

Seed supply in Quebec

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Abstract

This paper presents the needs for seedlings and seeds for the coniferous and hardwood plantation programs in the province. To meet these objectives, seeds are now collected from natural or artificial stands, in seed collection and seed production areas, in seed orchards, in rogued genetic tests and in specific recommended seed sources. Informations are also presented on the cost of seeds and on perspectives for the future.

Résumé

Approvisionnement en semences au Québec.

Ce document présente les besoins en plants et en semences pour le programme de reboisement en espèces résineuses et feuillues au Québec. Pour rencontrer ces objectifs, les semences sont présentement récoltées dans des peuplements naturels et artificiels, des aires de récolte de semences, des peuplements semenciers, des vergers à graines, des tests génétiques et dans diverses sources spécifiquement recommandés. On donne des informations sur le coût de production des semences. Finalement, on présente des perspectives pour l'avenir.

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Introduction

Reforestation is a long-term undertaking. A seed will give birth to a tree which will remain on the same site for decades or even a century. It is thus important to choose the right species for a given site and select the best genetic stock to obtain maximum returns from future plantations.

In Quebec, up to a few years ago, all cones and seeds were collected from natural stands and a few from good plantations which were not improved by any means. Those seeds were collected from felled trees in cutovers or from standing trees which, most of the time, were short, limby and very easy to climb. Little or no attention was paid to provenances and seed transfer rules were more or less respected. That is why some plantations here in Quebec and elsewhere are not as productive as could be expected; some even were destroyed by frost because they were not adapted to the sites.

Fortunately, the situation has changed and at least in Quebec, seed zones and seed transfer rules exist, seeds are collected in improved stands, in seed orchards and in other appropriate sources. In this paper, these aspects and others will be reviewed in regard of the reforestation program in the province.

I must emphasize the fact that in Quebec, all activities pertaining to cones and seed collection, seed extraction and seedling production are, by law, under the jurisdiction of the *Ministère de l'Énergie et des Ressources*.

Reforestation program

Only reforestation by planting will be considered since direct seeding is no longer accepted as a reforestation means in Quebec.

The total plantation program for the province is currently set at 238.8 million seedlings per year. Coniferous species account for 98.8% (235.9 millions) of the total needs (Table 1). The most important of the 11 coniferous species actually planted are black spruce (47%), white spruce (22%) and jack pine (18,6%). Two types of seedlings are produced : bareroot and containerized. For each type, 4 viable seeds are required to produce one plantable seedling. The total annual requirements for these species are thus 943.5 million viable seeds or 5 839 hl of cones (Table 1).

Yellow birch, sugar maple, white ash and red oak account for 83.3% of the 2.9 millions seedlings required for the hardwood plantation program (Table 2). The number of viable seeds to produce one plantable seedling varies from 2 to 10 depending on species and the type of seedlings produced (bareroot or containerized). For all hardwood species, 15.6 million seeds or 800 hl of seeds are required annually to meet the demand (Table 2).

Seed zones

Up to this year, the province of Quebec was divided into 13 seed zones established in the early 70's. Those were based on Rowe's (1972) forest regions and on various climatic data. The resulting demarcation lines were adjusted to existing administrative boundaries such as administrative regions, townships or counties.

Beginning in 1990, the ecological regions as defined by Thibault and Hotte (1985) serve as seed zones and the following transfer rules are currently applied :

Table 1. Number of seedlings and number of hectolitres of cones, per species, required annually for the coniferous plantation program in Quebec (1990)

Species	Number of seedlings (x 1 000)	Number of viable seeds per plant	Number of hectolitres of cones
Black spruce	111 332	4.0	1 484
Norway spruce	9 445	4.0	581
Red spruce	5 398	4.0	92
White spruce	52 346	4.0	598
European larch	55	4.0	3
Tamarack	3 424	4.0	54
Black pine	74	4.0	21
Jack pine	43 828	4.0	1 402
Red pine	5 923	4.0	948
Scotch pine	53	4.0	7
White pine	4 056	4.0	649
Total	235 934	–	5 839

Table 2. Number of seedlings and number of hectolitres of seeds, per species, required annually for the hardwood plantation program in Quebec (1990)

Species	Number of seedlings (x 1 000)	Number of viable seeds per plant	Number of hectolitres of seeds
Yellow birch	742.5	5.0	1.77
Sugar maple	650.5	10.0	130.10
Red oak	565.0	2.0	108.65
White ash	463.0	8.0	21.05
Black cherry	115.0	3.0	1.23
Black walnut	101.0	5.0	454.50
White elm	75.0	5.0	0.56
White oak	58.0	3.5	11.60
Butternut	40.0	4.0	63.64
Bur oak	37.0	3.0	3.97
Red ash	23.0	6.0	0.80
Others	36.0	3.0	2.01
Total	2 906.0	–	799.88

- a) Use local provenances, ex. : same township in which seeds are collected.
- b) Use the seeds in the same ecological region in which they were collected.
- c) Use the seeds in adjacent ecological regions but within one domain or sub-domain.
- d) Move the seeds into the adjacent domain northward but within one degree of latitude (300 m in altitude correspond to 1 ° of latitude).

4. Seed sources

In the province of Quebec, cones and hardwood seeds are currently collected from various sources. The genetic quality of these seeds varies with the sources from which they are collected. In time, as seed orchards and genetic tests become older, it is expected that the proportion of seeds collected from unimproved sources will decrease while that from improved sources will increase.

4.1 Natural or artificial stands

Most of the seeds (80%) are still collected from natural or artificial stands. An effort is made to identify the best natural stands which are going to be cut during the year. Arrangements can be made between the Ministry and the companies to delay cutting until the cones are mature, specially during good producing years, and most if not all cones are collected from felled trees.

Plantations with well adapted and phenotypically adequate trees serve more and more as seed sources. The seeds are usually collected from standing trees.

The needs for hardwood seeds being rather low, most of them are collected from a few phenotypically good individual trees within a given seed zone either from felled or, more often, from standing trees.

4.2 Seed collection areas (SCA)

These areas are basically established to provide a conveniently located source of better than average quality seeds of known origin for use in local plantation programs. No treatments to improve the quality or the productivity of these stands are applied. They are established on a temporary basis. Cones or seeds are usually collected from felled trees during good seed years.

This particular source of seeds is quite appropriate for the large black spruce and jack pine natural stands.

The amount of seeds collected in these stands is increasing from year to year. In 1989, 15% or 673 hl of all the seeds collected in the province were from these areas.

4.3 Seed production areas (SPA)

Seed production areas are designed to provide a conveniently located seed source of better than average quality. In these areas, selection, roguing and other silvicultural treatments are carried out in order to increase genetic quality and seed yields. Cones and seeds are usually collected from standing trees. Like seed collection areas, they are also of a temporary nature but are expected to serve for a longer period of time.

The total amount of cones and seeds collected in these areas between 1977 and 1988 varies from 1 to 16% of the total collections. The best years were 1985 with 947 hl and 1988 with 1 468 hl of cones. More cones and seeds are expected to be collected in these areas in the near future.

Tables 3 and 4 show, for coniferous and hardwood species respectively, the total seed collection and seed production areas actually established by the Ministry.

4.4 Seed orchards

Seeds orchards are plantations consisting of clones or seedlings from selected trees, isolated to reduce pollination from outside sources, rogued of undesirables, and cultured for early and abundant production of seeds (Snyder, 1972).

Table 5 shows the total area, the expected production and the total number of seed orchards, per species, in the seed orchard program of the Ministry. It also gives the total number of progeny tests established in relation with the seedling seed orchards. The last first-generation seed orchards will be established in 1991. This program began in 1980, with one exception (1978). These orchards are thus very young and just beginning to produce cones. Fifty-two hl of cones were collected in 1989. Usually, a genetic gain from 5-8% over unimproved material is expected from these orchards.

No seed orchards have been established yet for hardwood species.

4.5 Rogued genetic tests

Since the beginning of tree improvement work at the Ministry in Quebec around 1969, more than 800 experimental designs have been established. Some of the oldest, from which data are available, have been rogued to keep the best material. We feel that valuable cones and seeds can be collected from these plantations located in the arboreta system of the Ministry or in genetic tests from Forestry Canada researchers. Small commercial quantities of Norway spruce and larches have been collected in these tests. Moreover, small quantities of seeds have already served as donor plants from which cuttings are taken to be rooted at the Saint-Modeste propagation center. The degree of genetic improvement of this material depends on species, site and intensity of roguing.

Table 3. Total seed collection (S.C.A.) and seed production (S.P.A.) areas, per coniferous species, established by the *Ministère de l'Énergie et des Ressources* in Quebec

Species	Seed Collecting Areas (ha)	Seed Producing Areas (ha)
Black spruce	162.5	423.11
Norway spruce	26.0	35.93
Red spruce	0.0	70.30
White spruce	169.9	93.10
Tamarack	30.0	22.30
Jack pine	454.0	685.80
Red pine	7.0	292.70
White pine	23.0	38.0
Total	872.4	1 661.24

4.6 Recommended seed sources

A document was prepared in 1987 by the genetic tree improvement R-D division, in which a number of provenances for coniferous species were recommended as good seed sources. The document contains, for each species, recommended provenances for different seed zones. These provenances can be from the province of Quebec, from neighbouring provinces (Ontario or New Brunswick), or from Europe for exotic species like Norway spruce, European and Japanese larches, and their hybrids. In many cases or when available, informations are given on persons and establishments to contact to get the right sources.

Efforts are made to collect more cones from these good sources or to obtain seeds from European countries. When possible, S.P.A. are established in these sources.

All these sources were recommended following tests conducted on a number of sites in the province either by the ministry's R-D group or by Forestry Canada forest geneticists.

5. Cost of seeds

Table 6 shows the cost of seeds for coniferous species collected in 1988. Each year, a purchasing cost is established according to the needs for a given species, the quantity needed, and the importance of the crop for that year.

To this purchasing cost, direct and indirect costs must be added to obtain the cost of production. Direct costs include transportation, rent of warehouses and salary of supervisors. Indirect costs include salaries of permanent employees who overlook the entire process and the value of vehicles already owned by the Ministry.

Table 4. Total seed collection (S.C.A.) and seed production (S.P.A.) areas, per hardwood species, established by the *Ministère de l'Énergie et des Ressources* in Quebec

Species	Seed Collecting Areas (ha)	Seed Producing Areas (ha)
Black cherry	10.0	30.0
Red oak	12.3	42.2
Sugar maple	0.0	14.0
Butternut	22.0	0.2
Black walnut	3.0	0.0
White elm	0.0	3.0
Total	47.3	89.4

Table 5. Total area, expected production, total number of first generation seed orchards and progeny tests, per coniferous species, in the *Ministère de l'Énergie et des Ressources* seed orchard program

Species	Total area* (ha)	Expected production (1 000 seedlings)	Total number of :	
			Seed orchards	Progeny tests
Tamarack	13.1	3 195	3	4
European larch	2.9	478	1	0
Hybrid larch	1.0	190	2	0
Black spruce	560.6	76 795	23	38
Norway spruce	26.7	12 136	6	0
Red spruce	19.5	8 864	4	0
White spruce	115.6	105 091	17	0
Jack pine	245.0	38 889	11	14
Red pine	2.7	99	1	0
Scotch pine	6.1	1 220	1	0
White pine	30.8	4 219	6	0
Total	1 024.0	251 176	75	56

* Includes 8 orchards (36.5 ha) to be established in 1991 and completing the program

When the mean extraction cost for all species (37 \$/hl) and the mean depreciation cost (20 \$/hl) of the extraction plant and its equipment are added to the cost of production, we get the total cost per hectolitre of cones. From these, the total costs per kilogram of seeds and the cost of seeds in a plantation can be calculated. For the main coniferous species used in plantation in Quebec, cost of seed production represents less than 1% of the total cost per hectare planted.

Also, the costs of establishment and management of different seed sources (seed production areas, seed orchards) are not included in the cost of seeds. Variation in the total cost of seeds is noted according the volume collected. Usually, when more cones or seeds are collected, the cost per unit is lower.

Table 6. Cost of seeds for coniferous species collected in 1988

Species	Purchasing cost (\$/hl)	Production cost ¹ (\$/hl)	Total cost ² (\$/hl)	Total cost/kg of seeds (\$)	Cost of seeds in plantation ³ (\$/ha)
Tamarack	250	416	473	732.55	16.11
Black spruce	181	211	268	496.94	6.22
Norway spruce	32	60	117	141.60	16.15
Red spruce	142	169	226	188.57	6.07
White spruce	117	155	212	151.33	4.64
Jack pine	67	121	178	337.15	11.21
Red pine	162	199	256	456.99	28.03
White pine	50	73	130	205.51	79.03

¹ Purchasing cost plus direct and indirect costs.

² Production cost plus extraction cost (37 \$/hl) and depreciation (20 \$/hl)

³ Based on 2 275 plants/ha.

For hardwood species, the few seeds needed are collected from individual trees by permanent staff or by employees paid on a per hour basis. So the cost of seeds is difficult to establish and varies according to species and to the location of collection for a given species.

6. Perspectives for the future

Up to now, in Quebec, unimproved cones and seeds were collected mostly from natural stands and in some good plantations. Efforts are made to collect more cones and seeds in identified sources such as seed collection and seed production areas. Some of the seed orchards are beginning to produce cones but less than a hundred hl of cones have been collected up to now in these orchards.

In the coming years, it is expected that more and more cones and seeds will be collected from identified sources like seed production areas and seed orchards. We hope that by the turn of the century, all seeds needed for the Quebec artificial regeneration program will be collected from rogued seed orchards.

Meanwhile, efforts are being made to carry on with the second generation of improvement by concentrating on controlled crosses among the best individuals selected in the best families or clones represented in seed orchards. These crosses will be evaluated and the best ones for a given area will be repeated to give seeds and donor plants. Cuttings from these donor plants will be vegetatively propagated on a commercial basis. Rooted cuttings will then be planted and will represent an important genetic gain over the seed sources now being used.

We also hope that when somatic embryogenesis techniques become operational, planting material will become available directly from seeds derived from controlled crosses.

For hardwood species, commercial quantities of seeds will continue to be collected mainly from selected individual trees in various regions. The goal is to collect seeds from five trees per species in each ecological region and administrative unit. These trees are selected in the seed collection and the seed production areas already established or in good natural stands. About 150 to 300 trees will be selected per species. They will also serve as the genetic base population for the hardwood improvement program. Some of these trees will be classified as "seed trees" for seed collection during the coming years. All selected trees will be cloned and will

serve : 1\$ as a source of donor plants from which cuttings will be taken and rooted for producing material for commercial plantations, or : 2\$ for the establishment of breeding orchards or seed orchards, depending on species. Seeds derived from controlled pollination in the breeding orchards will act as donor plants for the large scale production of rooted cuttings.

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