PCAA

Programme canadien d'adaptation agricole

Final Report

Exploring the possibility that nordic apiculture can provide pollination services on the North Shore of Québec

Projet QP6502

Centre de recherche Les Buissons

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S. Kristine Naess, and Madeleine Chagnon

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1. *OBJECTIVES*

1.1. General Objective

The objective of this project was to establish an apiary in an isolated northern region in order to satisfy the growing pollination needs of the expanding small fruits industry in the area.

1.2. Specific Objectives

The specific objectives were:

1) the development of apiary management techniques specific to northern regions as a function of two different sources of honeybees.
2) to do a chronological inventory of floral resources in order to help find the best sites for apiaries in the region and to identify periods of shortages in the native floral resources.

2. RESULTS AND ANALYSIS

2.1. Results Achieved and Analysis

Methods

Development of apiary management techniques specific to northern regions

Site selection

1. Forested sites

Of the 10 forested sites visited three were of relatively good floristic potential. The two sites chosen for the establishment of beeyards were the best of the three sites based on observed flora diversity and the third best. The second best site was not retained as it was too close to a group of cottages who's owners did not accept the presence of honeybees in the area.

A brief description of the sites follows:

AGU : The site is 13 km east of Baie-Johan-Beetz, immediately after crossing the Véronique river. There is a road leading north from highway 138 which opens onto an approximately 10 year old clearing in the forest. Plants noticed along the roadside include fireweed, lowbush blueberry, dandelions, bunchberry, skunk currants, pin cherry, willows and even red elderberry. A "Google Earth" map of the site showing the foraging zone (2 km radius) along with ecotype polygons is presented in figure 1.

The percentages of the foraging zone covered by the various ecotypes were estimated from the "Google Earth" map. The largest portion of the foraging zone at site AGU is occupied by spruce forest (64%) with some small bogs here and there (3%). The clearing, which represents the better foraging areas, covers about 13% of the zone. Two rivers and several creeks (11%) cross the foraging zone. Roads, trails and an area cleared for hydroelectric lines complete the zone (9%).

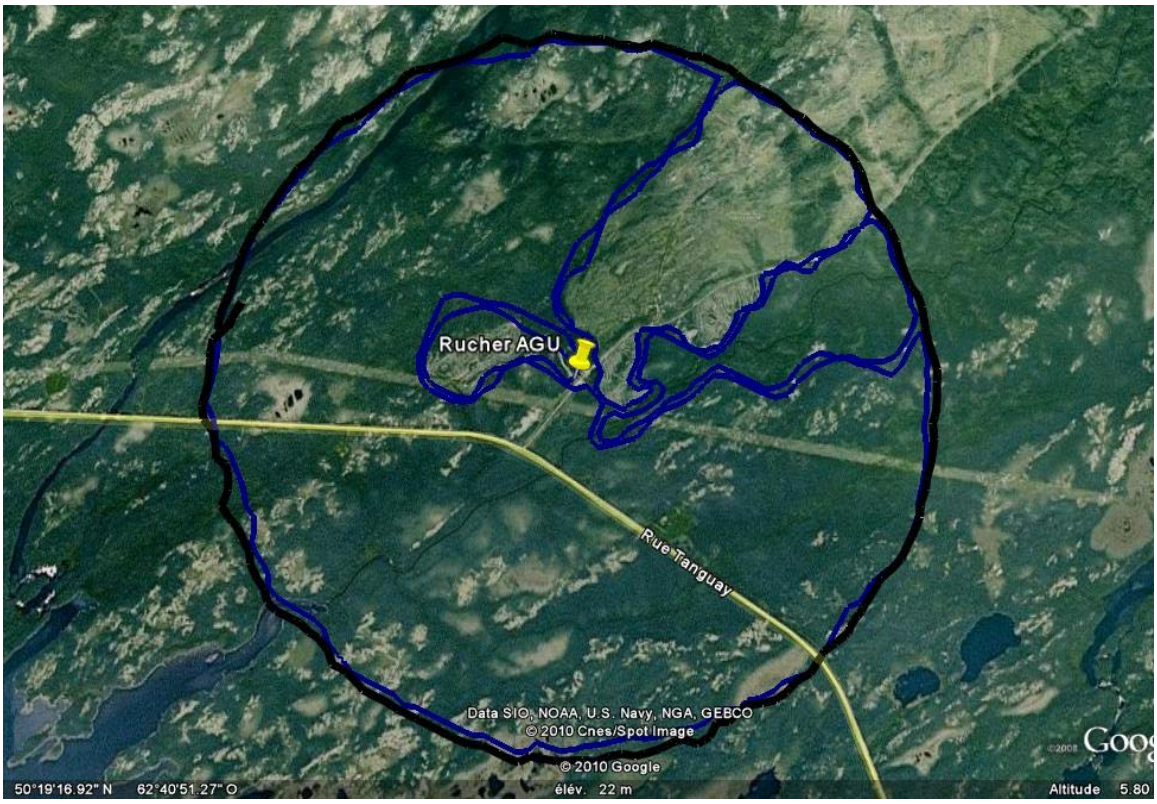


Figure 1. "Google Earth" map of the AGU site with the foraging zone indicated in black and the ecotype polygons in blue.

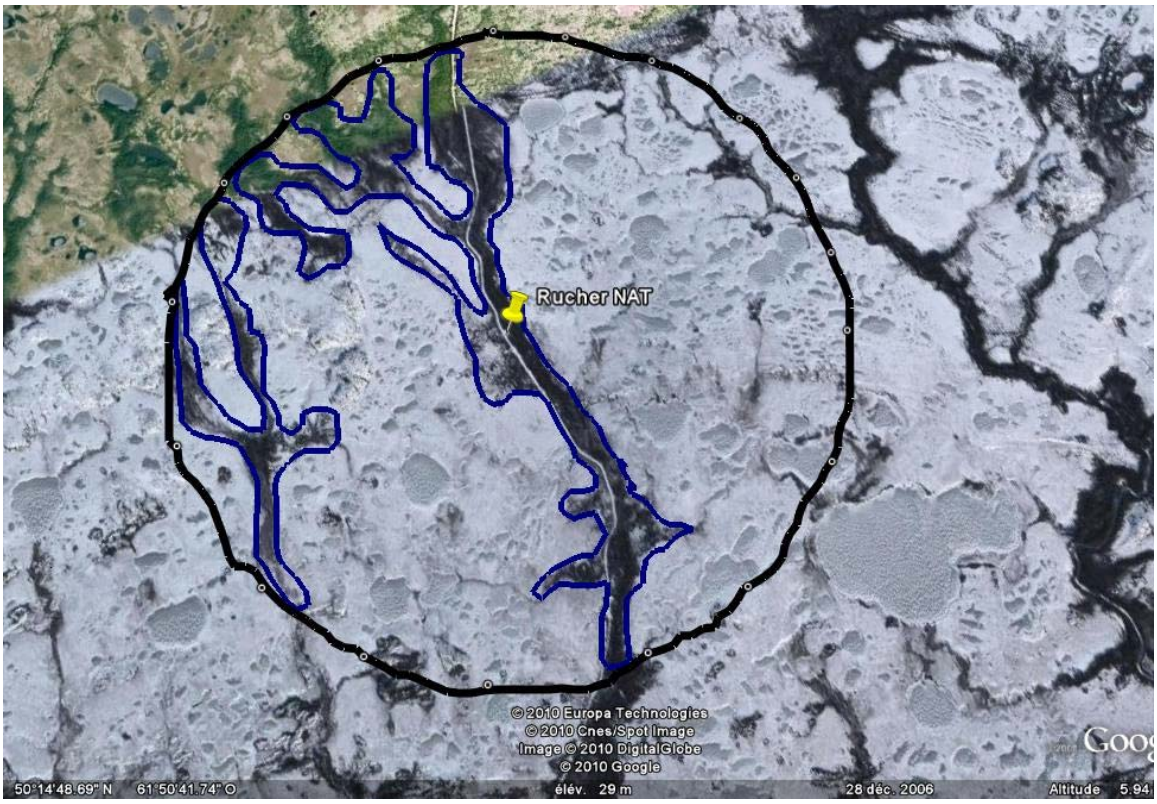


Figure 2. « Google Earth » map of the NAT site with the foraging zone shown in black and the ecotype polygons in blue.

NAT: The site is located about 20 km east of the Aguanish bridge, following a road north of highway 138 (old Rex for road). The plants noticed along the road were saskatoons, bunchberries, raspberries, Labrador tea, fireweed, willows, skunk currants and lowbush blueberry. A "Google Earth" map of the area with the foraging zone indicated is shown in figure 2.

Unfortunately the "Google Earth" photos of the area were taken during the winter. Despite this we can see that the foraging zone is pretty much boglands (70%) with quite a few small pools, some forested areas (19%), a small bit of roadside areas (3%) and some creeks (8%).

The two forested sites were separated by more than 50 km in order to prevent varroa contamination of the Newfoundland hives free of varroa at site NAT by bees from the Québec control hives located at site AGU (figure 3).

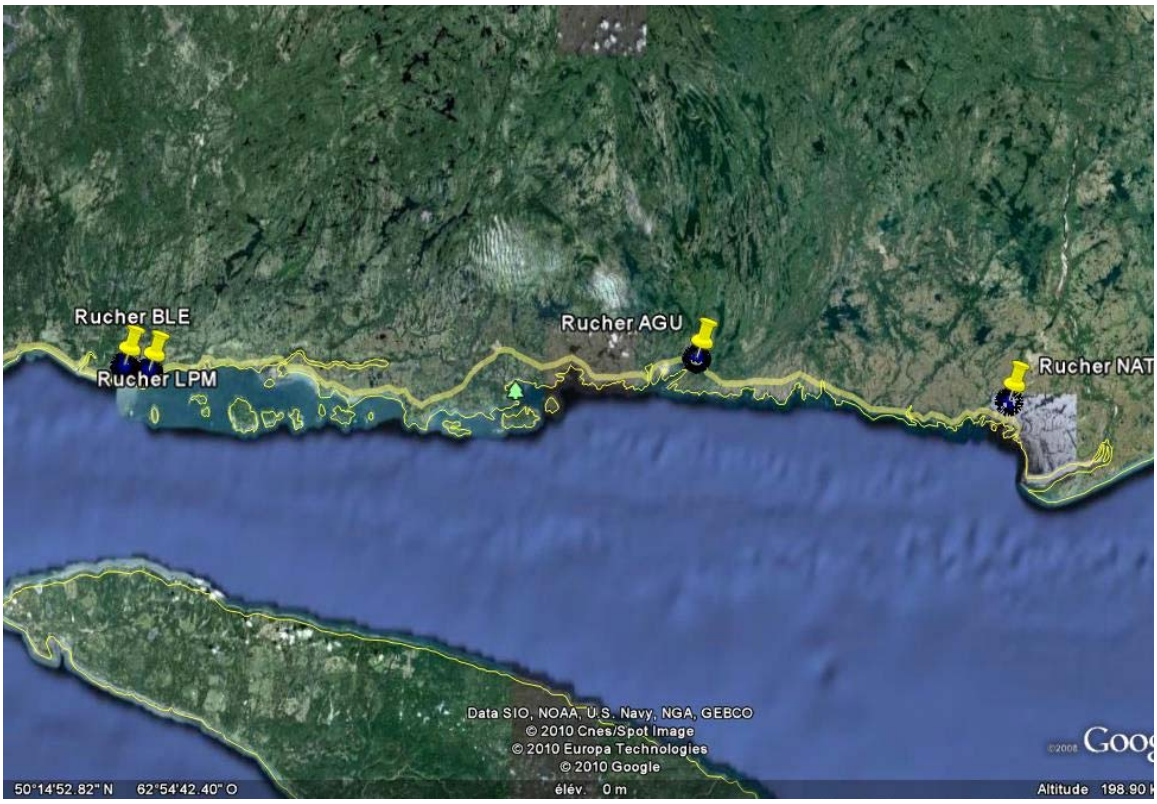


Figure 3. « Google Earth » map of four beeyards in the region of Minganie. Forested sites NAT and AGU and semi-cultivated sites LPM and BLE, Longue-Pointe-de-Mingan.

2. Semi-cultivated sites : Longue-Pointe-de-Mingan

The two semi-cultivated sites chosen in the region of Minganie are site BLE located on the lowbush blueberry fields at Les Bleuets du 50 Parallèle Inc., and LPM located between the blueberry fields and the village of Longue-Pointe-de-Mingan (figures 4 and 5). The foraging zone at site BLE consists of the blueberry fields (38%), boglands (32%) and more or less dense spruce forest (31%). Two hydroelectric lines pass through the foraging zone. The bees at the LPM site have easy access to the gardens of the village (9%), to cleared areas around an airport (13%), to a small bog (5%) and to the beach. Spruce forest constitutes 56% of the LPM foraging zone. The roads and the St Lawerence seaway cover respectively 8 and 9% of the zone. The blueberry fields are not part of the 2 km radius foraging zone; however they lie just outside of it (figure 5).

Figure 4. « Google Earth » map of the foraging zone at site BLE with the ecotype polygons shown in blue.

Figure 5. « Google Earth » map of site LPM with the ecotype polygons shown in blue.

Semi-cultivated sites: Sept-Îles

The two bee yards in the region of Sept-Îles were situated on the farms of two lowbush blueberry producers. The MOI site was established on the Ferme Christiane Morneau at Moisie while the GAL site was established at Gallix on the farm Les Fruits Nordco. Maps of the two sites created by Luc Denis, agronomist with the Club Agroenvironnemental Côte-Nord, are presented in figures 6 and 7.

MOI : The forage zone of this site consists of the lowbush blueberry fields (6%), fields either fallow or cultivated (11%), cleared areas in the forest (25%), and spruce forest (51%) containing a few small bogs and creeks. Roadside areas comprise about 7% of the zone. To the northeast of the site the Moisie river bank is an area presenting a richer flora than the dry spruce forest above.

GAL: The forage zone surrounding this bee yard consists of lowbush blueberry fields (21%), strawberry fields (1%), small bogs (7%), creeks (6%) and spruce/deciduous forest (54%). A hydro electric line (4%) passes through the blueberry fields and another 4% of the zone is made up of roadside areas. There is a small clearing (3%) in the forest not far from the bee yard.

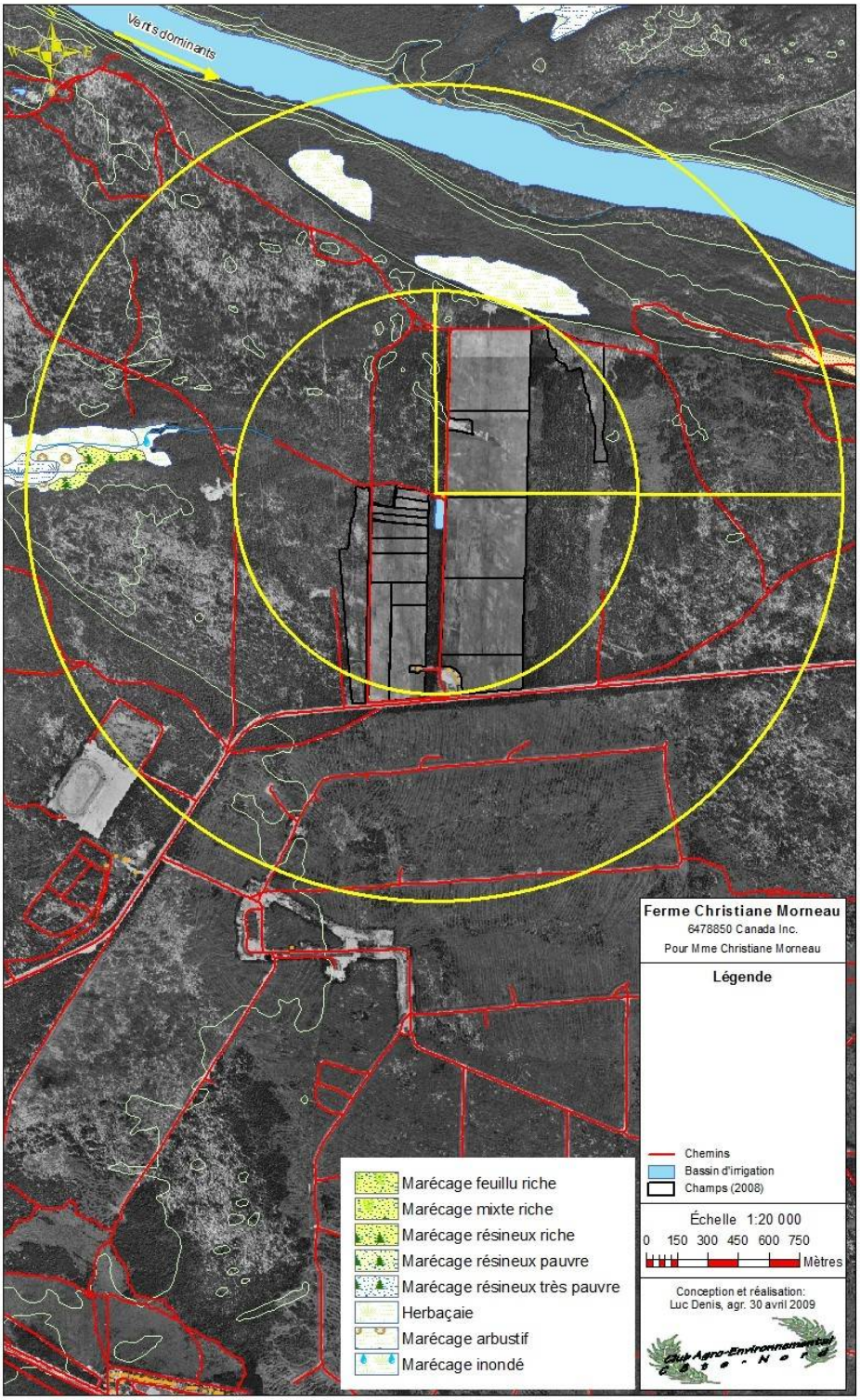


Figure 6. GPS map of the farm "Ferme Christiane Morneau" with the MOI site and forage zone (1 and 2 km radius) indicated in yellow.

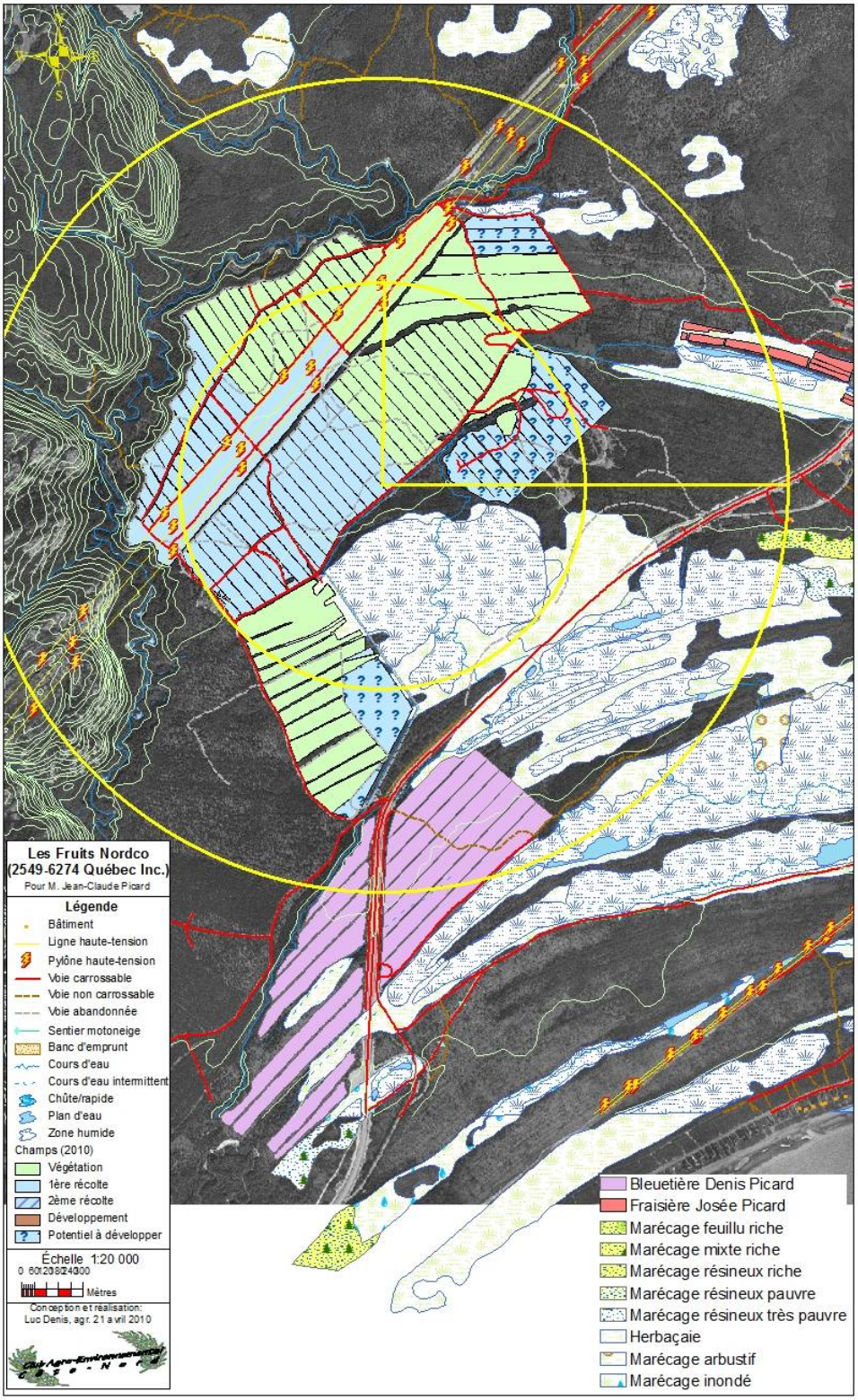


Figure 7. GPS map of the farm "Les Fruits Nordco" with the GAL site and the forage zone (1 and 2 km radius) indicated in yellow.

Hive installation

Québec source (Source A)
Hives with the Québec source of bees were prepared from hives brought in for lowbush blueberry pollination at Les Bleuets du 50^{e} parallèle. In the first week of July, three frames of brood and 1 frame of reserves were transferred to the hives and a new queen introduced. The hives were left alone for two weeks to allow for queen acceptance. The hives were fed but data on feed consumption was not taken during this time. All the queens were accepted. The 19th and 20th of July 6 hives were moved to each of their respective sites (AGU, BLE and GAL).

Newfoundland source (Source B)
Nuclei from Newfondland were prepared by the Newfoundland Bee Company. In these there were two frames of brood, 1 frame of reserves and 1 frame of foundation. On the 7th of July the nuclei were transported in cardboard transportation boxes from Newfoundland to Blanc Sablon. Because of poor weather conditions, the flight out of Blanc Sablon was delayed. The nuclei were therefore maintained in a garage for 2 days before being flown out to Aguanish in a small private plane. These nuclei had a more difficult start than those of source A because of the long transportation and also the heat in the plane. The 22nd of July the hives were distributed to their respective sites (NAT, LPM and MOI).

Hive Installation
Hives were placed on pallets, 2 or 4 hives to a pallet (figure 8). Because there are bears in all areas surrounding the bee yards, a woven electric fence was installed around the hives and electrified with an ecostop battery fencer supplied with a 12 volt rechargeable battery. Solar panels were used to recharge the batteries.

Only one of the 6 hives per bee yard was supplied with a pollen trap in order to follow the types of pollen gathered in 2010. However, because of the large variability noticed in the amounts of pollen gathered per hive in 2010, traps were placed on all hives in 2011 in order to differentiate between the site effects vs the effect of the individual hives on this factor.

Data collection
The bee yards were visited weekly from the end of July til the beginning of October 2010 and from the 5th of May until the 3rd of September 2011. The hives were weighed at each visit in 2010 and every other visit in 2011(figure 9). The consumption of sugar syrup and of pollen substitute was noted. The trapped pollen was weighed and a small sample collected for analysis. The rest of the pollen was placed in the hive on a sheet of newspaper along with the pollen substitute. In 2010 the number of varroa dropping onto sticky boards per week was noted during the five weeks preceding varroa treatment in mid August. In 2011, varroa counts (24 hour drop) were made in conjunction with the visits by the two project inspectors, Nicolas Tremblay and Raphaël Vacher.

Figure 8. Hives on pallets surrounded by electric woven fencing.

Figure 9. The system used to weigh the hives.

Hive inspections
Nicolas Tremblay, Provincial Apiculturalist, inspected the hives at the 6 sites the 28th and 29th of July, 2010, and the 2 and 3rd of June as well as the 25th and 26th of July 2011. Raphaël Vacher, Apiculturalist, inspected the hives at the 6 sites during the third week of August 2010 and again on the 25th of August 2011. The comments made in the course of these visits are included in the results section.

Overwintering
The hives from sites NAT, BLE and LPM were overwintered outside at Longue-Pointe-de-Mingan using the system that Raphaël Vacher of miels Raphaël uses with slight modifications. The hives on the pallet are topped with a 2 inch thick piece of Styrofoam and the hives are wrapped with 2 layers (instead of 1) of thermofoil. Each hive has an upper entrance leading out through the thermofoil (figure 10).

Figure 10. Exterior overwintering of hives from sites NAT, BLE and LPM.

The hives from sites MOI, GAL and AGU were transported to Pointe-aux-Outardes the second week of October for overwintering in a cold chamber. Hives were left outside until the 8th of December when they were placed into the chamber which was maintained at 4°C. The third week of April temperatures in the chamber reached 12-13°C and the hives had to be removed. There was still quite a bit of snow at that time and despite the fact that snow was removed from the area immediately surrounding the hives quite a few bees were found dead on the snow further away. At removal from the cold chamber the hives were wrapped with a single layer of thermofoil and the hive entrances reduced. Hives from site MOI (source B) were moved to a temporary bee yard several km removed from the other hives in order to prevent varroa contamination of these hives by the other hives from sites GAL and AGU (source A). Hives overwintered in the cold chamber were opened the 2nd of Mai, 2011. At this time the hives received 2 litres of sugar syrup (1:1) in a zip lock bag placed on top of the frames. The alders in the area had started flowering and the bees brought in a bit of pollen from this source. The hives were transported back to their respective bee yards on May 26th in two separate vehicles, one for each source of bees.

Chronological inventory of floral resources

Floral resources inventories

Ecotype mapping of the forage zones at each site was done using aerial photos available through "Google Earth", Map Source or Arc-view. Based on these maps four transects (1 km long) were established at each site radiating out from the bee yard. The transects were chosen to sample all of the ecotypes available to the bees. However, in order to inventory as many different floral species as possible, the transects traversed relatively more open grounds than forested areas. For data analysis the data are adjusted to reflect the true proportion of each ecotype in the foraging zone. Sampling stations were established every 50 meters along the transect. At each station the types of plants in flower were noted and floral abundance estimated. The number and types of insects seen visiting the flowers were recorded during a 2 minute period.

Pollen analysis

Pollen samples collected by the bees in 2010 and 2011 were analysed during the winter/spring 2011/2012. Pollen pellets collected weekly from each hive during the summer season were sorted into color groups. The percentage of each color group was noted. Five to 10 pellets of each color were suspended in 1 ml water and the different types of pollen in a 10 μl sample of the suspension were identified. A reference library of pollen slides from flowers gathered on the north shore was made and used in the identification of the pollen collected by the bees. Pollen types which were not successfully identified were sent to Melissa Girard, pollen analysis expert at Laval University, for identification. The protocols used for slide preparation are presented in appendice 1.

Calibration

Several authors have noted that the proportion of pollen pellets gathered from ericaceous species is underestimated when using pollen traps. Pollen pellets formed from ericaceous species are often small and do not fall into the trap as the bee passes through it. In order to better estimate the proportion of ericacous pollen gathered by the bees a sample of bees was taken at the hive entrance during the lowbush blueberry flowering season. Pollen pellets were collected directly from the bees' pollen baskets. The types of pollen in the pellets or, when no pellet was present, on other parts of the bee, were identified.

Changes made in the course of project completion

Chronological inventory of floral resources

Due to the underestimation of the time required to carry out data collection and inventories, the inventories were carried out only during the 2011 season and the transects were 1 km rather than 2 kms long. Four visits to the beeyards by professional inspectors per year were planned, however only 2 inspections were made in 2010 and 3 in 2011. The nuclei used in establishment of the bee yards were not available until July 2010, thus visits before this time were not needed. In 2011, the experts were not available in May and even in June at the first inspection the weather was too cold to open the hives at some of the sites (GAL and MOI).

Results

Hive losses 2010

Of the 36 hives started, four were lost during the first season. At the first hive inspection provincial apiculturist Nicolas Tremblay noted that two of the hives from Newfoundland (Source B), hive 4 at site NAT and hive 27 at site MOI, had lost their queens. It was too late in the season to get new queens from Newfoundland for these hives so they were eliminated from the experiment. Two hives, hive 6 at site NAT and hive 34 at GAL, were also destroyed by bears due to recurrent problems with the batteries used in the fencers.

Hive weight gain, 2010

Hives were installed at the bee yards in mid-July, 2010 and the weekly weighing commenced the last week of July. Between the end of July and the end of September weight gains per hive averaged 11 kg. The greatest weight gains (17 kg) were observed at the semi-cultivated site LPM whereas the hives at the forested site AGU gained the least (7 kg) (figure 11). There was a significant difference ($p = .04$) in average hive weights, respectively 30 and 33 kg, between hives at forested sites (AGU and NAT) and those at semi-cultivated sites (GAL, MOI, BLE and LPM).

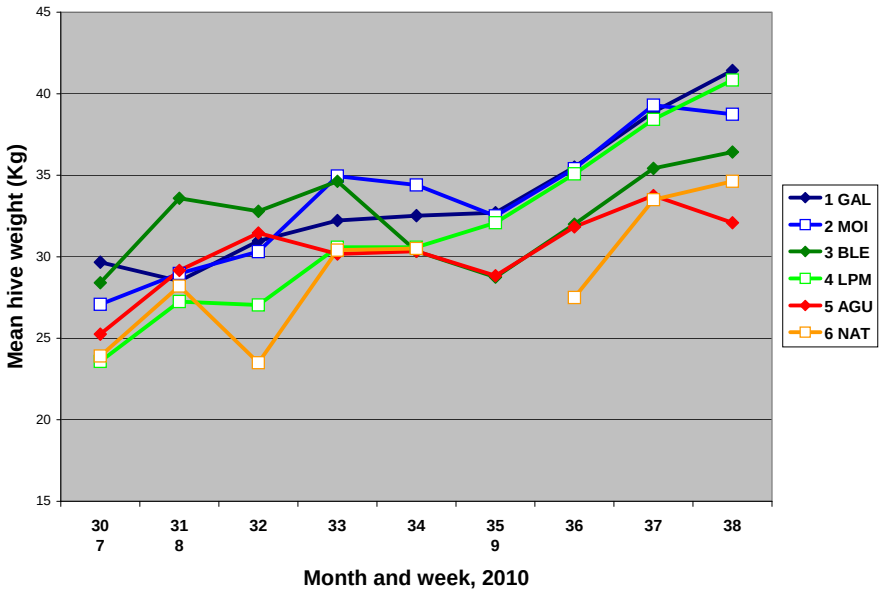


Figure 11. Mean weekly hive weights per site from the end of July to the end of September, 2010.

The Source B hives started with two frames of brood, one frame of reserves and 1 frame of foundation were weaker at the beginning of the experiment than those started from three frames of brood and one of reserves (Source A). Source B hives weighed on average 3 kg less than Source A hives at this time. During the 2010 season however the Source B hives caught up with the Source A hives, gaining on average 14 kg during the season as compared to 9 kg for the Source A hives (figure 12).

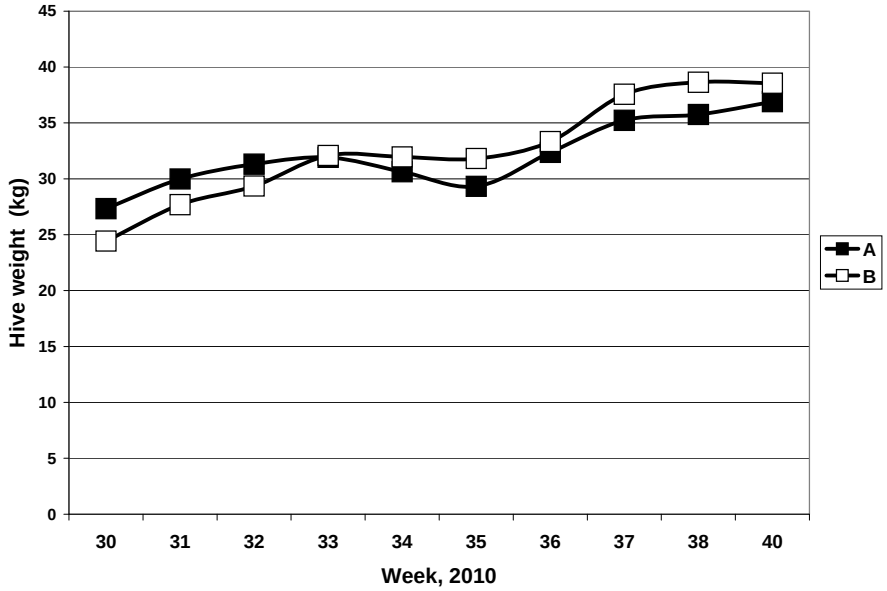


Figure 12. Mean hive weights over a ten week period for hives with bees from source A and from source B.

Overwintering

Twenty two (76%) of the 29 hives overwintered survived the winter 2010/2011. Overwintering survival was effected (p = .001) by the type of site, forested or semi-cultivated, on which the hvies were placed during the summer of 2010. Nintyfour percent of hives from the semi-cultivated sites (GAL, MOI, BLE, and LPM) survived versus only 40% of the hives from the forested sites (AGU and NAT). Overwintering in a cold chamber had a positive effect on survival of hives from the forested sites. While none of the hives overwintered outdoors from the forested site NAT survived, four of the hives from the AGU site overwinted in the cold chamber survived. Neither the overwintering method nor the source of the bees had an effet on survival of hives from the semi-cultivated sites (figure 13).

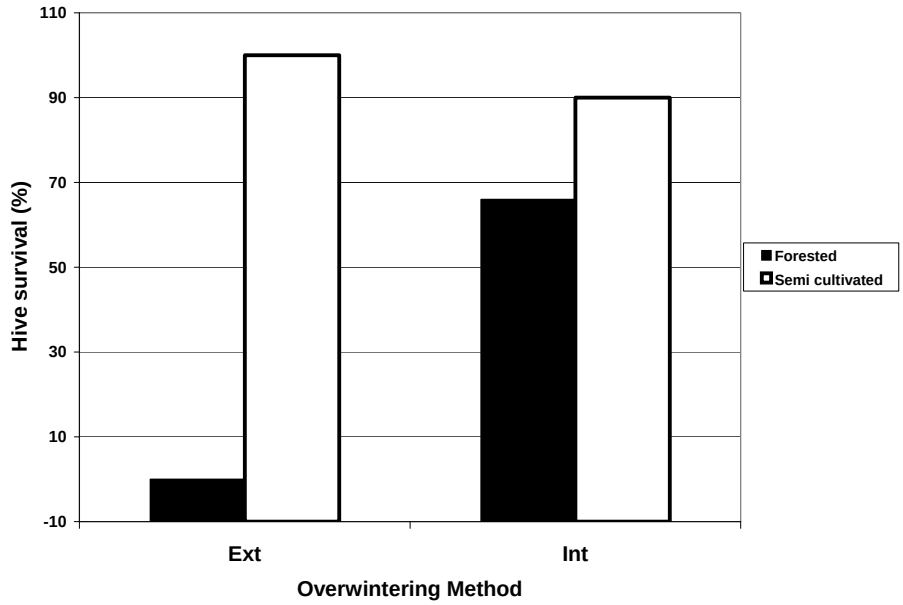


Figure 13. Winter 2010/2011 hive survival percentages as related to the type of summer site and the method of overwintering (interior vs exterior).

Reserves consumption during the winter varied depending on the summer site. Hives from sites LPM and GAL consumed more than the hives from the other sites (p = 0.0007, figure 14). Neither the overwintering method nor the source of bees had an influence on reserves consumption during overwintering. No correlations could be found between reserves consumption and other factors such as hive weight before overwintering, the number of frames of bees at the last 2010 inspection or the number of frames of bees observed at the first 2011 inspection.

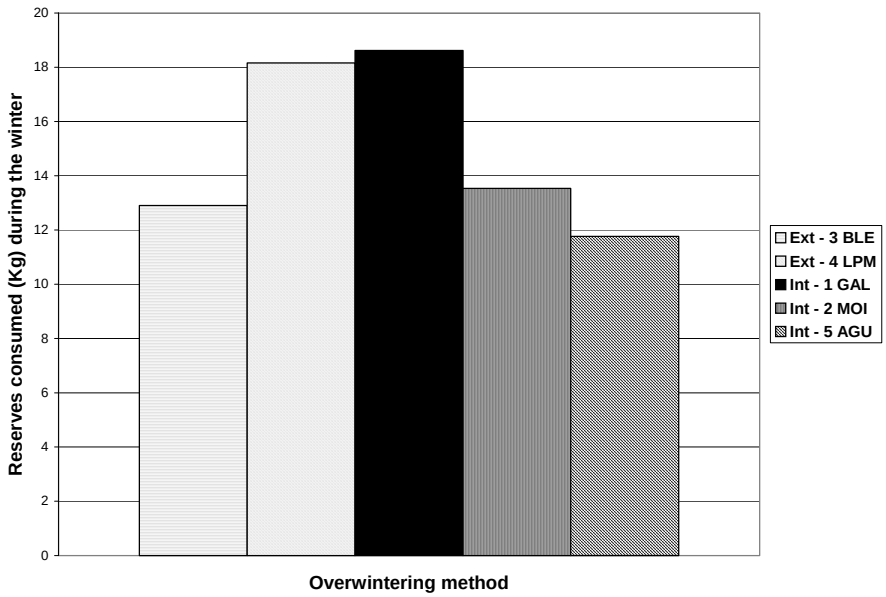


Figure 14. Reserves consumption during overwintering by hives from five sites overwintered outdoors (Ext) or in a cold chamber (Int).

Despite the good overwintering percentages obtained, the hives were very weak at the first 2011 inspection in early June. On average there were only 3.2 frames of bees in the hives at this time. Hives from bee source B (4 frames of bees) were stronger than those from bee source A (2.5 frames of bees) ($p = 0.05$) Overwintering method had no measurable effect on hive strength at the first inspection.

Hive weight gain 2011

In 2011 no differences in hive weights were noticed between hives at forested sites relative to those at semi-cultivated sites. However, only 1 forested site remained (AGU) as all hives at the NAT site had died over the winter.

Hive weight gain was greater in 2011 in hives with source B bees than in hives with source A bees (figure 15, $p = 0.0001$). On average source B hives weighed 35 Kg versus 27 Kg for source A hives.

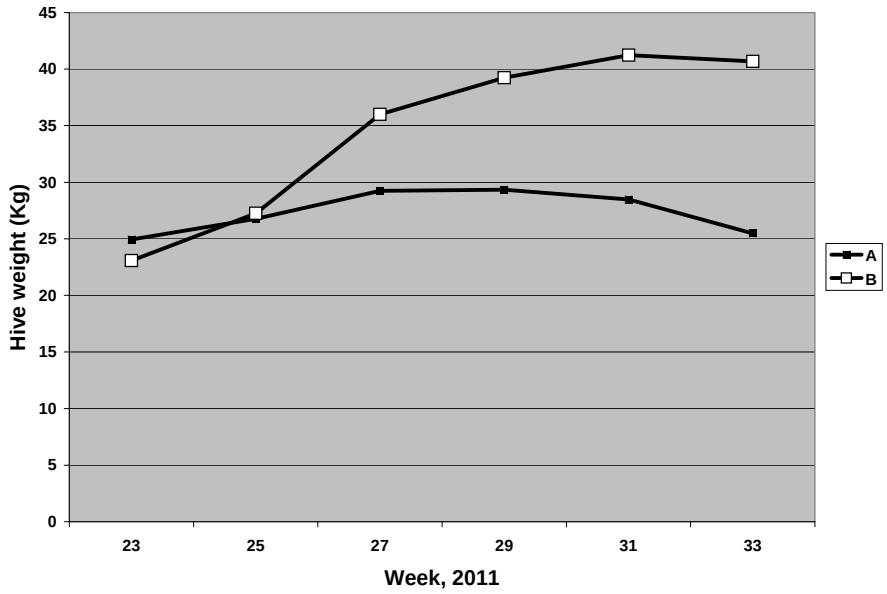


Figure 15. Mean hive weights across 10 weeks during the summer 2011 for the two sources of bees (A or B).

Pollen collection

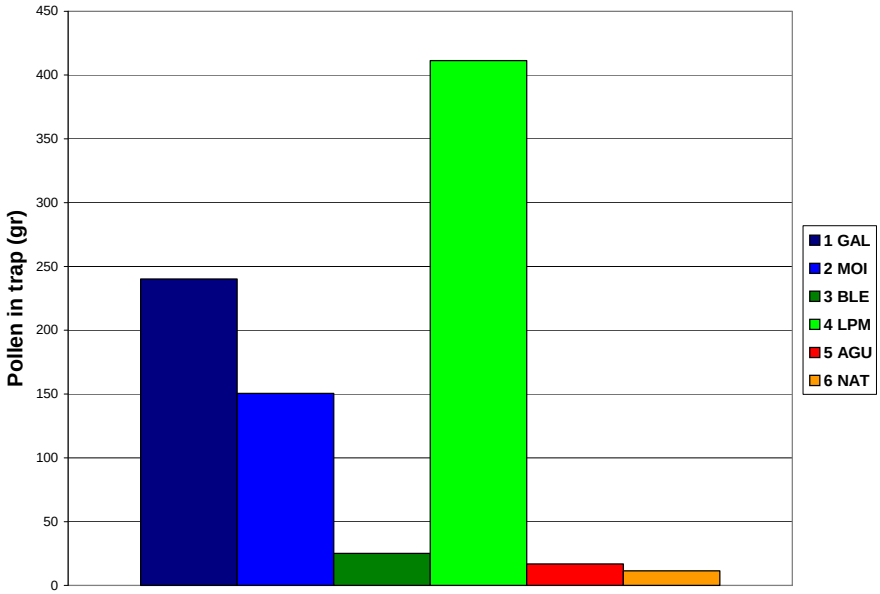


Figure 16. Average amounts of pollen (gr) collected per trap per week at the 6 sites in 2010.

Pollen collection was the factor that varied the most between sites in 2010 (figure 16). At the two forested sites, fewer than 20 gr of pollen per week were collected. At the semi-cultivated sites on

the other hand an average of 200 gr of pollen was collected per week. Bees at the LPM site collected the most pollen per week during the 2010 season.

In 2010 only one hive per site was equipped with a pollen trap thus for this variable we could not differentiate between site effects and hive effects. As this variable seemed to be of interest and we did not observe any negative effects of the pollen trap on hive weights in 2010 we decided to put pollen traps on all the hives for the 2011 season in order to detect the site effects on this variable.

Unfortunately we had a large problem with squirrels emptying the pollen traps at the LPM site and for this site very little data was obtained. There were also occasional problems at the other sites but only for one or two hives.

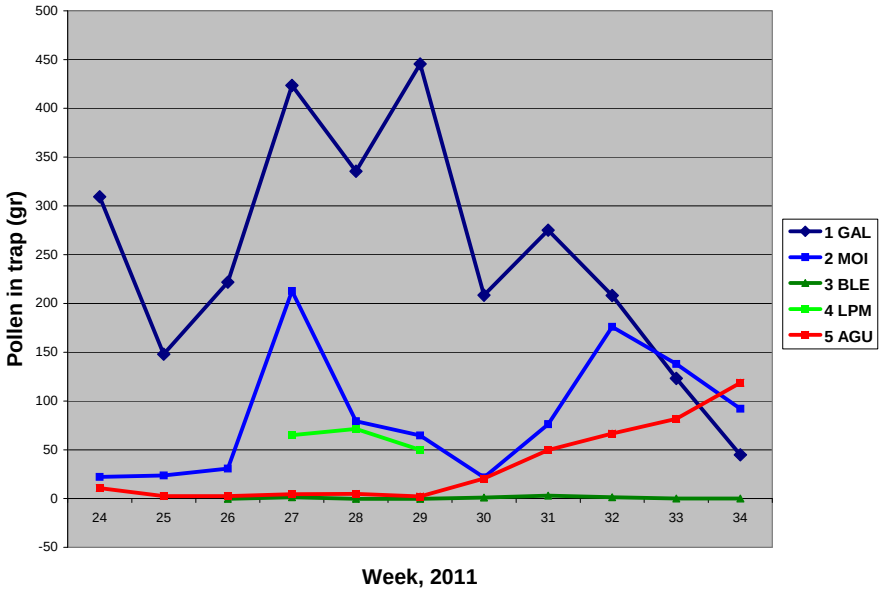


Figure 17. Pollen collection at five sites during 11 weeks, 2011.

There was a significant site effect on pollen collection ($p = 0.0036$). The three hives at the GAL site collected on average 250 gr of pollen per week while at the other sites from 1 to 85 gr of pollen per hive and week was collected (figure 17).

Pollen substitute and sugar syrup consumption

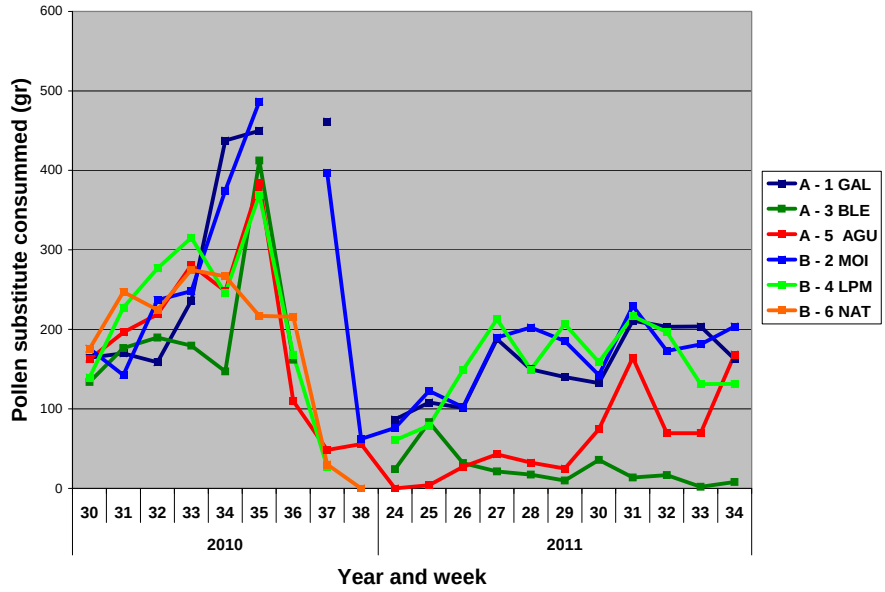


Figure 18. Pollen substitute (gr) consumed per week by bees at the 6 sites in 2010 and 5 sites in 2011.

In 2010 there were no site effects on pollen substitute consumption (figure 18). In 2011, on the other hand, a significant effect of the source of bees ($p = 0.0023$) and of the bee yard site ($p = 0.024$) was observed for this variable. Pollen substitute consumption was correlated with the number of frames of bees per hive and the apparent effects of bee source and bee yard site on this variable are secondary to the effects of these factors on hive strength (figure 19).

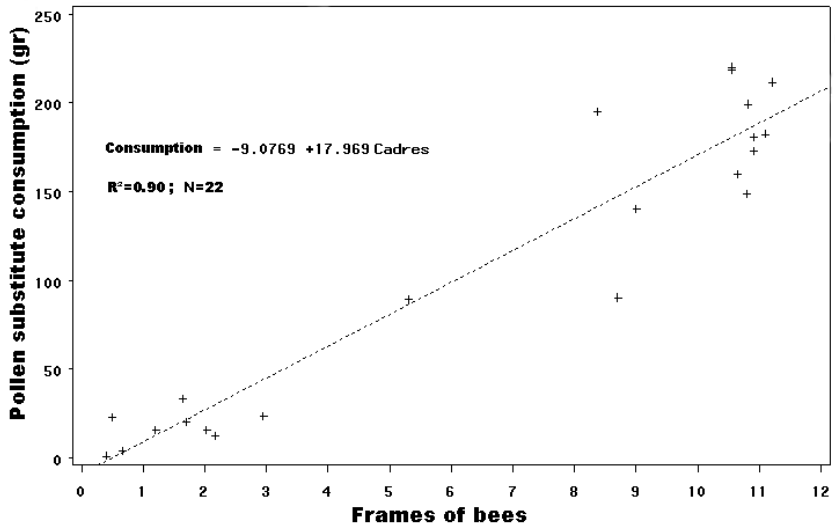


Figure 19. The correlation between the number of frames of bees and consumption of pollen substitute by the bees.

The availability of natural pollen sources did not inhibit the consumption of pollen substitute according to data collected from the pollen traps. The hives collecting the most pollen from the foraging area were also the hives which consumed the most pollen substitute in both 2010 and in 2011.

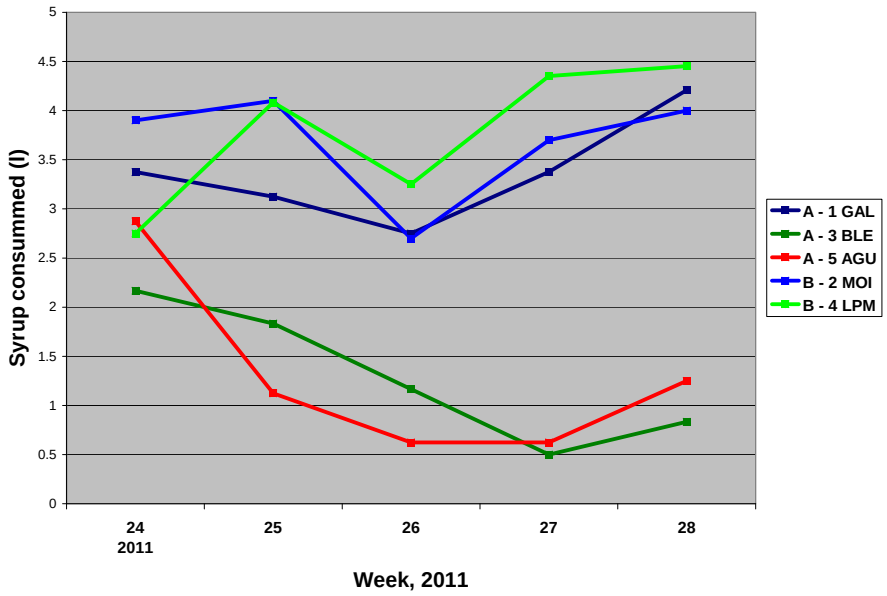


Figure 20. Sugar syrup consumption at the five sites in 2011.

As was seen earlier with pollen substitute consumption, the consumption of sugar syrup was correlated with hive strength. The weaker hives at sites AGU and BLE consumed much less syrup than the stronger hives at the other three sites (figure 20).

Parasites

Varroa

Varroa counts were made five times in 2010 by counting the number of varroa dropped onto a sticky board during a week. The amount of debris dropping onto the card during the week made counts difficult. In 2011, counts were made in connection with the three visits by the bee inspectors. Natural varroa drop was estimated by counting the number of varroa caught on the sticky board after 24 hours.

The hives from Newfoundland (source B) at sites MOI and NAT which remained isolated from other bee yards remained mite free for the duration of the study (figure 21). At the LPM site however, at the last inspection on the 25th of August, 2011, 2 mites were found on sticky boards of one of the hives from Newfoundland. Less than 3 km separate site LPM from site BLE (source A). As the hives at site BLE contained only low levels of varroa, it is most probable that the hive at site LPM was infected by bees from stronger hives brought onto the blueberry fields of les Bleuets du 50ième parallèle for pollination (200 hives). During the study period, the number of varroa dropping onto the sticky boards in the hives from Québec (source A) never exceeded 5 per day.

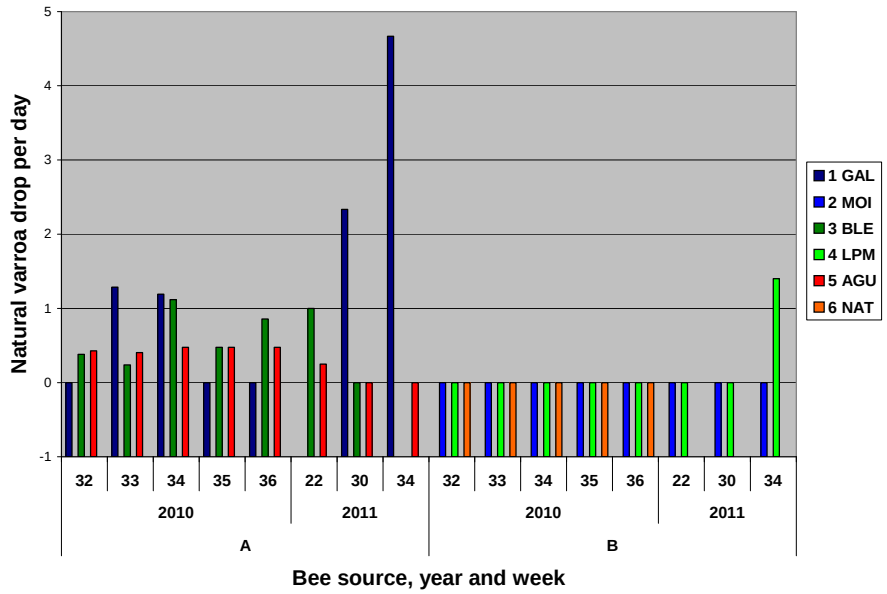


Figure 21. Natural varroa mite drop per day in 2010 and 2011 at sites with bees from Québec (source A) and from Newfoundland (source B).

Nosema

All hives were treated to control nosema with fumagilin B in mid-August, 2010, using the protocols supplied with the product. In the summer of 2012 two samples each of 100 bees from the two sources of bees were sent to LEPAQ (Laboratoire d'expertises en pathologie animale du Québec, MAPAQ) for analysis. The pathogen was not detected in either of the samples from source B bees while in the source A bees respectively 1,850,000 and 650,000 spores of Nosema sp. /bee and sample were detected.

European Foulbrood

During the inspections carried out by Raphaël Vacher and Nicolas Tremblay, a light infection with European Foulbrood was detected in three of the hives: hives 19 and 20 at the BLE site and hive 34 at the GAL site. None of these three hives survived.

Swarming and Supersedure

In 2010 a second hive body was added to the hives once there were 8 frames of bees. We had the impression that the addition of the second hive body at this time had a negative effect on the hive due to the relatively cold temperatures experienced on the North Shore. In 2011 the second hive body was therefore not added until there were 9 frames of bees in the lower hive body. This may have had an effect on swarming.

At least one of the LPM hives swarmed (figure 22). The swarm was caught and hived by Nicolas Tremblay and Claude Lussier during the second hive inspection on July 25, 2011. It is also highly probable that two of the three hives at the GAL site swarmed. In these hives the number of frames of bees increased rapidly between the first and second inspection then dropped off dramatically between the second and third inspection (figure 23).

Figure 22. A swarm of bees at the LPM site.

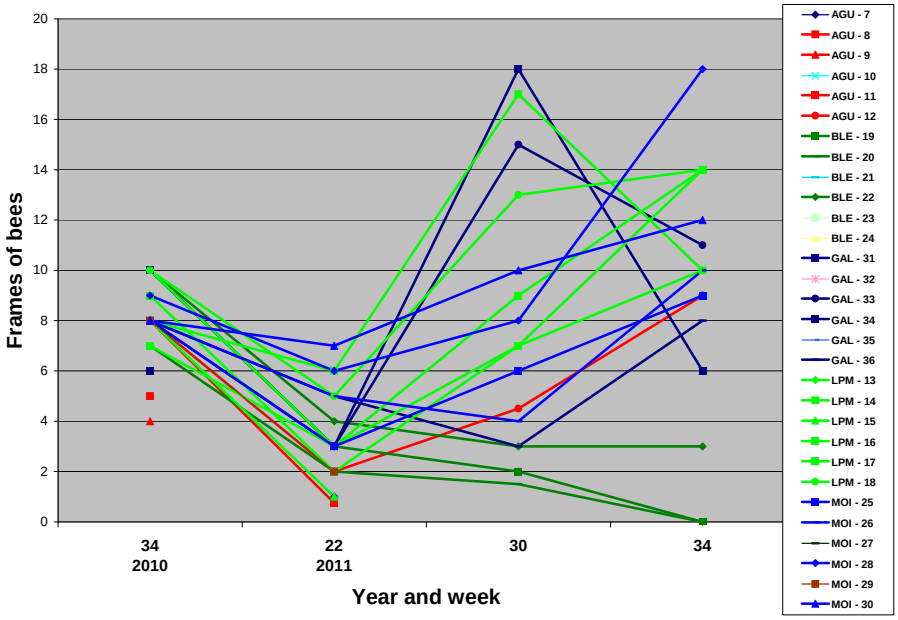


Figure 23. The number of frames of bees per hive at the five sites remaining in 2011.

In 21 of the 36 hives started the queen either died or left in the course of the study. A new queen developed in only 7 of these hives. The quality of the mating of these new queens is questionable given the degree of isolation from other bee yards and the resulting lack of genetic diversity among the males available for mating.

Chronological inventory of floral resources

Floral inventories and Pollen analysis

All in all, 88 species of flowering plants were observed in flower in the course of the floral inventories done in the foraging zones surrounding the 6 northern apiaries. Pollen of 12 other species was detected in the pollen samples analyzed (table 1). The pollen of 22 of the 88 species observed in the field was not detected during the analysis of pollen samples collected by the bees. However, most of these species were not abundant. Of the abundant species only the grasses and sweet gale (*Myrica gale*) seemed to be of little interest to the bees.

Based on data collected during the inventories, we calculated an estimate of the available floral resources for each site. Each sampling station along the transect was assigned one of four ecotypes: open areas, forested areas, lowbush blueberry field or wetland (including bogs and creeks). The relative abundance of each species in flower was noted on an arbitrary scale where 1 = rare, only 1 flower in sight, 10 = few, only a few flowers in sight, 20 = common, flowers here and there, 30 = abundant, and 40 = very abundant, a carpet of flowers in all directions. The number of species in flower multiplied by the average relative abundance of the species in flower per sampling station was multiplied with the percentage of the forage zone covered by the ecotype in question. Based on these calculations the two best sites were LPM and MOI. At site LPM 56 different species were encountered on the transects with an average of 2.1 species per sampling station and an average relative abundance score of 30 (table 2). The least appropriate apiary sites based on these calculations were the two sites located on the blueberry fields: GAL and BLE. Very few species were detected at these sites and the relative abundance of plants in flower was low. However, the correlation between the data collected on the transects and the data collected from the pollen analyses was poor. Several species detected in the pollen samples were not observed on the transects. For example, on adding the data from the pollen analyses to the transect data for site GAL one finds that many more flowering species were available to the bees than what was found on the transects. For this site in fact, among the 39 pollen types found during pollen analysis, 25 were not found on the transects. Given that not all flowering plants are of interest to the bees, the pollen analysis data was sorted by site and pollen species percentage in order to detect the species of most interest. The 16 species retained were those for which 10% or more of a given pollen sample consisted of the pollen of that species. All 16 of the most interesting species were present at the GAL site. As for the BLE apiary, the data collected on the transects correlate well with the data collected from the pollen samples. Of the two forested sites, AGU and NAT, the AGU site showed the most floral diversity. Pollen data for 2011 at the NAT site is missing as none of the hives there survived the winter 2010/2011.

Table1. Flowering species observed on transects near the apiaries or in pollen pellets*

Family	Species	Observed on transect							Observed in pollen						
		1 GAL	2 MOI	3 BLE	4 LPM	5 AGU	6 NAT	# Sites	1 GAL	2 MOI	3 BLE	4 LPM	5 AGU	6 NAT	# Sites
Aceraceae	mountain maple	No	No	No	No	No	No	0	Yes	Yes	No	No	No	NA	2
Araliaceae	bristly sarsaparilla	Yes	Yes	Yes	Yes	Yes	No	5							
Asteraceae	aster spp	Yes	Yes	Yes	Yes	Yes	Yes	6	Yes	Yes	Yes	Yes	Yes	Yes	6
	aster, blue	No	No	No	Yes	Yes	No	2	NA	NA	NA	NA	NA	NA	
	aster, bog	No	No	No	No	No	Yes	1	NA	NA	NA	NA	NA	NA	
	aster, flat topped	No	No	No	No	No	Yes	1	NA	NA	NA	NA	NA	NA	
	daisy	No	Yes	No	Yes	Yes	No	3	NA	NA	NA	NA	NA	NA	
	dandelion	No	Yes	No	Yes	Yes	No	3	NA	NA	NA	NA	NA	NA	
	dandelion, fall	No	Yes	Yes	Yes	Yes	No	4	NA	NA	NA	NA	NA	NA	
	everlasting, sweet	Yes	No	No	No	No	No	1	NA	NA	NA	NA	NA	NA	
	goldenrod	No	No	No	Yes	No	No	1	NA	NA	NA	NA	NA	NA	
	goldenrod, bog	No	No	No	No	No	Yes	1	NA	NA	NA	NA	NA	NA	
	goldenrod, grassleaf	Yes	Yes	No	Yes	Yes	No	4	NA	NA	NA	NA	NA	NA	
	goldenrod, roughleaf	No	Yes	No	No	No	No	1	NA	NA	NA	NA	NA	NA	
	hawkweed, orange	No	Yes	No	No	No	No	1	NA	NA	NA	NA	NA	NA	
	hawkweed, spotted	No	Yes	No	Yes	No	No	2	NA	NA	NA	NA	NA	NA	
	hawkweed, yellow	Yes	Yes	Yes	Yes	Yes	No	5	NA	NA	NA	NA	NA	NA	
	pearly everlasting	Yes	Yes	Yes	Yes	Yes	Yes	6	NA	NA	NA	NA	NA	NA	
	yarrow	No	Yes	No	Yes	Yes	Yes	4	NA	NA	NA	NA	NA	NA	
Balsaminaceae	impatiens	No	No	No	No	No	No	0	No	No	No	Yes	No	No	1
Betulaceae	alder	No	Yes	No	Yes	Yes	Yes	4	Yes	Yes	Yes	Yes	Yes	NA	5
	dwarf birch	Yes	No	Yes	Yes	Yes	Yes	5	Yes	Yes	Yes	No	Yes	NA	4
	sweet gale	No	No	No	No	Yes	Yes	2	No	No	No	No	No	NA	0
Brassicaceae	brassica spp	No	Yes	No	No	No	No	1	Yes	Yes	No	Yes	No	No	3
	icelandic cress	No	Yes	No	No	No	No	1	NA	NA	NA	NA	NA	NA	
	mustard	No	Yes	No	No	No	No	1	NA	NA	NA	NA	NA	NA	
Caprifoliaceae	red-berried elder	No	No	No	No	No	No	0	Yes	Yes	No	No	No	NA	2
	twinflower	Yes	No	Yes	Yes	Yes	No	4	No	No	No	No	No	NA	0
	viburnum spp	No	No	No	No	No	No	0	No	No	No	Yes	Yes	NA	2
Caryophyllaceae	chickweed	No	No	No	Yes	No	No	1	No	No	No	No	No	No	0
	spurry	No	Yes	No	No	No	No	1	No	No	No	No	No	No	0
	starwort	No	No	No	Yes	Yes	No	2	No	No	No	No	No	No	0
Coniferai	coniferous spp	Yes	Yes	Yes	Yes	No	No	4	Yes	Yes	Yes	Yes	Yes	NA	5
	jack pine	No	Yes	No	No	No	No	1	NA	NA	NA	NA	NA	NA	
	white spruce	Yes	No	Yes	Yes	No	No	3	NA	NA	NA	NA	NA	NA	

Family	Species	Observed on transect							Observed in pollen						
		1 GAL	2 MOI	3 BLE	4 LPM	5 AGU	6 NAT	# Sites	1 GAL	2 MOI	3 BLE	4 LPM	5 AGU	6 NAT	# Sites
Caprifoliaceae	red-berried elder	No	No	No	No	No	No	0	Yes	Yes	No	No	No	NA	2
	twinflower	Yes	No	Yes	Yes	Yes	No	4	No	No	No	No	No	NA	0
	viburnum spp	No	No	No	No	No	No	0	No	No	No	Yes	Yes	NA	2
Caryophyllaceae	chickweed	No	No	No	Yes	No	No	1	No	No	No	No	No	No	0
	spurry	No	Yes	No	No	No	No	1	No	No	No	No	No	No	0
	starwort	No	No	No	Yes	Yes	No	2	No	No	No	No	No	No	0
Coniferai	coniferous spp	Yes	Yes	Yes	Yes	No	No	4	Yes	Yes	Yes	Yes	Yes	NA	5
	jack pine	No	Yes	No	No	No	No	1	NA	NA	NA	NA	NA	NA	
	white spruce	Yes	No	Yes	Yes	No	No	3	NA	NA	NA	NA	NA	NA	
Cornaceae	bunchberry	Yes	Yes	Yes	Yes	Yes	Yes	6	Yes	Yes	Yes	Yes	Yes	NA	5
	red osier	No	No	No	Yes	No	Yes	2	Yes	Yes	Yes	Yes	Yes	NA	5
Cyperaceae	bulrush	No	No	Yes	Yes	Yes	No	3	No	No	No	No	No	NA	0
	cyperaceae/juncaceae	No	No	No	Yes	No	No	1	Yes	Yes	Yes	No	Yes	NA	4
Equisetaceae	horsetail	No	No	No	No	Yes	No	1	No	No	Yes	No	No	NA	1
Ericaceae	ericaceae spp	Yes	Yes	Yes	Yes	Yes	Yes	6	No	Yes	Yes	Yes	Yes	NA	4
	bearberry	No	Yes	No	Yes	No	Yes	3	NA	NA	NA	NA	NA	NA	
	bog-rosemary	No	No	No	No	No	Yes	1	NA	NA	NA	NA	NA	NA	
	indian pipe	No	No	No	No	Yes	No	1	NA	NA	NA	NA	NA	NA	
	Labrador tea	Yes	Yes	Yes	Yes	Yes	Yes	6	NA	NA	NA	NA	NA	NA	
	leather-leaf	Yes	No	Yes	Yes	No	Yes	4	NA	NA	NA	NA	NA	NA	
	lowbush blueberry	Yes	Yes	Yes	Yes	Yes	Yes	6	NA	NA	NA	NA	NA	NA	
	partridgeberry	No	Yes	No	Yes	No	No	2	NA	NA	NA	NA	NA	NA	
	rhododendron	No	No	Yes	No	Yes	Yes	3	NA	NA	NA	NA	NA	NA	
	sheep laurel	Yes	Yes	Yes	Yes	Yes	Yes	6	NA	NA	NA	NA	NA	NA	
	shinleaf	Yes	No	No	No	No	No	1	NA	NA	NA	NA	NA	NA	
	small cranberry	No	No	No	Yes	Yes	Yes	3	NA	NA	NA	NA	NA	NA	
	swamp laurel	Yes	No	Yes	No	Yes	Yes	4	NA	NA	NA	NA	NA	NA	
Fabaceae	beach pea	No	No	No	Yes	No	No	1	Yes	No	Yes	Yes	No	NA	3
	birds foot trefoil	No	No	No	No	Yes	No	1	No	No	No	No	Yes	No	1
	clover, red	No	No	Yes	No	No	No	1	Yes	No	Yes	Yes	No	No	3
	clover, white/alsike	No	Yes	No	Yes	Yes	No	2	Yes	Yes	Yes	Yes	Yes	Yes	6
	lupin	No	No	No	No	No	No	0	Yes	No	No	No	No	NA	1
	vetch	No	Yes	No	Yes	Yes	No	3	Yes	No	No	No	Yes	No	2
Fumariaceae	pale corydalis	No	Yes	No	No	No	No	1	No	No	No	No	No	No	0
Graminaceae	grasses	Yes	Yes	No	Yes	Yes	Yes	5	No	No	No	No	No	No	0

Family	Species	Observed on transect							Observed in pollen						
		1 GAL	2 MOI	3 BLE	4 LPM	5 AGU	6 NAT	# Sites	1 GAL	2 MOI	3 BLE	4 LPM	5 AGU	6 NAT	# Sites
Gentianaceae	bog-bean	No	No	No	No	No	No	0	Yes	No	No	No	No	No	1
Labiaceae	hemp nettle	No	Yes	No	No	No	No	1	NA	NA	NA	NA	NA	NA	
Lentibulariaceae	horned bladderwort	No	No	No	No	No	Yes	1	No	No	No	No	No	No	0
Liliaceae	blue eyed grass	No	Yes	No	Yes	No	No	2	No	No	No	No	No	No	0
	dogs tooth violet	No	No	No	No	No	No	0	Yes	Yes	Yes	No	No	No	3
	false solomons seal	No	Yes	No	Yes	Yes	No	3	Yes	Yes	Yes	No	Yes	NA	4
	starry solomons plume	No	No	No	Yes	Yes	No	2	NA	NA	NA	NA	NA	NA	
	wild lily of the valley	No	Yes	No	Yes	Yes	No	3	NA	NA	NA	NA	NA	NA	
	yellow clintonia	No	Yes	Yes	No	No	No	2	No	No	No	No	No	No	0
Nymphaeaceae	water lily	No	No	No	No	No	Yes	1	Yes	No	No	No	Yes	Yes	3
Onagraceae	evening primrose	No	Yes	No	Yes	Yes	No	3	No	Yes	No	Yes	No	No	2
	fire weed	Yes	Yes	Yes	Yes	Yes	Yes	6	Yes	Yes	Yes	Yes	Yes	Yes	6
Orchidaceae	dragonmouth	No	No	No	No	No	Yes	1	No	No	No	No	No	No	0
	ladies tresses	No	Yes	No	No	Yes	Yes	3	No	No	No	No	No	No	0
Oxalidaceae	wood sorrel	No	No	No	No	Yes	No	1	No	No	No	No	No	No	0
Polygonaceae	sheep sorrel	No	Yes	No	Yes	Yes	No	3	Yes	Yes	No	Yes	No	No	3
Ranunculaceae	buttercup	No	No	No	Yes	Yes	No	2	No	No	No	No	No	No	0
	goldthread	No	No	Yes	Yes	No	Yes	3	No	No	No	No	No	No	0
	meadow rue	No	No	No	Yes	No	Yes	2	Yes	Yes	Yes	Yes	Yes	NA	5
Primulaceae	starflower	No	Yes	No	Yes	Yes	Yes	4	No	No	No	No	No	No	0

Family	Species	Observed on transect							Observed in pollen						
		1 GAL	2 MOI	3 BLE	4 LPM	5 AGU	6 NAT	# Sites	1 GAL	2 MOI	3 BLE	4 LPM	5 AGU	6 NAT	# Sites
Rosaceae	bakeapple	Yes	No	Yes	Yes	Yes	Yes	5	Yes	Yes	Yes	No	Yes	NA	4
	burnet	No	No	No	No	No	Yes	1	Yes	No	Yes	No	Yes	Yes	4
	chokeberry	No	No	No	No	No	Yes	1	No	No	No	No	No	No	0
	cinquefoil spp	No	Yes	Yes	Yes	No	Yes	4	No	Yes	No	No	No	NA	1
	cinquefoil, rough	No	Yes	No	Yes	No	No	2							
	cinquefoil, shrubby	No	No	No	No	No	Yes	1							
	cinquefoil, three-tooth	No	Yes	Yes	Yes	No	No	3							
	mountain ash	No	No	No	No	No	Yes	1	Yes	Yes	No	No	Yes	No	3
	physocarpe	No	No	No	No	No	No	0	Yes	Yes	No	Yes	No	NA	3
	pin cherry	Yes	Yes	Yes	No	No	No	3							
	raspberry	No	Yes	Yes	Yes	Yes	Yes	5	Yes	Yes	Yes	Yes	Yes	NA	5
	rose spp	No	No	No	No	No	No	0	Yes	No	No	Yes	No	No	2
	saskatoon/pin cherry	Yes	Yes	Yes	Yes	No	Yes	5	Yes	Yes	Yes	Yes	Yes	NA	5
	saskatoon	Yes	No	Yes	Yes	No	Yes	4							
	spirea	No	No	No	Yes	No	Yes	1	Yes	Yes	Yes	No	No	Yes	4
	strawberry	No	Yes	No	Yes	No	No	2	No	Yes	No	Yes	No	NA	2
Salicaceae	willow	Yes	Yes	Yes	Yes	Yes	Yes	6	Yes	Yes	No	Yes	Yes	NA	4
Saraciniaceae	pitcher plant	No	No	No	No	No	Yes	1	No	No	No	No	No	NA	0
Saxifragaceae	skunk currant	No	Yes	No	Yes	Yes	Yes	4	No	No	No	Yes	No	NA	1
Scrophulariaceae	common linaria	No	No	No	Yes	No	No	1	No	No	No	No	No	No	0
	common rattle	No	No	No	Yes	No	No	1	No	No	No	No	No	No	0
	cow-wheat	Yes	No	Yes	Yes	Yes	No	4	No	No	No	No	No	No	0
	eyebright	No	No	No	No	Yes	No	1	No	No	No	No	No	No	0
Umbelliferae	parsnip	No	No	No	No	No	No	0	No	No	No	Yes	No	No	1
	umbelliferaie spp	No	No	No	No	No	No	0	Yes	No	No	No	No	No	1
	water hemlock	No	No	No	No	No	No	0	Yes	No	No	Yes	No	No	2
Mycètes	fungal spores	NA	NA	NA	NA	NA	NA		Yes	No	Yes	Yes	No	Yes	4

* Pollen images for most of the species listed in this table are available upon request from the Centre de recherche Les Buissons.

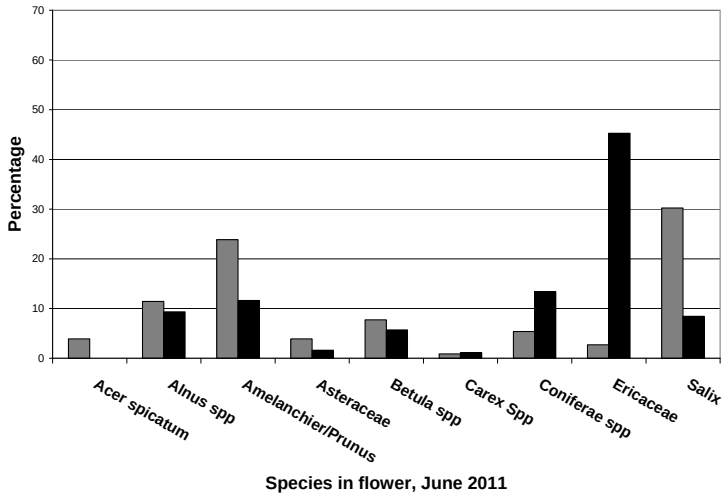
Table 2. The number of species in flower observed on the transects and their relative abundance per site compared with the number of pollen species observed in the pollen pellet samples

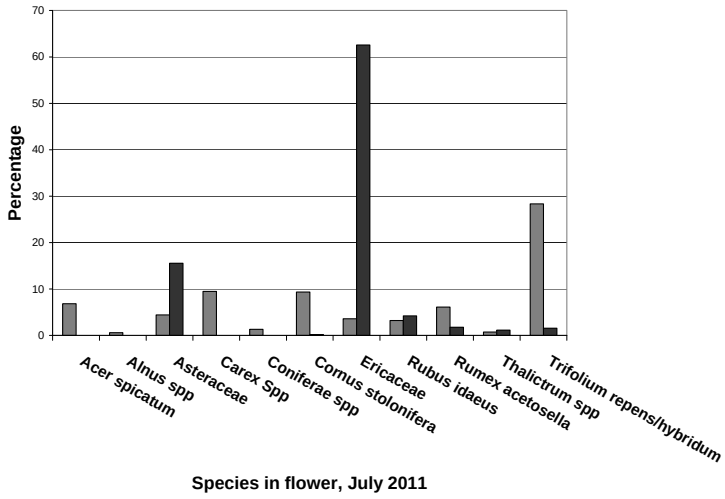
	From transects			From pollen pellet analysis* Number of species observed		
Site	Number of species	Species/station	Abundance	On Transect or in Pollen	In Pollen only	Among 16 best
1 GAL	22	1.2	20	39	25	16
2 MOI	43	1.6	28	40	12	15
3 BLE	26	1.2	22	26	8	11
4 LPM	56	2.1	30	43	6	14
5 AGU	43	1.5	24	38	10	15
6 NAT	39	1.5	24	NA	NA	10

* Note that pollen types were not always identified to the species level but often grouped by family, thus the number of species total is underestimated relative to the number of species observed on the transects.

Flowering season of floral species of interest to honeybees on the North Shore of Québec

The 16 flowering plants present in the foraging zones of the northern apiaries and found to be of most interest to the bees in the study are shown in figure 25 by flowering month. The percentage of pollen collected from these 16 species as well as an estimated of the percentage of their presence in the foraging zone, are presented. The flowering seaons in the area does not start until the end of May. The first species of interest to the bees are the willows and alders, followed shortly by dandelions, pin cherries and saskatoons. Several ericaceous species are also flowering at this time starting with leatherleaf, sheep laurel and, towards the end of the month of June, the lowbush blueberry. Pollen was also collected from birches and conifers. The mountain maple seemed to be of particular interest in areas where it is found. Even though it was not spotted on the transects, large quantities of pollen of this species were gathered by bees at both the GAL and MOI sites. In July the white clover starts to flower and pretty much dominates the interest of the bees until the end of August. Other species of interest flowering in July include the mountain maple, hawkweed, raspberry, sorrel and red osier. Pollen of this last species, though the plant was rarely seen on the transects, was collected in much greater quantites than the pollen of the closely related bunchberry despite the fact that the bunchberry was the most abundant species observed in the study area. In August several species in the aster family are in flower including the pearly everlasting, several species of aster, the fall dandelion, daisies, and several species of goldenrod. Fireweed was also a common and good bee forage plant. Other less common species which nonetheless were used as bee forage were meadow rue and burnet. These two species are found in moist rich soils along creeks and forest edges.





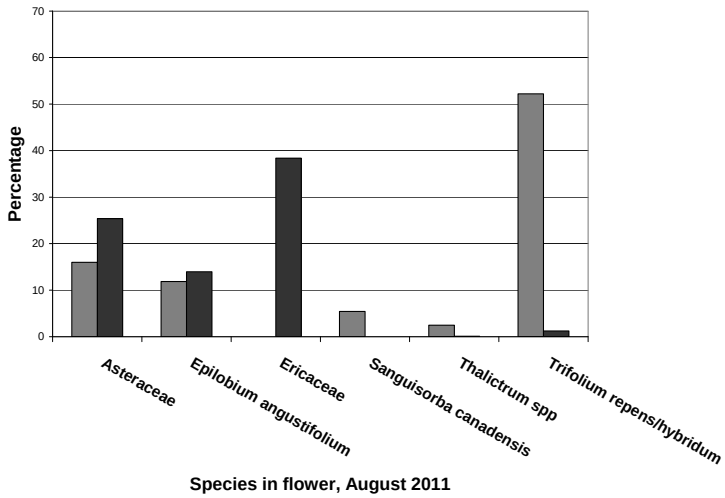


Figure 25. The 16 flowering species of most interest to the bees in northern regions: pollen percentage in grey versus the estimated percentage presence in black.

The 16 species chosen are both of interest to the bees and relatively abundant in northern areas. Other species of interest are those which one finds in the pollen pellets despite their relative rarity in the area. Species for which we found pollen in the pollen pellets without having seen any plants in the area were the mountain maple, lupin, bogbean, dogtooth lily, physocarp, rose and various species in the carrot family (figure 26). Water lily pollen was also present in the pollen samples at three sites but the plant was only seen in the field at one of the sites.

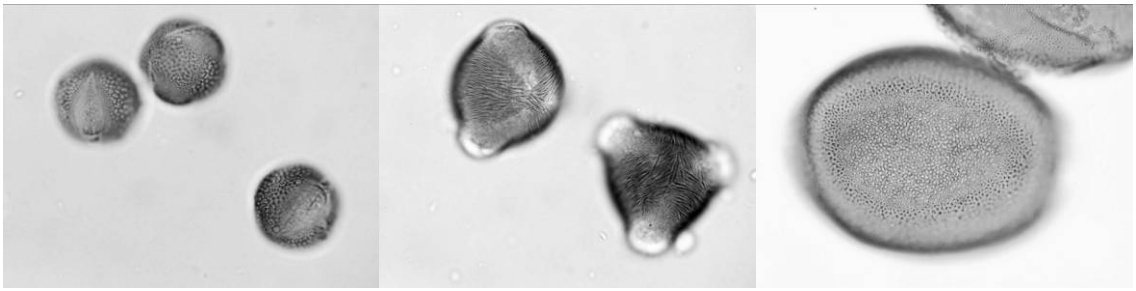


Figure 26. From left to right, pollen of lupin (1000x), of bogbean (1000x) and of dogtooth violet (1000x) (pollen identified by Melissa Girard).

The best types of sites for apiary establishment in northern regions

In order to analyse the correlation between ecotype and floral resources of interest to honeybees, each sampling station along the transects was classed into one of four ecotypes: lowbush blueberry field, forest including black spruce/moss stands, black spruce/lichen stands and mixed conifer/deciduous forest, open areas including road side areas, fields, clearings and abandoned airports, and bogs including bogs and the edges of creeks. The average number of species per sampling station as well as the average relative floral abundance per ecotype and flowering period are shown in figures 27 and 28. In general the forested sites were of least interest and the open sites of most interest for apiary location. In the beginning of the season bogs were of most interest in terms of number of species flowering and the relative abundance of the flower. However, by early July the flowering period of bogland species was over. At the other types of sites, and especially in open areas, the number of species in flower increased between June and July. By August flowering plants could only be found in open areas, the species specific to the blueberry fields and the forested areas having finished flowering by this time.

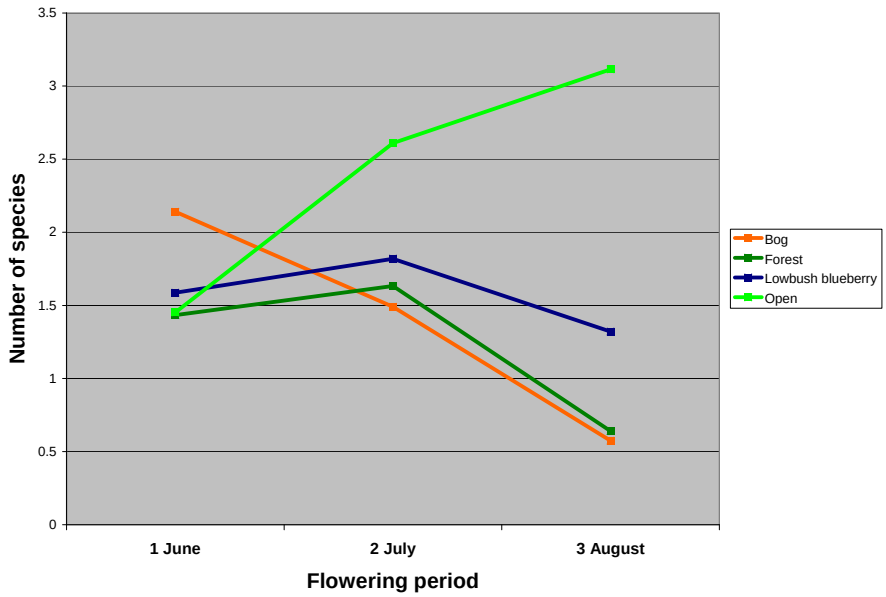


Figure 27. The number of species per sampling station, ecotype and flowering period (June, July and August).

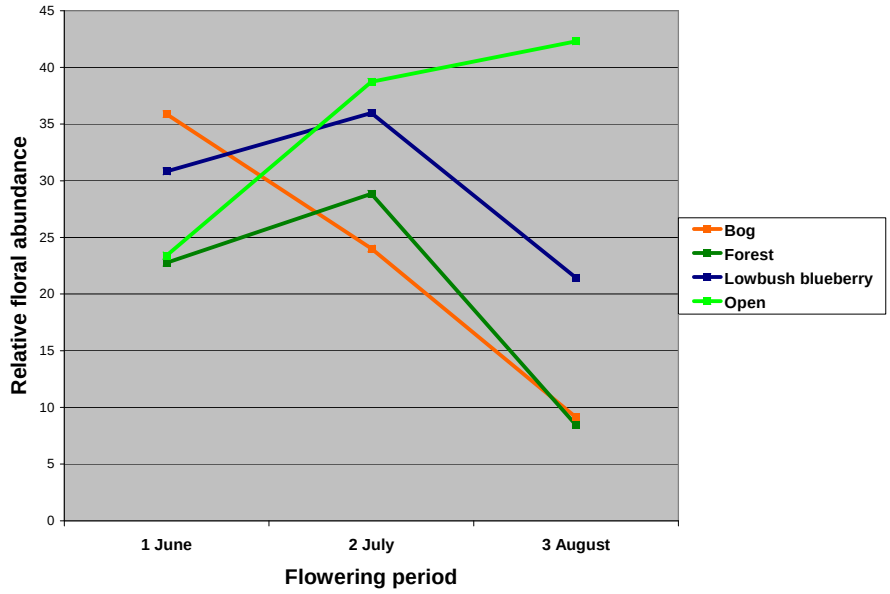


Figure 28. The relative abundance of flowering plants per sampling station, ecotype and flowering period (June, July and August).

Periods of floral scarcity among native species in northern areas

At the open sites there did not seem to be periods of floral scarcity. However, open areas cover only from 3 to 43 percent of the foraging zones surrounding the apiaries as compared to 19 to 64% covered by forested areas. In general, one should plan on managing the land to increase floral resources flowering after the lowbush blueberry in the areas surrounding the apiary. This can be done by clearing more land to allow for native species which require open areas or by cultivating plants of particular interest to bees.

Calibration

Several authors have noted that the quantity of pollen gathered from ericaceous species is underestimated by pollen traps relative to pollens of other plant species. Pollen pellets formed from ericaceous species are often small and are not redily removed from the bees pollen basket as she moves through the trap. In order to calibrate the data taken from the traps a sample of foraging bees returning to the hive was collected during the lowbush flowering period. Pollen pellets removed directly from the pollen baskets on these bees were analysed and the results were compared with pollen samples collected in the traps during a few hours the same day as the bees were collected. In those cases where the bees returning to the hive had no pollen pellets, pollen was collected from other parts of the bees body for analysis.

Table 3. The types of pollen (%) found in pellets in pollen trap, in pellets collected directly from the bees pollen basket and on the bodies of bees returning to the hive without a pollen pellet (respectively trap, bee, none).

	1 GAL			2 MOI			3 LPM			4 BLE			5 AGU			Average
Type of Pollen	**Trap**	**Bee**	**None**	**Trap**	**Bee**	**None**	**Trap**	**Bee**	**None**	**Trap**	**Bee**	**None**	**Trap**	**Bee**	**None**	
Acer	27	24	42	0	0	0	0	0	0	0	0	0	0	0	0	6
Alnus	0	0	0	0	0	0	22	44	51	0	7	0	0	0	43	12
Asteraceae	0	0	0	59	3	1	1	0	0	0	0	1	0	0	6	5
Coniferae	0	0	5	8	13	52	51	50	26	34	7	7	0	25	3	21
Cornus	49	41	25	0	0	0	6	0	0	6	0	0	83	75	14	15
Ericaceae	**0**	**3**	**16**	**0**	**11**	**6**	**0**	**5**	**4**	**3**	**52**	**62**	**5**	**0**	**34**	**13**
Monocotyledon	14	16	7	33	68	29	5	0	4	11	17	2	0	0	0	16
Rosaceae	5	8	2	0	0	0	5	2	12	0	7	0	0	0	0	3
Spores	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	1
Other species	4	9	3	0	1	0	8	0	3	0	0	0	0	0	0	2
Unknowns	0	0	0	0	5	2	1	0	0	47	11	11	0	0	0	4

The results of the analysis of pollen collected in the traps, from the bees pollen baskets or of pollen found elsewhere on the bee are given in table 3. From 16 to 52% of the bees returning to the hive had pollen in their pollen baskets. As has been noted previously, results from the pollen traps underestimated the percentage of ericaceous pollen collected by the bees. While pollen of ericaceous species was present in 1.5 % of the trapped pollen, 14.2% of the pollen in pellets collected directly from the bees pollen baskets was from ericaceous species. Over 50% of the bees returning to the hive were not collecting pollen. Twenty-four % of these bees had ericaceous pollen on their bodies. The disparity between the results obtained from the pollen traps and those obtained from samples taken directly from the bees pollen baskets was greatest for hives at the BLE site located on the lowbush blueberry fields of Les Bleuets du 50 Parallèle. Only 3% of the pellets found in the trap contained ericaceous pollen while 52% of the bees returning to the hive with pellets in their pollen baskets were gathering ericaceous pollen. Of the bees returning to the hive without pollen pellets, 62% had ericaceous pollen elsewhere on their bodies.

2.2. Dissemination of Results

Complete the table on the next page.
Describe:

- the scheduled activities as planned in Appendix A of the financial contribution agreement;
- the completed activities;
- the dates of the activities;
- the number of people reached.

In addition,

- join the news releases or other documents submitted during press conferences or other official events;
- add copies of newspaper or magazine articles that were published;
- include a copy of the activities' programs where results were disseminated (e.g. seminars or conferences) or any other dissemination document.

DISSEMINATION OF RESULTS

Remove or add activities that apply to your project and fill in the following columns.
Join the dissemination documents to the report.

APPENDIX A's planned activities	*Completed Activities*	*Description (theme, title, location, etc.)*	*Completion date*	*Number of people reached*	*Exposure given to the CAAP (logo, mention)*
Field day	An overview of the project with preliminary conclusions was discussed with the producers involved in the project.	On location at two of the apiaries, site GAL at Gallix and site MOI at Moisie	30.08.2011	3	Mention
Leaflet, brochure	Photos and a short video were provided to the New Brunswick Agricultural Council Inc for use in their promotional video.	New Brunswick			Mention and logo
Presentation Stand	A PowerPoint presentation including a project description and preliminary results was given to interested people visiting a beekeeper. A microscope was available for people to view pollen collected from native and cultivated species.	At the Herbamiel farm, Sacré-Coeur-du-Saguenay, during the Open House on the Farm day organized by UPA	11.09.2011	300	Logo and mention in the PowerPoint presentation
Other	The PowerPoint presentation described above was translated into English and made available to the New Brunswick and Newfoundland Agricultural Councils Once accepted the final report will be submitted to Agri-réseau Un fois accepté, le rapport final sera soumis pour deposition sur Agri-réseau	Apiary development in northern regions	July, 2012		Logo and mention. Logo and mention of financial participation of CDAQ in connection with the PCAA

3. CONCLUSIONS

A new requirement for increased pollination services in isoloated northern regions has developed due to the expansion of the small fruits industry on the North-Shore of Québec. In Minganie, 800 hectares of boreal forest has been cleared for lowbush blueberry production and by 2015 the region is predicted to have 2000 hectares in production. For the region of Minganie alone, the number of hives needed for pollination is 500 and 600 for respectively 2012 and 2013.

There are very few hives on the North-Shore and few beekeepers providing pollination services further south willing to move their hives as far north as Minganie. The closest professional beekeeper providing pollination services is at Alma and the 12 hour trip from Alma to Minganie weakens the hives. The transportation costs increase the costs of pollination services significantly. In 2008, over half of the professional beekeepers surveyed were not willing to provide pollination services to Minganie and among those who would, the cost per hive varied from $250 to $650. At such prices, pollination services are not cost effective for lowbush blueberry producers.

With the long term goal of providing pollination services on the North-Shore, we evaluated several potentially important factors influencing apiary development in northern regions in the course of the present project. A management calendar specific to northern regions was anticipated at the end of the project. The management of the hives in the course of the project however was gouverned by the experimental protocols and very different from how a beekeeper would manage hives. For example, while preparing the hives for winter the weak hives were not combined, nor were they overwintered in the cold chamber despite the recommendations for overwintering these hives made by Raphaël Vacher during the fall inspection, 2010. The brood and laying pattern was only inspected three times during the season. Swarm prevention, normally based on the number of frames of brood, was in the course of the project based on the number of frames of bees, an indirect and less reliable measure of brood quantities. During his last hive inspection Raphaël Vacher noted that there was very little pollen stocks in the hives. The pollen traps installed on all the hives in 2011 to inventory the types of pollen available to the bees in northern areas could have hindered the hives ability to collect sufficient quantities of pollen despite the fact that only small samples of pollen were removed and the rest returned to the hive. The availability of pollen substitute at all times may also have hindered the collection of pollen from the field. It would be premature to present a management calendar specific to northern regions which had not actually been tried in the field. Nonetheless, we present conclusions with comments and recommendations on possible ways to solve the main problems encountered in the course of this expermiment with northern apiculture.

Northern apiculture is primarily limited by a lack of floral resources with the climate providing an additional challenge. Even with very small bee yards (6 hives per yard in our case), the constant availability of sugar syrup and pollen substitute could not compensate for the lack of floral resources at the forested sites. Of the four ecotypes examined (bogs, lowbush blueberry fields, open areas, forested areas) only the open sites were suited to apiculture. These sites however, cover only 6% of the areas surrounding the lowbush blueberry fields in this study. Agricultureal diversification in northern regions is necessary in order to support the large number of hives required to sufficiently pollinate the lowbush blueberry fields in the region.

Overwintering in a cold chamber was beneficial to the survival of hives from the forested sites. For the hives from the semi-cultivated sites no effect of overwintering method used during the winter of 2010/2011 was detected. However, the winter 2010/2011 was a mild winter. At the first inspection in 2011 most of the hives were weak. Regardless of the overwintering method used, the use of insulated hives in the spring should be considered in order to prevent brood loss and spring dwindling due to the cool spring temperatures in northern regions.

Queen loss, either due to swarming or other unknown reasons was problematic. Brood chamber management was complicated by the cool spring and summer temperatures in northern regions. Adding an additional hive body when there were 8 frames of bees in the first hive body seemed to have a negative effect on hive development in 2010 while swarming became a problem in 2011 when additional hive bodies were added only when 9 frames of bees in the first hive body were obtained. The use of insultated hives might permit the expansion of the brood chamber space without compromising the ability of the bees to maintain proper brood chamber temperatures. Polystyrene hives such as those used in Scandinavia or insulation of standard wooden hives as is done by beekeepers in Gaspésie might be envisioned.

A new queen developed in only 7 of the 21 hives which had lost their queen. Nicolas Tremblay noticed a spotty brood pattern in a couple of the hives during inspections which may have been due to inbreeding. The chance that new queens developing in isolated areas with few hives in the area will be well mated are low. In such regions one must therefore have extra well mated queens on hand, for example in the form of nucs, to combine with any hives that lose their queen. Alternatively one can start with a sufficient number of hives to assure adequate genetic diversity in the vicinity of the apiary.

As mentioned earlier, the hives were weak at the first inspection in the beginning of June, 2011. They were too weak during the blueberry flowering season two weeks later to provide good pollination services. Renewing the queen at the end of the summer might help assure better populations in the fall before overwintering. In the spring, stimulative feeding with sugar syrup and high quality pollen patties at least 6 weeks in advance of blueberry flowering is needed to assure decent populations of foraging bees ready for pollination.

Of the two sources of bees used in the study, the source B bees obtained higher populations and had a better survival rate. Of the 9 hives remaining at the end of the study in August 2011, 8 were hives with source B bees. We could however not differentiate the effects of apiary site from those of the source of bees used. According to floral resource inventory data collected, the B source bees were placed on the two best sites among the 4 semi-cultivated sites used. Nonetheless, the advantages of the source B bees were numerous; they were not infected with varroa mites and therefore did not suffer the ill effects of this parasite nor the negative effects of treatements used to control varroa. Nosema, a disease often associated with varroa infestation, was not detected in source B bees while spore loads in the source A bees were high in the spring of 2011 despite the fumagillin treatments made in the fall. A few cases of European foulbrood were also detected in the source A bees. Someone establishing a beekeeping operation in northern regions might take advantage of the opportunity isolation provides to work with bees free from varroa and associated pathogens.

In conclusion, beekeeping should be possible in lowbush blueberry production areas on the North-Shore of Québec under the following conditions:

- Ten to 20% of the bee foraging zone should be cleared to provide the hives with sufficient floral resources. Other small fruits such as Saskatoon berry and raspberry could be more extensively planted in the region to provide bee forage which blooms respectively before and after the lowbush blueberry.

- Special attention needs to be given to heat conservation in spring management of the hives in order to obtain sufficient numbers of foraging bees in time for lowbush blueberry pollination. Different types of hives, such as polystyrene hives, could be envisioned for use in northern areas.

- Compared with beekeeping operations further south, the costs of beekeeping in more northern regions stem primarily from reduced yields due to the shorter season, with additional costs related to changes in the management of the hives being of secondary concern. Advantages to northern beekeeping come in the form of reduced stress on the bees due to the non-migratory nature of the operation, the lack of pesticides in the area and the lack of varroa and associated pathogens.

- The small fruits producer benefits from northern apiculture through an increase in the availability of pollination services. In order to ensure sustainable beekeeping in these regions, lowbush blueberry producers should diversify their production to include floral resources blooming before and after the blueberry crop.

Project sustainability

The long term success of this project would be the development of sustainable apiculture on the North-Shore of Québec resulting in pollination service stability for the developing small fruits industry. Two of the producers involved in the project are continuing to keep bees and the third producer plans to do so in the future. An agricultural diversification project aimed at diversifying one out of every 11 blueberry fields in order to determine how many hives a diversified field can support has been proposed by La COOP agroforestière de Minganie for the lowbush blueberry fields of Les Bleuets du 50 Parallèle Inc. The project aims also to monitor the long-term viability of the apiary. Hive development before, during and after the blueberry flowering season will be monitored as well as the lowbush blueberry pollination efficiency of the apiary.

Possible follow-ups to the project

The establishement of a varroa-free apiary on the North-Shore of Québec would be of interest for anyone in the area interested in beekeeping. It would also be of interest to researches in need of negative controls when working for example with varroa and varroa/pathogen or pesticide interactions.

An analysis of the effects of hive type on population development in northern regions would also be of interest.

The results of a CDAQ projet currently in progress (number 6660), dealing with the cultivation of various bee forage plants may be applicable to the need for agricultural diversification in northern regions. However, the adaptability of the species and varieties currently on trial to more northerly regions would first have to be determined.

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Madeleine Chagnon	Université de Québec à Montréal
Domingos De Oliveira	Université de Québec à Montréal

Club Agroenvironnemental Côte-Nord (CAECN)
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4. SUMMARY OF PROJECT ACHIEVEMENTS

The expansion of the small fruits industry on the North-Shore of Québec is increasing the need for pollination services in the region. There are very few hives on the North-Shore and few beekeepers providing pollination services interested in transporting their hives as far as the region of Minganie. The goal of this project was the establishment of an apiary in an isolated and northern region in order to provide pollination services to the expanding small fruits industry in the area.

In the course of the present project we evaluated several factors of potential importance to beekeeping in the north. More specifically, we evaluated the effects of apiary site, the overwintering method and the source of bees used in the study. A chronological inventory of floral resources available to the bees was done in order to evaluate site effects and to determine periods of native floral resource dearth.

The project partners were le Club Agroenvironnemental Côte-Nord (CAECN), le Conseil Agricole du Nouveau Brunswick inc., le Conseil pour le développement de l'Agriculture du Québec, le Centre de recherche Les Buissons (CRLB), le Centre de recherche en sciences animales de Deschambault (CRSAD), La COOP agroforestière de Minganie, Les Bleuets du 50 Parallèle Inc., Les Fruits Nordco and le Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ).

Northern apiculture is primarily limited by a lack of floral resources with the climate providing an additional challenge. Even with few hives per apiary, the constant availability of sugar syrup and pollen substitute could not compensate for the lack of floral resources at the forested sites. Of the four ecotypes examined (bogs, lowbush blueberry fields, open areas, forested areas) only the open sites were suited to apiculture. Agricultureal diversification in northern regions is necessary in order to support the large number of hives required to sufficiently pollinate the lowbush blueberry fields in the region.

Hives were weak coming out of winter regardless of the overwintering method used, too weak to provide pollination services to the blueberry fields in bloom two weeks later. A prerequisite to the success of northern apiculture with respect to blueberry pollination will be the use of early spring stimulative feeding and hive management geared towards the conservation of hive heat.

An agricultural diversification project aimed at diversifying one out of every 11 blueberry fields in order to determine how many hives a diversified field can support has been proposed by La COOP agroforestière de Minganie for the lowbush blueberry fields of Les Bleuets du 50 Parallèle Inc. The project aims also to monitor the long-term viability of the apiary. Hive development before, during and after the blueberry flowering season will be monitored as well as the lowbush blueberry pollination efficiency of the apiary.

5. FINANCING PLAN AND EXPENDITURE RECONCILIATION

The budget for the project, in the form of an Excel file, has been submitted to CDAQ.

Appendix 1

Protocol for making pollen slides from pellets or pollen from anthers

*****The description underlined below refers to the pollen extracted from anthers.

1. Turn on the hot plate.
2. Put a very small amount (1/4-1/8 of mm) of pollen from the pellet on a microscope slide.
3. Cut a cube of gelatine-glycerine (2 mm^3) and put it on the pollen.
4. Use the cube of gelatine to get pollen in the bottom of the beaker.
5. Put the slides on the hot plate at 40 °C (approximately) or more if the gelatin does not melt after ~30 seconds.
6. Always close the container of gelatine to avoid any contamination in it.
7. Always wash your tools with alcohol (scalpel, needle, etc.) between each pellet or plant species to avoid contaminating the samples.
8. When the gelatine is melted, stir softly with a needle to even the pollen grains. Mix gently to avoid making air bubbles in gelatine.
9. Be careful not to enlarge the drop of gelatine. It will expand when you will put the cover slide on it.
10. Place a cover slide over the drop of gelatine and press gently to spread the drop.
11. Put a piece of paraffin wax next to the cover slip. When it will melt it will go under the cover by capillarity.
12. When the wax surrounds the entire gelatine, remove the rest of wax and let it solidify.
13. Remove excess of wax very gently with the needle, scraping the edges of the cover slide and the surplus on the slide.
14. Rub gently the slide with hand paper to clean it.
15. Seal the sides of the slide cover with clear nail polish.

N.B. Those slides will last many years if kept in a dark box.

Material:

- Microscope slides (25x75 mm)
- Cover glass (22x22mm)
- Clear nail polish
- Paraffin wax (any brand)
- Hot plate
- Scalpel
- Needle (mounted on a wood stick is better)
- Gelatine-glycerine containing fuchsine (see recipe)

Preparation of the gelatine-glycerine of "Kaiser"

- 8 g of gelatine, "Knox" brand
- 32 g water (mix gelatine in it)
- Add 56 g of glycerine
- Add 1g of phenol (in crystals)
- Heat 15 min on a hot plate (~ 40°C)
- Filter if necessary
- Let the mixture stand for 2 hours

Coloration of the gelatine-glycerine

- Prepare a solution of 0,1% of alkaline fuchsine in alcohol:

  0.5 g of alkaline fuchsine diluted in 50 ml of alcohol at 95%

- In a beaker of 50 ml, melt 10 ml of gelatine-glycerine on a hot plate
- Incorporate 1.0 ml of the solution of fuchsine
- Stir slowly to avoid making air bubbles.
- Let cool down with a paper on top of the beaker
- When cool enough put a Parafilm® over it and keep it in the refrigerator.