 19, W 5) sites. The data are reported in Table 6.

At the request of the A.F.S. two soil profiles and one surface sample were obtained at the Clyde site - Sec. 23, Twp. 60, R. 23, W 4. One profile, samples 5 to 9 inclusive, Table 6, was taken in a stand of

jack pine (*Pinus banksiana*) about 150 feet east of an abandoned house. A second profile, samples 10 to 14, Table 6, was examined in a formerly cultivated field about ¼ mile east of the abandoned house. A third site consisting of organic soil was sampled near the northwest corner of the S.W. ¼ of Sec. 23. The locations of these sampling sites are marked on aerial photograph 64-3A 5405, MSL 20-53. This photograph was returned to the A.F.S.

The aerial photograph was examined stereoscopically to provide an interpretation of the boundaries between the well-drained soil and the poorly drained soil, which was colored blue. A line was also drawn to separate the gently undulating land and the depressional land from the gently rolling land. From the photograph, overlays showing the distribution of cleared land (Figure 5) and usable land (Figure 6) were prepared. Both originals have also been returned to the A.F.S. although copies, at reduced scale, are included herewith.

The legend used on the air photo was as follows:

U = Usable land
R = Gently rolling land
D = Depressional land
W = Wet land
· = Soil sample sites

A. Usable Land:

Most of the area marked as usable land, "U" (Figure 6), has been cleared and cultivated previously. This portion has scattered jack pine up to 6 feet high, and has been pastured in recent years. It has some gently undulating topography with short slopes up to 5% but there are sufficiently large areas of level land to permit layout

of a tree nursery, very probably without levelling. The uncleared portion is covered mostly with jack pine, 40 to 50 feet high and having Shepherdia and grass components under it. The pine is infected with mistletoe and very probably with western gall rust. The present distribution of trees lends itself to easy establishment of windbreaks.

The profile was classified as Degraded Dystric Brunisol of alluvial origin. It is well drained; it is assumed from evidence of buried horizons and from the data of Table 6, as well as from apparent relief differences, that the water table and free lime accumulations are at considerable depth from the surface.

The soil texture is almost ideal to the extent that the profile is a loamy sand in the surface 10 to 20 inches of soil and overlays a sand. Levelling is probably best avoided in order to preserve the textural relationships of this profile. The horizon nomenclature and depths are given in Table 6.

The usable acreage is in excess of 300 acres.

It must be noted that because the surface soil was frozen at the time of investigation in mid-November, and since there was a considerable depth of snow, the sampling was limited. It was not possible to see whether the soil has much gravel or stone. Hence, a more intensive investigation may be required in the spring of 1974.

B. Gently Rolling Land:

The gently rolling land, marked "R" on the air photos, indicates the land has 5 to 9% slopes, with a few up to 10 to 12%.

This land occurs mostly on the S.E. ¼ of Sec. 23. It has essentially the same kind of soil as found in the usable area, although it was not examined in detail, mainly because of topography and the frozen snow-covered soil.

There are areas up to 10 acres in size that could be used for nursery fields if necessary. The young jack pine growing on them is probably also infected with mistletoe and western gall rust.

C. Depressional Land:

Some lower lying land is indicated in the west side of the N.W. ¼ of Sec. 23 on air photo 53. It is also scattered throughout the usable portion described under subsection A above. It is to be avoided, as such areas may be more susceptible to frost. They were not examined in detail because of frozen soil and snow cover.

D. Wet Land:

This land, colored blue on air photo 53, is too wet for tree nursery purposes. The soil is organic (Sample No. 15, Table 6) and may be suitable as an amendment for the usable mineral soil described above. Due to the restraints mentioned above, it is suggested that additional organic soil samples be collected in 1974.

E. Climatic Data:

Climatic data, especially for the Clyde area, are sparse owing to the lack of weather records. Table 7 provides some data from the nearest stations, some of which are as far away as 30 miles. Also, Sion and Rochester, the stations nearest to Clyde, are in different climatic zones.

Because of the lack of data and the landforms in the vicinity of Sec. 23, it is suggested that a series of mobile thermo-dew-point recording traverses be made to determine whether or not a frost pocket exists on this site.

SOIL ANALYSES

Results of analyses of soil from the three additional prospective nursery sites are shown in Table 6.

pH. The soils from all sites are sufficiently acid to be suitable for a tree nursery. The A horizons at Watino and Reno were pH 6.4 and 5.4, respectively, whereas that at the Clyde site was pH 5.7-5.9. Furthermore, at Clyde, pH decreased within the top 20 inches and then increased thereafter, approaching surface values at depths of 56-60 inches. Peat from the Clyde site is also acid (pH 5.7) and could be used as a soil amendment.

Electrical Conductivity. All soils have very low electrical conductivity indicating that the level of concentration of soluble salts will present no hazard to plant growth. Conductivity also decreased with an increase in depth, indicating that cultivation and irrigation will tend to reduce even further the level of soluble salts in surface horizons. No free carbonate was found in any of the samples.

Texture. Surface soils at Watino and Clyde are loamy sand but at depths greater than 10 to 20 inches, the texture is sand. Loamy sand is the ideal texture for a tree nursery. Soils at the Reno site are finer-textured, sandy loam above sandy clay loam, and therefore unsuitable for growing coniferous stock.

Organic Matter. Soils at all sites are very low in organic matter. A maximum of 1.65 percent was found in the A horizon of one of the Clyde profiles compared to a minimum requirement of 5 percent. At all of the sites, the application of peat would be a necessary prerequisite to the development of a tree nursery in order to supplement organic matter and water-holding capacity. From analysis of a single sample, the peat occurring at Clyde appears suitable as a soil amendment there. The homogeneity of the deposit is, of course, not known at this time.

Nitrate Nitrogen (NO_3-N). Nitrate nitrogen is extremely low at all three sites. The maximum found in the plow layer at any site was 0.8 ppm or approximately 1.6 lbs/acre. Available nitrogen (nitrate-N) at 45 lbs/acre is regarded as an adequate level for some nursery soils. Additional nitrogen at 80-100 lbs/acre as urea or ammonium nitrate will be required. Long-term use of ammonium sulphate is not advised since soil pH might be lowered significantly.

Phosphorus. The level of available phosphorus is high at the Watino site, intermediate at Clyde and very low at Reno. The application of superphosphate at around 50 lbs P/acre is necessary at the Clyde and Reno sites before tree production is considered.

Exchangeable Bases

Potassium. Potassium is adequate at Watino (0.30 me/100 gm) but deficient at all other sites. A minimum of 0.20 me/100 gm or 156 lbs/acre is required for satisfactory growth of coniferous stock in nurseries. Like nitrogen and phosphorus, deficiencies of potassium

may be corrected through fertilization. Calcium and magnesium are adequate at all sites but levels are such that depletion will occur after the production of a few crops. Both elements are adequate in the Clyde peat and supplies in the mineral soil at this site could be supplemented by adding peat. At other sites, peat or dolomite may be used. Sodium is low enough at all sites to present no hazard to seedling production.

Base exchange capacity or total exchangeable bases (the sum of Ca + Mg + K + Na) is low in all cases. The highest level in a surface soil is 4.38 me/100 gm. Exchangeable hydrogen was not determined and its inclusion in the sum above gives cation exchange capacity, an acceptable level for which is around 15 me/100 gm. Owing to their relatively coarse textures, these soils are expected to be low in exchangeable hydrogen and, therefore, will be low in cation exchange capacity. This situation could be corrected by increasing the content of organic matter. Peat at the Clyde site, for example, contains 101 milliequivalents of exchangeable bases per 100 gm and would be ideal for this purpose.

CONCLUSIONS

1. Of the three additional prospective nursery sites, physical characteristics are most suitable at Clyde and Watino. Short slopes are present at Clyde but there is adequate acreage of level land otherwise to permit the layout of a tree nursery without any levelling. Land at Reno is variable in relief; levelling would be necessary and therefore this site is least suitable. Also, it has areas of Leith soils which are not suitable for a tree nursery.

2. Vegetation at Clyde is infected with mistletoe and probably some western gall rust but with proper sanitation measures, the site could be used. The Watino and Reno sites have not been assessed for disease but this is believed to be minimal.

3. Soil characteristics are suitable at Clyde and Watino only. Acid, well-drained, loamy sand is underlain by sand at both sites but Clyde is more favourable on account of its greater depth. Reno soil is unsuitable because of its high clay content in surface and subsurface horizons. All soils were very low in organic matter and nitrogen and somewhat low in phosphorus and potassium. These deficiencies can be corrected by applying peat and fertilizers during preparation of a particular site.

4. At Clyde further sampling of the peat, depressional areas and rolling areas is needed because frozen ground conditions in November did not permit a more intensive sampling of the soil.

5. On the basis of location, Clyde is most favoured. It possesses greater accessibility (in all directions) than the more northerly

centres. Clyde (pop. less than 250) is seven miles from Westlock (pop. 5,000), a service and distribution centre, and 55 miles from Edmonton. Reno (pop. less than 250) is 35 miles from Peace River (pop. 7,000), the nearest service centre. Watino (pop. less than 250) is 60 miles from Peace River.

6. The three potential nursery sites are rated in decreasing order of suitability as follows: 1) Clyde, 2) Watino and 3) Reno. If all six sites are considered together, the rating in decreasing order of suitability would be as follows: 1) Clyde, 2) Grande Prairie, 3) Watino, 4) Egremont, 5) High Prairie and 6) Reno.

RECOMMENDATIONS

1. No water samples were collected at any of the sites owing to freeze-up. Sampling is recommended during the free-water season of 1974. The Smoky River is a possible supply for Watino, the North Heart River is near Reno and there are four lakes in close proximity to the Clyde site.

2. Climatic data for the Watino, Reno and Clyde sites are not available and can only be estimated from nearby stations. It is suggested that mobile thermo-dew-point traverses be made to detect any occurrence of local frost pockets.

Table 6. Results of analysis of soils from additional prospective nursery sites.

Sample No.	Location	Hor.	Depth ins.	pH[1]	E.C.[2] mmhos/cm	Sand %	Silt %	Clay %	Textural Class	O.M.[3] %	NO_3-N ppm	P ppm	Ca	Mg	K	Na	B.E.C.[4]
													me/100 gm				
1	Watino	A	6	6.4	0.09	86.6	7.0	6.4	LS	1.03	0.4	30	3.49	0.52	0.30	0.07	4.38
2	"	BC	24	6.4	0.04	88.6	3.5	7.9	S	0.37	1.0	44	2.51	0.51	0.32	0.01	3.35
3	Near Reno: Culp series	A	12	5.4	0.08	81.6	4.5	13.9	SL	0.31	0.8	3	2.68	1.07	0.18	0.02	3.95
4	"	BC	24	4.9	0.06	61.6	8.5	29.9	SCL	0.48	1.1	5	8.28	4.40	0.37	0.05	13.10
5	Clyde #1, near barn	Ae	0- 8	5.7	0.17	86.6	7.5	5.9	LS	1.03	0.8	22	1.79	0.10	0.14	0.01	2.04
6	"	Bm_1	8-20	5.2	0.05	87.6	5.4	7.0	LS	0.25	1.0	19	1.86	0.12	0.06	0.01	2.05
7	"	Bm_2	20-31	5.6	0.06	95.1	1.5	3.4	S	0.09	0.1	11	1.32	0.06	0.04	0.01	1.43
8	"	Bm_3	37-41	5.8	0.03	96.1	1.0	2.9	S	0.05	0.8	8	1.59	0.08	0.04	0.01	1.72
9	"	C	54-56	5.9	0.02	96.6	1.0	2.4	S	0.05	0	7	1.28	0.08	0.03	0.01	1.40
10	Clyde #2, old field	AC	0- 8	5.9	0.08	86.6	6.9	6.5	LS	1.65	0.5	16	3.91	0.14	0.19	0.01	4.25
11	"	Bm_1	8-10	5.7	0.04	85.1	7.4	7.5	LS	0.27	0.4	34	3.12	0.09	0.06	0.01	3.28
12	"	Bm_2	10-20	5.1	0.02	88.1	6.4	5.5	S	0.17	0.5	26	2.16	0.13	0.06	0.01	2.36
13	"	Bm_3	20-35	5.3	0.02	98.6	0.9	0.5	S	0.04	0	4	0.90	0.03	0.02	0.01	0.96
14	"	C	50-60	5.7	0.02	96.6	0.9	2.5	S	0.04	0.4	5	0.78	0.08	0.02	0.01	0.89
15	Clyde Peat Bog		0-12	5.7	0.14					53.92	1.0	10	95.68	3.13	0.71	1.63	101.15

[1] Soil-paste method

[2] Electrical Conductivity

[3] Organic Matter

[4] Sum of Ca + Mg + K + Na

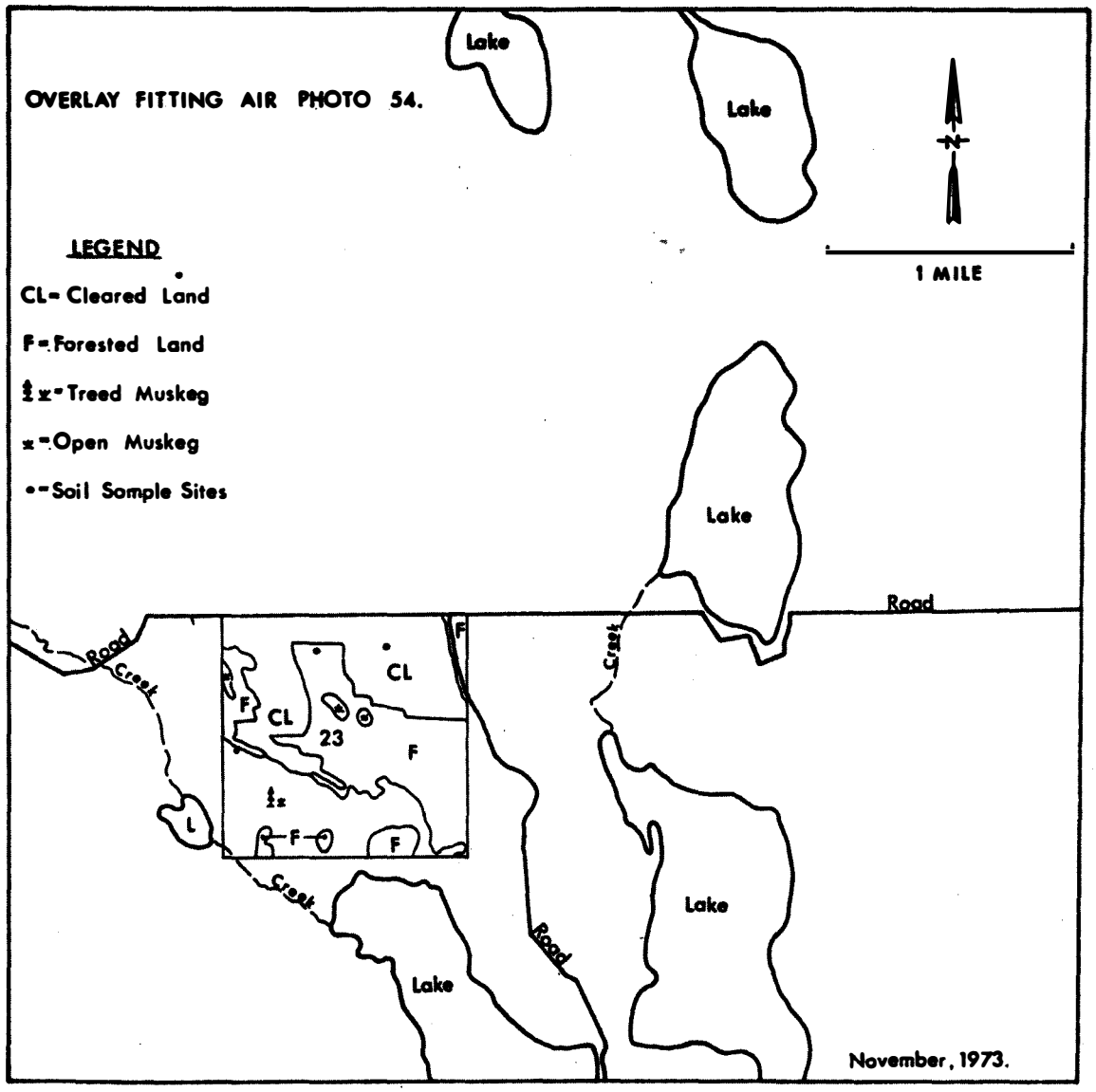

Figure 5. Distribution of cleared land at the Clyde site.

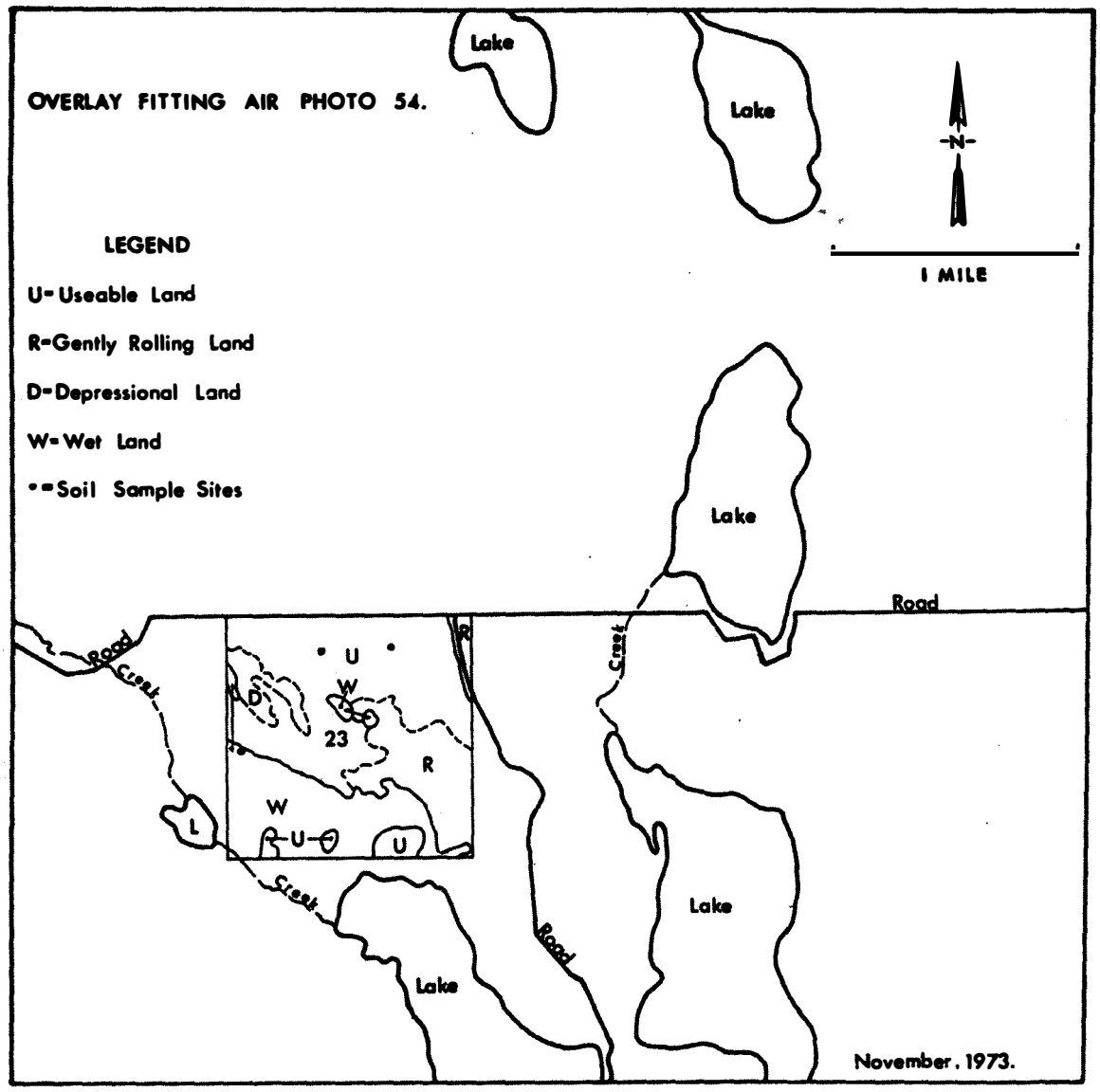

Figure 6. Distribution of main areas of usable land at the Clyde site.

Table 7. Selected Climatic Data

Climatic Stations	Elevation Feet	Mean Annual Temperature °F	Mean Annual Precipitation Inches	Frost Free Period Days
Rochester	2050	33.5	17.01	74
Sion	2300	36.3	19.20	100
Thorhild	2075	34.0	16.27	70
Falher	1910	33.7	16.63	101
Peace River A	1866	32.2	13.81	88
Wanham CDA EPF	1960	34.0	18.63	104

Climatic References:

Anon., 1956. Climatic summaries for selected meteorological stations in Canada. Meteorological Div., Dept. of Transport. Vol. 3 (Frost data).

Anon., 1968. Climatic normals. Meteorological Branch, Dept. of Transport. Vols. 1-6.

Anon., 1972. Canadian normals. Atmospheric Environment, Environment Canada. Vols. 1-2.

Hemmerick, G.M. and G.R. Kendall, 1972. Frost data 1941-1970. Atmospheric Environment, Environment Canada.