

Feasibility Assessment of Afforestation for Carbon Sequestration

Complementary information on the pilot project of the *Agence de mise en valeur des forêts privées des Appalaches*

Location and surface area of the experimental sites

2003 sites: 4 experimental blocks established in spring 2003 on 4 different sites (total of 5 ha)

2004 sites: 9 blocks established in spring 2004 on 7 different sites (total of 14 ha)

In all: 13 experimental blocks established on 11 different sites (total of 19 ha)

22,800 hybrid poplar seedlings (7 different clones) planted

Five municipalities in the Appalachians region: Saint-Philémon, Saint-Léon-de-Standon, Lac-Etchemin, Saint-Camille-de-Lellis and Sainte-Rose-de-Warford.

See the attached file which contains a map of the experimental sites.

Owners of experimental sites

Most of the nine site (land) owners are between 50 and 55 years of age.

Three are pensioners, three others professionals, two are blue collar workers and one owner is a hog producer.

Work and services provided free of charge for site owners

- Technical and scientific supervision
- Seedlings
- Site preparation (harrowing and ploughing in all cases; brush cutting, relief drainage and road improvement in some cases)
- Planting in accordance with the research protocol
- Fill planting to replace dead or dying seedlings.
- Mechanical tending of competing vegetation (about four times a year)
- Annual fertilization with liquid hog manure, initiated in 2004 on the sites established in 2003
- Complementary chemical fertilization to correct mineral deficiencies

Landowner participation

- The landowners are providing the use of their land for the experimental sites for a period of 15 years.

- The landowner who is a hog producer provides liquid hog manure for annual fertilization of plantations.

Documentation on the costs associated with the experimental plantations

The costs associated with the establishment and tending activities are documented for each experimental block in a georeferenced database.

Weighted average cost of establishment and tending for the 2003 experimental blocks ^a

Activities	Weighted Cost
	(\$/ha)
<i>Site preparation</i>	
Drainage, roads and rock removal	\$452
Ploughing and harrowing	\$452
<i>Subtotal</i>	<i>\$904</i>
<i>Planting</i>	
	<i>\$776</i>
<i>Tending</i>	
Harrowing between rows	\$310
Weeding between seedlings	\$370
Mice poisoning systems (equipment and chemicals)	\$68
<i>Subtotal</i>	<i>\$749</i>
Total	2428 \$

^aExcluding mechanical brush cutting, contour drainage and brush removal on the periphery of a block, done by owners at their expense.

With regard to the 2004 experimental blocks, the only costs compiled so far are those incurred for partial site preparation (mostly ploughing) in fall 2003. The cost of the harrowing and planting work done in spring 2004 will be compiled over the coming months.

Experimental protocols

The goal of the experimental protocols is to quantify the effect that fertilization with liquid hog manure has on the growth and yield of hybrid poplar plantations, on the carbon budget and on the environment (percolating water). Separate but similar protocols were developed for the sites established in 2003 and 2004.

Each site contains one or two one-acre experimental blocks.

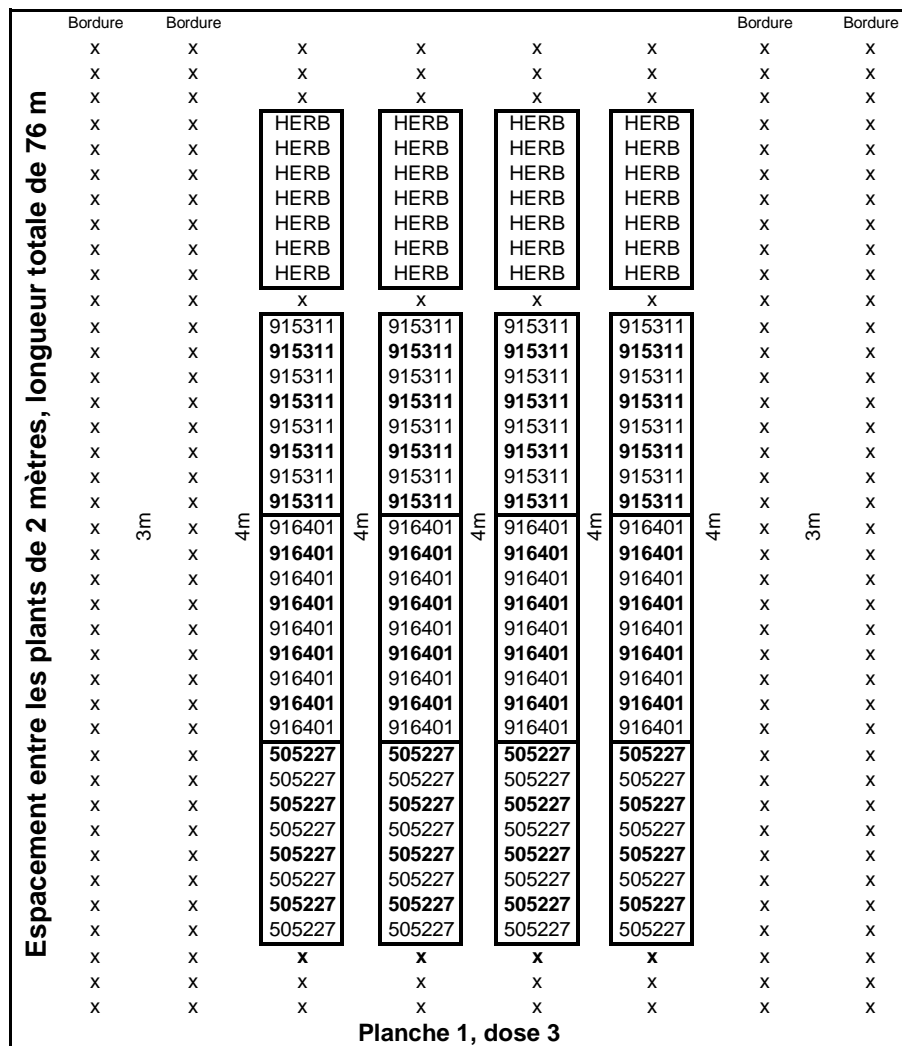
Each block consists of four beds corresponding to the different fertilization rates being tested (no fertilization, base rate set by taking into account the nitrogen requirements of a hay field that is cut, 1.5 and 2 times the base rate).

Each bed is composed of four plots: one for each of the three hybrid poplar clones in each protocol and one plot with herbaceous vegetation.

Each permanent tree¹ in the plots is tagged and georeferenced for data capture and processing purposes.

Example of a bed established within an experimental block

- The clone numbers shown in bold represent the seedlings that will be monitored over a 15-year period.
- Each bed measures 76 metres by 26 metres.



Below is an overview of the scientific data collected and analysed in the 2003 experimental blocks:

¹ One in every two trees will be harvested about 5 years after planting.

Data on the soil, the soil solution and carbon

In fall 2003, 10 soil samples were collected per plot in the seedling rows, and 10 between the rows, to make up two composite samples per plot.

The samples were analysed for the following parameters: pH, texture, C, N, P, K, Ca, Mg, K, Na, Al and H.

Samples will be taken in 2004 to assess soil density.

In each plot, three tension lysimeters were installed at a depth of 20 cm, and three others at a depth of 40 cm. Four or five times a year, after annual spreading of liquid manure and after a heavy rainfall, the soil solution is collected in order to measure the concentrations of NO₃, NH₄, PO₄, K, Ca and Mg, as well as ionic conduction and pH.

Forest mensuration data

In fall 2003, the diameter at breast height (dbh) and the height of the permanent trees in the 2003 blocks were measured to quantify the above-ground volume.

Poplar nutrition

In August 2003, the tree foliage was sampled in order to monitor nutrition. In each plot of poplars, five leaves collected from 10 trees of each clone were dried and then weighed to determine the unit mass of the foliage. The samples were subsequently analysed for nitrogen, P, K, Ca and Mg, in order to detect any mineral deficiencies.

Fertilization with liquid manure

Prior to the spreading operation in spring 2004, samples collected from the liquid manure tanks were analysed to determine the theoretical base fertilization rate for each plot.

During spreading, a densimeter was used to analyse the liquid manure in the tanks so that the theoretical rates could be adjusted.

Statistical analyses

Analysis of variance or multivariate analysis was performed on the data. The relationships between the variables were examined using correlation analysis. Vector analysis was also used.

Preliminary scientific results – 2003 blocks

Soil and foliage analyses

Only one of the four experimental sites was found to have a pH level (and a calcium level) high enough to supply the poplars with sufficient Ca firstly and P secondly, with the availability thereof increasing in the soil up to a pH of 6.5. This is borne out by the foliar concentrations of P. The other three soils appeared to require the addition of two to three tonnes of agricultural lime per hectare. One site is particularly poor in phosphorus (P) and phosphorus saturation (P/Al). There is every reason to believe that this site will respond well to the addition of liquid manure. The four soils under study exhibit fairly low K concentrations, but the liquid manure will provide little K. The addition of 100 kg K-K₂SO₄ ha⁻¹ is therefore recommended as a means of meeting the poplars' requirements. Although the nitrogen concentration in the foliage is too low (< 1500 mg kg⁻¹), the application of liquid manure should correct this situation.

Carbon analysis

The total C content ranges from 2.52 to 3.58% on average depending on the site. The highest values are found where the pH is most acidic. These concentrations will be linked to density values so that the pools can be calculated in kilograms per hectare.

The C/N ratio is fairly consistent (11 to 13), indicating that the quality of the organic matter varies little among the blocks.

Context and issues

Afforestation in Quebec: a structured and subsidized activity

For decades, afforestation of private lands in Quebec has been subsidized by the provincial government. In recent years the forest industry has also contributed financially to Quebec's efforts. For example, the Quebec private forest development program (Programme de mise en valeur des forêts privées) subsidizes about 80% of the costs associated with site preparation, planting, tending of young plantations and technical support, in addition to supplying seedlings free of charge. Landowners therefore expect to receive considerable support for afforestation.

Afforestation activities on privately owned land are carried out within a highly structured context involving regional private forest development agencies, the Ministère des Ressources naturelles, de la Faune et des Parcs du Québec (MRNFP, Quebec Department of Natural Resources, Wildlife and Parks), municipal officials, the forest industry, representatives of private woodlot owners and silviculture firms. The agencies identify regional strategies and priorities and manage the funding earmarked for regional private forest development.

Industrial plantation forestry still in its infancy

Silvicultural operations centring on fast-growing species have been conducted in Quebec for nearly 40 years on an experimental scale. The MRNFP recommends more than 44 hybrid poplar clones for afforestation in the different ecological subregions of southern Quebec, whereas 9 larch/hybrid species are adapted to grow in six ecological regions. It is only in the past six to eight years that industrial plantation forestry has become operational, thanks to the impetus provided by forestry companies seeking to secure supplies for their processing plants.

Afforestation with fast-growing species still accounts for only a small portion of the planting operations carried out each year in Quebec. In 2002, production of hybrid poplars and hybrid larch, to a lesser extent, accounted for nearly 2% of the seedlings delivered. There has nevertheless been a significant increase in the production of hybrid poplar seedlings in recent years, with the total number rising from 200,000 seedlings in 1998 to 1.5 million seedlings in 2003.

An uncertain policy and budgetary situation

In 2000, the MRNFP announced its intention to adopt an increased yield policy in 2002 which would encourage planting of fast-growing species. For various reasons, this policy has not yet been implemented nor has a time frame been set in this regard.

In addition, in 2004, the Quebec government reduced the annual budget of the private forest development program by more than 10% from the 2003 level. In this context, regional agencies

are experiencing difficulty in subsidizing plantations of fast-growing species. Establishing such plantations and tending (mechanical) them over a number of years generates substantial costs, which do not necessarily correspond to regional priorities for private forest development.

Small areal extent of sites available for afforestation

The experimental sites of the pilot project have an area of 1.7 ha on average. This is typical for afforestation operations on privately owned land in Quebec and there are several factors that explain this situation. For example, in many cases the sites available for afforestation are too small or isolated to permit cost-effective agricultural operations or are insufficiently fertile (poor drainage, acid soils or shallow soils). Owing to the fragmentation of sites, additional costs must be incurred to identify sites for afforestation, move machinery between sites and handle administrative and technical tasks (more landowners and biophysical diversity per unit area of plantation). As indicated below, the survey that is planned as part of the pilot project will seek to shed light on these issues and challenges.

Manual cleaning of plantations

A government directive prohibits the use of chemical herbicides for plantation cleaning operations on public and private land when this work is subsidized by the Quebec government. Since the experimental plantations in the pilot project are subsidized in part by the provincial government, cleaning cannot be done with chemicals. This has a major impact on afforestation costs: production and planting of large seedlings, intensive site preparation, four to five mechanical cleaning operations per year during the first three or four years after planting takes place.

Difference of opinion between agriculture and forestry stakeholders regarding the use of abandoned farmland and effect on the orientation of the pilot project. In Quebec, most of the marginal agricultural land which is eligible for afforestation in accordance with the Kyoto Protocol is zoned agricultural. Consequently, any request for afforestation must first be authorized by the Ministère de l'Agriculture du Québec (MAPAQ, Quebec Department of Agriculture). In several regions of the province, it is very difficult to obtain this authorization. This situation stems partly from the differing views of agriculture and forestry stakeholders concerning the use of abandoned farmland, but also from the strong demand for spreading of liquid hog manure on agricultural lands.

This context explains the primary thrust of the pilot project, namely to test the use of liquid hog manure in fertilizing plantations of fast-growing species. This thrust is intended as an incentive for afforestation for hog producers, MAPAQ and some owners of marginal agricultural land. Other expected benefits are as follows:

- Enhancing the oft-deficient fertility of the sites to be afforested, particularly for fast-growing species, thereby increasing timber yields and carbon sequestration.
- Reclaiming liquid hog manure by minimizing the associated environmental impacts.
- Assisting in countering deforestation through the spreading of liquid manure².

² In recent years, thousands of hectares of private forest in Quebec have been deforested and used as cropland with the primary aim of spreading liquid hog manure.

Stem dieback on 2003 sites

When establishing the sites for the 2003 experimental layout, we encountered an unexpected situation. Following reforestation with hybrid poplar seedlings, we noticed abnormal stem dieback (progressive mortality from top to bottom) in nearly all of the seedlings. A meeting was held at the site in June 2003 with MRNFP specialists from this Quebec department's seed production and seedling directorate and experts from the Pépinière de Grande-Pile nursery. The conclusion that was reached, which partly explains this phenomenon, is that the hybrid poplar seedlings produced in 2002 at the Pépinière de Grande-Pile nursery received an excessive amount of fertilizer owing to the substrate used as a soil amendment. As a result of this occurrence, combined with the very warm fall and the very cold weather in October, the seedlings did not harden off sufficiently before extraction. This caused necrosis at the base of the buds and severe stem dieback after planting.

The treatment that was recommended was to cut back the seedlings, i.e. to remove the dead parts so that the wood would be free of necrosis. Severe pruning was required. The seedlings, initially between 1.8 and 2.0 metres tall, were only 10 to 80 centimetres high after this pruning operation. An inventory was conducted in fall 2003 to assess the progression of the necrosis over the summer, and it was found that the necrosis had progressed in some cases. This led to increased fill planting in spring 2004 and the loss of seedlings for each clone being tested³. In addition, because the pruning reduced the seedlings' height, the competing herbaceous vegetation was able to become established and develop more easily. We plan to mechanically tend these plantations for one or two additional years, or for enough time to allow the rows to close.

It should be noted that there was no abnormal dieback on the experimental sites established in 2004.

Financial participation by the MRNFP

During fiscal 2003-2004, the MRNFP funded nearly 30% of the total cost of the pilot project under an R&D component (component 1) of the Quebec government's Forest Resource Development Program. This financial participation can be explained by the fact that the pilot project dovetails with the R&D goals for the region. However, owing to budgetary cuts affecting the 2004-2005 budget for component 1, this financial assistance, which was intended to be recurrent, may fall through. And if the Quebec government department provides a contribution, the amount may be much lower than in the past. This situation may not only have an impact on the pilot project in 2004-2005, it may also jeopardize its furtherance over the coming years. In fact, as of 2005, as funding will no longer be available from FAACS, the *Agence de mise en valeur des forêts privées des Appalaches* and its partners will have to continue the activities related to tending the sites, annual manure spreading and data collection and analysis.

Survey of owners of land possibly eligible for afforestation under the Kyoto Protocol

The second thrust or aim of the pilot project consists in collating new information on afforestation through a survey of owners of land that may be eligible for afforestation under the

³ In spring 2004, the replacement seedlings of two of the three clones from the 2003 protocol had to be replaced with seedlings from different clones. The working group of the pilot project is currently assessing the effect of this change on the scientific protocol for the 2003 sites.

Kyoto Protocol. For more than a year already, a sub-working group has been planning this survey, which is to be carried out in fall 2004 through telephone interviews.

Survey objectives

1. Obtain information on lands that may potentially undergo afforestation (areal extent, types of vegetation, use patterns, reasons for the absence of crops)
2. Evaluate the interest of landowners in afforestation (interested or not and reasons; areal extent, species and objectives related to afforestation with traditional species and fast-growing species; information needs;
3. Assess the landowners' interest in new afforestation approaches using fast-growing species, in particular, leasing of land over the medium term and fertilization with liquid hog manure (interested or not and reasons, areal extent, minimum lease amount in the event of leased land, information needs)
4. Obtain information on the circumstances of deforestation (deforested areas and forecast deforestation, reasons)
5. Obtain socio-economic data concerning the landowners (age group, main occupation, income bracket, distance from place of residence to main deforested tract of land)

Target population and type of survey

The survey will centre on the Appalachians area, one of the two components of the Chaudière-Appalaches administrative region, located on the south shore of the St. Lawrence River, to the south and southeast of Quebec City. The target population consists of landowners of sectors without trees where there is no agricultural production, in particular, abandoned farmland and pastureland. Also targeted is a sub-population of landowners who are also hog producers.

Database and strata

The population to be surveyed will be identified using the assessment roles of the four RCMs (regional county municipalities) of the Appalachians area and the City of Lévis. The landowners who are also hog producers will be identified through local hog producers' associations.

The database is divided into three territorial strata:

- stratum of municipalities whose economy centres on agriculture;
- stratum of municipalities whose economy centres on forestry;
- stratum of municipalities whose economy centres on agri-forestry activities.

Sampling

Once the database has been mounted, the sampling details will be specified, notably with respect to the size of the sample per stratum and the type of sampling (random or purposive selection) that will be undertaken.

Questionnaire

The questionnaire has been prepared. It contains these six sections:

1. Validation of the respondent's eligibility
2. Description of sites
3. Interest in afforestation
4. Incentives for afforestation
5. Deforestation
6. Profile of respondent

Technical specification

The technical specification has been prepared. It describes the main components of the survey and the mandate of the firm that will carry out the survey.

Upcoming steps

- Complete the database on the population targeted by the survey (summer-fall 2004)
- Determine the sampling procedure (fall 2004)
- Select the survey firm (fall 2004)
- Carry out data collection (fall 2004)
- Analyse the results and prepare a report (winter 2004)

Communication and technology transfer activities

The communication and technology transfer activities carried out to date are outlined below.

Conferences and presentations

- Meeting of the regional private forest development agencies of Quebec, Stoneham, October 25, 2002
- 58th annual convention of the Association forestière des Cantons de l'Est. Saint-Georges, October 17, 2003.
- 6th Federal Workshop on Sustainable Development. Montreal, February 12, 2003
- Representatives of Réseau Ligniculture Québec, Sainte-Foy, February 17, 2003

Newspaper articles

- *Forêts de chez nous*, December 2003. « Diversification des sources de revenu. Une réalité grandissante pour les propriétaires forestiers : La culture de l'if du Canada et le captage

du CO₂ ». [Trans. title: Diversification of income sources. An increasingly important reality for forest owners: Canada yew plantings and CO₂ sequestration].

- *Le Monde forestier*, November 2003. « Une avenue étudiée pour l'utilisation du lisier de porc ». [Trans. title: Research on a potential use for liquid hog manure].
- Article for the newsletter of Réseau Ligniculture Québec (submitted in March 2004).

Visits to experimental sites

- November 21, 2002
- June 3, 2003
- June 13, 2003
- August 27, 2003
- October 22, 2003
- July 8, 2004

Reports

Annual report 2002-2003 on the pilot project.

Annual report 2003-2004 structured as follows:

1. Background
2. Orientations
3. Roles and responsibilities of the partners
4. Methodology
5. General achievements 2003-2004
6. Location of the 2003-2004 experimental layouts
7. Specific achievements by block, 2003 layout
8. Specific achievements by block, 2004 layout
9. Results by block for the 2003 layout
10. Analysis of results for the 2003 layout
11. Eligible project costs for fiscal 2003-2004
12. Main issues and challenges
13. Documents available

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July 23, 2004