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SEED ORCHARD SITE SELECTION FOR THE MARITIMES

by

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MARITIMES

CANADIAN FORESTRY SERVICE

MARITIMES FOREST RESEARCH CENTRE

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The program consists of two major elements - research and development, and technical and information services. Most research and development work is undertaken in direct response to the needs of forest management agencies, with the aim of improving the protection, growth, and value of the region's forest resource for a variety of consumptive and non-consumptive uses; studies are often carried out jointly with provincial governments and industry. The Centre's technical and information services are designed to bring research results to the attention of potential users, to demonstrate new and improved forest managment techniques, to assist management agencies in solving day-to-day problems, and to keep the public fully informed on the work of the Maritimes Forest Research Centre.

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Maritimes Forest Research Centre
Canadian Forestry Service

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ABSTRACT

The cooperative tree improvement programs in the Maritimes are establishing seed orchards to maximize the production of genetically superior seed. The climate and edaphic factors of the orchard site are necessary considerations when choosing a location.

Temperature, rainfall, drought, light, frost and wind affect the quantity and quality of seed produced. Isolation from undesirable pollen, freedom from disease and insect pests, and ease of management are also important points to consider.

Recommendations are to establish seedling seed orchards on warm microsites within the individual agency's administrative area and to establish clonal seed orchards in the Annapolis Valley of Nova Scotia and the lower St. John River Valley in New Brunswick.

RESUME

Les programmes conjoints d'amélioration des arbres dans les provinces Maritimes sont en train d'établir des vergers à graines pour maximiser la production de graines génétiquement supérieures. Les facteurs climatiques et édaphiques de la station du verger constituent des considérations nécessaires lors du choix d'un site.

La température, les précipitations, la sécheresse, la lumière, le gel et le vent influent sur la quantité et la qualité des graines produites. D'autres points importants à considérer seraient l'isolement de pollen indésirable, l'absence de maladies et d'insectes nuisibles et la facilité d'aménagement.

Il est recommandé d'établir les vergers à graines de familles sur des microstations chaudes à l'intérieur de l'aire administrative d'utilisation et d'établir des vergers à graines clonaux dans la Vallée d'Annapolis en Nouvelle-Ecosse et dans la Vallée inférieure du fleuve St-Jean au Nouveau-Brunswick.

INTRODUCTION

Seed orchards are plantations of seedlings or vegetative propagules (grafts or rooted cuttings) from selected trees, rogued of undesirables and cultured for early and abundant production of seed. Seed produced in orchards should be genetically and physiologically better than average stand-produced seed. Seed orchards are presently being established in Nova Scotia and New Brunswick as a means of mass producing genetically improved seeds for the cooperative tree improvement programs. Tree improvement programs are expensive and it is imperative that expenditures on the many phases of breeding complement each other. Seed orchards are costly to establish and maintain, and to be sound investments must maximize the production of high quality seed. The quantity and quality of seeds produced in an orchard are greatly influenced by climate and edaphic variables of the orchard site, so great care must be taken to locate favourable orchard conditions.

Two distinctly different types of seed orchard, seedling and clonal, are being established in the Maritimes.

Seedling Seed Orchard

Seedling seed orchards are established with families of seedlings from selected parents. Initially, these orchards will be composed of open pollinated families (one parent known) although as the program progresses, controlled pollination in existing orchards will yield full-sib families (both parents known) for future orchards.

Seedling seed orchards are used for those species which flower at an early age (5 to 10 years) and for those species in which the heritabilities of selected traits are low. Of our native species, black spruce (*Picea mariana* (Mill.) B.S.P.) and jack pine, (*Pinus banksiana* Lamb.), fall in these categories. Both flower at an early age and environmental influence on height growth, which is our main criterion for selection, is high. The breeding strategy we have chosen for both species is low intensity selection (best tree in the stand) of a large number of individuals. Selection is followed by simultaneous establishment of seedling seed orchards and progeny tests of the open pollinated families. The progeny tests provide data with which to rogue all but the best families from the orchards. Seedling seed orchards may also be considered as progeny tests because, based on growth in the orchard, the poorest individuals of the remaining families are removed. This practice of selecting within a seedling seed orchard dictates that the orchard be established within a climatic zone similar to that in the region of seed use and on a typical planting site for the species. The orchard site must also meet the requirements for abundant seed production.

Clonal Seed Orchard

Clonal seed orchards are established with grafts (ramets) or possibly rooted cuttings from selected parents. Clonal seed orchards are used for species that flower later in life (20-30 years) or for which intensive selection is practiced because of the suspected high heritability of the chosen traits. Because scions collected from mature trees retain their maturity when grafted on young root stock, clonal seed orchards usually begin flowering about five years from establishment, thus greatly reducing the waiting time for seed production.

White spruce (*Picea glauca* (Moench) Voss), red spruce, (*P. rubens* Sarg.), Norway spruce, (*P. abies* (L.) Karst.), and white pine (*Pinus strobus* L.) do not begin to flower abundantly until about 20 years from seed. Tamarack (*Larix laricina* (Du Roi) K. Koch) flowers fairly early but grafts easily and there is evidence to suggest that the heritability of stem straightness and crown form is sufficiently high to warrant intensive selection.

Ideally, we are trying to achieve the maximum genetic gain for the expense involved. Experience elsewhere has shown that a rogued seedling seed orchard produces about the same or slightly more gain as does an unthinned clonal seed orchard. With roguing based on open pollinated or full-sib progeny tests however, a clonal seed orchard will yield a greater genetic gain (Wright 1976).

FACTORS AFFECTING FLOWERING

It is now widely accepted that site qualities of an orchard contribute more to flowering than any other factor. Thus there is a great need to select orchard sites with maximum care and with a full understanding of the factors that influence flower and seed development. Unfortunately, there is little information available for our native species so what follows is based on information from Europe, Australia, New Zealand, and southeastern United States.

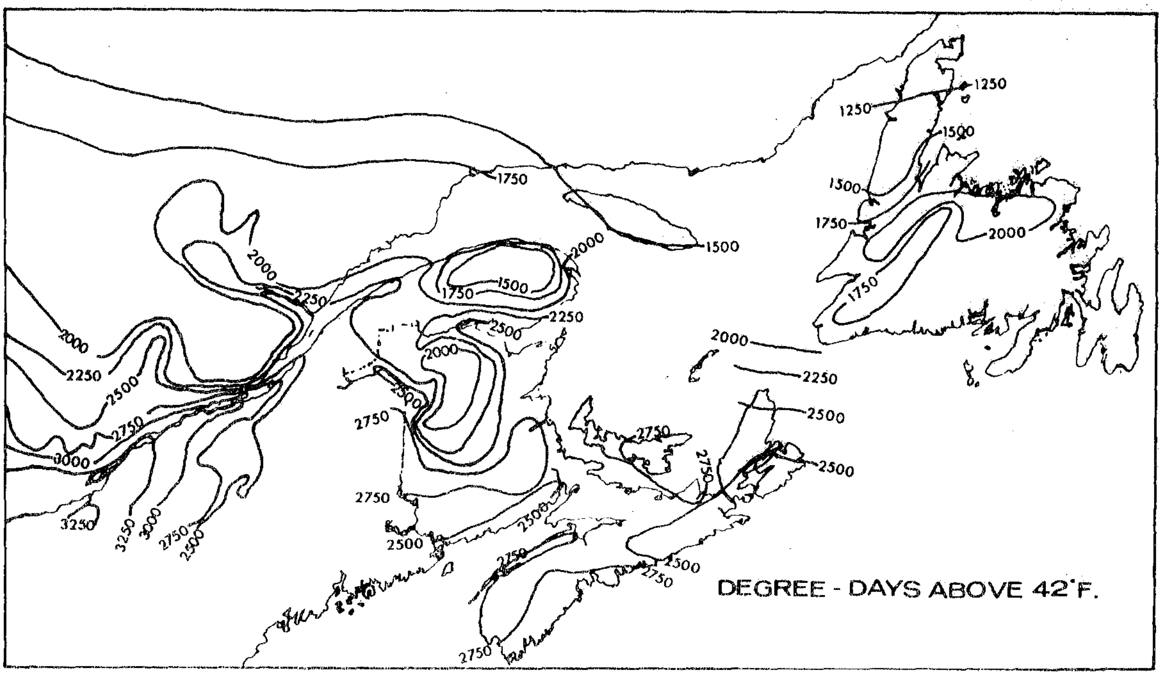


Figure 1. Degree-days above 42°F. From the Canada Land Inventory, 1966. Climates of Canada for Agriculture.

Temperature

A warm summer climate is advantageous for flower initiation and development. Flowering has been increased greatly by transferring material from its natural habitat to warmer climates, i.e., an increase in the degree days. This technique has proven very successful in Scandinavia where an increase of 160% in the number of degree days provides the maximum yield of cones (Sarvas 1970). The Danes have established their recent Norway spruce seed orchards in southern France. In British Columbia, the moving of white spruce and Engelmann spruce (*P. engelmannii* Parry) orchards from Prince George to Vernon has produced phenomenal increases in cone production (Kiss Pers. Comm.). It will be possible to obtain an increase in the number of degree days within both New Brunswick and Nova Scotia by establishing orchards in the warmest areas available (Fig. 1, Table 1). A warm microsite can also be obtained by locating on a south to southwest slope.

Rainfall and Drought

Stress often promotes flower bud as opposed to vegetative bud differentiation. Trees should be under moisture stress or drought conditions during the weeks (late June and July) when flower primordia are differentiating. Adequate moisture should be available however, during the rest of the flower and cone development cycle (Fig. 2).

Obviously, each June and July can't have a water deficit to favour differentiation of flowers to the detriment of the developing crop. We may have to adjust the moisture availability with irrigation to match the years with excellent developing cone crops and other years provide drought to differentiating flower crops. Areas in both New Brunswick and Nova Scotia are available which exhibit a water deficit (Fig. 3). The selection of a site with a slight slope and with soil of the proper texture will ensure that water drainage is adequate.

Light

The amount of light the tree crown receives has a definite bearing on cone production. This was dramatically illustrated recently in the red pine, (*Pinus resinosa* Ait.), seed production area in the Garden of Eden, N.S. Full crown release produced an abundant crop compared to the crop in an unthinned section. Others have also found that full crown light increased the number of viable seeds per cone. Initial spacing in an orchard should be such that trees receive full light until roguing opens up the orchard further.

Spruce and Tamarack Flowering Cycle

Year 1 — Year 2

Differentiation — Development — Collection

May J J A S O N D Jan F M A M J J A S O N

Moisture Stress ------------Adequate Moisture---------

Figure 2. The flowering cycle of spruce and tamarack in the Maritimes.

Atlantic Region/Région atlantique **New Brunswick/Nouveau Brunswick**

Name of Station Nom des Stations	Record Period Years Période D'années	April Avril	May Mai	June Juin	July Juillet	August Août	Sept. Sept.	Oct. Oct.	Nov. Nov.	Annual Total Total Annuel
Alma	28	16	119	258	357	355	244	129	37	1520
Bathurst	25	15	136	304	435	395	236	90	14	1646
Chatham A.	28	20	149	317	444	407	256	101	19	1718
Doaktown	15	16	138	293	412	377	224	86	22	1612
Edmunston Fraser	21	19	156	320	417	366	223	87	13	1600
Fredericton A.	20	29	178	335	444	408	255	109	23	1783
Gagetown 2	29	36	190	334	451	424	280	131	28	1884
Grand Falls	23	22	171	310	416	374	235	80	11	1641
Kedgwick	11	12	106	263	358	306	168	52	11	1297
Moncton A.	30	23	152	298	425	397	259	115	28	1704
Rexton	28	18	138	297	442	405	251	109	21	1680
Saint John	25	26	143	263	366	370	270	137	33	1620
St. Andrews	30	32	162	288	394	390	271	134	30	1705
Woodstock	23	36	198	343	448	410	263	103	19	1785

Nova Scotia **Nouvelle Ecosse**

Debert A.	15	29	149	292	423	397	263	121	36	1692
Digby	24	43	167	294	410	392	281	158	52	1825
Greenwood A.	28	39	179	326	446	417	277	138	43	1886
Halifax	30	35	152	287	417	423	320	182	58	1891
Halifax Int'l A.	11	20	130	292	410	404	273	137	41	1703
Kentville CDA	30	36	170	316	444	416	286	144	43	1872
Liverpool	18	40	157	279	413	400	295	159	51	1814
Mount Uniacke	27	20	136	271	391	376	247	117	31	1582
Nappan CDA	30	22	143	285	408	386	261	123	33	1670
Shearwater A.	27	24	131	265	392	402	296	160	49	1726
Stillwater	24	18	113	247	390	383	255	114	32	1584
Sydney A.	29	14	101	244	406	402	272	130	36	1625
Upper Stewiacke	28	25	140	279	411	387	258	120	39	1687
Yarmouth A.	30	28	138	253	357	359	271	157	53	1633

Prince Edward Island **l'Ile du Prince Edouard**

Alliston CDA	28	19	132	283	426	413	288	135	34	1720
Charlottetown	30	20	140	293	439	422	290	139	33	1782
St. Paul Island	15	2	30	148	340	369	259	118	21	1291
Summerside A.	28	16	138	293	437	419	289	136	30	1750

Table 1. Growing degree-days. One growing degree-day assigned to each degree Celsius that the daily mean temperature exceeded 5°C. From Handbook on Agricultural and Forest Meteorology. 1974 Atmospheric Environment, Environment Canada.

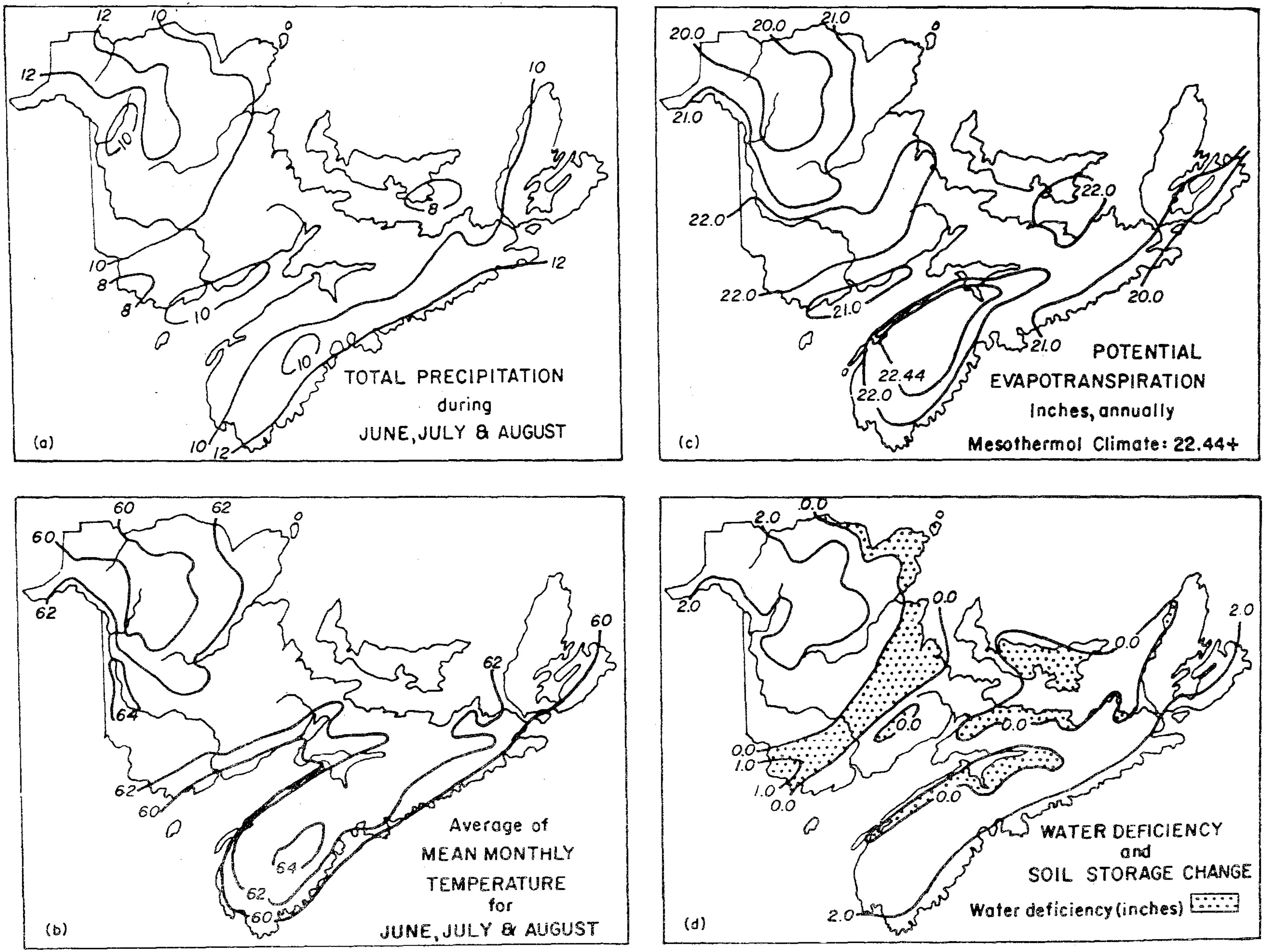


Figure 3. From Loucks, O.L. 1962. The Forest Classification for the Maritime Provinces.

Soil Properties

Soil texture is essentially unchangeable and therefore is a very important characteristic to consider during site selection. Soils that range between sandy and silty loam to loamy sand will have the fewest problems. The soil should be a well-drained, fairly deep (25-40 cm) layer of sandy loam underlain by a friable subsoil. Soil survey reports should be consulted to determine the most suitable soil series and its location in the desired region.

Heavy traffic within a seed orchard for protection, cone collection, etc. results in soil compaction. Subsoiling may be required prior to and after establishment.

Soil fertility can be modified and as such should be given a lower weight than other more critical factors when selecting orchard sites. There are differences of opinion as to what constitutes the optimum fertility level for cone production. Extremely poor sites are to be avoided as are very rich sites that may favour vegetative growth. An orchard should be located on soils of moderate and balanced fertility.

Fertilization to enhance flower production may be necessary and will likely produce more branches, more flowers per branch, and a greater proportion of the tree crown bearing flowers.

Soil acidity (pH) is also an important factor but one that can be modified. The optimum pH for cone production of our native species is not known. The problem of improper pH may exist only when orchards are established on abandoned farmland.

The need for lime or fertilizer in orchard management should be based on the results of an analysis of soil samples taken prior to establishment of the orchard.

Figure 4 shows soil temperature and moisture conditions for the Maritimes.

Frost and Wind

Areas that may suffer from late or early frost, a high occurrence of ice storms, or freeze-and-thaw conditions in winter (Fig. 5, Table 2) should be avoided.

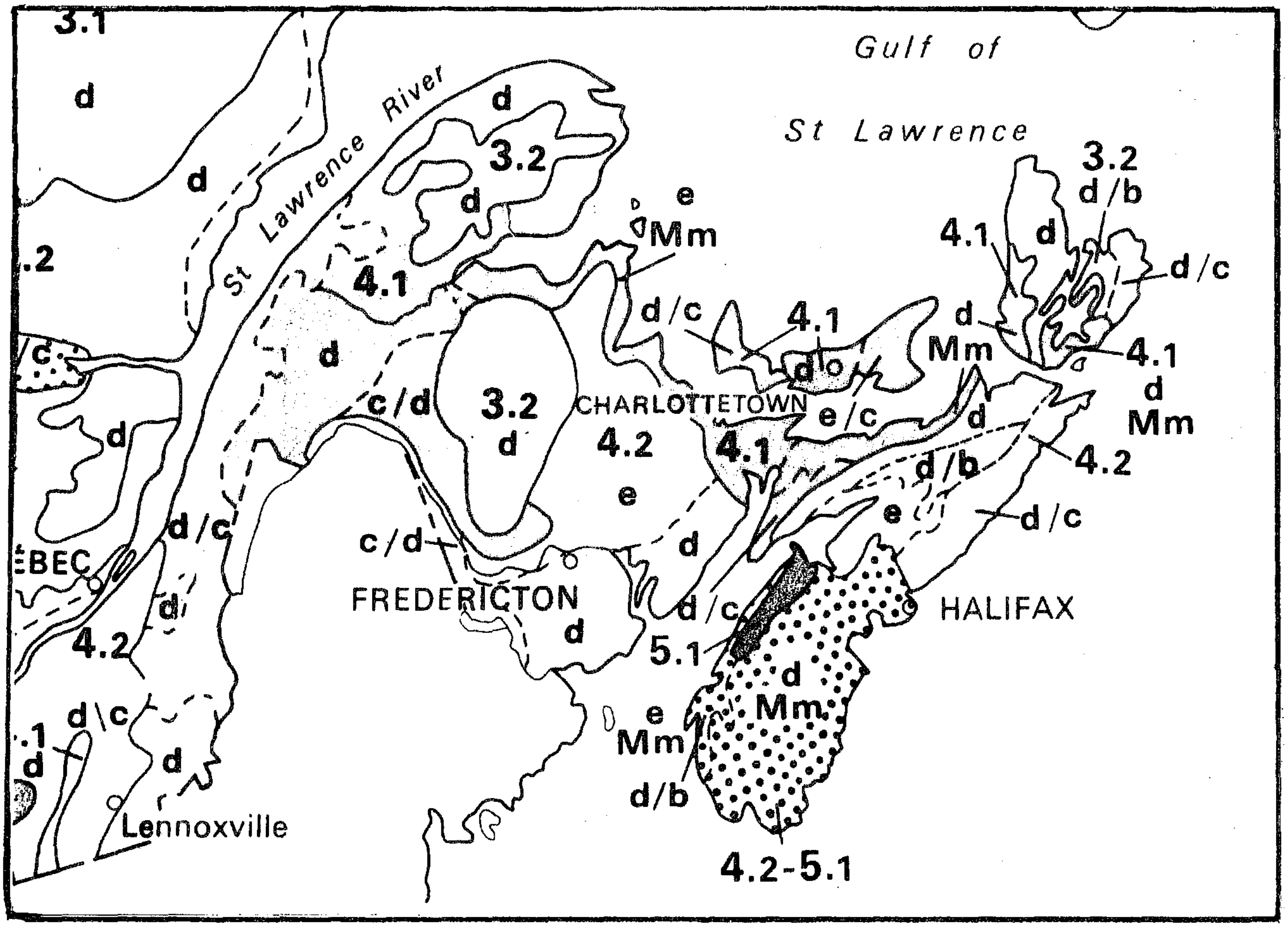
The effect of rivers and lakes on frost protection is quite apparent. This is well illustrated by the drop from 138 frost-free days at Gagetown on the St. John River to 81 at Blissville airport and from 130 frost-free days at Newcastle Creek on Grand Lake to 93 at Chipman (Fig. 6). Protection from spring and fall frosts may be expected up to 15 miles from large rivers or lakes depending on the contours of the intervening area. (Dickison 1962).

Orchards should not be located at high elevations or near the limits of the species' range. The site should be protected with wind breaks from the prevailing winter winds. The site should be free from localized frost pockets and as such should be on relatively high ground with a slope to provide good air drainage. A south to southwest aspect will ensure the warmest possible microsite.

OTHER CONSIDERATIONS

Isolation from Undesirable Pollen Sources

It is essential to isolate the orchard so that foreign, and hence unselected, pollen will not contaminate the orchard. Depending on the species and its distribution within a region, width of isolation barriers may range from 500 feet to many miles. Some contamination may take place even with an isolation barrier of many miles; therefore, the size of the barrier



SOIL TEMPERATURE CLASSES

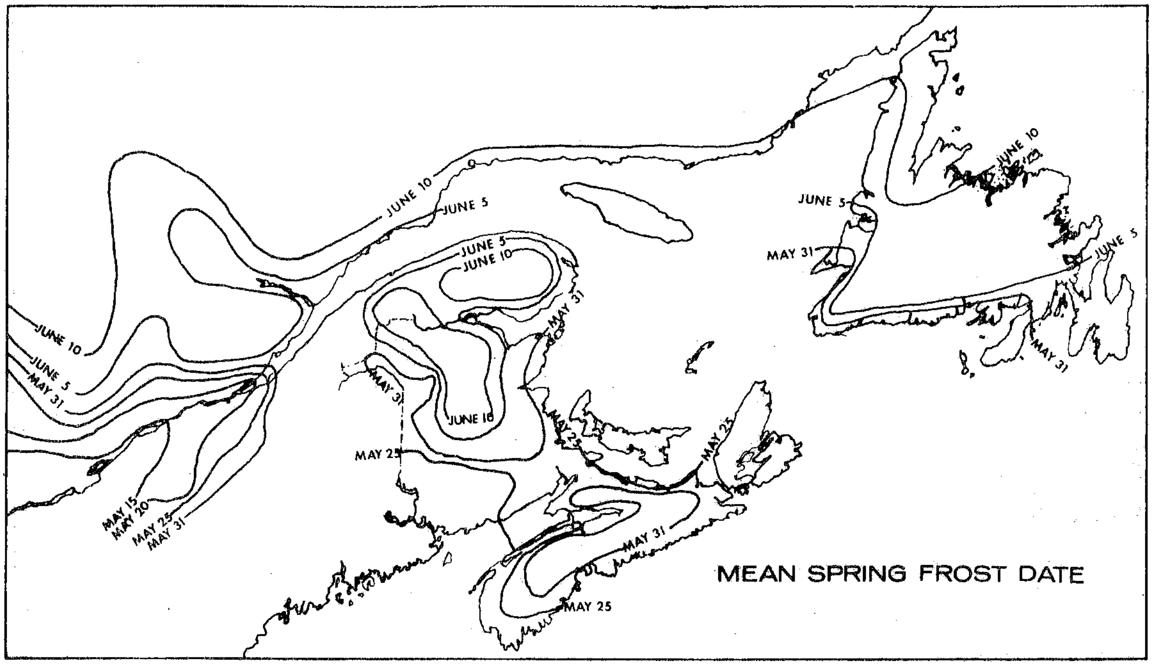
3.2	Moderately Cold
4.1	Cool
4.2	Moderately Cool
5.1	Mild

SOIL MOISTURE CLASSES

b	Aquic	Soil saturated for moderately long periods.
c	Subaquic	Soil saturated for short periods.
d	Perhumid	Soil moist all year, seldom dry. No significant water deficits in the growing season. Water deficits 0 - <1 in. (≤2.5 cm). Climatic Moisture Index (CMI) >84.
e	Humid	Soil not dry in any part for as long as 90 consecutive days in most years. Very slight deficits in the growing season. Water deficits 1 - <2.5 in. (2.5 - <6.4 cm). CMI 74-84.

Mm - classes modified by Maritime influence.

Figure 4. From Clayton, J.S. _et al_. 1977. Soils of Canada.



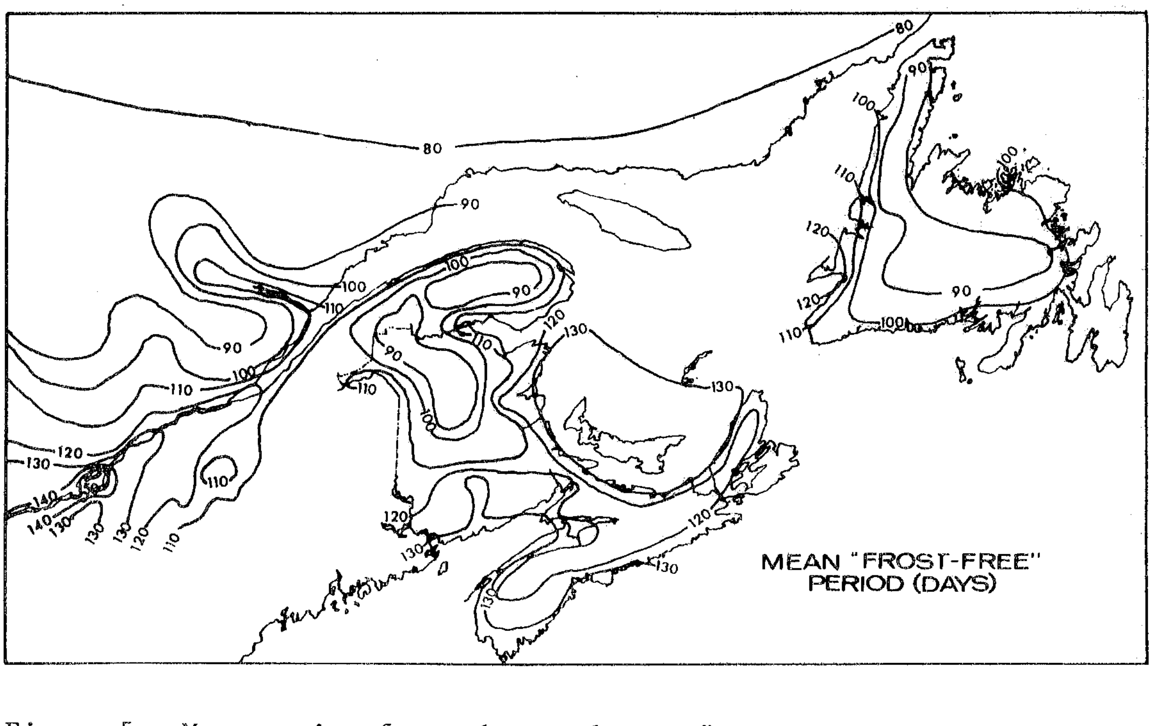


Figure 5. Mean spring frost date and mean "frost-free" period (days). From The Canada Land Inventory, 1966, Climates of Canada for Agriculture.

	Northern New Brunswick	Southern New Brunswick	Bay of Fundy	Prince Edward Island	Northern Nova Scotia	Annapolis Valley	Southern Nova Scotia	Eastern Nova Scotia	Sable Island
Mean annual temp.	°F. 37.0	40.2	41.6	40.7	41.4	43.3	44.0	41.6	45.0
Jan. mean temp.	°F. 8.1	13.3	19.5	16.8	18.7	22.6	24.4	21.3	30.6
April mean temp.	°F. 34.3	38.0	38.9	35.7	37.7	40.2	39.5	35.5	37.4
July mean temp.	°F. 64.0	65.5	61.5	64.8	63.9	64.1	63.4	62.1	59.1
Oct. mean temp.	°F. 42.3	45.5	46.9	46.8	46.8	48.7	48.8	47.6	52.3
Mean annual range	°F. 55.9	52.2	42.0	48.7	45.8	42.3	39.9	43.2	34.6
Extreme low	°F. 47.0	−52.0	−30.0	−27.0	−37.0	−25.0	−32.0	−40.0	−3.0
Extreme high	°F. 103.0	103.0	96.0	92.0	101.0	100.0	99.0	99.0	86.0
Extreme range	°F. 150.0	155.0	126.0	119.0	138.0	125.0	131.0	139.0	89.0
Mean daily range	°F. 22.0	20.0	16.0	15.0	19.0	17.0	18.0	17.0	10.0
Beginning of the growing season	May 6	Apr. 26	Apr. 26	May 3	Apr. 29	Apr. 22	Apr. 24	May 6	May 8
End of the growing season	Oct. 15	Oct. 25	Oct. 29	Oct. 30	Oct. 31	Nov. 3	Nov. 10	Oct. 31	Nov. 24
Av. length of growing season (days)	162	182	186	180	185	195	200	178	200
Date of last spring frost	June 10	May 30	May 8	May 20	June 4	May 20	May 22	June 4	May 8
First fall frost	Sept. 10	Sept. 20	Oct. 15	Oct. 12	Sept. 30	Oct. 12	Oct. 12	Oct. 7	Nov. 24
Length of frost-free period (days)	91	113	160	145	118	145	143	125	200
Mean annual precipitation (inches)	35.0	38.9	43.2	39.9	41.9	39.1	50.6	50.9	51.1
Mean annual snowfall, (inches)	105	96	80	80	72	72	72	75	46
Average rainfall, Apr. 1—Sept. 30 (inches)	18.17	18.33	19.11	18.39	19.14	17.10	22.82	23.00	20.92
Average rainfall June, July, Aug. (inches)	10.14	9.48	9.56	9.61	9.66	8.90	11.30	11.25	10.43
Mean annual rel. humidity	73%	77%	80%	83%	78%	78%	85%	83%	90%
Mean annual cloudiness	54%	55%	59%	63%	65%	57%	62%	74%	70%
Average no. of rainy days per year	114	113	130	140	117	127	145	141	151

Table 2. From Putnam, D.F. 1940. The Climate of the Maritime Provinces.

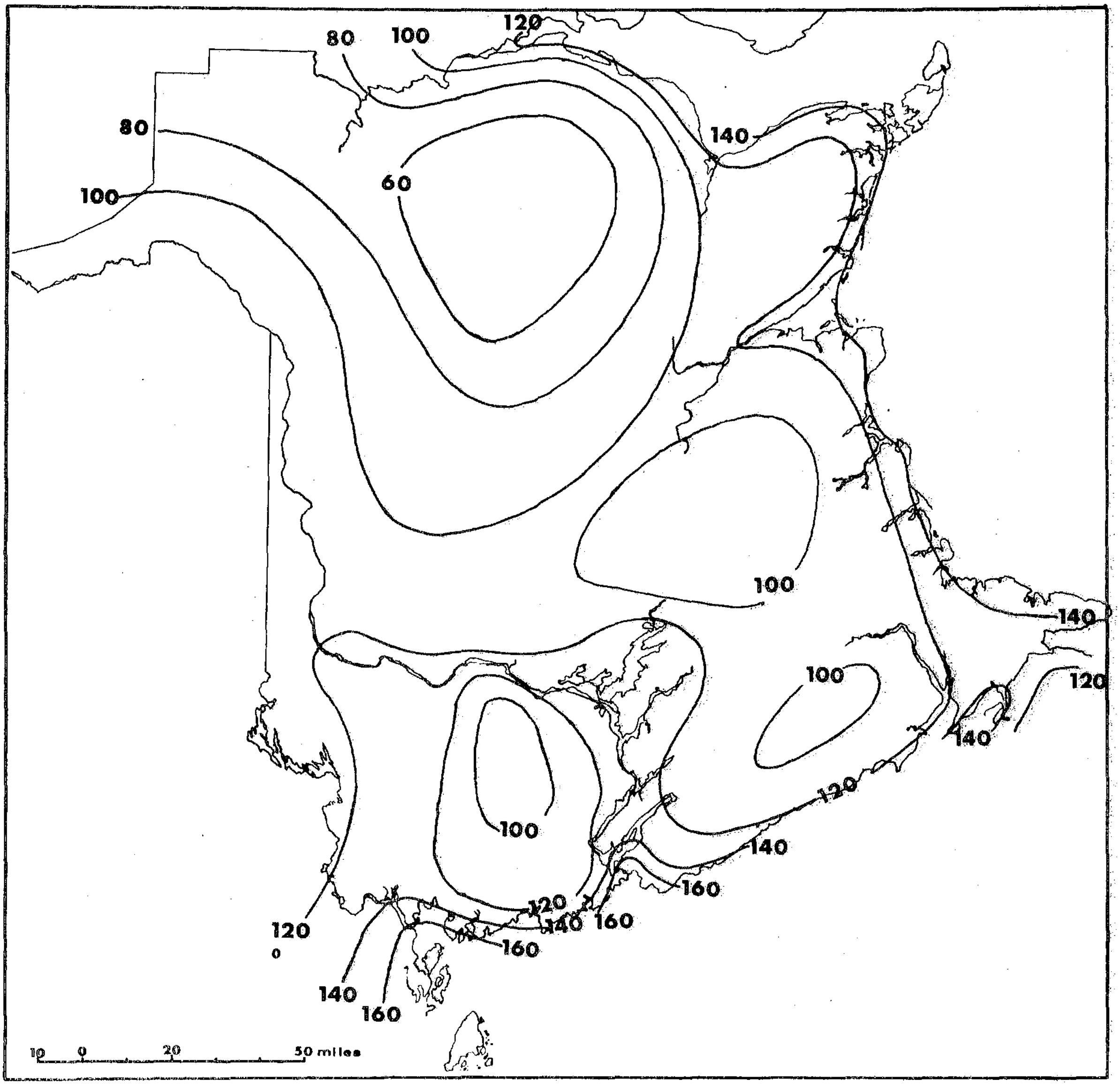


Figure 6. Average frost-free days. From Dickison, 1962. The Agriculture Climate of New Brunswick.

is a matter to be determined by practical considerations. Within younger orchards where pollen is limited, some contamination is expected (and beneficial) across the more narrow isolating barriers, but the mass effect of pollen produced within older orchards will minimize the effect of foreign pollen. For the same reason, pollen management in large orchards will be much less a problem than in small orchards. Isolation barriers can also act as fire breaks.

Two other techniques are available to control foreign pollen. Irrigation with cold water can be used to delay the development of flower buds within the orchard until after local pollen has dispersed. This is being practiced with Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco in British Columbia. The transfer of breeding material to a warmer climate can also effect an isolation barrier. The mass of pollen produced by extensive forests in the cooler part of the Maritimes will not contaminate the orchard until after the female flowers have been pollinated by orchard pollen.

Diseases and Insects

Possible adverse or harmful factors associated with sites and hosts which are to be avoided:

Spruce

- *Armillaria* - avoid poor sites and hardwood sites.
- *Polyporus tomatosus* - avoid old field sites and extremely acid sites.
- Chrysomyxa rusts - remove *Ledum groenlandicum*.
- Bark beetle - clean up blowdowns and dead trees.

Larch

- Miscellaneous cankers - avoid "offsite".
- Rusts - remove poplars and willows.
- Bark beetles - clean up blowdowns and dead trees.

Jack Pine

- Scleroderris - ensure proper control in nurseries, avoid "offsite" and areas of abundant natural infection.
- Sweet-fern blister rust - avoid areas with a high natural abundance of *Comptonia peregrina* and *Myrica gale*.

White Pine

- Blister rust - avoid areas with a high natural incidence of *Ribes* and microclimates with high humidity in late summer and fall.

Management Considerations

Accessibility and Size

Orchards must be accessible and operable during all seasons of the year. A permanent road system and gentle terrain are important considerations when selecting a location. When choosing a cutover, site preparation by crushing, burning, or removing the stumps would be advantageous.

It is desirable to plan an area of orchards as large as possible in a single district to (a) develop and fully utilize expertise to the best advantage, (b) keep overhead expenses to a minimum, (c) get maximum use of specially purchased machinery for ground maintenance, chemical spraying, and cone collections. Operationally, this approach is much more efficient than establishing each orchard at a separate location, but risk of catastrophic loss from ice, wind, drought, or fire is intensified. An alternative is to centralize the commercial orchard operations but to preserve the parent trees in a clone bank at a separate location as insurance against catastrophic loss.

Services and Labour

An adequate water supply is essential. Irrigation will likely be necessary to promote development of flower crops, provide fire protection, and possibly to delay flower budburst.

Communications should be good and an electricity supply is very desirable. The location should be such that vandalism and damage from offroad vehicles are minimized.

Orchard work is seasonal and sources of reliable labour must be available, when needed, and organized well in advance of requirements. Basic site work, including tree and scrub clearance and drainage, should be conducted at least one year ahead of planting. Shelterbelts for wind protection should be established as required. These belts should be composed of a mixture of short-lived fast-growing species and longer-lived, shade tolerant species.

An accurate map of the area should be produced on which to base the layout of the planting positions, internal roads, water points, etc. An orchard scheme must be properly costed and funded at the outset and there must be reasonable assurance that the estimated annual operating costs will be met. As the seed orchard program progresses, it will be essential to attempt to analyze the cause of failures and successes for different sites and species.

SPECIFIC RECOMMENDATIONS

Seedling Seed Orchards

Geographic Location

Seedling seed orchards should be located within the region or administrative district in which the resulting seed crop will be used for reforestation. Progeny tests provide the data with which to rogue families from the orchard, while orchard data determine which individuals of the better families are rogued. It is important that the orchard be on a representative planting site for the region. However, it is also important that the site be conducive to seed production as that is the primary function of an orchard. Very favourable conditions are essential for the continuous high production of orchard seed.

Sites

Seedling seed orchards should be located on typical planting sites that best fulfill the flowering and seed production needs, that is,

- in the warmest, driest area within the region or administrative district
- on well drained, deep sandy loam soils of moderate fertility
- on an area with some slope for good air drainage, with no frost pockets or wind funnels
- in an area as free as possible from pollen contamination of the same species
- in an area that satisifies as many as possible of the management considerations, particularly the presence of an adequate water supply.

Clonal Seed Orchards

Clonal seed orchards are rogued based on the results of progeny tests only, are established at close to final spacing, and are much more expensive to establish than seedling seed orchards. As such, it is imperative that the utmost care go into selecting a site conducive to the continuous high production of seed. There should be no financial restraints.

Based on the accompanying figures and tables of climatic and edaphic variables, the following recommendations may be made.

Nova Scotia

Clonal seed orchards should be established in the Annapolis Valley (Fig. 7). The Valley is a long narrow lowland with steep slopes and is climatically the most favoured part of the Maritimes. It has a long "frost free" period; the probability of damaging late spring frosts is slight, there is a chance of water deficiency, and the growing degree-days are high.

New Brunswick

Clonal seed orchards should be established in the lower St.John River valley or in the southwestern portion of the province but excluding the immediate coastal area between Saint John and St. Stephen. The area bounded by McAdam, Canterbury, Fredericton, Minto, Hampton and Westfield is considered to be the most suitable (Fig. 7). In this area, the springs begin moderately early; the summers are warm and reasonably long with little chance of frost after May 30th; the number of degree-days is high and there is a chance of water deficiency. Within this area however, the central portion should be avoided because of fewer frost-free days (Fig. 6).

Prince Edward Island

The Island overall has a very favourable climate, although the area east and south of Charlottetown appears the most favourable for the possibility of drought (Fig. 7).

Within these general areas of each province the location of the orchard site should comply with the recommendations for seedling seed orchards namely:

- on well-drained, deep, sandy loam soils of moderate fertility
- on an area with some slope for good air drainage, with no frost pockets or wind funnels
- on a south to southwestern slope for a warm microsite
- in an area free from contamination by pollen of the same species; and free from damaging ice and wind storms
- in an area that satisfies as many as possible of the management considerations particularly the presence of an adequate water supply.

Land Acquisition and Management

To dramatically enhance cone production, it is strongly recommended that agencies cooperate in finding and purchasing fairly large tracts of land (100-200 ha), in the suggested area of each province, that are suitable for development into seed orchard complexes. The management of these complexes could be contracted to capable agencies within the area.

The Annapolis Valley of Nova Scotia is excellent agricultural land and, as such, land values are

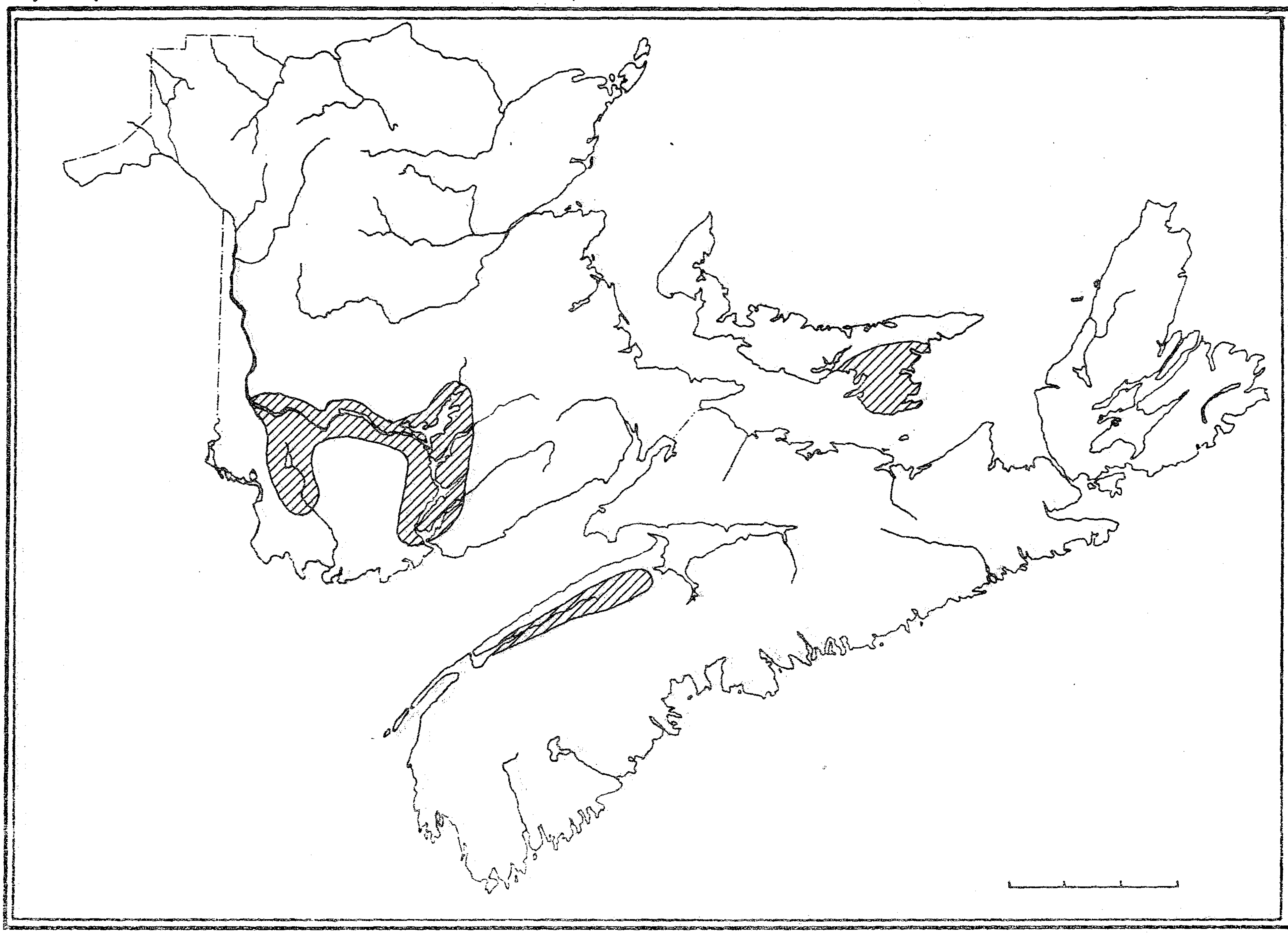


Fig. 7. Recommended areas for establishment of clonal seed orchards in the Maritimes.

high. The problem of cost is not as severe in New Brunswick but action to acquire land should be taken now. To put Maritime land values in perspective, however, consider the case of four Vancouver Island agencies. The most favoured site on the Island is the Saanich Peninsula within the greater Victoria area where land values range between $8,000 and $12,000 an acre. The British Columbia Forest Service, Pacific Logging, Tahsis and Rayonier have all established seed orchards there within the last few years. Good sites can still be acquired in the Maritimes for a tenth of that cost.

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