River Valley Ecosystems Study
Boreal Owl Component

Progress Report
Work Carried Out in 2003

PRELIMINARY

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Introduction

The river valleys located in the Military Training Area of Quebec-Labrador are particularly appealing for low-level flying because they provide a natural corridor appropriate for training routes and they enable pilots to practise radar detection avoidance. Given the relatively large number of low-level training flights occurring in river valleys and the biological importance of these valleys, the Institute for Environmental Monitoring and Research (IEMR) has developed a research program over the past few years to investigate the impact of overflights on the ecological components of river valleys. The first work to be carried out was designed primarily to identify certain species that are closely associated with the river valleys and could be targeted for more specific studies.

Birds of prey are located at the top of the food chain, and this makes them vulnerable to stress factors and changes in their habitat. They are therefore excellent indicators of the health of the environment, and several species have been chosen as indicator species in a number of locations around the world. In the area of Quebec-Labrador used for low-level flying, studies have been carried out in an attempt to identify the effects of these flights on diurnal birds of prey, more specifically the osprey (*Pandion haliaetus*) (Trimper et al., 1998ab; Thomas, 1999). However, the increase in military activities at night has recently brought to light the need to initiate studies of nocturnal species.

Searching for nocturnal raptor nests for such studies can involve considerable effort in the field and result in the discovery of a relatively small number of nests, particularly in inaccessible regions with no access roads. The best way to find an adequate number of nests with relatively little effort is to install nesting boxes for species that nest in cavities. In this context, the boreal owl (*Aegolius funereus*) is the most attractive target species in the Quebec-Labrador region. Not only does the boreal owl readily use nesting boxes (Korpimäki, 1981, 1985), but it is also reported that, in northern latitudes, this owl is mainly confined to riparian forests given the relative scarcity of appropriate breeding habitats outside the river valleys (Mossop, 1997). Consequently, the home range of the boreal owl extends for long distances along watercourses (Hayward & Hayward, 1993). Such habitat use by the boreal owl should therefore favour this species' presence in the ecosystems targeted for study in the low-level flying area, making it an ideal indicator species for possible studies designed to evaluate the repercussions of these low-level overflights. The Société de la faune et des parcs du Québec (FAPAQ) therefore proposed that a study be undertaken to this effect, and some preliminary work got under way in 2003.

Hypotheses

Low-level flying could affect boreal owls in various ways. First, the flights could affect the hearing ability of these owls, which depend greatly on this sense to feed themselves. This could lead to a decline in the feeding efficiency of the adults. The number of eggs laid by the female depends to a large extent on the energy reserves she has built up (Korpimäki, 1987), which in turn depend on the hunting success of the male and the female. Boreal owls live in the same area year-round, and the number of eggs laid serves as an indicator of the feeding conditions in their home range. Also, it has been shown that large clutches produce more young (Korpimäki, 1987). During incubation and rearing, the female normally stays on the nest, and the male provides food for her (Hayward & Hayward, 1993). Consequently, a reduction in hunting efficiency could have an impact on nesting effort, egg-laying effort, and survival of the young. But it is recognized that the nesting effort of boreal owls is closely related to the availability of prey (Löfgren et al., 1986; Korpimäki, 1988; Hörnfeldt & Eklund, 1990). In northern regions, small mammal populations go through cycles characterized by years of very low abundance, which have an impact on the breeding effort of boreal owls (Korpimäki, 1981, 1994; Löfgren et al., 1986; Hörnfeldt et al., 1990). During these lean years, the owls may even refrain from reproducing. It is therefore necessary to know the population levels of small mammal species so as not to wrongly attribute the observation of a poor breeding effort to low-altitude flights alone.

Fault bars, which were particularly well documented in the scientific study of raptors, are malformations in the feathers that were initially associated with a scarcity of food resources and low energy reserves. However, recent work leads us to believe more and more that these fault bars may also be caused by stress factors (Machmer et al., 1992; Negro et al, 1994; Bortolotti et al., 2002) and could therefore be used to compare stress levels between different sectors. Whether fault bars are caused by a reduction in food intake or by stress factors, their number and frequency of occurrence should be higher in juvenile birds reared in sectors affected by low-level flying. Causes of stress during feather development in adult females may make it possible to predict their reproductive status (Bortolotti et al., 2002); consequently, the presence of fault bars in females could also be investigated in an attempt to explain nesting success.

On the basis of these hypotheses, different parameters can therefore be looked at with a view to determining the possible effects of low-level flying:

1. Nesting box occupancy rate
2. Egg-laying effort (number of eggs)
3. Nest attendance of the female, and food supply provided by the male
4. Nesting success
5. Survival of the young
6. Number and frequency of fault bars in the feathers
7. Availability of food (abundance of small mammals).

Selection of Study Sectors

The Natashquan River was selected for the study for the following reasons:

1. Along with the Petit-Mécatina and Olomane rivers, the Natashquan is among the rivers most affected by the low-level flying carried out in Québec, where nearly 60% of all flights are made.
2. Of these three rivers, the Natashquan is the one where the habitats along the banks are the most homogeneous, making it easier to select suitable sectors for experimental/control comparisons.
3. The Natashquan River is the only one that is easily navigable over long distances.
4. The mouth of the Natashquan River is located near the village of Natashquan, which is accessible by road, thus facilitating all the logistics of the project.

The stretch of the Natashquan River located immediately to the north of the southern boundary of the training area was therefore selected as an experimental sector (Figure 1). Since the section of the Natashquan River located to the south of the boundary of the training area is not long enough to install the required number of nesting boxes (see "Methods" section), a stretch of the Aguanus River, situated only 20 km to the west and presenting roughly the same habitat characteristics was selected to complete the control sector (Figure 1).

In any new research project, a considerable part of the first season in the field is often spent developing the methods to be used. The remoteness and inaccessibility of the sectors chosen for this study are such that the project costs would have increased unduly had this step been carried out in those sectors. Consequently, in 2003, the experimentation work was carried out in the immediate vicinity of the city of Sept-Îles.

Methods

Development of Methods in the Sept-Îles Region

In January 2003, 99 nesting boxes were installed in two sectors near the city of Sept-Îles: a coastal sector located to the east of the city, where 67 nesting boxes were placed along Route 138 (Figure 2) and another sector located inland, where 32 nesting boxes were located along the road leading to the hydroelectric facilities on the Sainte-Marguerite River (Figure 3). Two visits were made to all these nesting boxes on April 30 and May 19. The nesting boxes that had been occupied during the first visit were paid regular visits throughout the season, until June 17, in order to track nesting progress and determine how the devices described below were functioning.

Active infrared motion detectors (Trailmaster TM1550) were tested to determine their effectiveness in recording the comings and goings of breeding adults from the nesting boxes. This type of device consists of a transmitter that transmits an infrared beam towards a receiver, which must be placed opposite. The device records the date and time whenever an animal passes through the beam. The data can be collected in the field using a device such as the Trailmaster Data Collector and subsequently downloaded into a computer using the Trailmaster TM Statpack Software.

To install the motion detectors, a metal support was attached directly to the tree behind the nesting box. This support was equipped with two arms extending horizontally on either side of the tree to the front of the nesting box. These arms made it possible to install the two components of the motion detector on either side of the nesting box and to adjust the distance between the detector and the front of the nesting box, initially established at around 8 cm (Figure 4). Two nesting boxes occupied by boreal owls (see “Results” section) were equipped with these motion detectors. Testing was carried out from late April to mid-June.

It is possible that females whose mates do not supply an adequate number of prey may be forced to leave the nest more often to go hunting (Korpimäki, 1981). Such behaviour may go unnoticed if the total number of times the motion detectors are activated is more or less the same as in cases where the males are efficient and the females remain on the nest. Obtaining images of the inside of the nesting box should make it possible to determine whether low-level overflights may have an impact on the female's nest attendance. The Trailmaster TM1550 is equipped with connectors so that it can be hooked up to cameras. Photographs can be taken when the detector is activated. However, this motion detector is not designed to be connected to a camcorder or video recorder for the purpose of obtaining continuous images. It actually can be connected, but once the device has been activated, it cannot be stopped from recording, and filming continues until the end of the cassette is reached. This is not practical if we want to avoid having to go and replace the cassette every day in an area that is not easy to get to. To solve this problem, an electronics specialist developed a control box for us that is hooked up between the motion detector and the video recorder and makes it possible to set the desired recording time. As a result, every time the system is activated, the video recorder can record images for 10, 15, 20, 25, or 30 seconds, depending on the length of time selected. The date and time of the recording, which are already registered by the motion detector, are also noted automatically on the cassette. The full system used to record images consisted of the following components:

- An **infrared camera** (National Electronics, Bullet-C/IR) placed in the nesting box to view the contents and the birds' behaviour.
- A **motion detector** (Trailmaster TM1550) placed in front of the nesting box to detect all comings and goings. This device is connected to the infrared camera and to the tape recorder, thus making it possible to transfer images from one device to the other.
- A **water-tight carrying case** (Pélikan, Model 1400) that protects the control box and the video recorder from bad weather.

- A **control box** connected in series between the motion detector and the video recorder, making it possible to set the length of the recording time.
- A **miniature video recorder** (Sony Video Walkman, Model GV-D800) that uses cassettes that can record for an hour in digital mode and for two hours in analogue mode.
- A **full-discharge battery** (marine battery) that supplies the current needed to run the infrared camera and the video recorder.

This system was installed on another nesting box that was occupied during the 2003 season. Testing took place between April 30 and early June.

Installation of Nesting Boxes on the Natashquan and Aguanus Rivers

On the basis of the estimates of the sample sizes required to obtain a sufficient level of precision regarding boreal owl productivity parameters (Hayward et al., 1992), 300 nesting boxes were installed in each of the river sections selected, for a total of 600. Since the rivers being studied are relatively wide, they probably impede boreal owl movements from one bank to the other, such that the home ranges should be considered separated by the rivers. Consequently, nesting boxes could be installed on both banks. A distance of 0.5 km between each of the nesting boxes is recommended (Hayward et al., 1992). However, because of the light amounts of precipitation on the North Shore in the summer of 2003, the level of the rivers was particularly low when the nesting boxes were installed in September. Vast stretches of sand banks were exposed in certain locations, making it more difficult to reach the banks in a number of sectors. These sectors had to be avoided to speed up the work, and the locations selected for the installation of nesting boxes therefore had to be spaced farther apart. The distance of 0.5 km therefore represents the minimum distance between two nesting boxes on a same bank. GPS was used to determine the exact location of all the nesting boxes.

Trapping of Small Mammals

Ten sites were selected in order to determine the abundance of small mammals in the region: five in the training area and five to the south of the training area (Figure 1). In each of these sectors, three sites were located in closed environments (mature coniferous forests) and two, in open environments. The open environments selected in the training area were located in vast, relatively dry burnt forests covered in lichens. No comparable habitat could be found outside the training area, which meant that the open environments selected for trapping were covered in lichens as well but were also dotted with slight, wet depressions.

On each of the sites, 100 kill traps (Victor M035) were systematically set every 10 metres along four 250-metre transects, also spaced 10 metres apart. Owing to the configuration of site #5, the traps had to be distributed over six transects. The traps, which were baited with peanut butter, remained in place for three nights and were visited every day. The specimens caught were put in plastic bags, and then labelled and placed in the freezer at the end of the day. They were subsequently identified in the lab by means of skull characteristics and dentition (Lupien, 2001 and 2002; Maisonneuve et al., 2002). The abundance of small mammals was expressed in terms of number of captures per 100 trap-nights. A correction reflecting the number of traps sprung accidentally was included in the calculation of this index (Nelson & Clark, 1973). The Wilcoxon test was used to compare capture success in the training area with that in the control area.

Results

Development of Methods in the Sept-Îles Region

Nesting

The first visit, made on April 30, showed that 5 of the 99 nesting boxes were occupied by boreal owls. No new nests were found during the second full visit, made on May 19. None of the nesting boxes in the coastal environment was occupied. If we consider only the 32 nesting boxes installed inland along the road leading to the hydroelectric facilities on the Sainte-Marguerite River, we get an occupancy rate of 16%.

All of the occupied nesting boxes contained small mammal carcasses piled up around the perimeter of the nest. As many as 16 carcasses were counted in one nest. The vast majority of these small mammals were headless. Three of the nesting females were caught and banded. Three of the young in one nest were banded as well. None of the birds handled, whether juveniles or adult females, had feathers with fault bars. The paragraphs below provide the individual results for each of the occupied nests.

Nesting Box No. 68

This nest contained only three eggs during the visit of April 30. These eggs were very cold, indicating that the nest had been abandoned. Snowshoe tracks observed nearby lead us to believe that this disturbance could have been the reason for the nest being abandoned. It is difficult to establish the initiation date for an abandoned nest without any other further indicator concerning laying and hatching periods.

Nesting Box No. 76

Five eggs were present during the visit of April 30. Laying had already been completed by that time since, during the next visit, on May 13, the eggs had hatched, and five chicks were present. All five were still alive during the visit of May 21. An examination of the data recorded by the motion detector installed on the nesting box indicates that the young left the nest on May 30, or 30 days after the first visit. The young normally fly away about 28 to 36 days after hatching (Korpimäki, 1981; Hayward & Hayward, 1993). Hatching must therefore have started shortly after the visit of April 30. Using an average incubation period of 28 days, and considering that incubation begins after the second egg is laid and a two-day interval separates the laying of each egg, the initiation date for this nest is estimated to be April 1. With a total of five eggs, the date on which laying was completed is therefore estimated to be April 7 (Table 1).

Nesting Box No. 93

This nesting box contained five eggs during the visit of April 30. On May 13, four of the eggs had hatched, and the last egg had hatched by the visit of May 21. On May 26, the five chicks were still alive. The data from the motion detector indicate that the young left the nest around June 7. Using an average hatching rate of 1.3 eggs/day (Korpimäki, 1981), hatching can be estimated to have started on May 10. Using the same back-calculation as for the previous nesting box, we can estimate the nest initiation date as being April 10 and the day on which hatching was completed as being April 18 (Table 1).

Nesting Box No. 96

This nesting box contained five eggs during the visit of April 30. One of the eggs was accidentally broken while attempts were being made to catch the female in the nesting box. Hatching was under way on May 14, with two chicks present at that time. The egg broken during the previous visit had been removed from the nesting box. Hatching therefore began around May 11. The initiation date for this nest is estimated to be around April 11, and laying must have been completed by April 19 (Table 1). On June 10, three chicks were present, and the nest was empty on June 17. This nesting box was not equipped with a motion detector so it is not possible to establish the exact date on which the young left the nest.

Nesting Box No. 98

Egg-laying was still under way in this nesting box during the first visit. It contained four eggs at that time. Five eggs were present during the visits of May 13 and 21. Laying was therefore initiated on April 24 and completed on May 2. By the visit of May 23, the eggs had disappeared, and the nest contained just one empty shell. This was apparently a case of predation. The nest's late initiation date indicates that, had there been no predation, the young would have left the nest around June 24.

Nesting Box Monitoring Devices

During the period from April 30 to May 19, the motion detector at one of the nesting boxes was activated a total of 930 times. Our observations enabled us to conclude that the device was too close to the nesting box's entrance, such that the detector could be activated when the female poked her head out of the nesting box without actually leaving. She could activate the system regularly without really leaving the nesting box. It can be assumed that the same thing would occur when the male returned with food. He has to perch at the entrance to the cavity to let the food drop into the nesting box and could activate the system with his tail a number of times while perched in this way. As a result of this finding, the motion detectors were moved about 15 cm away from the front of the nesting box. This simple modification made it possible to reduce the number of activations to a much more realistic number, or to about 20 a day (10 or so comings and goings).

We experienced a few problems with the video recorder system when it came to taping images inside the nesting box. First, the system stopped working prematurely when the nest was still occupied and the birds were obviously coming and going. At first, we thought the problem could be attributed to the partial severing of the wire connecting the motion detector to the video recorder, probably from being chewed by a squirrel. However, the problem occurred again even though the wire had been placed in a protective sheath. Not only did the system stop working while the nest was still active, but it had also experienced some failures before that, while the device was functioning and some recordings had been made successfully. The date and time of the recordings did not always match those noted by the motion detector. The larger number of activations noted by the motion detector indicates that the video recorder did not start up every time a bird activated the system. A detailed examination of the system by an electronics expert made it possible to conclude that this problem was due to the poor quality of the connectors on the motion detectors, which meant that the contact could be interrupted intermittently. Last of all, some of the sequences filmed occasionally showed images that were completely blurry. It seemed fairly obvious that this happened on days with unusual weather conditions, such as heavy rains. Such conditions caused a significant increase in the degree of humidity in the nesting boxes, thus creating a layer of condensation on the lens.

Installation of Nesting Boxes on the Natashquan and Aguanus Rivers

The 600 nesting boxes were installed in 15 days in early September. Data collection should begin in April 2004.

Trapping of Small Mammals

A total of 681 small mammals belonging to 6 species were caught (Table 2). The Gapper's red-backed vole accounts for 88% of all specimens collected. The only other species caught in relatively large numbers is the heather vole, at 9%. Average capture success on the sites selected in closed mature forests (34.7/100 trap-nights) was nearly five times higher than on the sites selected in open environments (7.2/100 trap-nights). For each of the habitat types, capture success in the training area was not significantly different from that in the control sector (Figure 5), in either the closed (Z = 12.00; P = 0.542) or the open environment (Z = 7.00; P = 0.219).

Discussion

Development of Methods in the Sept-Îles Region

Nesting Boxes

All the nesting boxes occupied by boreal owls were in the inland sector. The occupancy rate (16%) in the Sainte-Marguerite River sector, although based on a relatively low number of nesting boxes, indicates that using nesting boxes to keep track of boreal owl nesting has excellent potential. Two factors may have contributed to the fact that the nesting boxes in the coastal sector were not occupied, i.e., habitat quality and weather conditions. The forest environments located on the coast along Route 138 were quite a bit different from those found inland. The road leading to the hydroelectric facilities on the Sainte-Marguerite River is relatively new and goes through an area that has been almost untouched by forestry operations, such that mature forests cover vast areas, which is not really the case near the coast. The inland forest is therefore made up of larger trees with a generally more open understorey likely to appeal to boreal owls in their hunt for small mammals.

In addition, during the winter of 2002-03, the coastal sector was subject to fairly severe ice conditions. The crust of ice that formed on the snow cover limited small mammal movements and affected the boreal owls' hunting conditions. Small mammal tracks in the snow were much more numerous in the Sainte-Marguerite River sector. The conditions encountered in the inland sector should be fairly representative of those along the Natashquan and Aguanus rivers, which are bordered by vast stretches of mature forest as well. The results obtained therefore seem to indicate that the nesting boxes installed in this sector are likely to be used frequently.

The entire area located to the north of the nesting box network on the Sainte-Marguerite River also contains vast stretches of mature forest. Since the nesting boxes installed in the coastal sector were unoccupied, these were moved in December 2003 to expand the Sainte-Marguerite network. The boreal owl occupancy rate for this network of nesting boxes will likely be higher there. This might make it possible to continue experiments that could be useful in conducting the study. For example, a controlled disturbance could be carried out near the occupied nesting boxes to determine the owls' reaction and to evaluate the noise levels and the frequency of disturbance likely to have an impact on reproduction and the formation of fault bars in the plumage of young birds affected by the disturbance.

Monitoring Devices

The motion detectors used have proved to be very effective for collecting the data we needed to determine the number of comings and goings from the nesting boxes. Above all, we will have to make sure they are placed at a reasonable distance from the front of the nesting boxes, i.e., at a distance of about 15 cm, to prevent the recording of "false events" due to the female's poking her head out or the male's wagging his tail in front of the detector during food deliveries. The support used in 2003 to attach the detectors to the trees consisted of a single piece that was fairly cumbersome and difficult to install. A new type of support will be used in 2004 to facilitate transportation and installation. Two separate supports will hold the two components of the motion detector. Since they are separate, these supports will be much easier to handle and install. They will be attached directly to either side of the nesting boxes.

However, the connectors used to hook up these devices to the cameras proved to be of poor quality. Contact was sometimes intermittent, and this meant that the video recorder did not necessarily switch on every time a bird activated the detector. An alternative system has been developed over the past few weeks and is currently being tested. So far, it appears that this new system meets the requirements. Also, the relatively expensive miniature video recorder ($1,300) has been replaced by a standard model costing 10 times less.

Trapping of Small Mammals

Capture success during the trapping campaign of September 2003 appears to be exceptionally high. A comparison of the values obtained with those taken from other studies carried out at similar latitudes in the boreal forest of Québec and Labrador indicates clearly that small mammal populations were particularly abundant (Table 3). This considerable availability of food on the territory seems to suggest an excellent breeding season for the boreal owl in 2004. Indeed, in Finland, years in which small mammal capture success in the fall is very high (20-30 captures/100 trap-nights) are often followed by seasons where the nesting box occupancy rate exceeds 20% (Korpimäki, 1994). The nesting boxes installed along the Natashquan and Aguanus rivers will likely have high occupancy rates in the spring of 2004.

The absence of any difference in small mammal abundance between the training area and the control sector indicates that, if differences were ever detected in the breeding success of owls nesting in these two sectors, they could not be attributed to a difference in food availability.

Work Planning – 2004

The nesting phenology established on the basis of nesting box monitoring in the Sept-Îles region (Table 1) should be used to plan the work scheduled for 2004 along the Natashquan and Aguanus rivers. Obviously, these data resulting from a single year of work and a small number of nesting boxes must be considered approximate for the purposes of such a planning exercise. Provisions should be made for annual variations on the basis of weather conditions and fluctuations in the abundance of small mammal populations. In addition, opportunities to access these rivers are limited to certain times, especially in the spring when the rivers thaw and flood. An examination of the flow data for the Natashquan River compiled by the Ministère de l'Environnement du Québec (Figure 6) may help with this planning. According to these data, it should be possible to make the first visit by snowmobile during the month of April (Figure 7), just before the thaw. This visit should start around April 12 or 13 and be completed as quickly as possible, before the ice melts. Several teams should share the work so that it can be completed in under a week. This visit to all 600 nesting boxes would make it possible to collect data (egg-laying effort) on the earliest nesters and to install motion detectors and camera systems so they can be monitored.

However, a subsequent visit should ideally be planned to detect late nesters in an effort to obtain a more accurate estimate of the nesting box occupancy rate. It is much more problematic to plan the exact date of this second visit. Ideally, it should take place before the end of May and again cover all 600 nesting boxes. By this time, the rivers are often flooded and difficult to access in a boat without endangering the safety of the field teams. If this visit has to be made late, cases of abandoned nests and predation at the beginning of the incubation period could go unnoticed. Nevertheless, the bias generated will be the same in both the military training area and the control sector, and comparisons should not suffer as a result. The work done during this second visit should therefore include accurately establishing the nesting box occupancy rate, determining the egg-laying effort of late nesters, evaluating the hatching success of early nesters, banding chicks that are old enough to wear a band, and downloading the data collected by the monitoring devices.

Another visit should be made in June to determine the hatching success of the late nesters, to band the chicks that could not be banded during the previous visit, and to recover the monitoring devices. It is likely that certain hatchings will not yet be big enough for banding at this time. An additional visit would probably be required to band them and possibly obtain a more accurate assessment of the survival rates. However, project costs increase considerably with each additional visit, and the number of visits required to achieve a sufficient level of accuracy in the assessment of survival rates will have to be determined.

Last of all, a final visit will have to be made in September. A small mammal trapping campaign will make it possible to determine the availability of food for the coming season. The occupied nesting boxes will be cleaned and their content checked for the presence of bands indicating that chicks died in the nest. These data will be used to calculate survival rates.

The main reason for using motion detectors is to verify the hypothesis that the hearing ability of boreal owls nesting in the military training area is affected to the point where their hunting efficiency decreases. According to this hypothesis, the average number of prey taken back to the nest would be higher in the control sector. To be able to detect significant differences, it will be necessary to ensure that an adequate number of occupied nesting boxes in the two sectors are monitored and that a sufficient number of motion detectors are installed. In the study by Korpimäki (1981), mechanical devices were used to count the number of visits made daily to the nest by the owls. On the basis of these data collected for eight nests during the incubation, hatching, and rearing period, we can make calculations to evaluate the number of devices required to obtain significant differences between our two study sectors. By using the averages and variances calculated on the basis of the 1981 data, we can determine the number of nesting boxes that should be monitored in each of the sectors in order to detect differences of a given number of visits between the two sectors (Table 4). Thus, with a variance of 1.8, as obtained by Korpimäki for the incubation period, it would be sufficient to monitor 19 nesting boxes per sector in order to detect a difference of 1.5 visits/day with an accuracy rate of 95%, 80% of the time. The number of nesting boxes required increases for the hatching and rearing periods. But we have to consider that the data used in making these calculations were collected on the basis of only eight nests. Monitoring a larger number of nests should normally result in a smaller variance. Consequently, if, in the case of a rearing period where the number of nests required to detect differences is higher (Table 4) and we use a variance of 2.3 instead of 2.7 as obtained by Korpimäki, we can see that it would be sufficient to monitor 25 nesting boxes in each sector in order to detect a difference of 2 visits/day between the two sectors. With an occupancy rate of 10% for the nesting boxes installed on the Natashquan and Aguanus rivers, which seems fairly realistic given the abundance of food in the area (see preceding section), it can be expected that worthwhile results will be obtained. However, the budgets needed to acquire an adequate number of motion detectors to monitor this many nesting boxes would have to be allocated.

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Table 1: Nesting phenology established for nesting boxes occupied in the Sept-Îles region in 2003.

Nesting box	Initiation	Egg-laying completed	Hatching	Nest leaving
76	April 1	April 7	May 1	May 30
93	April 10	April 18	May 10	June 7
96	April 11	April 19	May 11	June 10-17
98	April 24	May 2	predation	

Table 2: Abundance and species of small mammals caught within and outside the Military Training Area (MTA) in closed and open environments located along the Natashquan River, September 2003.

	Closed Environments		Open Environments		
	MTA	Control	MTA	Control	Total
Gapper's red-backed vole *Clethrionomys gapperi*	257	265	59	16	597
Heather vole *Phenacomys intermedius*	17	0	33	6	56
Northern bog lemming *Synaptomys borealis*	6	0	6	0	12
Meadow vole *Microtus penssylvanicus*	2	2	2	0	6
Rock vole *Microtus chrotorrhinus*	1	1	0	0	2
Unidentified voles	2	0	0	0	2
Masked shrew *Sorex cinereus*	3	1	1	0	5
Woodland jumping mouse *Napaeozapus insignis*	1	0	0	0	1
TOTAL	289	269	101	22	681

Table 3: Small mammal capture success (no./100 trap-nights) in different habitats in the northern regions of Québec and Labrador.

	Drolet & Crête, 1994	Simon et al., 1998	Sharpe et al., 2002	Our Study
	James Bay	Labrador	Lower North Shore-Labrador	Lower North Shore
Burnt forests, young open forests	2.60 – 3.07	0.13 – 2.63	0.78 – 1.69	7.2
Scrublands	2.95			
Fens		1.75		
Mature forests (islands)	11.51 – 12.88			
Mature forests (coniferous)	2.26	1.50 – 2.26	2.09 – 2.12	34.7
Mature forests (hardwood)		6.77		

Table 4: Sample sizes required to detect differences in the number of nest visits during the (a) incubation, (b) hatching, and (c) rearing periods (a = 0.05, P = 80%) based on data obtained during the monitoring of eight nests by Korpimäki (1981).

(a)

Δ / σ	1	1.5	2	2.5
1.6	33	15	9	6
1.8	**41**	**19**	**11**	**8**
2.0	51	23	14	9
2.2	61	28	16	11

(b)

Δ / σ	1	1.5	2	2.5
1.9	58	27	16	11
2.1	71	32	19	13
2.3	**85**	**38**	**22**	**15**
2.5	100	45	26	17

(c)

Δ / σ	1	1.5	2	2.5
2.3	85	38	22	15
2.5	100	45	26	17
2.7	**116**	**52**	**30**	**20**
2.9	134	60	35	23

The values in bold indicate those associated with the variance obtained on the basis of Korpimäki's results (1981).

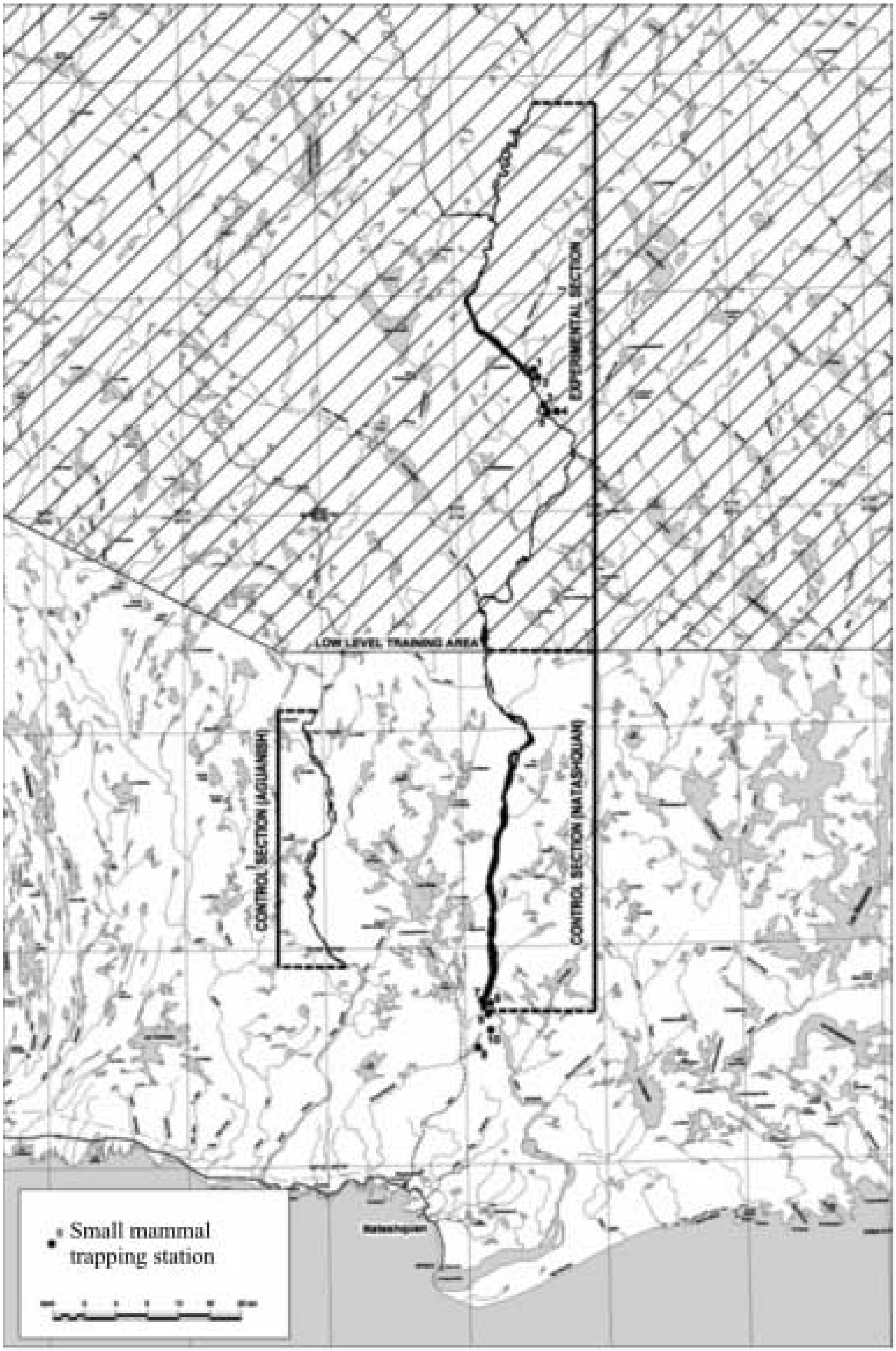

Figure 1: Location of river sections being studied and small mammal trapping stations.

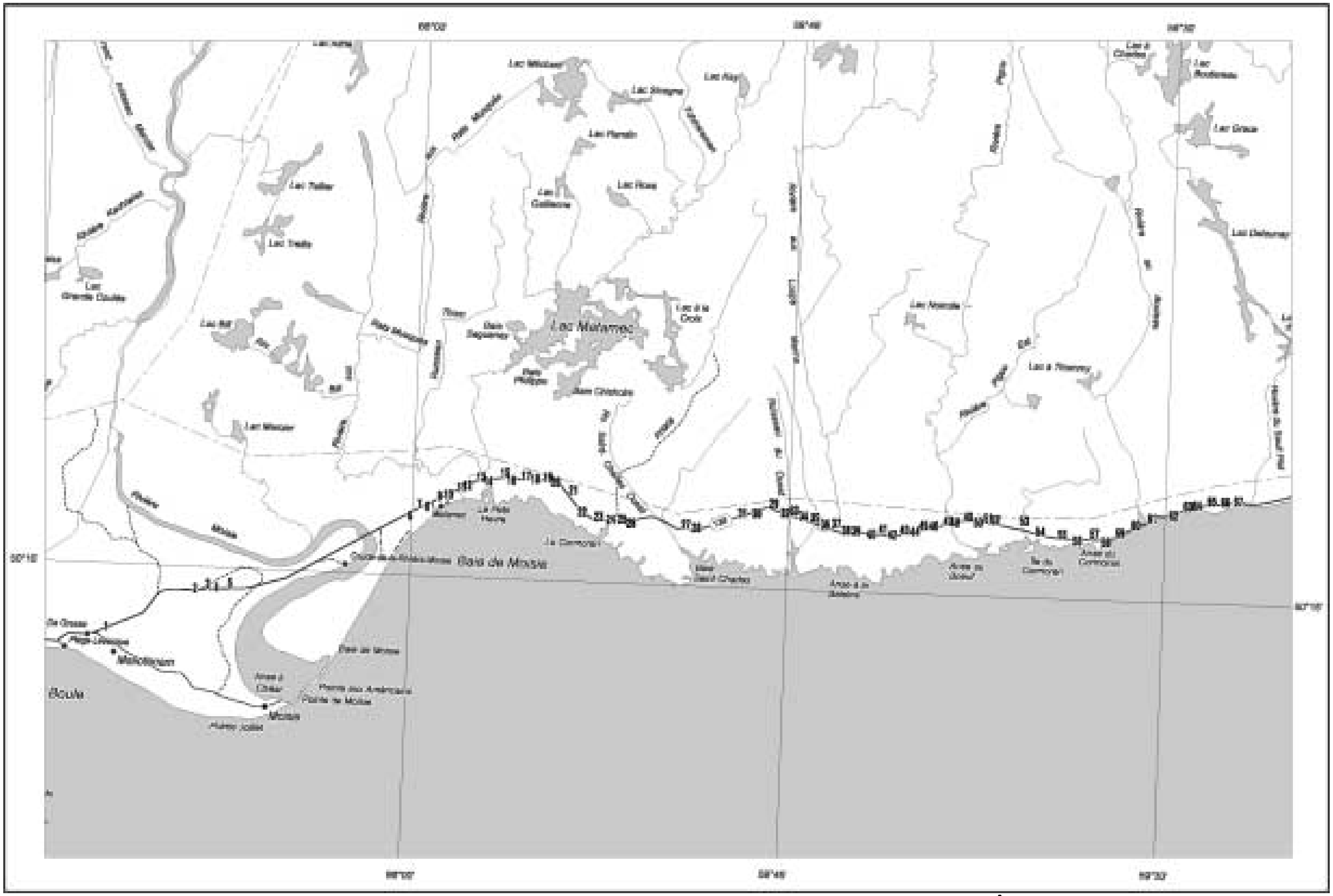

Figure 2: Location of nesting boxes installed in the coastal sector to the east of the city of Sept-Îles.

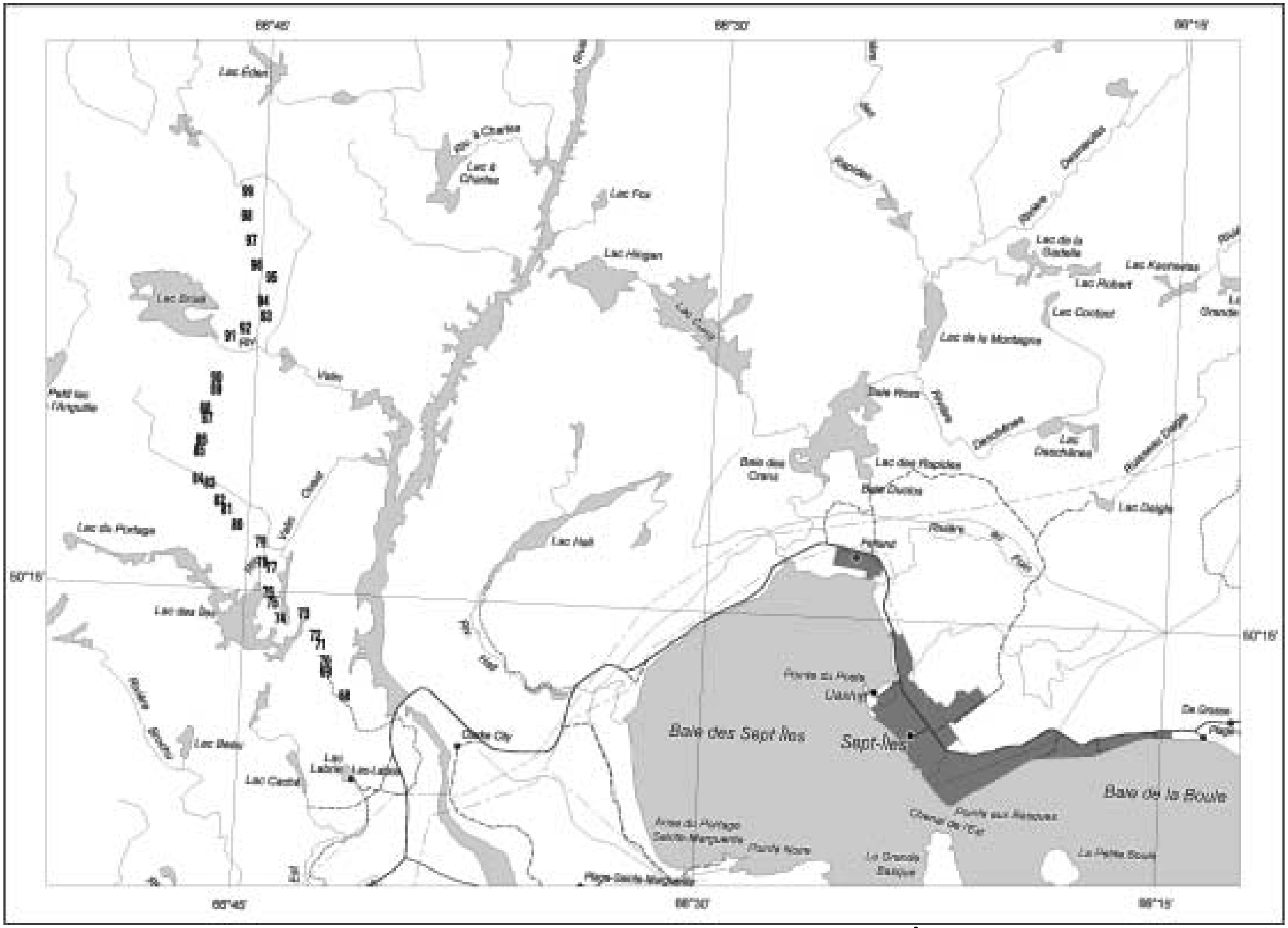

Figure 3: Location of nesting boxes installed inland to the west of the city of Sept-Îles.

Figure 4: Installation of a Trailmaster TM1550 motion detector for recording the comings and goings from a nesting box of boreal owls.

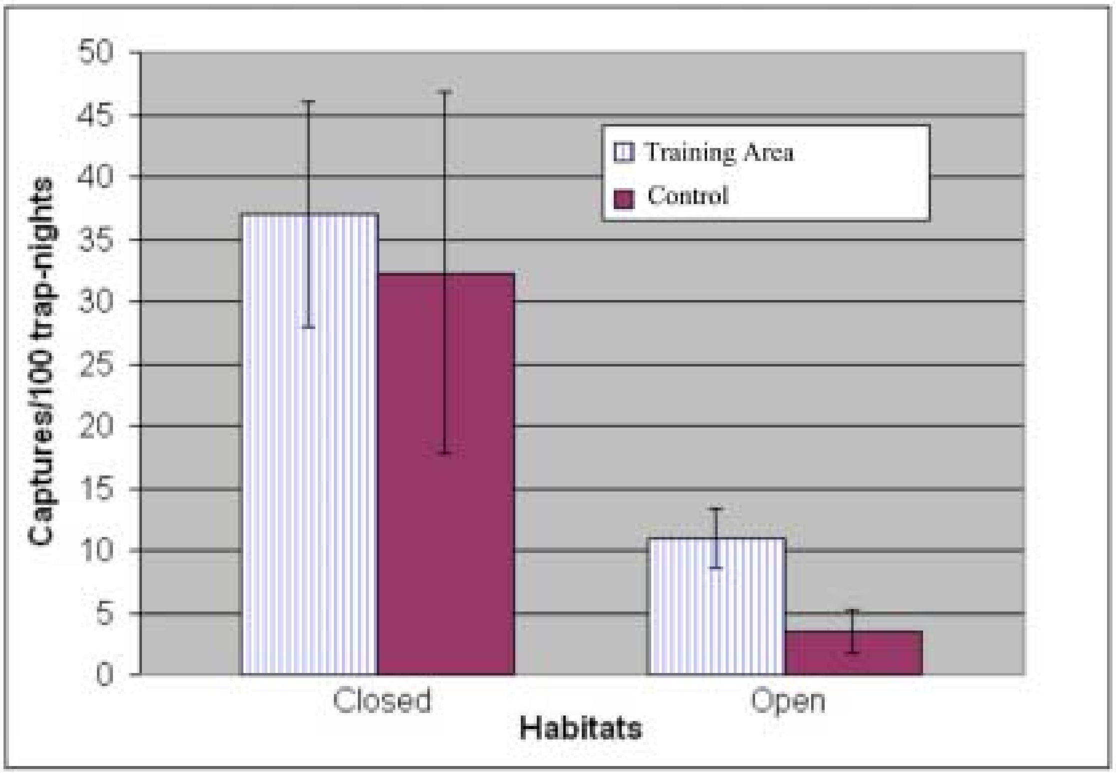

Figure 5: Small mammal capture success in closed and open environments along the Natashquan River within and outside the training area, September 2003.

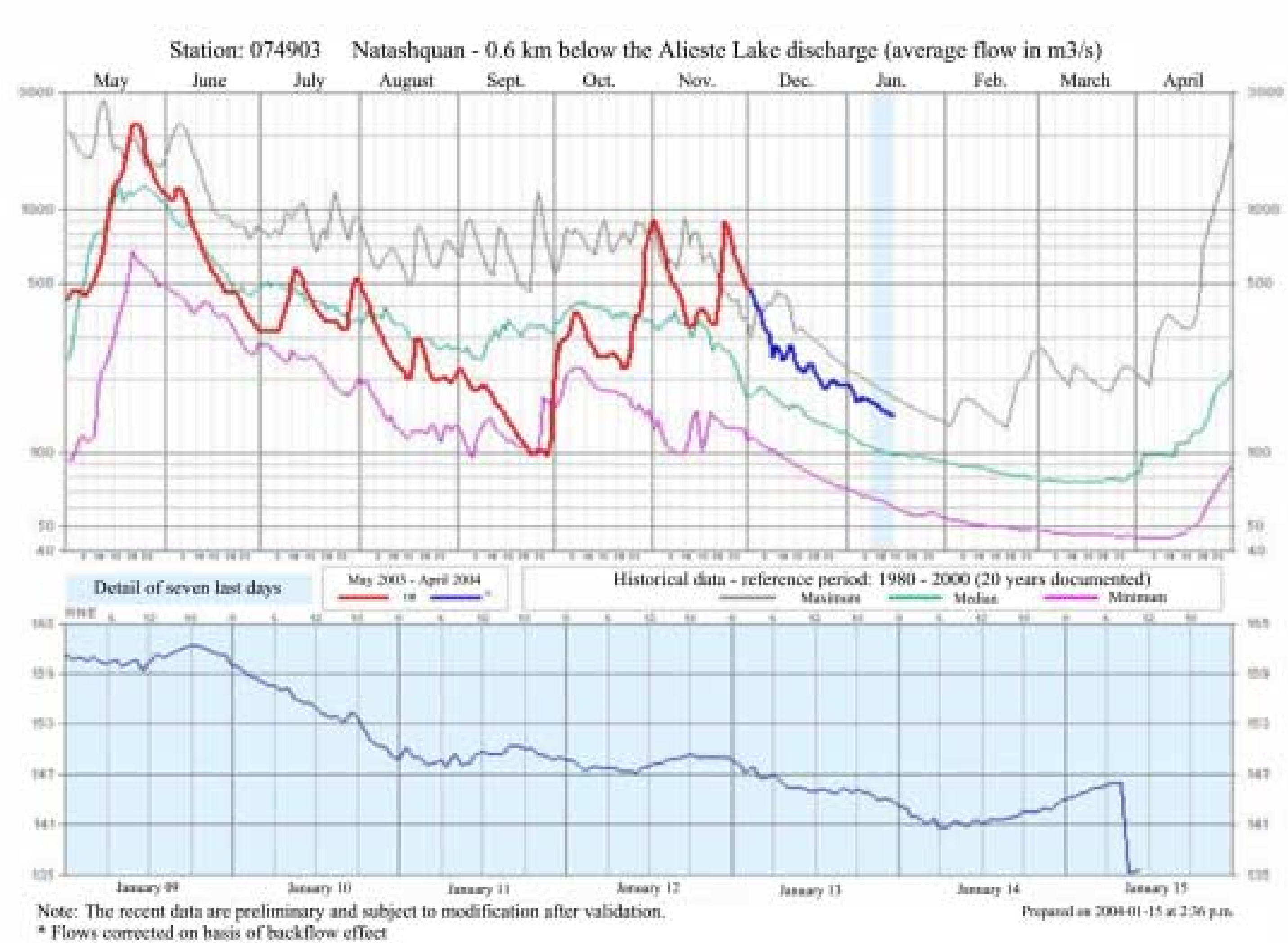

Figure 6: Diagrams of average flow (m^3/s) on the Natashquan River from 1980-2000 and of flow recorded during the recent period of January 9 to 15, 2004.

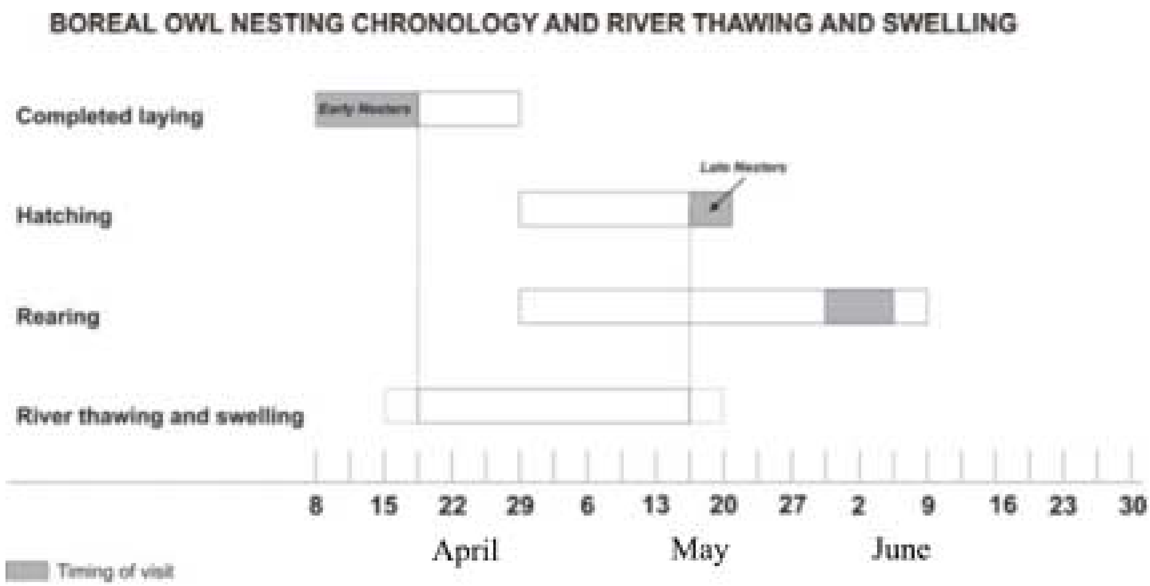

Figure 7: Planning of visits to nesting box network on the Natashquan and Aguanus rivers based on the approximate nesting phenology of the boreal owl and river thawing and flooding.