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# Surveys and Habitat Use of the Whimbrel (Numenius phaeopus) During Fall Migration Along the Acadian Peninsula of New Brunswick, Canada, 2014

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## Executive Summary

The whimbrel (*Numenius phaeopus*) is a large, highly migratory shorebird that breeds in arctic and sub-arctic latitudes and winters in the tropics. The North American race (*N.p. hudsonicus*) includes three disjunct breeding populations, all of which winter primarily in Central and South America. The two *rufiventris* populations breed in Alaska and the Northwest Territories of Canada (Engelmoer and Roselaar 1998). These western whimbrels primarily use different migration routes and wintering grounds and are most likely genetically segregated populations (CCB/CWS unpublished tracking data). The *hudsonicus* population breeds in the Hudson Bay Lowlands along the James and Hudson Bays (Jehl and Smith 1970, Skeel and Mallory 1996). The populations of whimbrels utilizing the Atlantic Coast and northeast South America have declined by up to 50% in recent decades (Watts and Truitt 2011, and RIG Morrison *et al*., unpublished data, from Andres *et al*. 2012) and both the *hudsonicus* and Northwest Territories *rufiventris* populations are of conservation concern (Morrison 2006, Bart et al. 2007, Watts and Truitt 2011).

In an effort to better understand the population size and habitat use of whimbrels utilizing the Acadian peninsula during fall migration, we designed aerial and ground based surveys to accomplish this goal. We detected 339 whimbrels during the first aerial survey and 615 during the second survey. Whimbrels were distributed along the peninsula from Brantville to Miscou Island, though concentrations of whimbrels were higher near Miscou Island. Of the 954 whimbrels detected on aerial surveys, 908 (95%) were observed in harvest stage fields, 5 (<1%) in development stage fields, 7 (<1%) flushed from unknown stage fields, and 34 (3.5%) from coastal beaches or barrier islands. We surveyed 103 ground transects twice each during the field season. We surveyed a total length of 58.5 km of transects within the five geographic areas (Brantville, Lord and Foy, Val-Doucet, Tracadie-Sheila, and Pigeon Hill/Lameque Island). We surveyed approximately 1,448 hectares of blueberry fields, with 773ha in active blueberry production, 653ha in growth stage, and 32ha in development. A total of 690 whimbrels were detected in the two survey rounds, with majority of detections in harvest stage fields (N=637, 92%), and 53 detections (8%) in either growth or development stage. A total of 565 (82%) whimbrels detected during survey round 1, and 125 (18%) during survey round 2.

The Acadian Peninsula of New Brunswick, Canada appears to support a significant portion of the total whimbrel population that uses Atlantic Canada in fall migration. Over 99% of all whimbrels detected during the aerial, ground, and evening roost surveys originated from blueberry fields, suggesting that tidal influences on behavior are negligible. Warden pressure on the whimbrels in the blueberry fields is quite high and needs to be addressed.

## Background

The whimbrel (*Numenius phaeopus*) is a large, highly migratory shorebird that breeds in arctic and sub-arctic latitudes and winters in the tropics. The North American race (*N.p. hudsonicus*) includes three disjunct breeding populations, all of which winter primarily in Central and South America. The two *rufiventris* populations breed in Alaska and the Northwest Territories of Canada (Engelmoer and Roselaar 1998). These "western" whimbrels primarily use different migration routes and wintering grounds and are most likely genetically segregated populations (CCB/CWS unpublished tracking data). The *hudsonicus* population breeds in the Hudson Bay Lowlands along the James and Hudson Bays (Jehl and Smith 1970, Skeel and Mallory 1996). The populations of whimbrels utilizing the Atlantic Coast and northeast South America have declined by up to 50% in recent decades (Watts and Truitt 2011, and RIG Morrison *et al*., unpublished data, from Andres *et al*. 2012) and both the *hudsonicus* and Northwest Territories *rufiventris* populations are of conservation concern (Morrison 2006, Bart et al. 2007, Watts and Truitt 2011).

Whimbrels depend on relatively few staging areas where they refuel for nonstop flights as long as 6,500 km (Smith et al 2010). The Atlantic Canada region (especially New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland) has been identified as a terminal staging area during fall migration where whimbrels stop, gorge on berries and aquatic invertebrates for up to a month, and then fly non-stop over the Atlantic Ocean to their wintering grounds (CCB/CWS unpublished tracking data). During the 2012-2014 breeding seasons, the Center for Conservation Biology (CCB), in collaboration with Canadian Wildlife Service (CWS), deployed satellite telemetry units to track 10 individuals captured on breeding grounds from the Mackenzie Delta to Atlantic Canada and Gulf of St. Lawrence regions, then on to wintering grounds in Brazil. Prior to this tracking study, the breeding origin of the whimbrels using the Atlantic Canada region as a fall stopover were unknown and were assumed to be *hudsonicus* (Taverner 1942, Peters and Burleigh 1951, Morrison et al. 1994, and Skeel and Mallory 1996). The likely origin of whimbrels using the Atlantic Canada region during fall stopover is from the Mackenzie Delta breeding population (CCB/CWS unpublished data). The tracking study uncovered the first link between Alaskan/western breeding whimbrels and mid-Atlantic staging areas (Watts et al 2008).

## Objectives

1) The primary objective (Phase 1, fall 2014) of this project is to survey the population and determine habitat use of whimbrels using portions of the Acadian Peninsula.

2) The secondary objectives are to determine "catchability" of the whimbrels along the Acadian Peninsula, and to assist in future directions of the study.

## Study Area

The Acadian Peninsula of Canada encompasses portions of Gloucester and Northumberland Counties (Figure 1). The study was confined to the Acadian Peninsula between Miramichi Bay and Miscou Island. This area, referred to as the New Brunswick Lowlands or "maritime plain" (Bostoc 1970), has relatively flat topography, with high concentrations of interior and coastal wetlands (bogs and heathlands, freshwater wetlands, and saltmarshes). The coastal portions of the study area are characterized by large intertidal mud and sand flats, a barrier island system, and numerous large saltmarsh patches fringing the outer coastal mainland edge. Many of the

larger bogs and peat extraction sites are adjacent to the outer coast. The inland portions of the study area include moderate topographic relief and temperate coniferous forest.

Based on a preliminary satellite imagery assessment of available whimbrel foraging/roosting habitat, the aerial survey was designed to incorporate four main habitat types: 1) Active blueberry fields, 2) Natural heathland and bogs, 3) Peat extraction areas, and 4) barrier islands, beaches, and tidal mudflats. The study area encompasses the Tabusintac Lagoon and River Estuary Important Bird Area (BirdLife International 2015).

**Figure 1.** Whimbrel survey study area, August 2014.


**Blueberry Farm Land Use:**

Approximately 11-13,000 hectares (28-33,000 acres) of New Brunswick are in blueberry production i (Dorph 2012, Province of New Brunswick 2012). The province plans to develop at least 8,000 new hectares within the next decade (Province of New Brunswick 2012). The province produces the 3rd largest yield of blueberries in Canada, with over 20,000 metric tons of berries produced in 2012 (Province of New Brunswick 2012). Between 1986 and 2011, managed blueberry field acreage increased 20 fold with to the advent of mechanized harvesting technique (Dorph 2012). 6,800 of 8,500 hectares (80%) of blueberry fields are crown land leases within the northeast section of New Brunswick. The value of the New Brunswick blueberry crop tripled between 2001 and 2012, from 10 million to 30 million dollars (Figure 2).

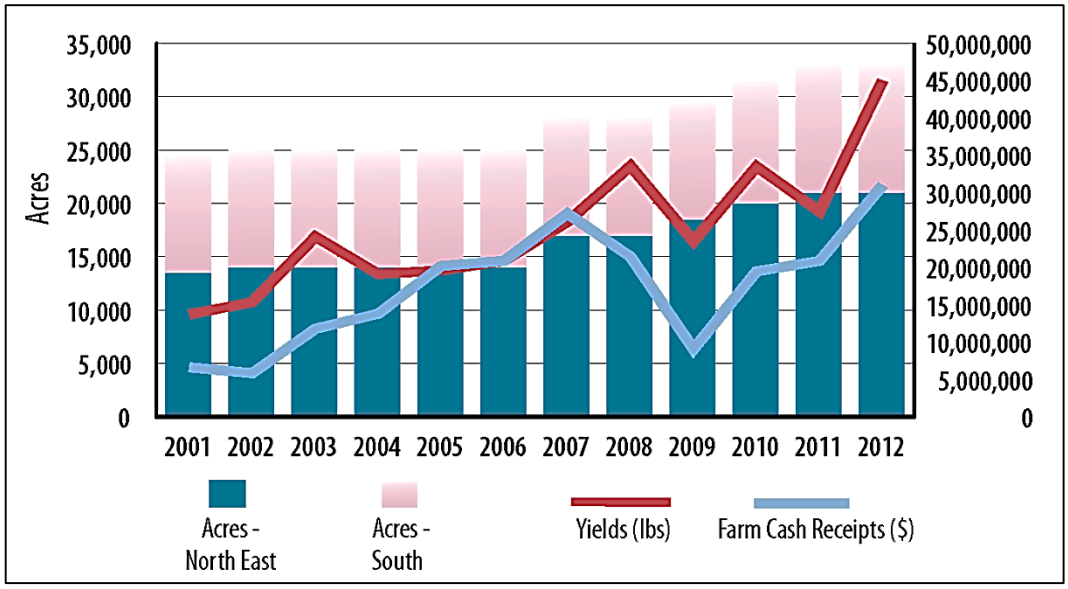



**Figure 2.** Blueberry acreage, yields (lbs), and revenue for New Brunswick. From New Brunswick Wild Blueberry Sector Strategy 2013-2018.

## Methods

**Aerial Survey Sampling Design –** We developed a survey design incorporating all potential habitats used by whimbrels during fall migration on the Acadian Peninsula. Aerial surveys were performed with a fixed-wing Cesna aircraft by systematically flying over selected blueberry fields (harvest, growth, and development patches), natural heathlands and bogs, peat extraction areas, and barrier islands (both isolated from and connected to the mainland) at an altitude of approximately 50-150m and a speed of 110-200kph. On larger sites, we made multiple low passes to ensure survey coverage. All bird species and numbers were recorded on a digital voice recorder by the primary observer and mapped on a GPS-enabled laptop computer to the habitat that they flushed from by the secondary observer. The sampling framework was stratified geographically along the entire Acadian Peninsula from Miramichi Bay to Miscou Island (Figures 3-6). To examine the influence of geography and proximity to tidal water sources on whimbrel distribution, patches were surveyed along the entire coastal/upland gradient; from barrier islands and mudflats to inland fields, bogs, and peat extraction sites.

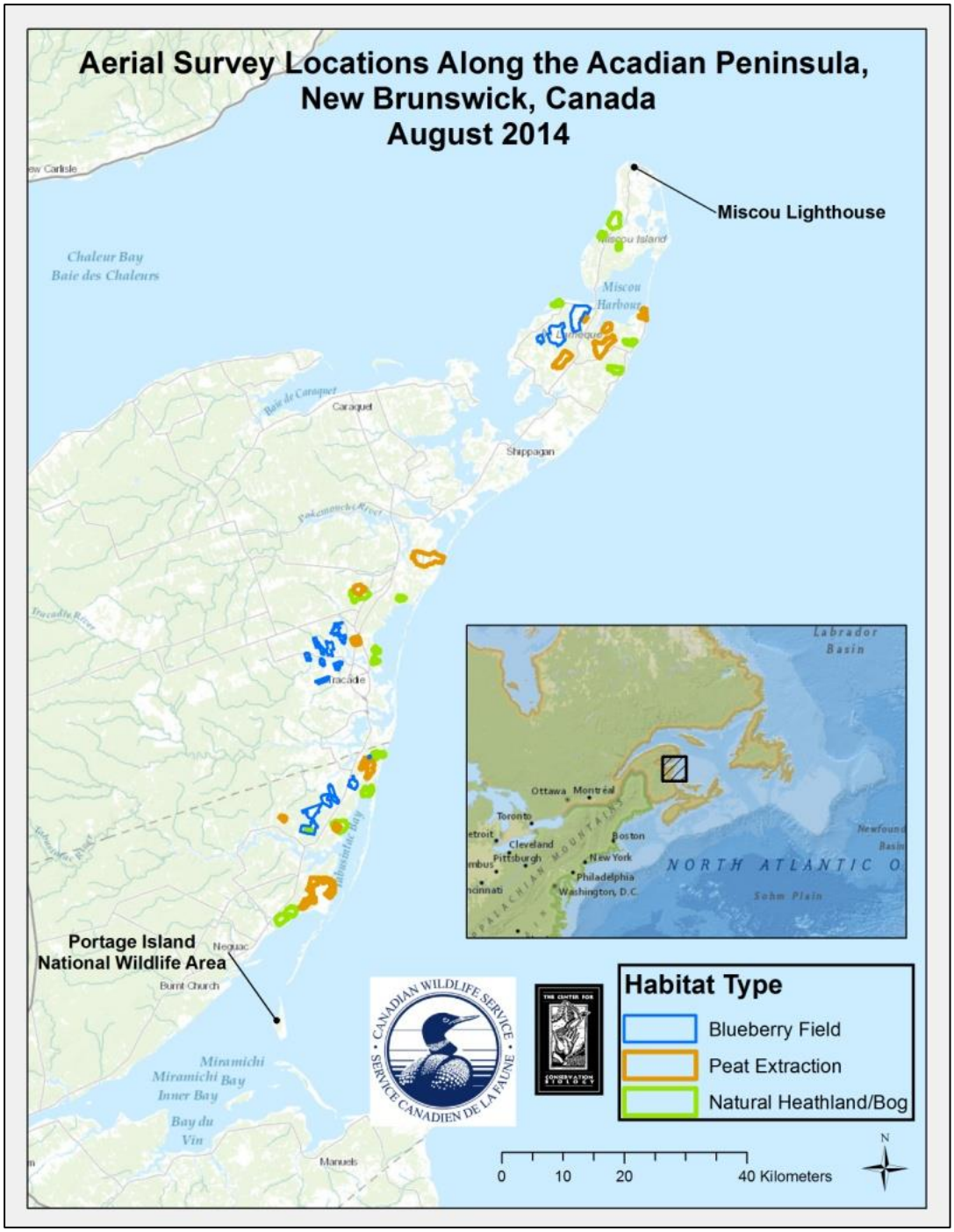



**Figure 3.** Overview of all aerial survey locations by habitat type, August 2014. All barrier islands and coastal beaches were surveyed between Miscou lighthouse and Portage Island National Wildlife Area during the first aerial survey conducted on 3 August 2014.

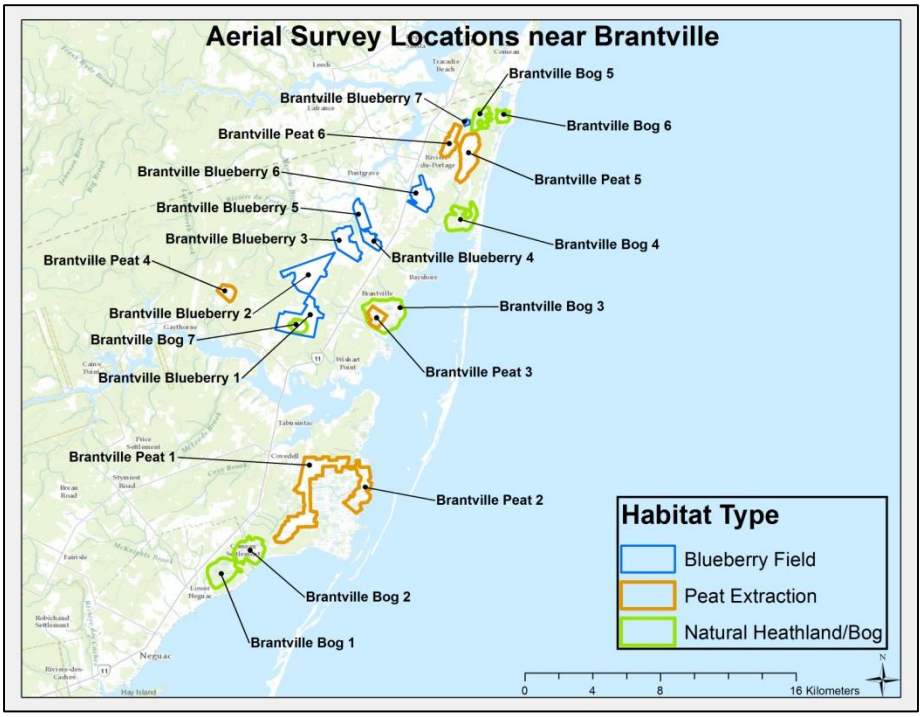



**Figure 4**. Aerial survey locations and coded transect names in the Brantville area of the Acadian Peninsula, August 2014.

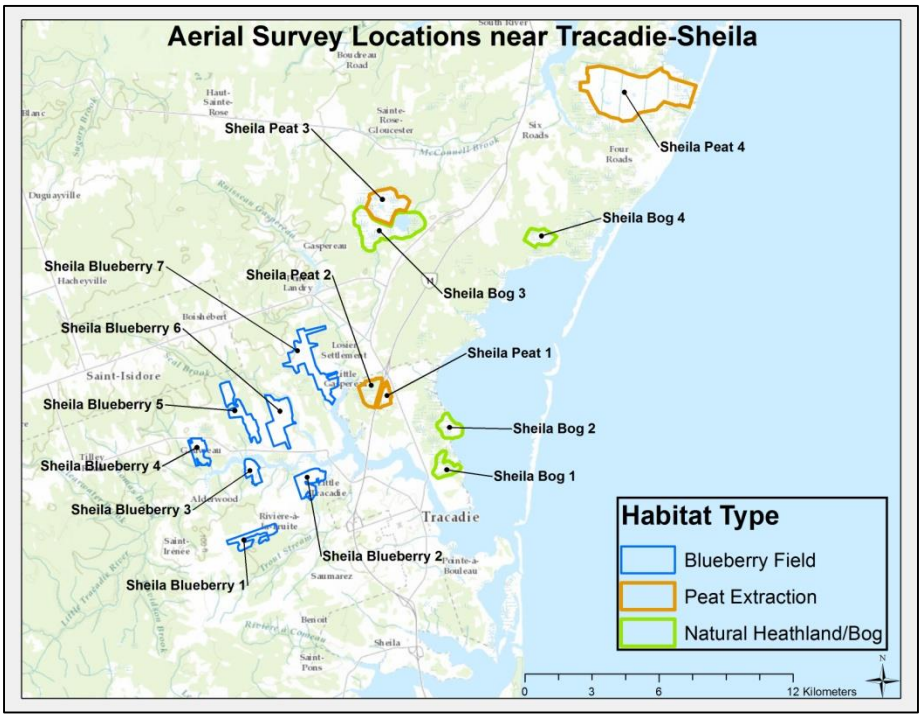



**Figure 5**. Aerial survey locations and coded transect names in the Tracadie-Sheila area of the Acadian Peninsula, August 2014.

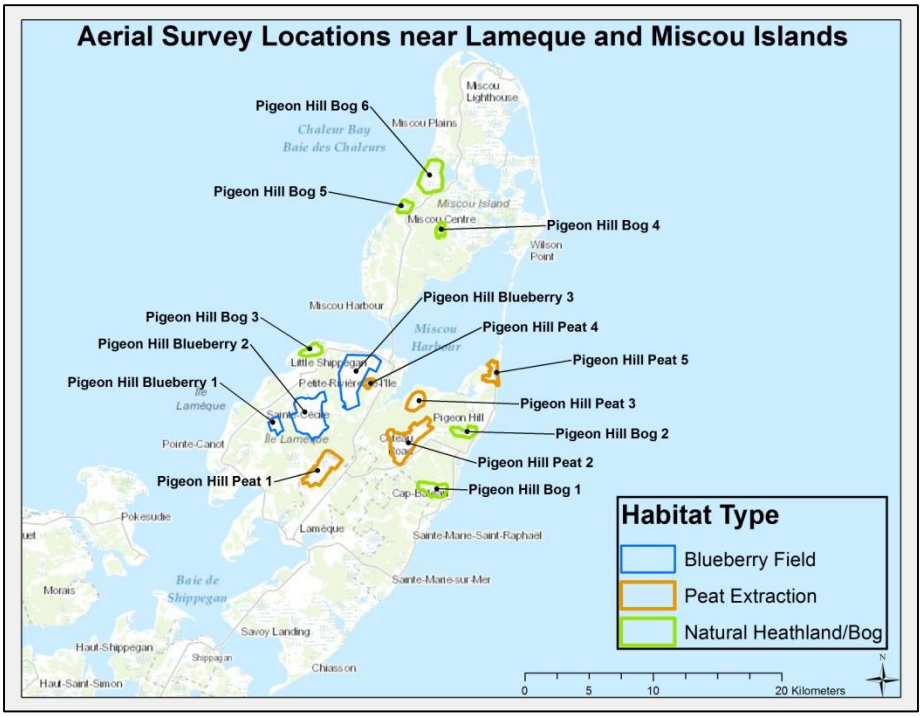



**Figure 6**. Aerial survey locations and coded transect names in the Lameque and Miscou Island area of the Acadian Peninsula, August 2014.

**Ground Survey Sampling Design–** We focused ground survey efforts on blueberry fields after our initial aerial survey found little to no whimbrel use in any of the other habitats surveyed (natural heathland and bog, peat extraction, and barrier islands). Patches were coded based on five primary geographic areas, including Brantville, Lord and Foy, Val Doucet, Tracadie-Sheila, and Pigeon Hill (Appendix 1) and were clustered to improve survey efficiency (Figures 7-10). Within a patch, survey routes were designed to incorporate one designated field type (ie either growth, harvest, development only, not mixed types). Data recorded included date, location, stage (growth, development, harvest), patch and transect number, start and end time, species detected, detection distance (using Leica© Rangemaster 1600 CRF), distance off of transect, and notes on warden presence, non-human deterrence, and snow break structure and spacing.

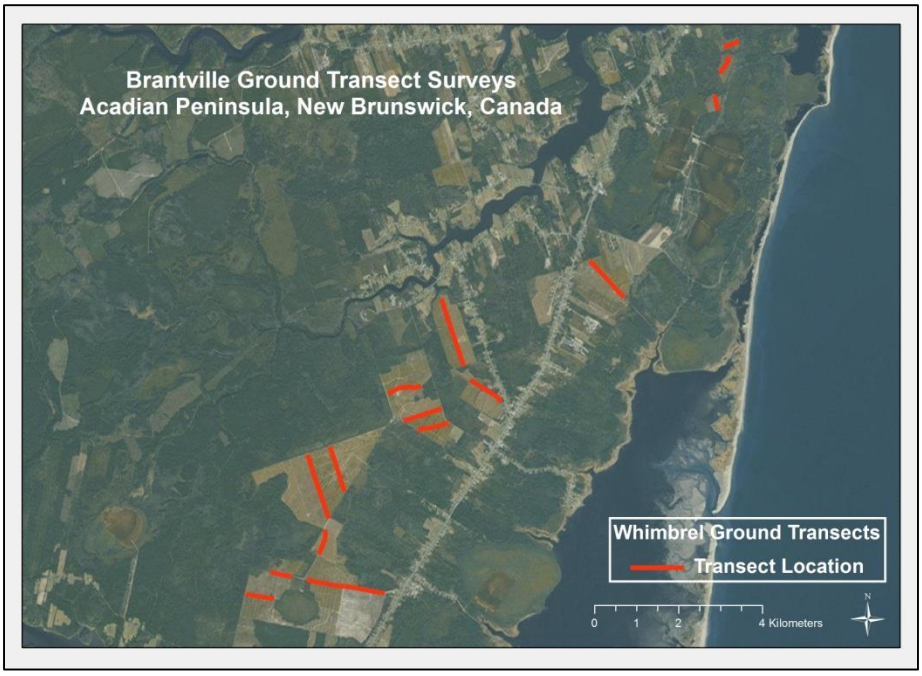



**Figure 7**. Ground survey locations in the Brantville area of the Acadian Peninsula, August 2014.

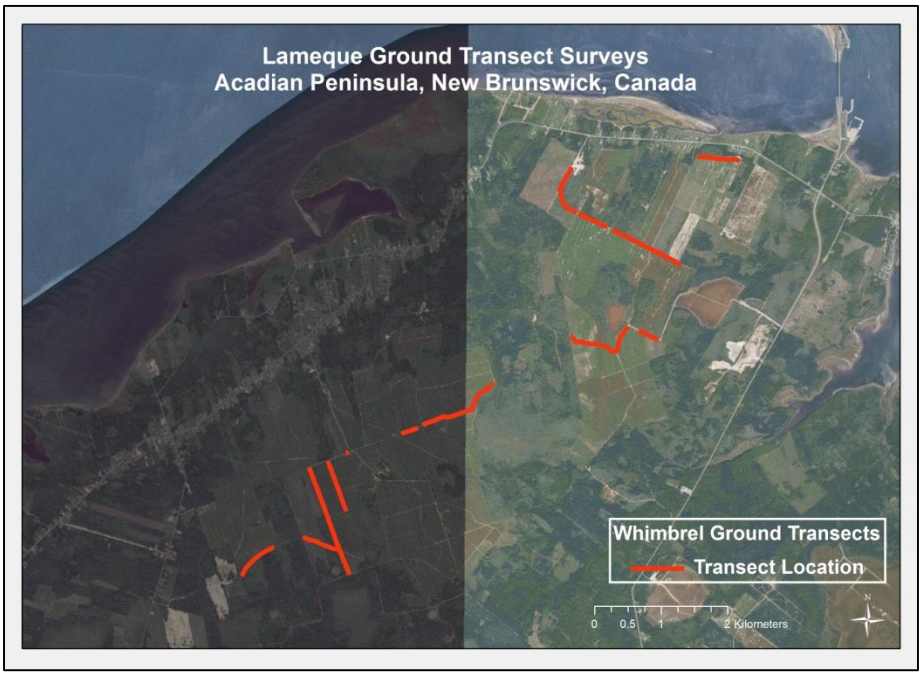



**Figure 8**. Ground survey locations in the Lameque Island/Pigeon Hill area of the Acadian Peninsula, August 2014.

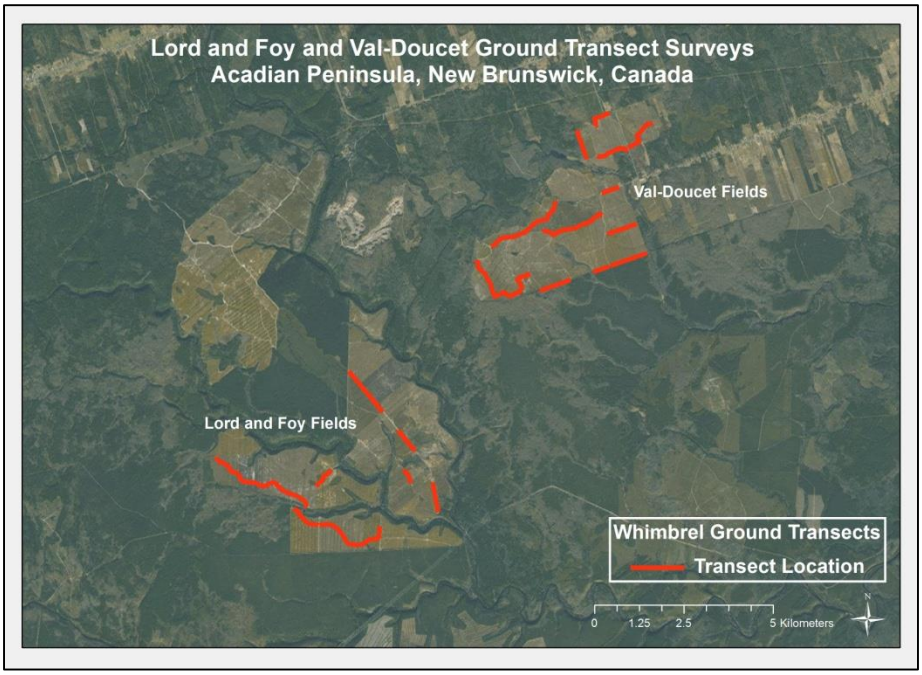



**Figure 9**. Ground survey locations in the Lord and Foy and Val-Doucet fields of the Acadian Peninsula, August 2014.

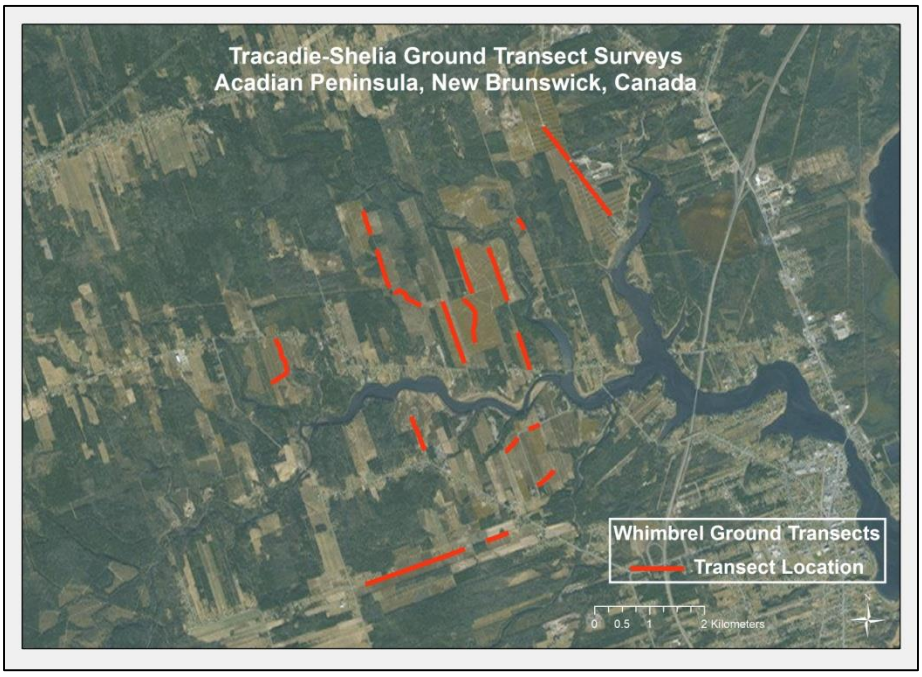
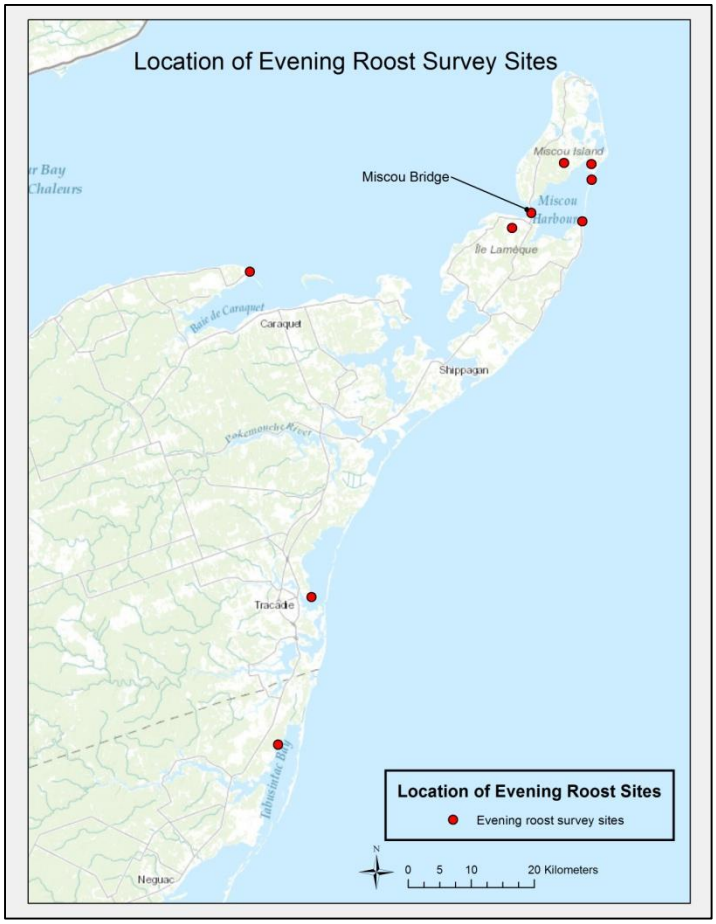



**Figure 10**. Ground survey locations in the Tracadie-Sheila area of the Acadian Peninsula, August 2014.

**Roost Survey Sampling Design –** We surveyed multiple locations along the peninsula during the early morning and evening time periods to determine if and where whimbrels were using night roosts in the region. During evening roost site surveys, observers were positioned along

likely whimbrel pathways to probable roosting locations (Figure 11). Observers recorded date, flock size, flight direction, time of day, and general flock behavior notes. Morning surveys took place in the Brantville and Pigeon Hill/Miscou areas. Our main objective for morning surveys was to document warden pressure on whimbrels arriving from night roosts.

**Figure 11**. Locations of evening roost site surveys along the Acadian Peninsula, August 2014.




## Results

**Aerial Survey Results –** We surveyed the Acadian Peninsula on 3 August and 11 August 2014. We detected 339 whimbrels during the first aerial survey and 615 during the second survey. Whimbrels were distributed along the peninsula from Brantville to Miscou Island, though concentrations of whimbrels were higher near Miscou Island (Table 1 and 2). Of the 954 whimbrels detected on aerial surveys, 908 (95%) were observed in harvest stage fields, 5 (<1%) in development stage fields, 7 (<1%) flushed from unknown stage fields, and 34 (3.5%) from coastal beaches or barrier islands. All barrier islands and outer coastline between Miscou lighthouse and Portage Island National Wildlife Area were surveyed on the 3 August survey. Access to the barrier islands is difficult, and these islands are largely unsurveyed during fall shorebird migration. Whimbrels utilize this habitat for foraging and roosting in other Atlantic Coast migration stopover sites. The initial survey was completed during the low tide cycle to examine the possibility that whimbrels were using tidal flats to forage and then moving to

blueberry fields during high tide cycles. Two small flocks of whimbrels were observed on the beach/tidal flat substrate on the 3 August survey. The outer beaches and barrier islands were not surveyed during the 2nd aerial survey due to the lack of whimbrels in this habitat type during the first survey. The second survey began just after sunrise.

**Table 1.** Results of aerial survey round 1. Table includes date, patch code identifier, total number of whimbrels detected within patch, field stage that whimbrels flushed from, and coordinates of sighting.

| Date | Survey Round | Patch ID | Total # Whimbrels | Field Stage | Latitude | Longitude |
|---|---|---|---|---|---|---|
| 03-Aug-14 | 1 | Brantville-Blue-01 | 5 | Development | 47.35940 | -64.98592 |
| 03-Aug-14 | 1 | Brantville-Blue-06 | 38 | Harvest | 47.40723 | -64.92897 |
| 03-Aug-14 | 1 | Brantville-Blue-07 | 28 | Harvest | 47.43318 | -64.91069 |
| 03-Aug-14 | 1 | Sheila-Blue-06 | 1 | Unknown | Bird spotted in flight | |
| 03-Aug-14 | 1 | Pigeon Hill (not numbered) | 22 | Harvest | 47.83172 | -64.64450 |
| 03-Aug-14 | 1 | Pigeon Hill-Blue-03 | 12 | Harvest | 47.87612 | -64.59824 |
| 03-Aug-14 | 1 | Pigeon Hill-Blue-03 | 6 | Unknown | Birds spotted in flight | |
| 03-Aug-14 | 1 | Pigeon Hill-Blue-03 | 200 | Harvest | 47.87622 | -64.59816 |
| 03-Aug-14 | 1 | Barrier Island | 27 | N/A | 47.57110 | -64.85067 |
| **Subtotals Round 1** | | | **339** | | | |

**Table 2.** Results of aerial survey round 2. Table includes date, patch code identifier, total number of whimbrels detected within patch, field stage that whimbrels flushed from, and coordinates of sighting.

| Date | Survey Round | Patch ID | Total # Whimbrels | Field Stage | Latitude | Longitude |
|---|---|---|---|---|---|---|
| 11-Aug-14 | 2 | Brantville-Blue-04 | 3 | Harvest | 47.39302 | -64.96235 |
| 11-Aug-14 | 2 | Brantville-Blue-06 | 125 | Harvest | 47.40723 | -64.92897 |
| 11-Aug-14 | 2 | Pigeon Hill-Blue-03 | 280 | Harvest | 47.87825 | -64.59644 |
| 11-Aug-14 | 2 | Pigeon Hill-Blue-03 | 200 | Harvest | 47.87530 | -64.58925 |
| 11-Aug-14 | 2 | Miscou Island (beach) | 7 | N/A | 47.97627 | -64.55020 |
| **Subtotals Round 2** | | | **615** | | | |

**Ground Survey Results –** We surveyed 103 ground transects twice each during the field season. We surveyed a total length of 58.5 km of transects within the five geographic areas. We surveyed approximately 1,448 hectares of blueberry fields, with 773ha in active blueberry production, 653ha in growth stage, and 32ha in development. A total of 690 whimbrels were detected in the two survey rounds, with majority of detections in harvest stage fields (N=637, 92%), and 53 detections (8%) in either growth or development stage. A total of 565 (82%) whimbrels detected during survey round 1, and 125 (18%) during survey round 2. We detected 459 whimbrels at Pigeon-Hill-03 on 3 August 2015, comprising 67% of all ground survey detections.

**Roost Survey Results –** Evening roost surveys were completed each day between 3 August and 7 August 2014. We detected 32 flocks totaling 1,731 whimbrels flying towards night roosts from Miscou Bridge. On 5 August 2014 we detected 11 flocks totaling 1,259 whimbrels flying from the Petit-Shippegan blueberry fields towards roost sites at Windsors Mal Bay (N = 1,100) and towards an unknown roost south of Lameque (N=159). It is possible that many of these whimbrels flying towards Miscou Island were departing and in migration, as subsequent evening counts on 6 and 7 August totaled just 319 birds (with 3 flocks heard and not seen on 7 August due to fog). Other whimbrel flocks were encountered at Wilson Point, Pigeon Hill, near Windsors Mal Bay, and on Lameque Island, though all of these flocks were also recorded from the Miscou Island bridge site. We conducted evening roost counts at Maisonnette (0 whimbrels), Tracadie-Sheila (0 whimbrels), and at Bayshore (75 whimbrels). The Bayshore whimbrels flew north and the specific roost location was not found. There is a night roost in the Windsors Mal Bay area, and very likely another between Tracadie-Sheila and Le Goulet. The Inkerman marsh complex is a strong candidate for this unknown roost location, but we were unable to access the site during our study.

| Date | Time Start | Time Finish | Location | Total Flocks Detected | Total Whimbrels Detected |
|---|---|---|---|---|---|
| 4 August 2014 | 1925 | 2036 | Miscou Bridge | 7 | 153 |
| 5 August 2014 | 1904 | 2008 | Miscou Bridge | 11 | 1,259 |
| 6 August 2014 | 1844 | 2017 | Miscou Bridge | 5 | 250 |
| 7 August 2014 | 1809 | 2046 | Miscou Bridge | 7 | 69 |

Morning surveys were conducted daily between 5 August and 8 August. We observed 791 whimbrels during 70 interactions during the morning time period. The primary focus was to observe the interactions between wardens and whimbrels, and during one such event a flock was deterred from landing in a harvest field 18 times by a warden before flying out of view towards another field (Watts 2014).

## Discussion

The Acadian Peninsula of New Brunswick, Canada appears to support a significant portion of the total whimbrel population that uses Atlantic Canada in fall migration. The estimated population size of the Mackenzie Delta population is 22,232 ± 13,252SE (Rausch and Johnston

2012). Approximately 1,259 individual whimbrels were observed from the Miscou Bridge en route to the Windsors Mal Bay area during an evening roost count on 5 August 2014. This count represents at least 5% of the total Mackenzie Delta population. Large flocks (>100 whimbrels) were observed in nearly every area of the study, in Brantville, Lord and Foy and Val-Doucet, and also the Pigeon Hill area of Lameque Island. Whimbrels also arrived at Brantville area fields pre-dawn, giving evidence another roosting location closer than Windsors Mal Bay.

Over 99% of all whimbrels detected during the aerial, ground, and evening roost surveys originated from blueberry fields, suggesting that tidal influences on behavior are negligible. Miscou Island was a known whimbrel hunting grounds during the turn of the century (Green, J.O. 1904), and the birds were foraging on the abundant berries “in the moss” that dominates the landscape on the island. The abundant farmed blueberry crop, which is orders of magnitude higher in energy for foraging whimbrels than “the moss”, appears to have shifted the habitat use from natural heathlands and bogs to farm field use in a relatively short period of time. The increase in blueberry fields in the region will increase the conflict between farmers and whimbrels if a concerted effort is not made to educate the growers.

Oxford Frozen Foods stands alone as the largest blueberry grower and processor on the Acadian Peninsula. Their fields hold hundreds of whimbrels during migration, and the wardens hired on these properties are vigilant in harassment of the whimbrels. Most of the large Oxford fields have wardens living on the premises, presumably to deter human theft of blueberries, but also to deter whimbrels from landing in the harvest fields. The case should be made to Oxford and other large corporate land owners that whimbrel harassment is a net negative in terms of dollars spent for deterrence compared to dollars saved in product. The incorporation of best management practices by these larger corporate farms could have an effect on at least some of the smaller family farms as well.

Pigeon Hill/Petit-Shippagan has the highest whimbrel concentrations observed along the peninsula, with 459 whimbrels detected on the 3 August ground survey, 1,259 detected during the evening survey on 5 August, and 480 whimbrels detected on the 11 August aerial survey. These whimbrels were concentrated on very few small family farms on the north end of Lameque Island. These farms are not occupied by paid wardens like the larger corporate farms; rather they are patrolled by members of the families that own the farms. This is the same area where a report of 40 dead whimbrels came from in recent years. There are likely more whimbrels in this small section of farms than on the rest of the Acadian Peninsula combined. This area should be a focus for outreach to attempt to educate the farmers on the life history of whimbrels and the metabolic constraints of the birds. Many farmers and wardens that we spoke to in the region have an unrealistic idea of the magnitude of blueberry crop damage caused by whimbrels. The whimbrels will likely occupy this area every fall in large numbers, but field use will rotate with the blueberry field stage. The importance of this area to whimbrel conservation cannot be overstated due to the high volume of birds that are fattening before migration.

The warden pressure on the whimbrels is quite high. All of the wardens we spoke with were aware of whimbrels as a crop pest in the region. Several patches (including all of the large farms) had full time presence and whimbrels were constantly harassed at these sites. We observed wardens utilizing a variety of methods to deter whimbrels from blueberry harvest patches at most of the patches surveyed. Deterrence pressure was placed on whimbrels through many means, including propane air cannons, scarecrows (of many varieties), audio callers, guns loaded with banger and cracker shells (12guage and pistol), guns loaded with regular lead shot shells (12 gauge), and general physical presence. Blueberry fields in the development stage had some whimbrel use, though it appeared unlikely that the whimbrels

were foraging in this type of field. Wardens were observed driving into the development stage fields and harassing the whimbrels on the ground.

## Future Direction of Study Recommendations:

**Corporate Policy –** Oxford Frozen Foods controls a large market share on the Acadian Peninsula so what they do matters. We need to get them to change policy toward whimbrels on their properties. In talking with the wardens there is a clear misconception that birds are doing a lot of crop damage. This doesn't add up with known metabolic demands of whimbrels in hyperphagia during migration vs fruit availability the economic facts of what the birds are eating vs what is costs to deter them from landing to be laid out and packaged as an educational booklet for growers on the peninsula and elsewhere. There could be an initial agreement to designate some disturbance-free sites so that we could study these as controls to monitor both bird use and expected take. We need to then move down the food chain to smaller corporate holders and then finally family farms. There are a number of strategies for doing this but changing management practices should be the top priority.

**Outreach/Education –** We believe that the people of the Acadian Peninsula need to understand the role the peninsula plays in the life cycle of whimbrels. There is a great outreach/educational opportunity with blueberry growers, the public, and schools. We need to have corporate buy-in for any major changes in blueberry management/whimbrel harassment but we also need public support for these policy changes.

**Nanotag Study –** We believe that we can catch whimbrels on the peninsula (this bird is very wary and very hard to capture). Whimbrels require quite a bit of reconnaissance work to determine how best to capture them. This trip has provided some of that ground work. We believe that if we had a capture program we could 1) take blood samples that could be used for possible pesticide/fungicide work, 2) look at stopover duration which we already have a sense is about 3 weeks, and 3) look into the spatial movement patterns in more detail. The latter would be particularly interesting if we could get buy in from Oxford or other growers to have some designated no disturbance sites. We believe that on the order of 30-100 birds could be captured in a season.

**Foraging/Behavioral Observations –**We believe data on foraging rates and behavioral interactions with wardens can be collected with a focused effort if needed. We collected cursory data on warden interactions and no foraging data.

**Satellite Transmittering –** Deployment of additional satellite tags within this staging area would increase the sample size of whimbrels tagged using the Atlantic Flyway and help with local outreach and education about how significant this site is to this population. These tags will help to solidify the connection between this site and others throughout the annual cycle. Interestingly, in Canada, this site is connected to both Mackenzie where they breed but also to Alberta and Saskatchewan where they stage in spring before their last leg to the Northwest Territories breeding grounds.

**Nova Scotia – Newfoundland – Labrador –** Survey work should continue in other parts of Atlantic Canada to be able to evaluate their relative significance to staging whimbrels. This should involve some aerial survey work to identify high-use areas but also follow up ground work to learn more about resource use. It would be particularly useful to do some capture work in Newfoundland which is believed to be used later in the season and possibly by more

hatching-year birds. It may be possible to use that work to develop an approach to visually separating adults from hatching-year birds that could be used long-term as an index to productivity.

## Acknowledgements

This study and publication were completed with funds provided by the Canadian Wildlife Service and the Center for Conservation Biology at the College of William & Mary and Virginia Commonwealth University. We thank Julie Paquet from the Canadian Wildlife Service for providing logistical support, administrative oversight, and assistance with study design throughout the length of the project. Lewnanny Richardson of Nature NewBrunswick and Kirsten Snoek of Canadian Wildlife Service assisted with field data collection and provided logistical support. Dick Lubbersen of FD Air Tours piloted the aerial surveys. We also thank Erica Lawler, Jane Lopez, and Michael Cole from the William and Mary Sponsored Programs office for fiscal and administrative assistance.

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**Appendix 1.** Ground transect codes, beginning and end points, approximate survey area, and field stage. Transects are geographically coded as follows: B = Brantville, L = Lord and Foy, P = Pigeon Hill, S = Tracadie-Sheila, and V = Val-Doucet.

| Transect Code | Begin Latitude | Begin Longitude | End Latitude | End Longitude | Survey Area (hectares) | Transect length (m) | Field Stage |
|---|---|---|---|---|---|---|---|
| B1A-L | 47.36293 | -64.98059 | 47.36393 | -64.98907 | 31.20 | 653 | Development |
| B1A-R | 47.36293 | -64.98059 | 47.36393 | -64.98907 | 14.40 | 653 | Production |
| B1B-L | 47.36531 | -65.00053 | 47.36595 | -65.00504 | 12.90 | 347 | Growth |
| B1B-R | 47.36393 | -64.98907 | 47.36481 | -64.99719 | 19.80 | 626 | Production |
| B1C-L | 47.36205 | -65.0042 | 47.36277 | -65.01032 | 18.50 | 465 | Production |
| B1D-L | 47.36848 | -64.99481 | 47.37213 | -64.99342 | 3.99 | 422 | Growth |
| B1D-R | 47.36848 | -64.99481 | 47.37213 | -64.99342 | 9.79 | 422 | Growth |
| B2A-L | 47.37383 | -64.99251 | 47.38296 | -64.99706 | 17.00 | 1,095 | Growth |
| B2A-R | 47.37383 | -64.99251 | 47.38296 | -64.99706 | 33.20 | 1,095 | Production |
| B2B-L | 47.38403 | -64.99227 | 47.37765 | -64.98911 | 28.40 | 762 | Production |
| B3A-L | 47.38784 | -64.9766 | 47.38968 | -64.96834 | 10.00 | 653 | Production |
| B3A-R | 47.38784 | -64.9766 | 47.38968 | -64.96834 | 10.10 | 653 | Growth |
| B3B-L | 47.38757 | -64.96706 | 47.38649 | -64.97347 | 8.34 | 502 | Production |
| B3C-L | 47.39175 | -64.97992 | 47.39296 | -64.97285 | 12.30 | 573 | Production |
| B3C-R | 47.39175 | -64.97992 | 47.39296 | -64.97285 | 10.70 | 573 | Production |
| B4A-L | 47.39058 | -64.95587 | 47.39235 | -64.9587 | 6.27 | 304 | Growth |
| B4B-L | 47.39235 | -64.9587 | 47.39388 | -64.96227 | 8.28 | 318 | Production |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B4C-L | 47.39579 | -64.96368 | 47.40566 | -64.96837 | 23.40 | 1,144 | Production |
| B4C-R | 47.39579 | -64.96368 | 47.40566 | -64.96837 | 20.60 | 1,144 | Growth |
| B6A-L | 47.41111 | -64.93671 | 47.40582 | -64.92936 | 15.00 | 811 | Production |
| B6A-R | 47.41111 | -64.93671 | 47.40582 | -64.92936 | 19.00 | 811 | Growth |
| B7A-R | 47.43516 | -64.90999 | 47.43291 | -64.90929 | 3.95 | 254 | Production |
| B8A-L | 47.43820 | -64.90854 | 47.44080 | -64.90689 | 2.36 | 327 | Production |
| B8A-R | 47.43820 | -64.90854 | 47.44080 | -64.90689 | 3.71 | 327 | Production |
| B9A-R | 47.44207 | -64.90794 | 47.44287 | -64.90472 | 1.50 | 259 | Production |
| L1A-L | 47.47483 | -65.21107 | 47.4726 | -65.20827 | 13.90 | 328 | Growth |
| L1A-R | 47.47483 | -65.21107 | 47.46788 | -65.20244 | 34.50 | 1,013 | Growth |
| L1B-L | 47.4726 | -65.20827 | 47.46901 | -65.20378 | 20.10 | 526 | Development |
| L1C-R | 47.46481 | -65.19873 | 47.46122 | -65.19443 | 14.00 | 512 | Production |
| L1D-L | 47.45589 | -65.18996 | 47.45081 | -65.18854 | 10.60 | 576 | Growth |
| L1E-L | 47.45571 | -65.19556 | 47.458 | -65.19737 | 15.40 | 291 | Production |
| L1G-R | 47.4581 | -65.21540 | 47.45523 | -65.21921 | 5.49 | 452 | Production |
| L1H-L | 47.45168 | -65.22141 | 47.46025 | -65.24442 | 39.70 | 2,169 | Growth |
| L1H-R | 47.45168 | -65.22141 | 47.46025 | -65.24442 | 77.80 | 2,169 | Growth |
| L2A-R | 47.45144 | -65.22504 | 47.4486 | -65.21869 | 30.00 | 615 | Growth |
| L2B-L | 47.44859 | -65.21844 | 47.44526 | -65.20754 | 26.70 | 997 | Growth |
| L2B-R | 47.44859 | -65.21844 | 47.44526 | -65.20754 | 25.60 | 997 | Growth |
| L2C-L | 47.44526 | -65.20754 | 47.4462 | -65.20329 | 12.70 | 362 | Production |
| L2D-R | 47.4462 | -65.20329 | 47.44844 | -65.20331 | 7.97 | 252 | Production |

**Appendix 1 cont...** Ground transect codes, beginning and end points, approximate survey area, and field stage. Transects are geographically coded as follows: B = Brantville, L = Lord and Foy, P = Pigeon Hill, S = Tracadie-Sheila, and V = Val-Doucet.

| Transect Code | Begin Latitude | Begin Longitude | End Latitude | End Longitude | Survey Area (hectares) | Transect length (m) | Field Stage |
|---|---|---|---|---|---|---|---|
| P1A-L | 47.84184 | -64.65848 | 47.84243 | -64.65804 | 1.76 | 72 | Growth |
| P1B-L | 47.84243 | -64.65804 | 47.84359 | -64.65644 | 4.74 | 177 | Production |
| P1C-L | 47.843590 | -64.65644 | 47.84447 | -64.65411 | 4.72 | 199 | Growth |
| P2A-L | 47.852270 | -64.64683 | 47.84905 | -64.64507 | 12.20 | 380 | Production |
| P2A-R | 47.842000 | -64.64394 | 47.85175 | -64.64928 | 21.70 | 1,157 | Growth |
| P2B-L | 47.849050 | -64.645070 | 47.847730 | -64.644340 | 2.19 | 157 | Growth |
| P2B-R | 47.853090 | -64.644010 | 47.853000 | -64.644420 | 2.10 | 32 | Production |
| P2C-L | 47.854740 | -64.636930 | 47.855260 | -64.634610 | 9.10 | 183 | Production |
| P2D-L | 47.855510 | -64.633990 | 47.856540 | -64.628850 | 11.90 | 410 | Growth |
| P2D-R | 47.855510 | -64.633990 | 47.856980 | -64.627130 | 19.30 | 545 | Production |
| P2E-L | 47.856540 | -64.628850 | 47.856980 | -64.627130 | 4.35 | 138 | Production |
| P2F-L | 47.856980 | -64.627130 | 47.859377 | -64.624410 | 4.81 | 353 | Production |
| P3A-R | 47.863230 | -64.602160 | 47.864080 | -64.604860 | 10.50 | 223 | Growth |
| P3B-L | 47.864460 | -64.606280 | 47.863510 | -64.614070 | 30.80 | 794 | Production |
| P3C-L | 47.869970 | -64.599150 | 47.871410 | -64.602980 | 9.22 | 329 | Growth |
| P3C-R | 47.871014 | -64.601732 | 47.871410 | -64.602980 | 20.40 | 103 | Production |
| P3D-L | 47.871410 | -64.602980 | 47.873200 | -64.608400 | 15.20 | 453 | Production |
| P3E-L | 47.873430 | -64.609090 | 47.874710 | -64.612980 | 17.80 | 324 | Production |
| P3F-L | 47.874790 | -64.613260 | 47.878870 | -64.613850 | 17.20 | 562 | Production |
| P3F-R | 47.874980 | -64.613910 | 47.876870 | -64.615450 | 1.67 | 254 | Production |
| P3G-L | 47.879430 | -64.591210 | 47.879910 | -64.596840 | 19.30 | 432 | Production |
| P5A-L | 47.845380 | -64.650230 | 47.844730 | -64.647690 | 5.41 | 205 | Growth |
| P5A-R | 47.845380 | -64.650230 | 47.844730 | -64.647690 | 3.40 | 205 | Growth |
| P5B-L | 47.844730 | -64.647690 | 47.844300 | -64.645370 | 2.45 | 182 | Production |
| S10A-L | 47.534000 | -64.971510 | 47.540840 | -64.975170 | 9.92 | 806 | Production |
| S10A-R | 47.534000 | -64.971510 | 47.540840 | -64.975170 | 5.96 | 806 | Production |
| S11A-L | 47.548800 | -64.961720 | 47.550040 | -64.962830 | 1.98 | 160 | Production |
| S1A-L | 47.513530 | -64.971530 | 47.509630 | -64.987820 | 17.50 | 1,302 | Production |
| S2A-L | 47.520640 | -64.959730 | 47.522230 | -64.956950 | 7.42 | 282 | Growth |
| S2A-R | 47.526740 | -64.961060 | 47.527250 | -64.959240 | 5.21 | 148 | Production |
| S2B-L | 47.525820 | -64.962840 | 47.524350 | -64.964960 | 5.18 | 235 | Growth |
| S3A-R | 47.524490 | -64.978060 | 47.528170 | -64.980240 | 9.00 | 446 | Production |
| S4A-L | 47.536740 | -65.002460 | 47.531860 | -65.003220 | 9.52 | 690 | Growth |

**Appendix 1 cont...** Ground transect codes, beginning and end points, approximate survey area, and field stage. Transects are geographically coded as follows: B = Brantville, L = Lord and Foy, P = Pigeon Hill, S = Tracadie-Sheila, and V = Val-Doucet.

| Transect Code | Begin Latitude | Begin Longitude | End Latitude | End Longitude | Survey Area (hectares) | | Field Stage |
|---|---|---|---|---|---|---|---|
| S4A-R | 47.536740 | -65.002460 | 47.531860 | -65.003220 | 9.94 | 690 | Growth |
| S5B-L | 47.540430 | -64.978620 | 47.541930 | -64.983120 | 3.28 | 420 | Growth |
| S5B-R | 47.540430 | -64.978620 | 47.541930 | -64.983120 | 5.00 | 420 | Production |
| S5C-R | 47.542440 | -64.983610 | 47.546600 | -64.985880 | 6.86 | 503 | Production |
| S5D-L | 47.548270 | -64.986890 | 47.550855 | -64.988175 | 4.54 | 305 | Production |
| S6A-L | 47.536290 | -64.969820 | 47.541180 | -64.971660 | 10.80 | 607 | Production |
| S6A-R | 47.536290 | -64.969820 | 47.541180 | -64.971660 | 12.80 | 607 | Production |
| S6B-R | 47.541700 | -64.970260 | 47.546730 | -64.972870 | 11.70 | 592 | Production |
| S6C-L | 47.540910 | -64.964450 | 47.546790 | -64.967640 | 11.40 | 701 | Production |
| S6C-R | 47.540910 | -64.964450 | 47.546790 | -64.967640 | 11.10 | 701 | Production |
| S7A-L | 47.560100 | -64.958630 | 47.556380 | -64.954430 | 5.10 | 519 | Production |
| S7A-R | 47.560100 | -64.958630 | 47.557790 | -64.955990 | 7.57 | 325 | Production |
| S7B-R | 47.556151 | -64.954188 | 47.550330 | -64.947650 | 21.40 | 814 | Growth |
| S8A-L | 47.515317 | -64.964331 | 47.514420 | -64.968020 | 3.37 | 295 | Growth |
| S9A-L | 47.533260 | -64.960880 | 47.537430 | -64.962880 | 4.14 | 486 | Production |
| V1A-L | 47.518730 | -65.145380 | 47.518060 | -65.148100 | 7.79 | 222 | Growth |
| V1B-L | 47.518060 | -65.148100 | 47.516480 | -65.149050 | 1.61 | 245 | Development |
| V1C-L | 47.515820 | -65.153480 | 47.510910 | -65.151168 | 12.10 | 577 | Production |
| V1D-L | 47.511410 | -65.148570 | 47.512440 | -65.140860 | 19.70 | 633 | Growth |
| V1E-L | 47.512886 | -65.140836 | 47.517000 | -65.134600 | 21.00 | 764 | Growth |
| V1E-R | 47.512886 | -65.140836 | 47.517000 | -65.134600 | 18.90 | 764 | Growth |
| V2A-L | 47.506130 | -65.143137 | 47.505130 | -65.147460 | 14.00 | 344 | Production |
| V2A-R | 47.506130 | -65.143137 | 47.505550 | -65.145650 | 4.74 | 201 | Growth |
| V2B-L | 47.498090 | -65.146060 | 47.499880 | -65.138570 | 23.60 | 599 | Production |
| V2B-R | 47.498090 | -65.146060 | 47.499880 | -65.138570 | 16.50 | 599 | Production |
| V2C-R | 47.494900 | -65.136100 | 47.492710 | -65.145290 | 22.30 | 735 | Production |
| V2D-R | 47.492650 | -65.145550 | 47.491730 | -65.149600 | 16.40 | 323 | Growth |
| V2E-R | 47.490360 | -65.155280 | 47.488590 | -65.162990 | 17.20 | 620 | Production |
| V2F-L | 47.496030 | -65.175230 | 47.503500 | -65.158710 | 25.60 | 1,598 | Production |
| V2F-R | 47.491390 | -65.165370 | 47.493740 | -65.178810 | 54.30 | 1,863 | Growth |
| V2G-R | 47.498980 | -65.162170 | 47.501360 | -65.147350 | 40.90 | 1,276 | Growth |