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Appendices

Appendix A. Survey Sites

Appendix B. Calendars

Appendix C. Limitations

Appendix D. Encounter Histories

A. Survey Sites

Seventeen survey areas (see Figures 1-2, 6-1 and 6-2) were further divided into 342 survey sites, to enable surveyors to specify where geese were observed. The survey sites associated with each estuary are shown below, in Figures A-1, A-2 and A-3.

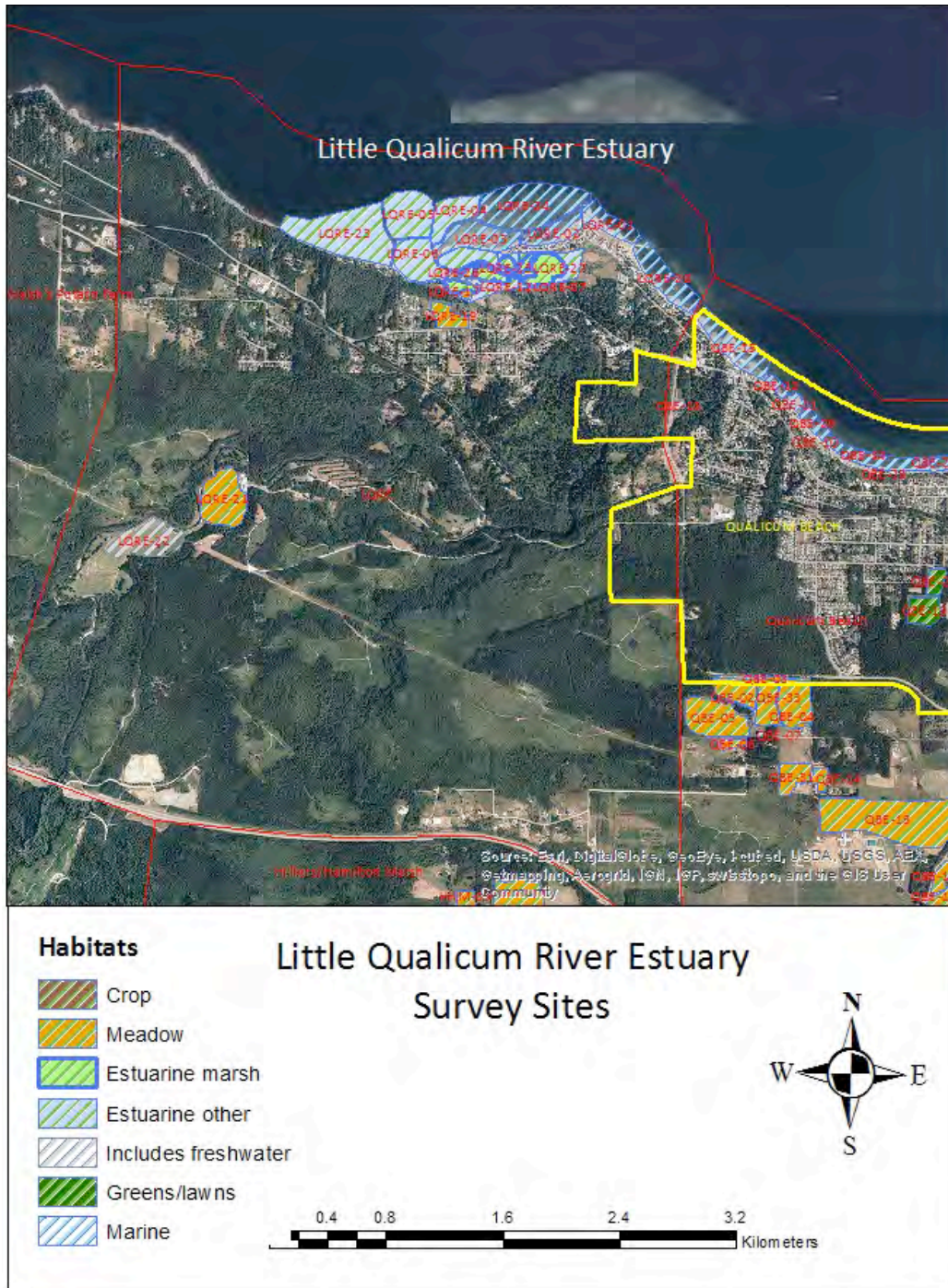


Figure A-1. Little Qualicum River estuary survey sites. The Town of Qualicum Beach is east of the estuary, outlined in yellow. Survey site codes are red.

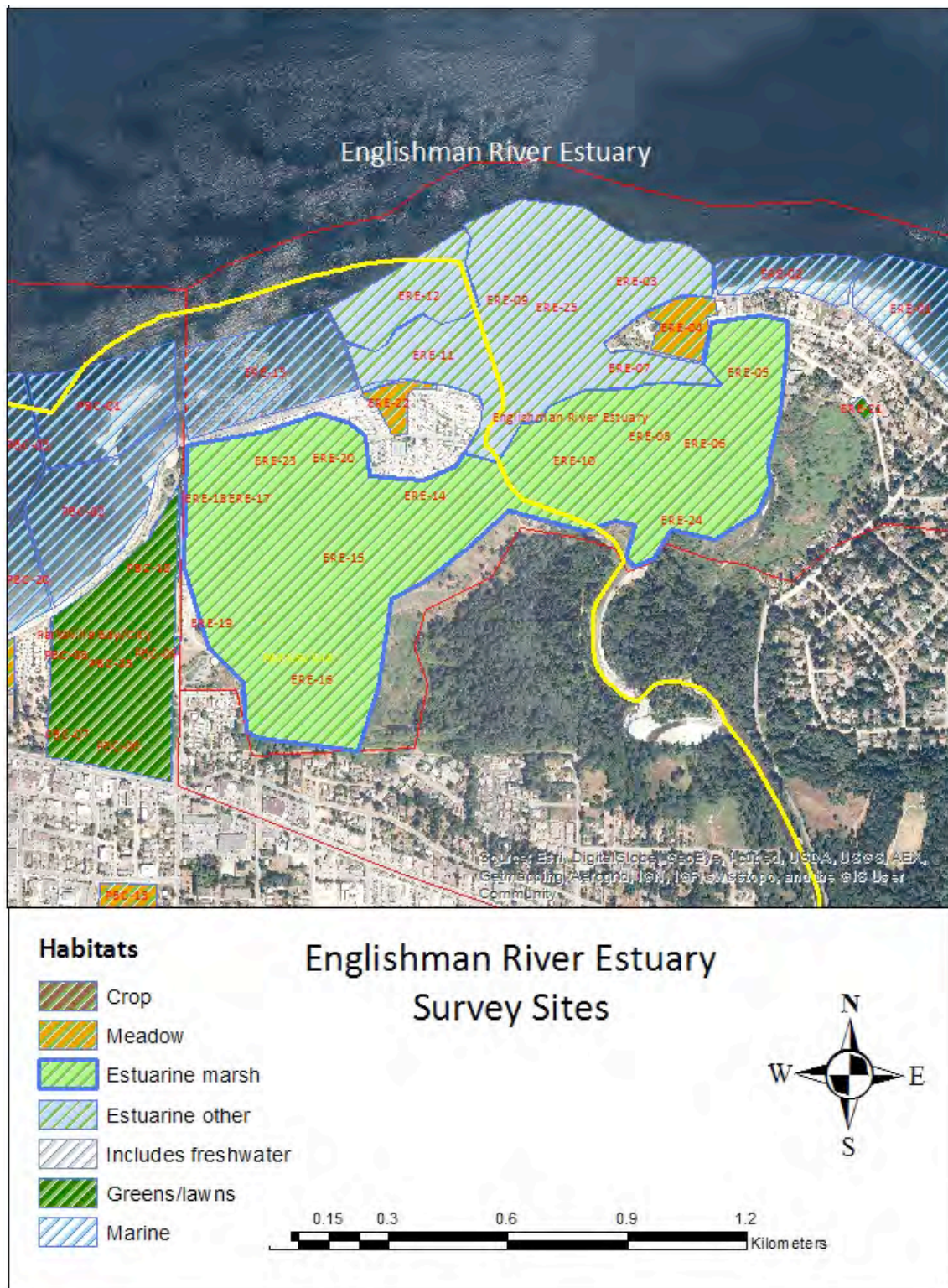


Figure A-2. Englishman River survey sites. The City of Parksville - Regional District of Nanaimo boundary bisects the estuary (west of the yellow line is the City of Parksville). Survey site codes are red.

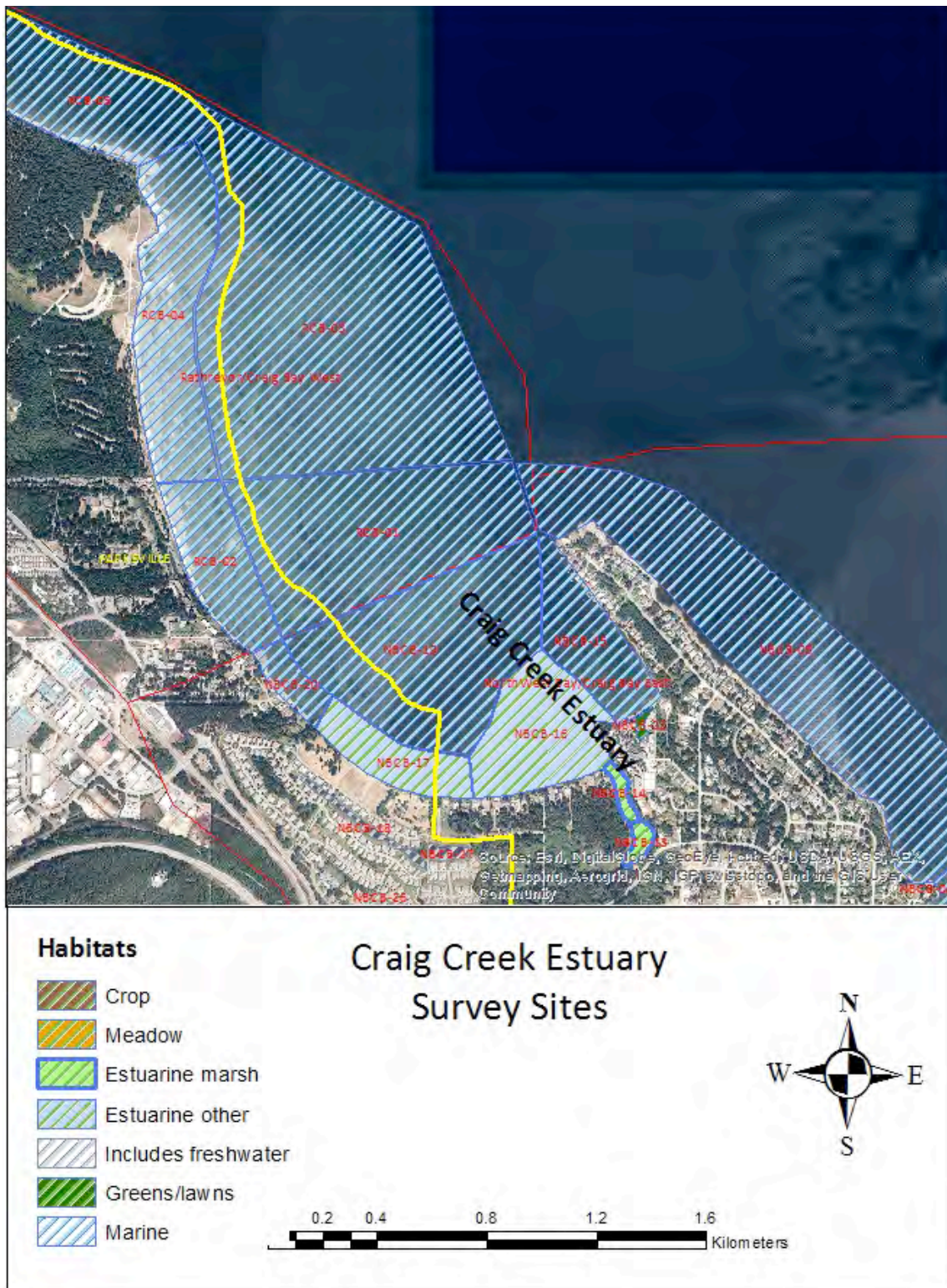


Figure A-3. Craig Creek estuary survey sites. West of the yellow line is the City of Parkville, east is part of the Regional District of Nanaimo. Survey site codes are red.

B. Calendars

Goose surveys conducted from 2010 through 2014 are shown in a series of calendars below (Figures B-1 to B-5).

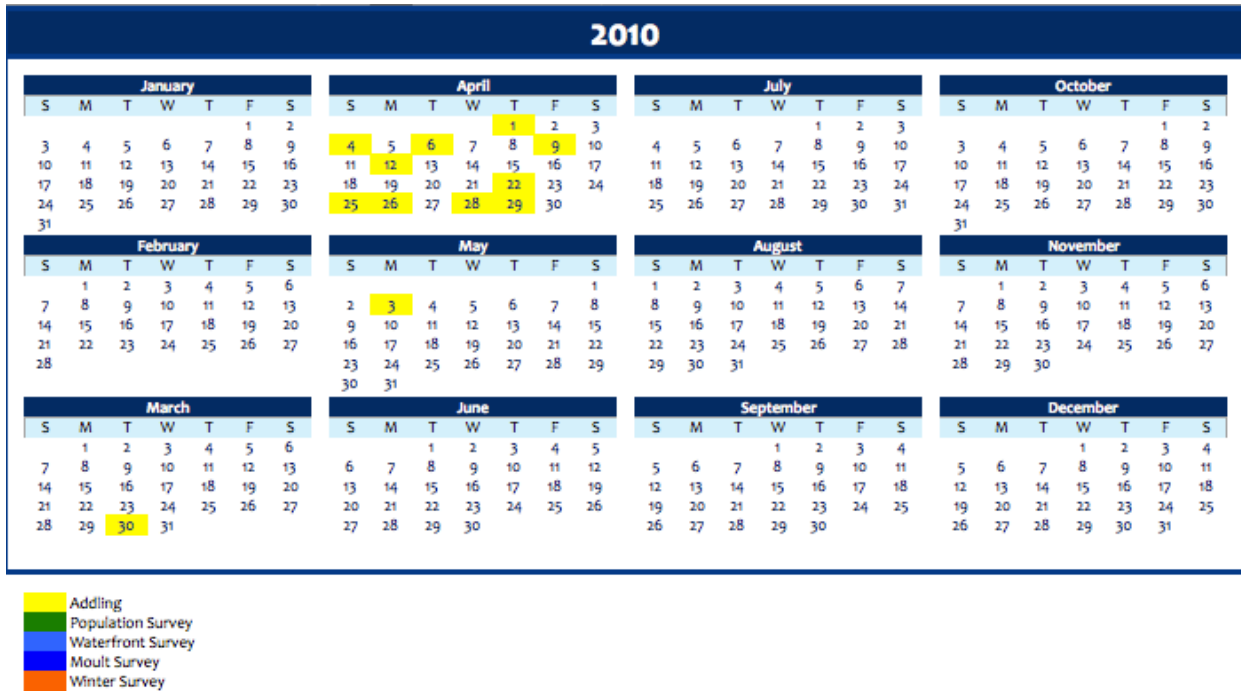


Figure B-1. Survey calendar, 2010.

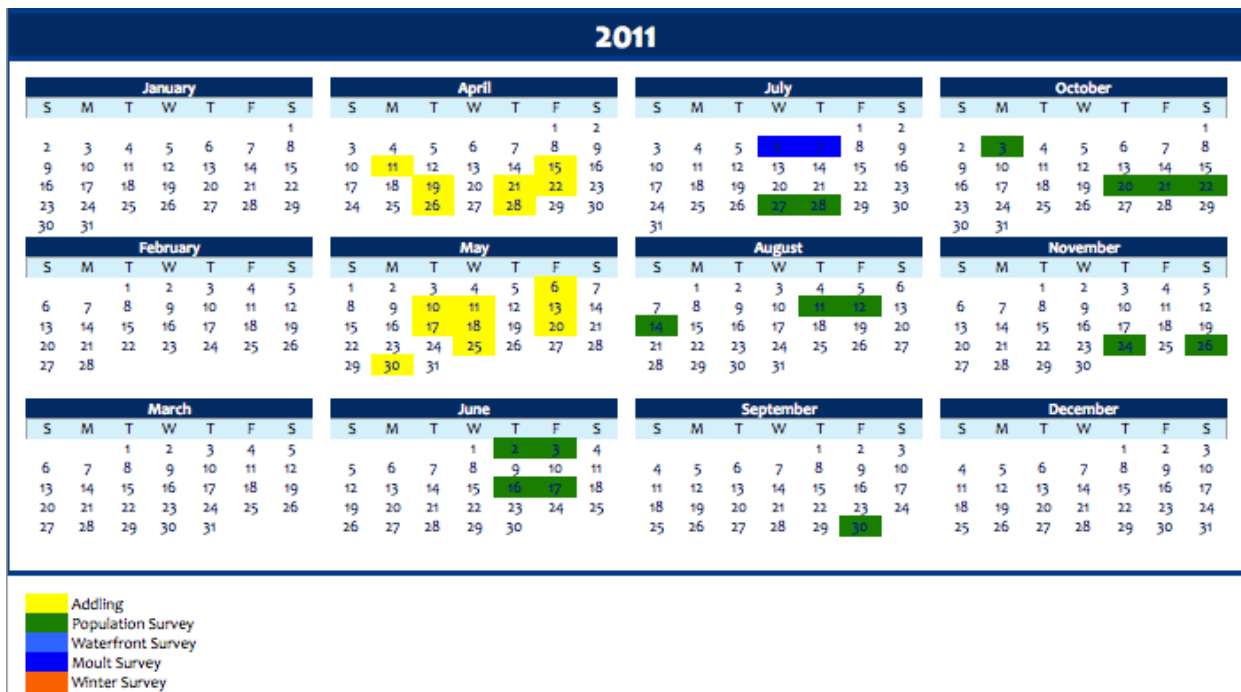


Figure B-2. Survey calendar, 2011.

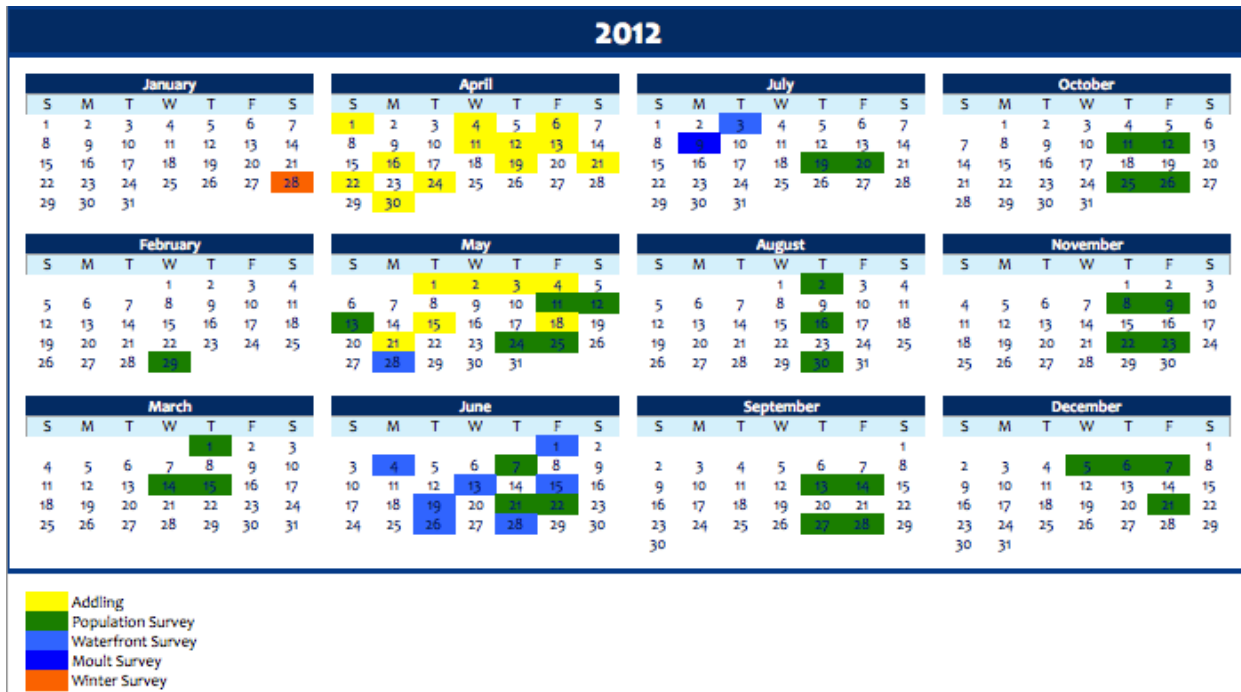


Figure B-3. Survey calendar, 2012.

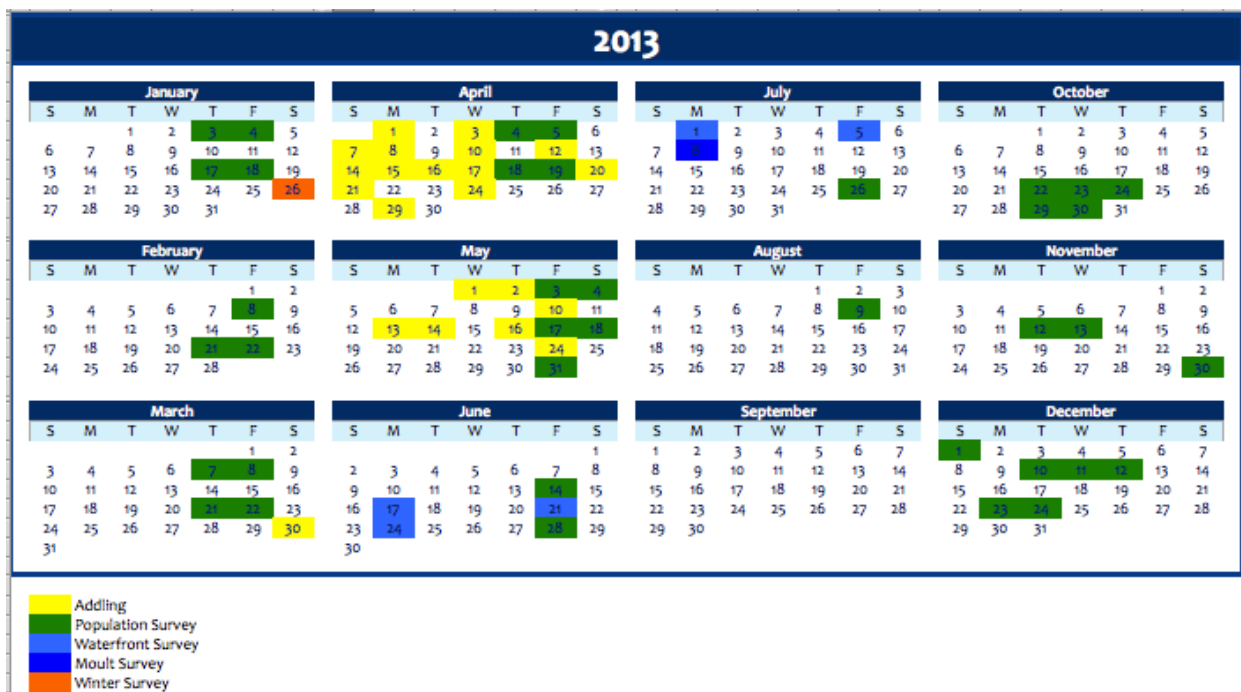


Figure B-4. Survey calendar, 2013.

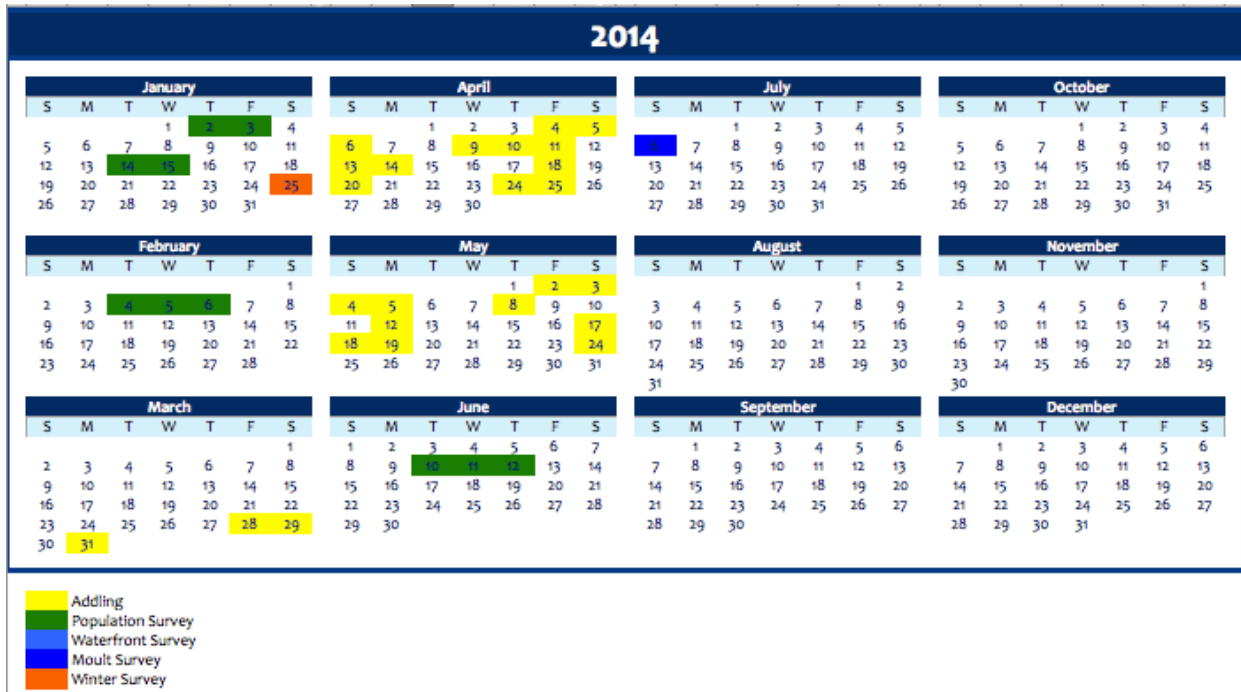


Figure B-5. Survey calendar, 2014.

C. Limitations

Seasonal Detection

Depending on the season, Canada Geese may be over- or under-counted. During nesting and brood-rearing, they avoid being seen by quickly crouching down and using vegetation to screen themselves. By contrast, moulting geese are concentrated in a few waterfront areas where they were more readily counted. During the spring and fall migration periods, they might use several different sites in a day, and could be in flight between sites when geese were counted. If geese were fitted with tracking devices, and surveys were consistent (using the same methods with no change in surveyors), we may better understand how visibility and detection influence the variability of survey counts within and between seasons.

Survey Effort

Canada Goose numbers were confounded by the extent and frequency of surveys (Figures C-1 and C-2). Additionally, there were several kinds of surveys and quasi-surveys, including banding, adding counts, population surveys, moult surveys, and winter surveys. Adding counts, which are conducted in late March, April, and May were not true surveys, as they involve repeated trips to the Englishman River and Little Qualicum River estuaries to sterilize eggs; documenting collars or bands was a secondary activity.

For each type of survey, and sometimes for individual surveys, there were variations in the number of surveyors, boundaries, time of day, and duration (cf. Perrins & Birkhead 1983). Further, our surveys did not consider tidal fluctuations, which definitely influenced how geese used the estuaries and other intertidal areas. Sampling intensity often reflected the availability of volunteer biologists/biological technicians and funding for paid staff. Access to privately-owned sites limited the survey effort, at least until permissions were granted.

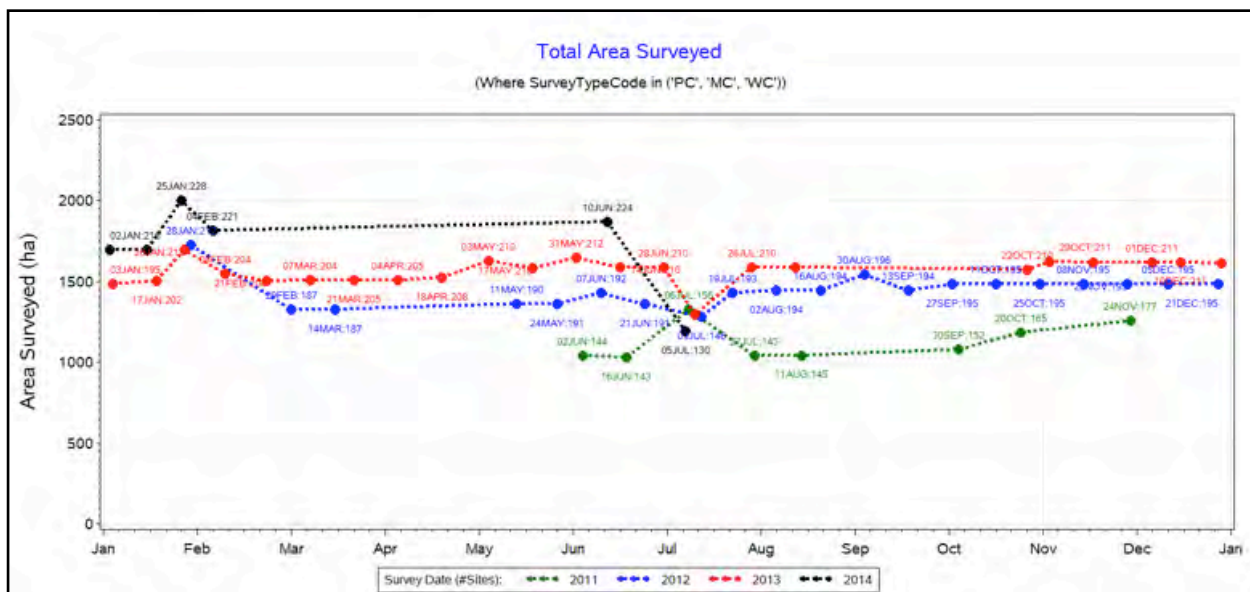


Figure C-1. Total area surveyed (in ha) during moult, winter, and routine population counts, across all sites, by survey date.

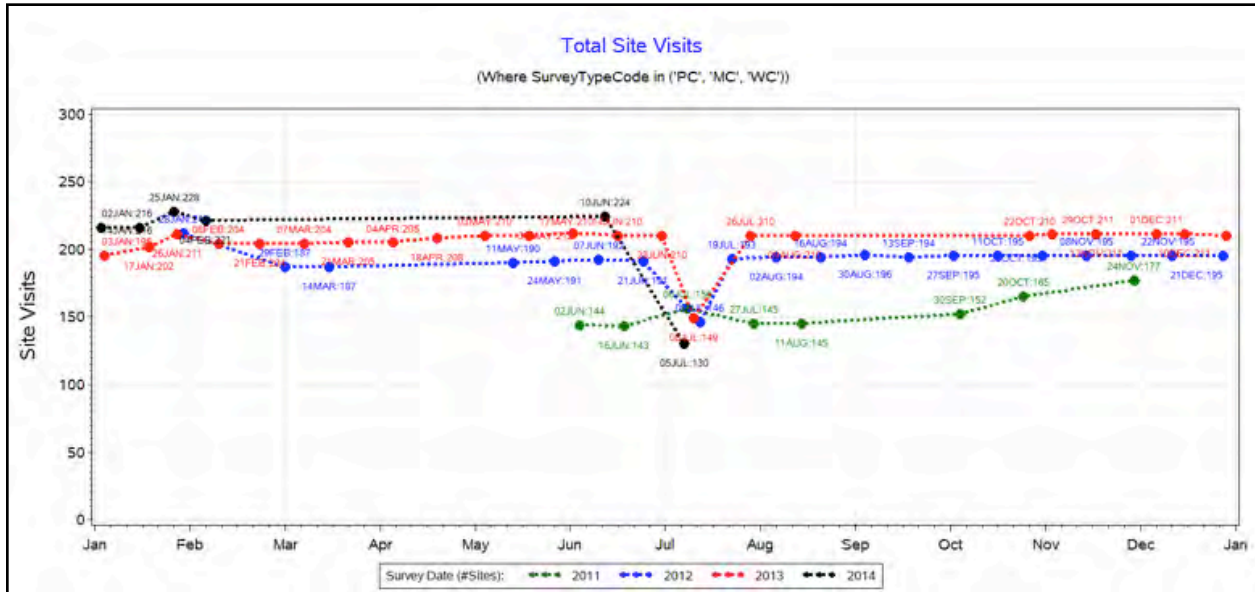


Figure C-2. Total site visits during moult, winter, and routine population counts, by survey date.

Figure C-3 shows the number of survey days each year. September surveys were only conducted once in 2011 (Sep 30), and twice in 2012 (Sep 13-14, 27-28). Contrast this with the month of June, when population surveys were conducted twice each month in 2011, 2012, 2013 and 2014 (See the calendars, Figures B-1 to B-5). The number of re-sighted birds, and the number of birds observed generally, will appear to be markedly lower in September when compared with June, simply because there were fewer surveys. Figures C-4 and C-5 demonstrate the before and after

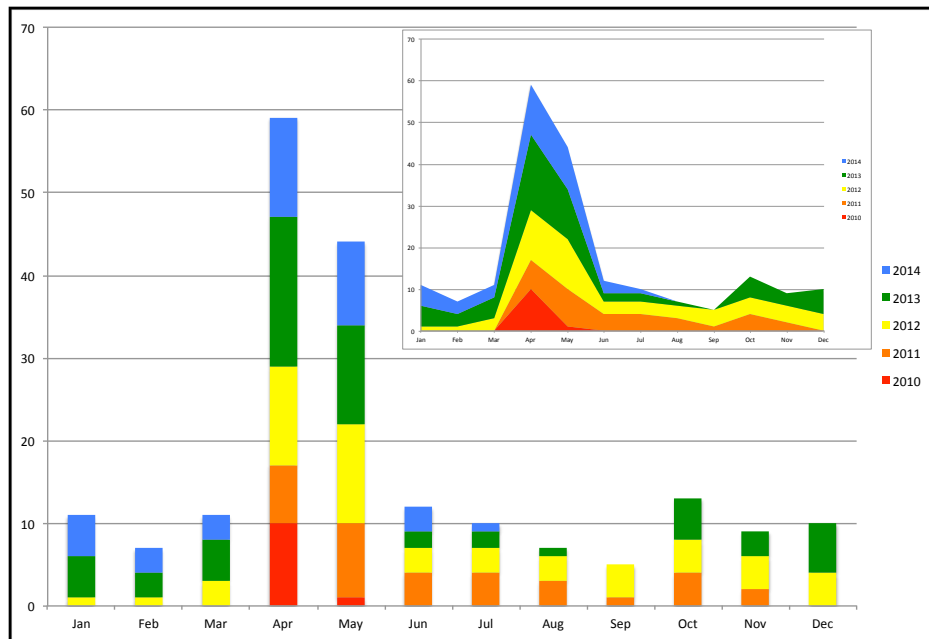


Figure C-3. Number of survey days each year, including adulling counts, population surveys, winter surveys, and moult surveys. Banding counts, waterfront surveys, volunteer submissions and data submitted by the banding office were not included. The inset includes the same data, shown as a stacked area graph.

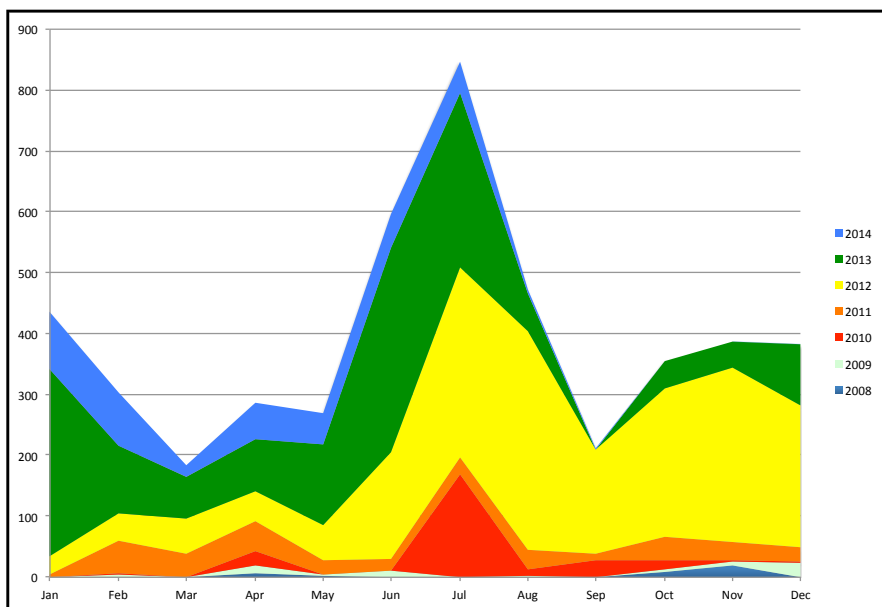


Figure C-4. Marked Canada Geese re-sighted each month for all years, 2008-2014 (n=4,371).

In both figures, goose numbers spiked during the moult in July. This peak encompassed Canada Goose roundups and banding in 2010 and 2012 (85 at the LQRE: 70 at ERE, and 106 at CCE). Excluding the banding dates resulted in a lower, flatter peak, but otherwise had little effect on the overall shape of the graph, as counts were done immediately afterwards and almost all marked birds were re-sighted.

In the graph uncorrected for effort (Figure C-4), a secondary peak occurred in January when the greatest numbers of birds were overwintering, and at the height of the nesting period in April.

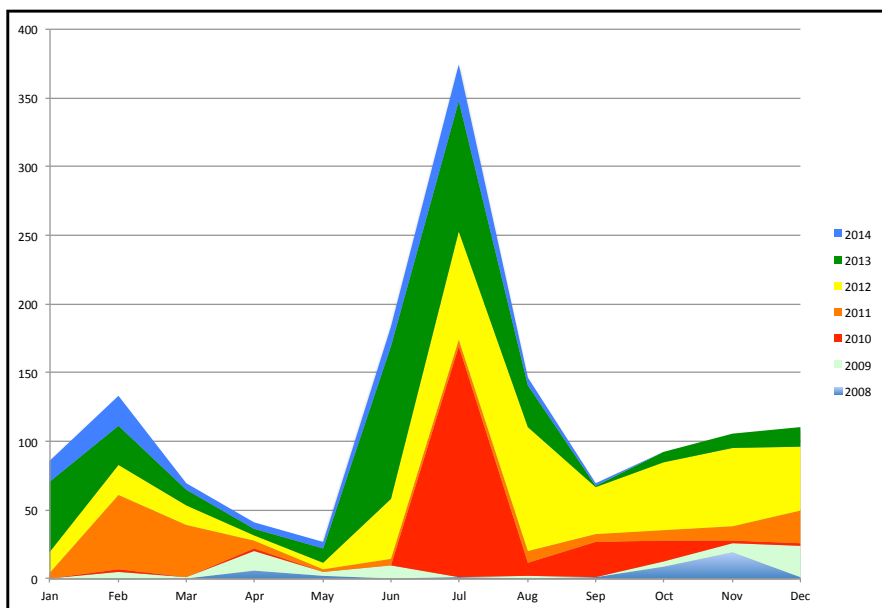


Figure C-5. Marked Canada Geese re-sighted each month for all years, 2008-2014 (n=4,371), with a measure of sampling intensity (sum of each month across years = monthly count totals / (number of surveys in the month + 1). Numbers along the y axis are relative, not absolute.

In the graph corrected for sampling intensity (Figure C-5), the peak shifts from the overwintering season to the spring migration period, showing that more marked geese were observed at this time of year. (Note that winter counts did not consistently identify marked birds.) The peak nesting period in April all but disappeared, due to the large number of sample days during the egg adding period.

D. Encounter Histories

In this section are summaries of marked Canada Goose encounter histories and associated maps for each migrant type. These exemplify typical home ranges and have been re-sighted more than others. ‘Season’ refers to the Canada Goose season, not the calendar season.

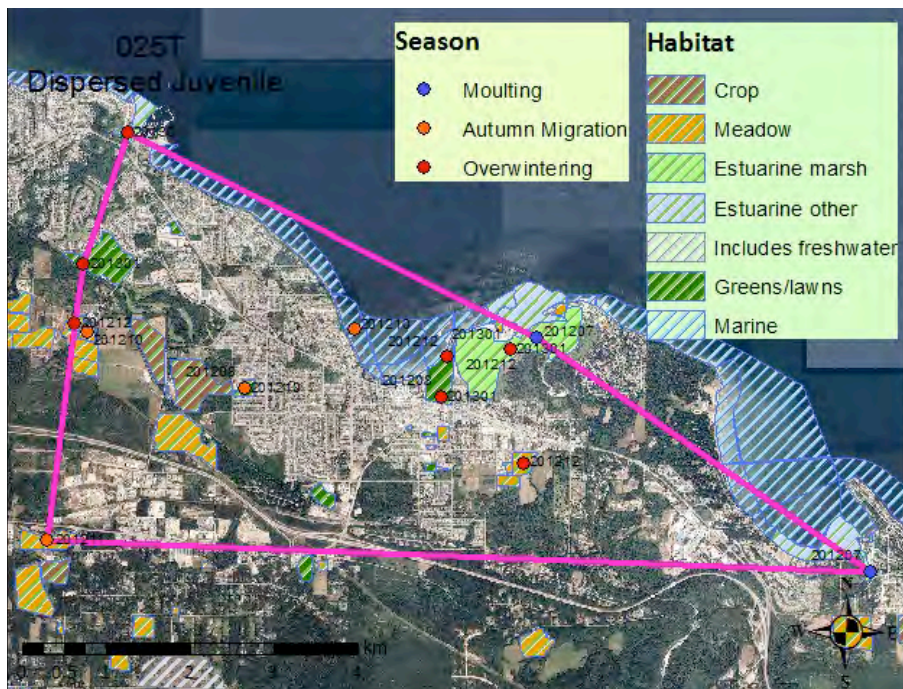
In many cases, there are two types of home range maps for each bird: minimum convex polygon (MCP) maps, and kernel density estimation (KDE) maps.

A MCP is the smallest polygon that encompasses all of the sites (or in this case, the centres of the sites) where the individual goose has been observed. It does not indicate whether the bird has been sighted more frequently in some areas than others. In the MCP maps below, the the home range is shown as a pink border. It connects the dots, drawing a perimeter around all of the sites where the bird was observed. Due to overlapping symbols, not every observation date will be visible.

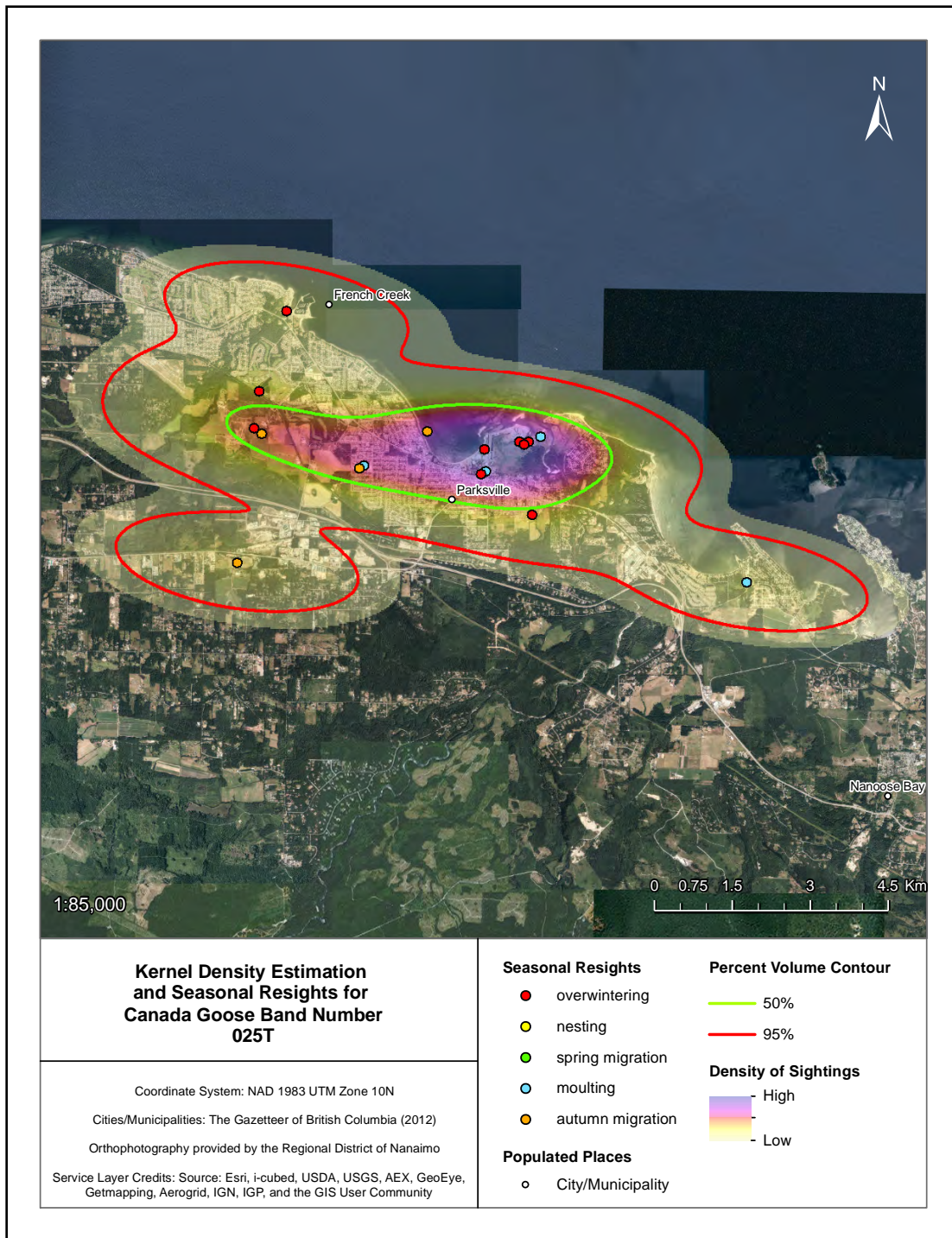
KDE mapping measures the density of the records within each grid cell in the study area, and uses this to estimate the probability that an individual goose will use neighbouring cells. KDEs are converted to percentage volume contours (PVCs) that identify areas where the goose is likely to occur 50% of the time (often referred to as the core range) and 95% of the time.

Dispersed Juvenile

025T was banded at the CCE in July 2012 as a hatch-year bird. It used the ERE and French Creek estuaries during the following winter. It was last seen in the area in January 2013.



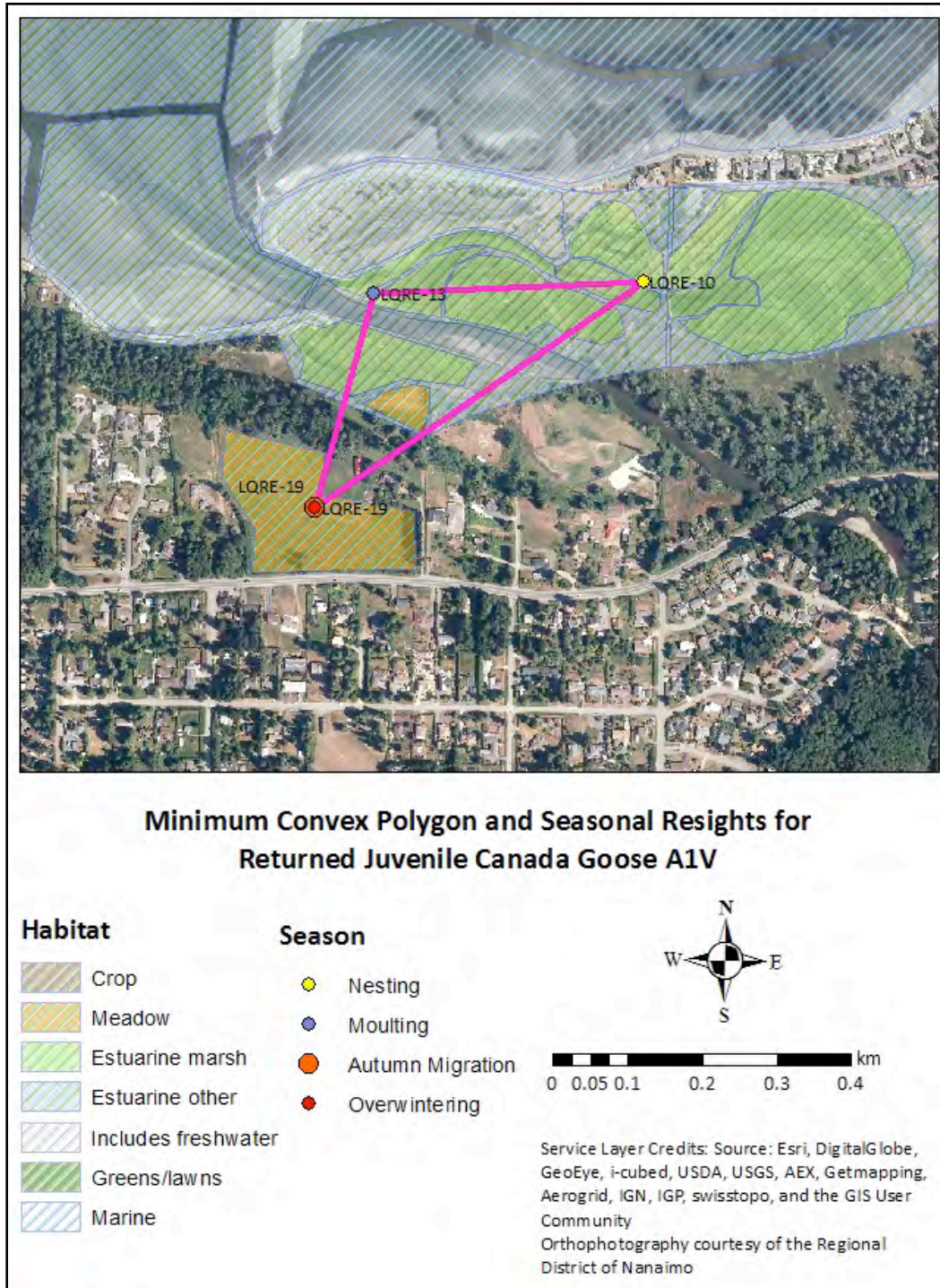
MCP map for Dispersed Juvenile 025T



KDE map for Dispersed Juvenile 025T

Returned Juvenile

A1V was banded at the LQRE in June 2009 as a hatch-year bird. She returned to the area in November 2012, and nested at the LQRE the following spring. Her three eggs were added on April 17, 2013.



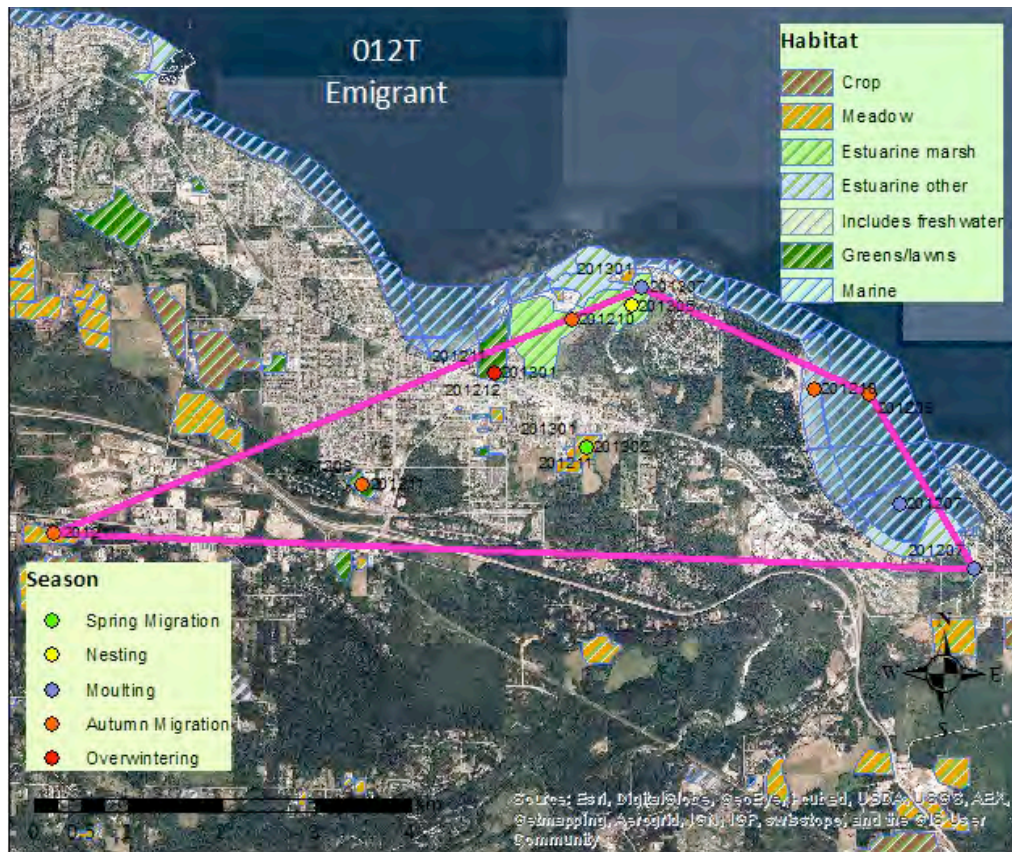
MCP map for Returned Juvenile A1V

Emigrant

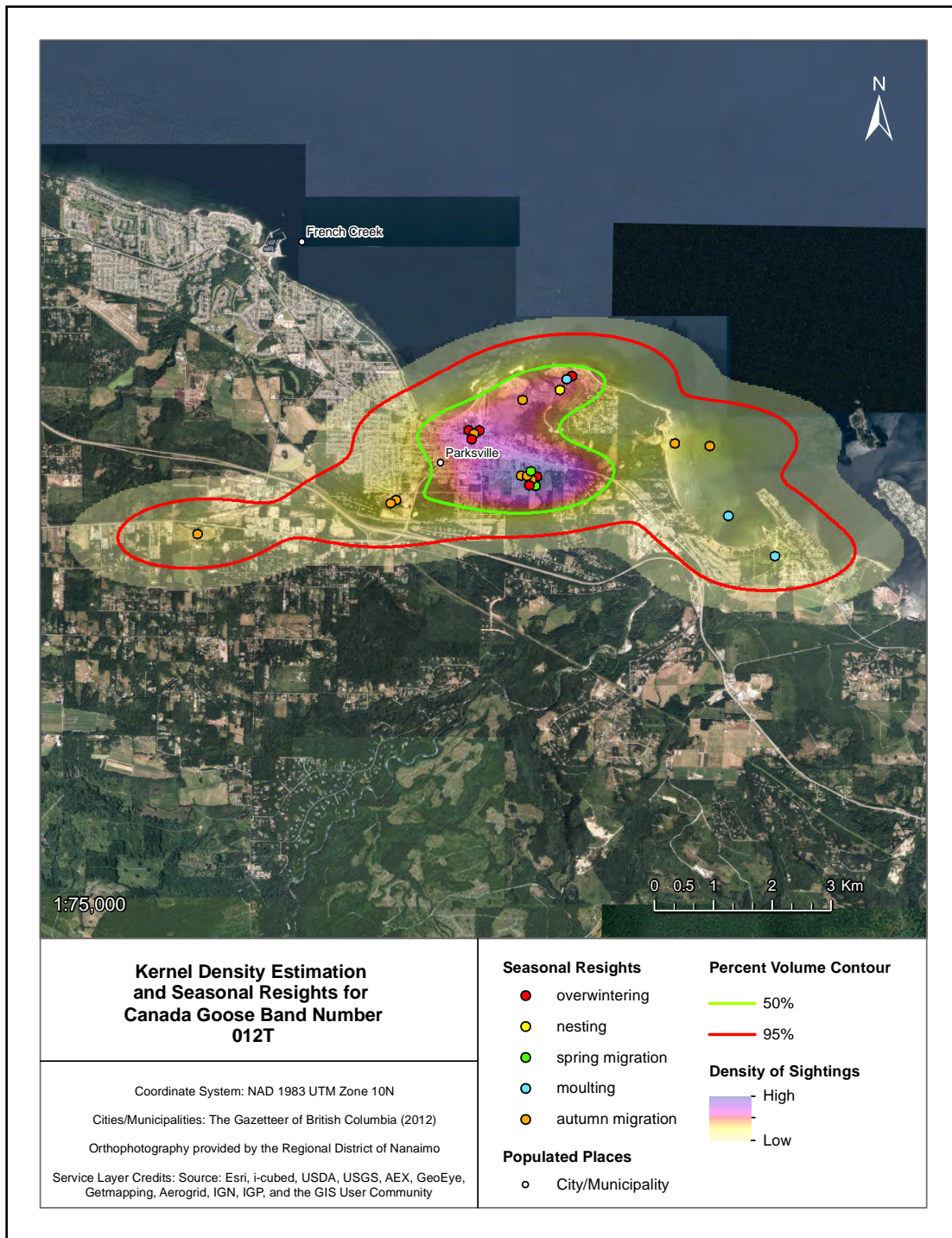
012T was banded at the CCE in July 2012. It used the ERE during the following autumn, winter, and spring migration seasons. It was last seen in the area, at the ERE, in July 2013.



Emigrant 012T (left), 012T with M017 (right)



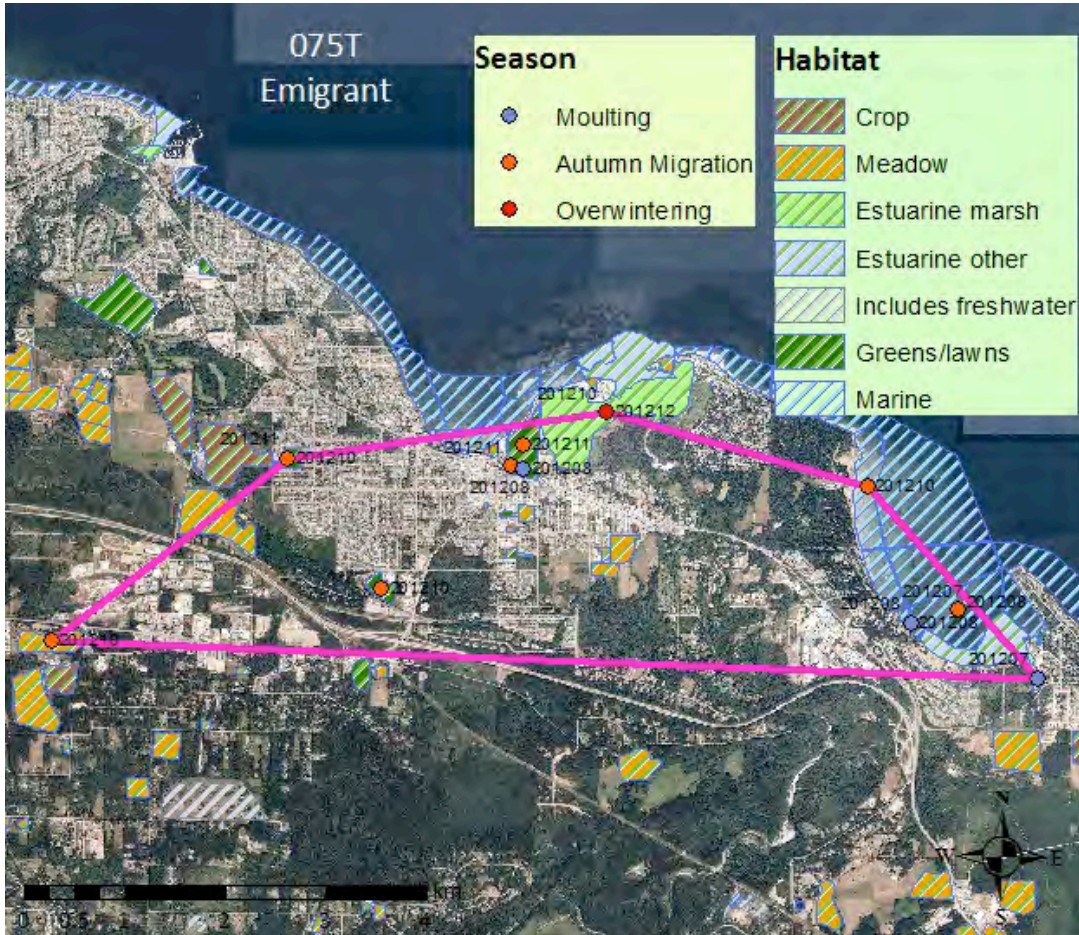
MCP map for Emigrant 012T



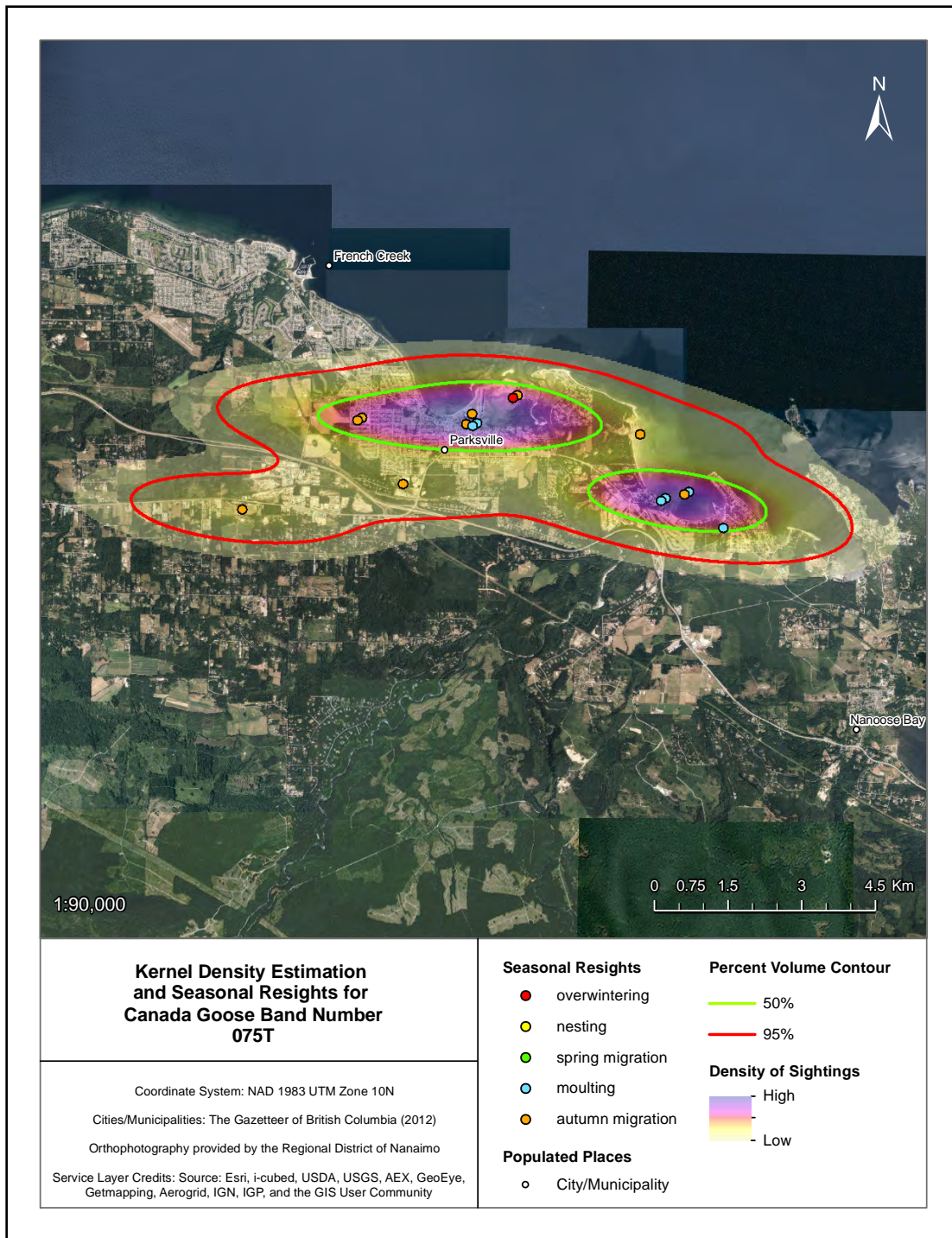
KDE map for Emigrant 012T

Emigrant

075T was banded at the CCE in July 2012, and had a home range similar to that of 012T. It used the ERE during the autumn and winter. It was last seen in the area in December 2012.



MCP map for Emigrant 075T



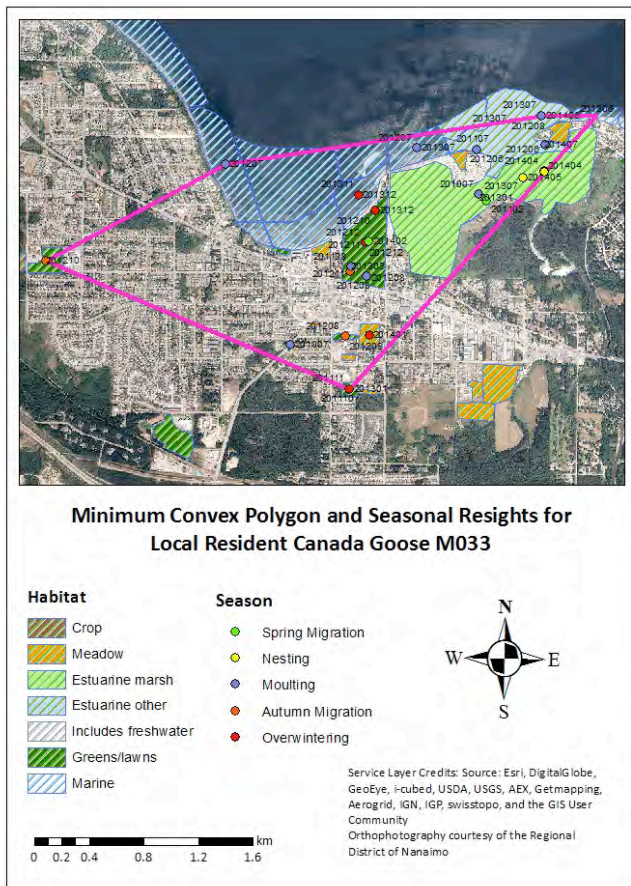
KDE map for Emigrant 075T

Local Resident

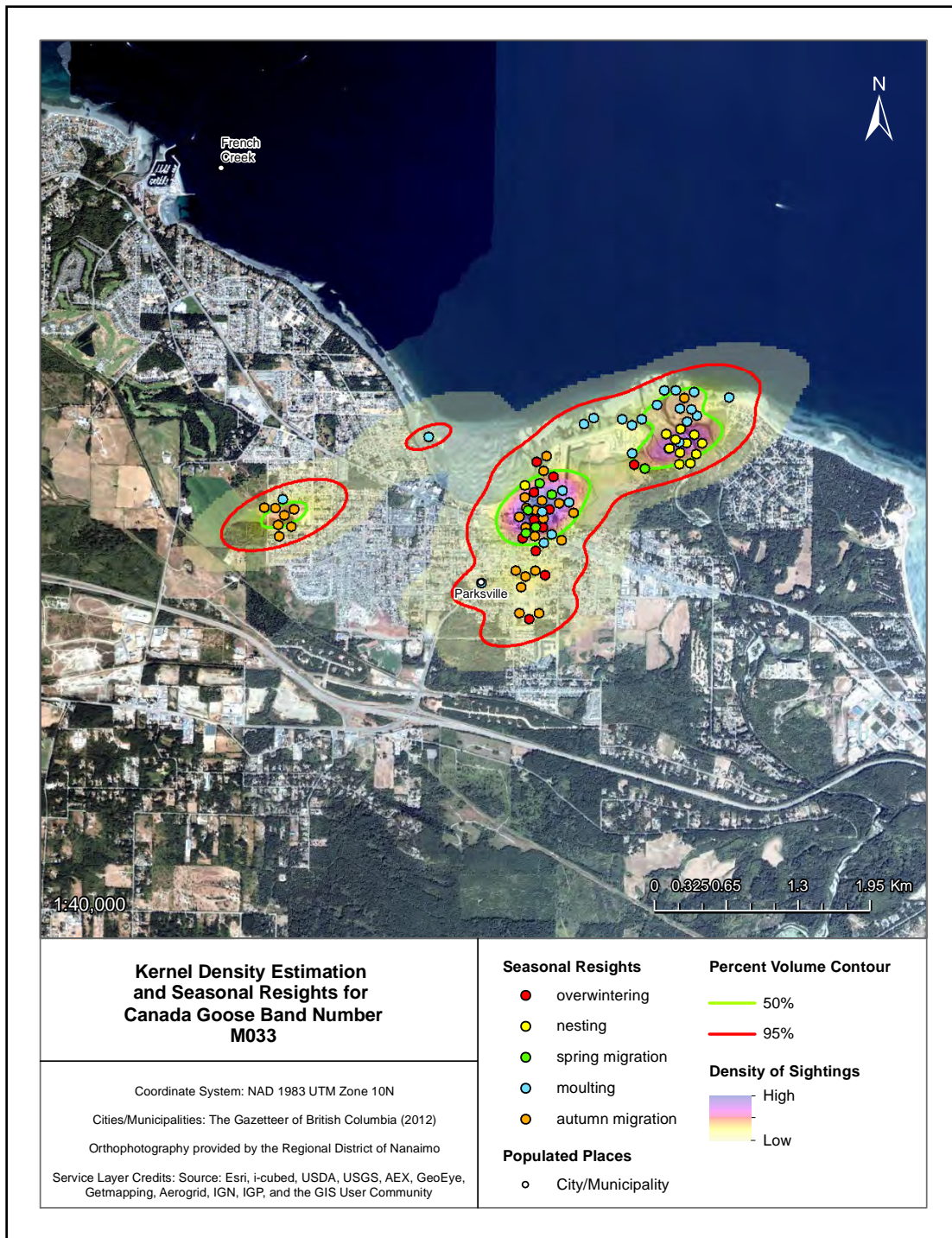
The local residents in each subpopulation use the landscape differently. M033 was banded at the ERE in 2010. Paired with M046, she laid 6 eggs in 2012, 7 eggs in 2013, and 6 eggs in 2014. She was seen at the ERE and in Parksville in each season.



Local Resident M033 on her nest



MCP map for Local Resident M033



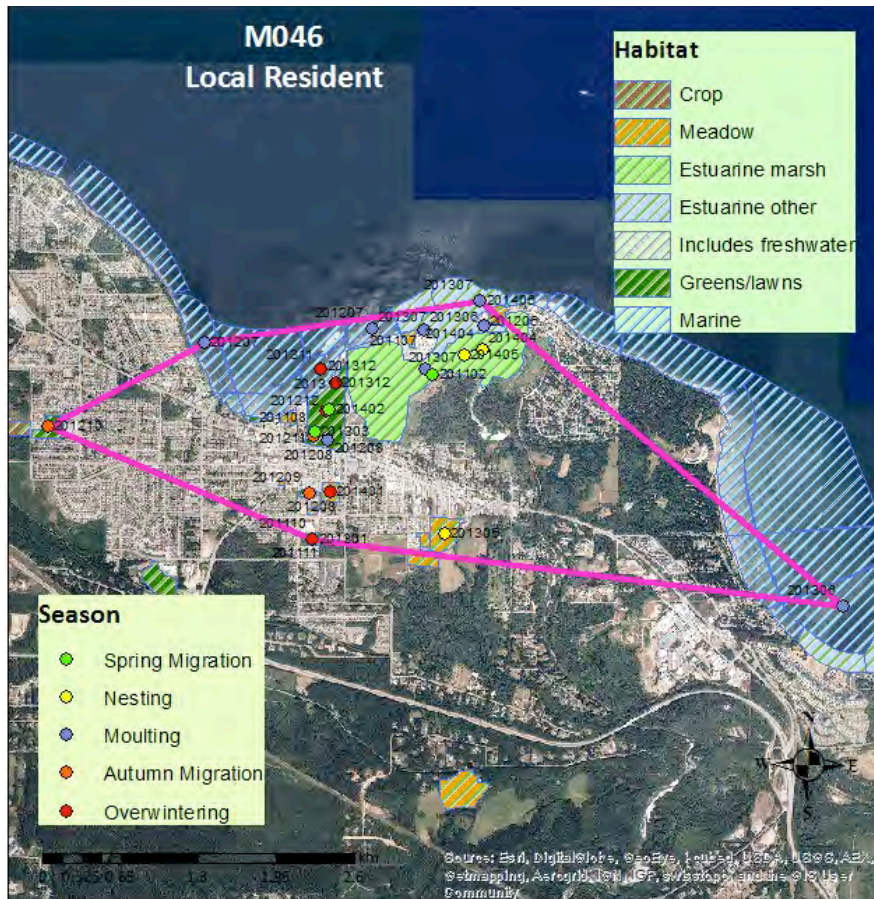
KDE map for Local Resident M033

Local Resident

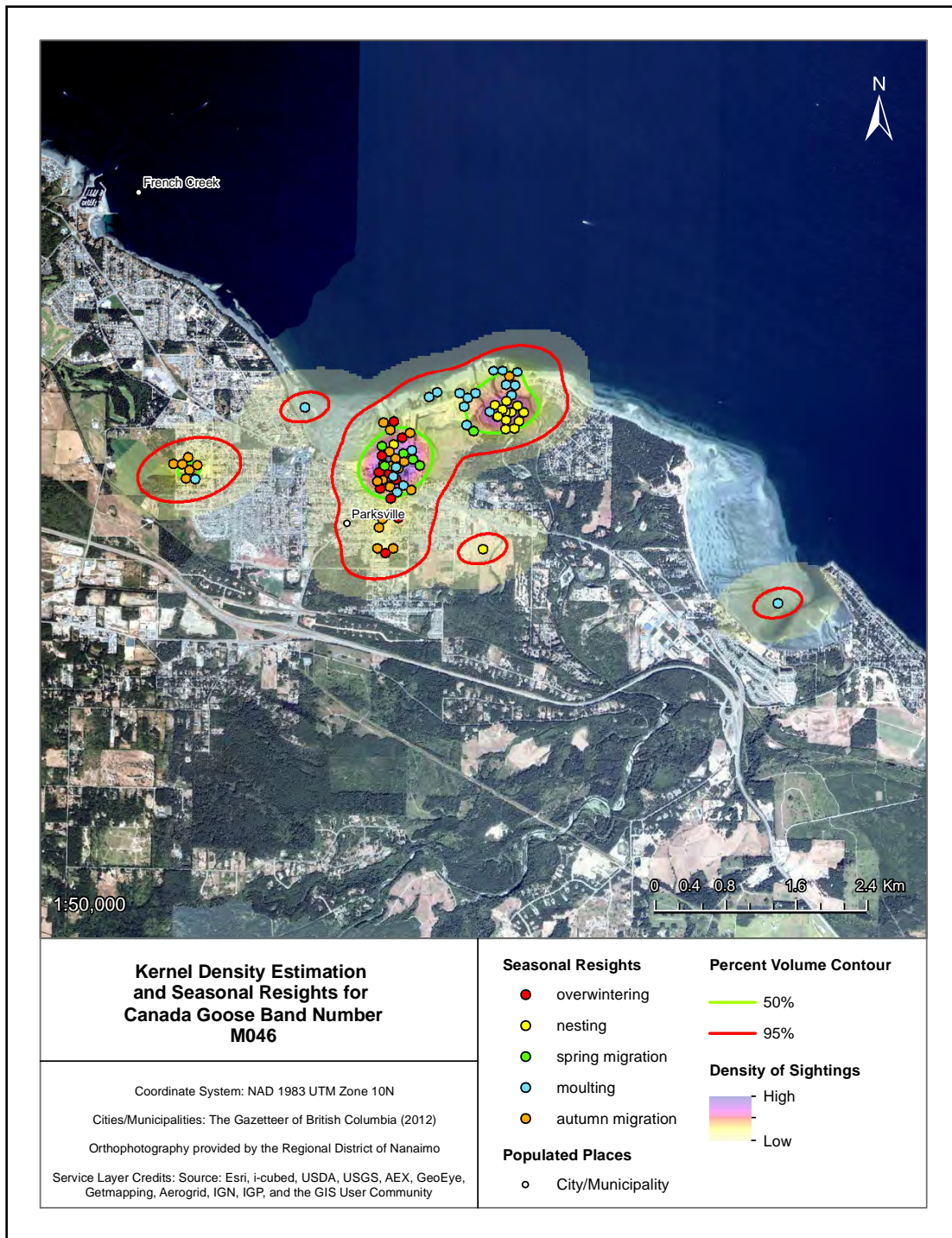
M046 is a gander banded at the ERE in 2010. He was paired with M033 (described above), and had a similar distribution. His moulting range included the CCE.



M033 and M046 on the nesting grounds



MCP map for Local Resident M046



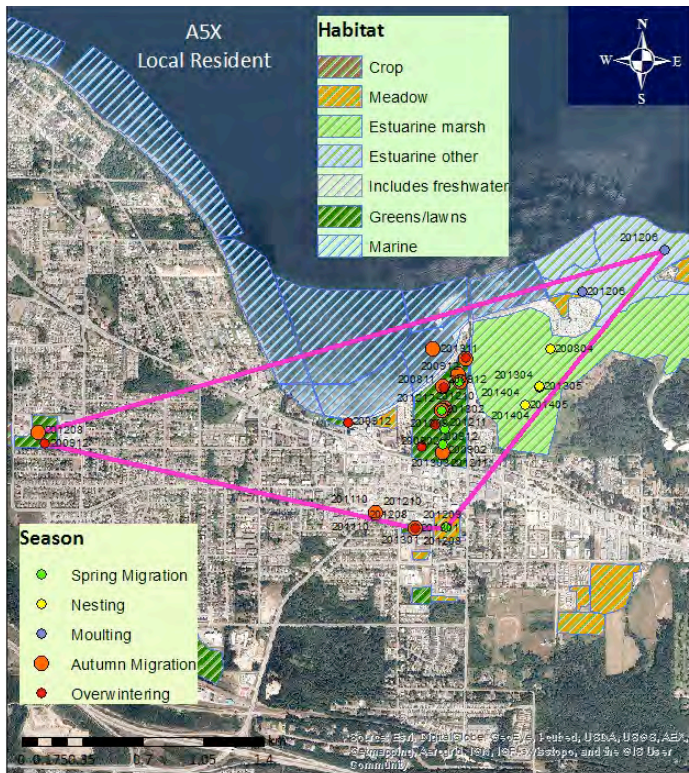
KDE map for Local Resident M046

Local Resident

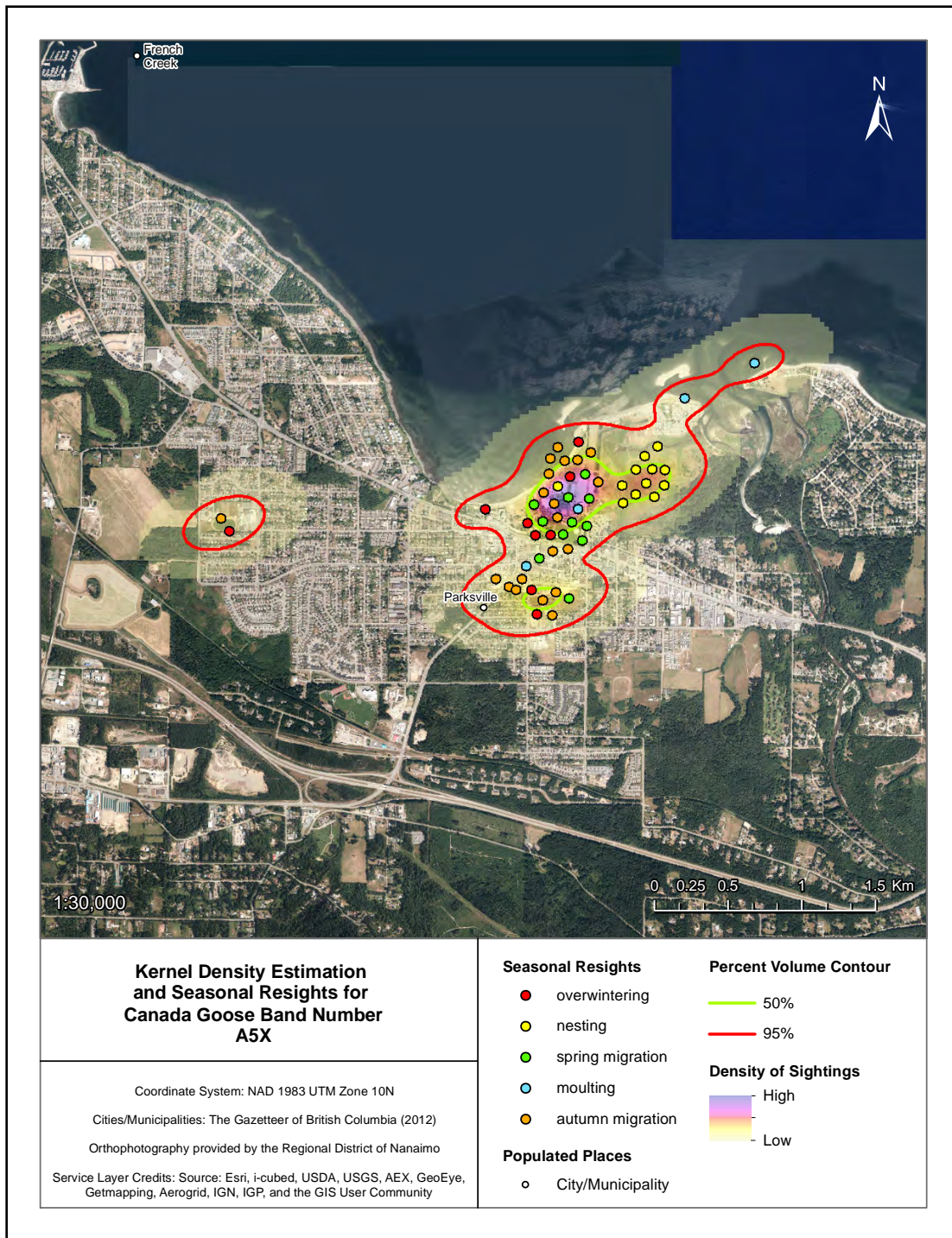
A5X was a nesting female banded at the ERE in April, 2008, incubating 8 eggs. A5X was incubating 6 eggs when her mate, A5M, was banded in 2009. They also nested on the ERE in 2011 (7 eggs), 2012 (8 eggs), 2013 (8 eggs), and 2014 (5 eggs Apr 5, 6 eggs Apr 28, 6 eggs May 5, 4 eggs May 19). Based on available data, A5X was primarily a resident of Parksville Community Park, never moving beyond the ERE and city limits. However, this leg-banded bird was not as visible as collared birds, particularly when swimming or standing in vegetation. She may have a larger range than shown here.



A5X defending her nest. Photo by Guy Monty.



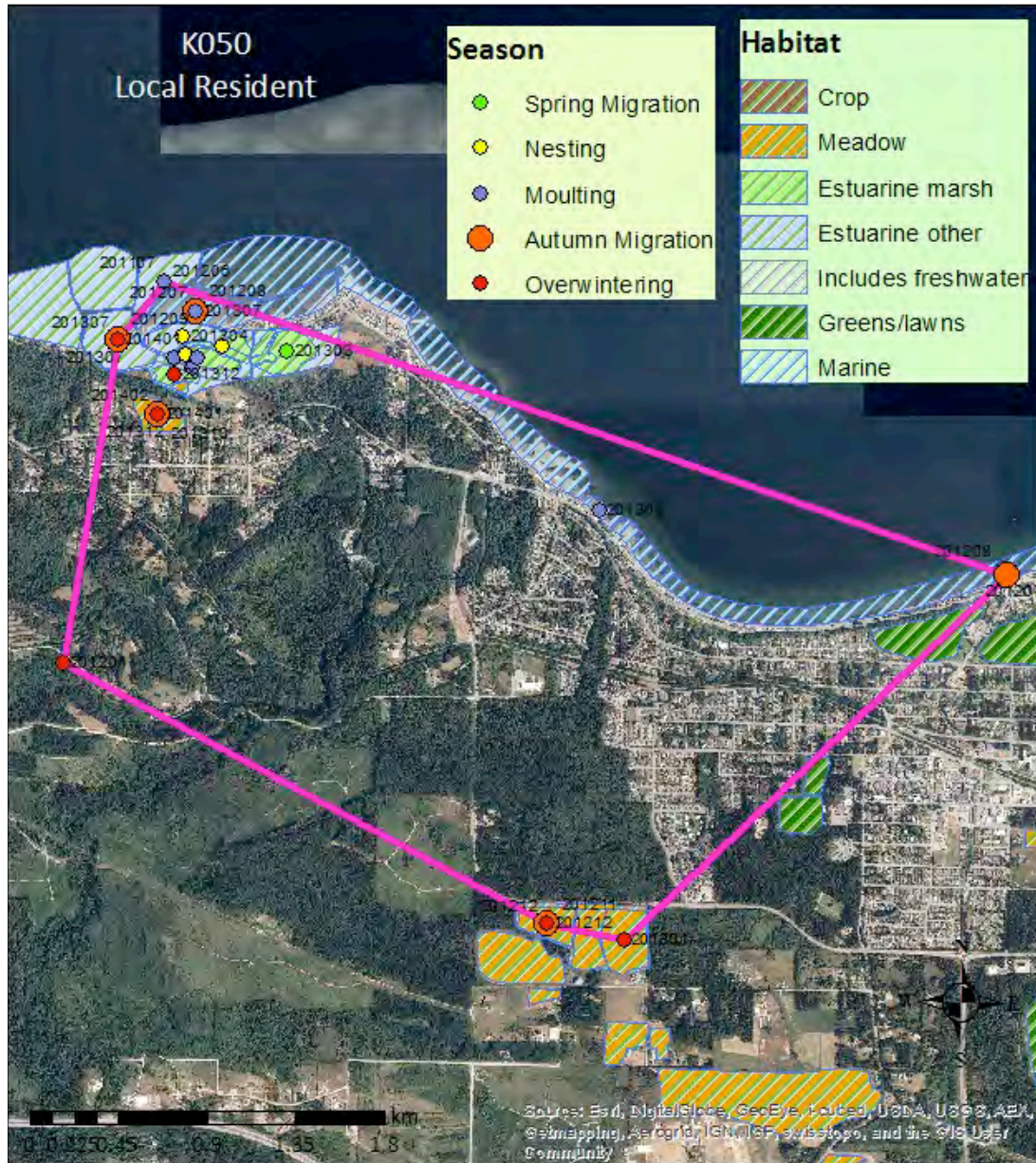
MCP map for Local Resident A5X



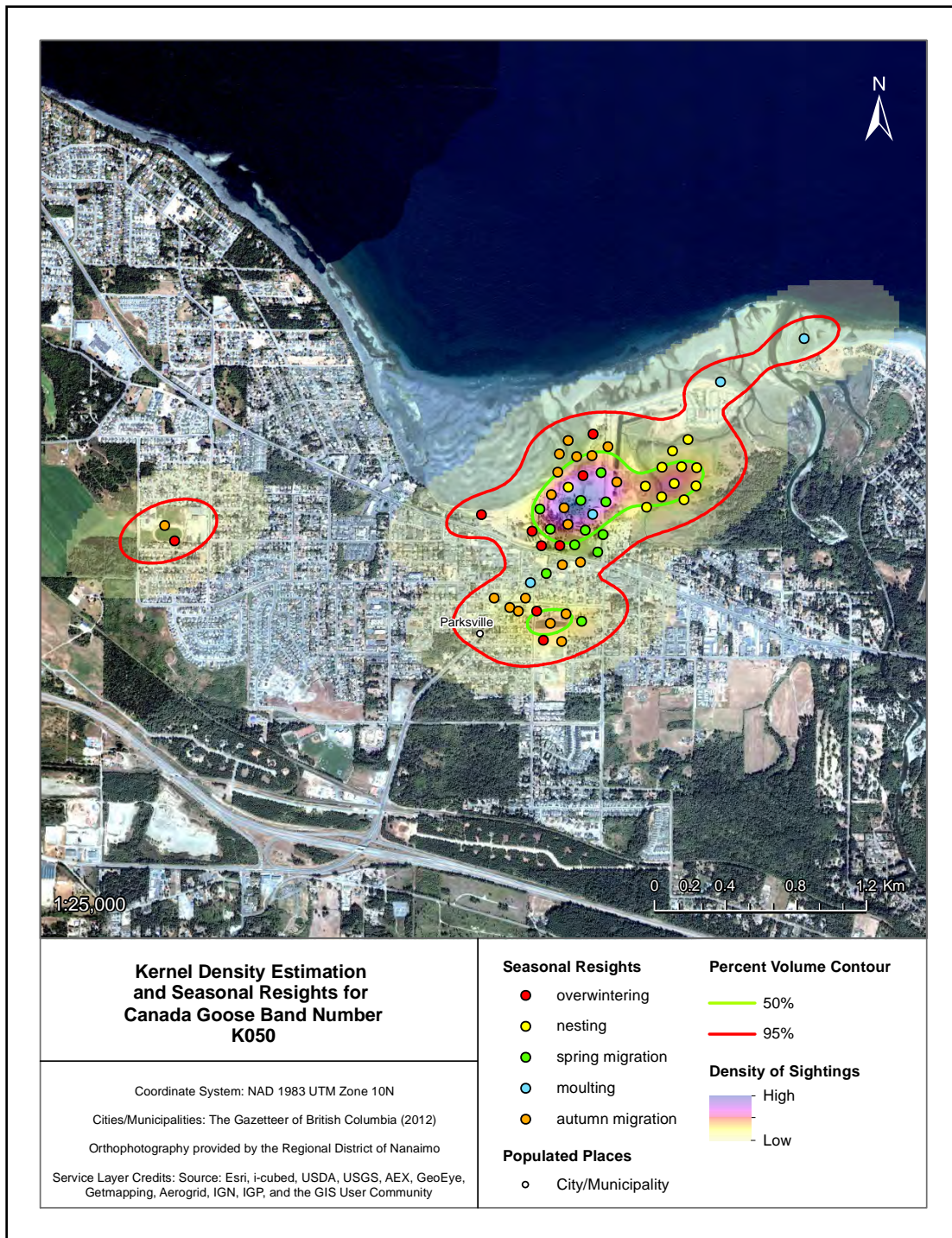
KDE map for Local Resident A5X

Local Resident

K050 was banded at the LQRE in 2010. It frequented the LQRE and nearby Windhaven Farm, and nested at the estuary in 2011. Its home range was typical of local resident “K” birds that do not frequent the Sunnymere/ Hamilton Marsh area.



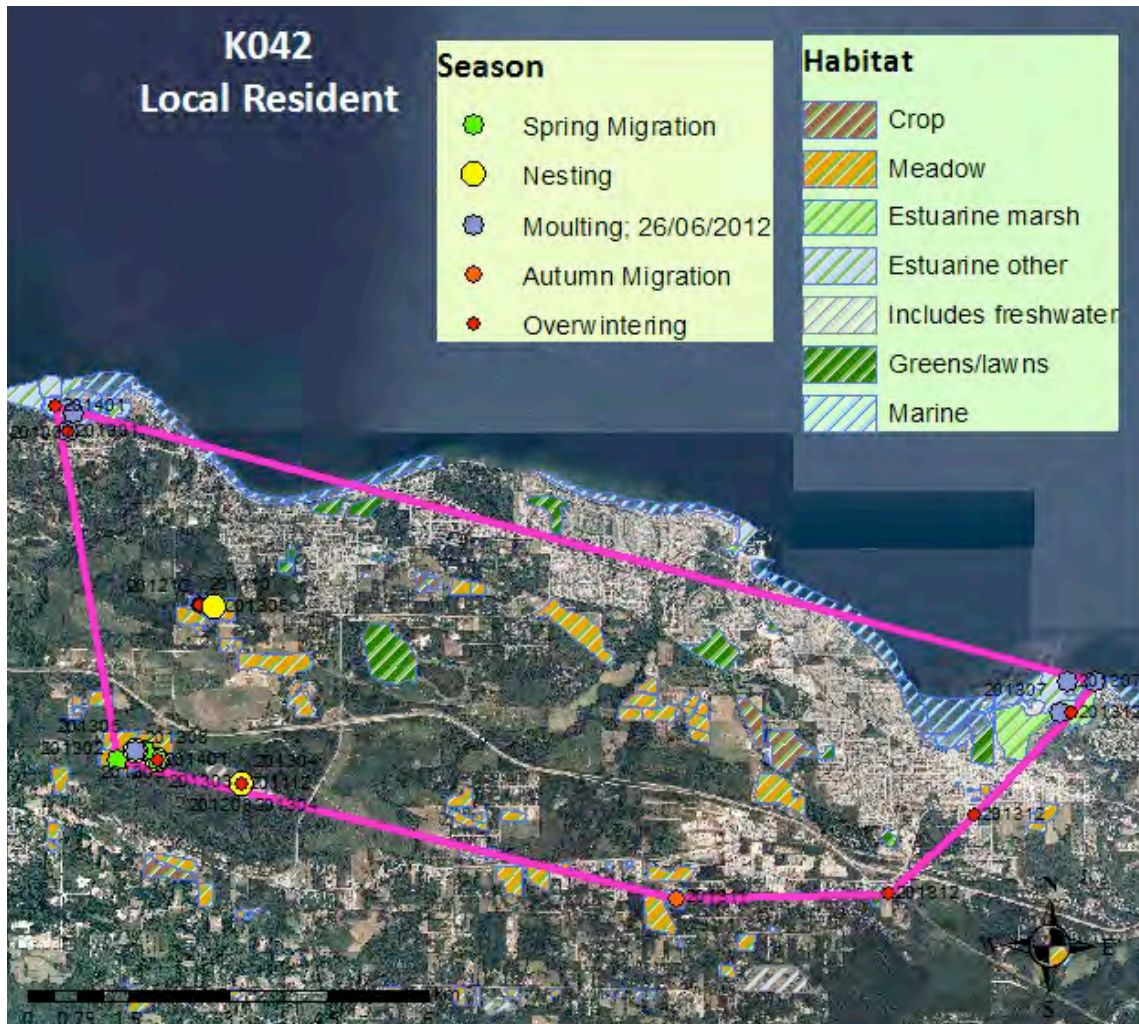
MCP map for Local Resident K050



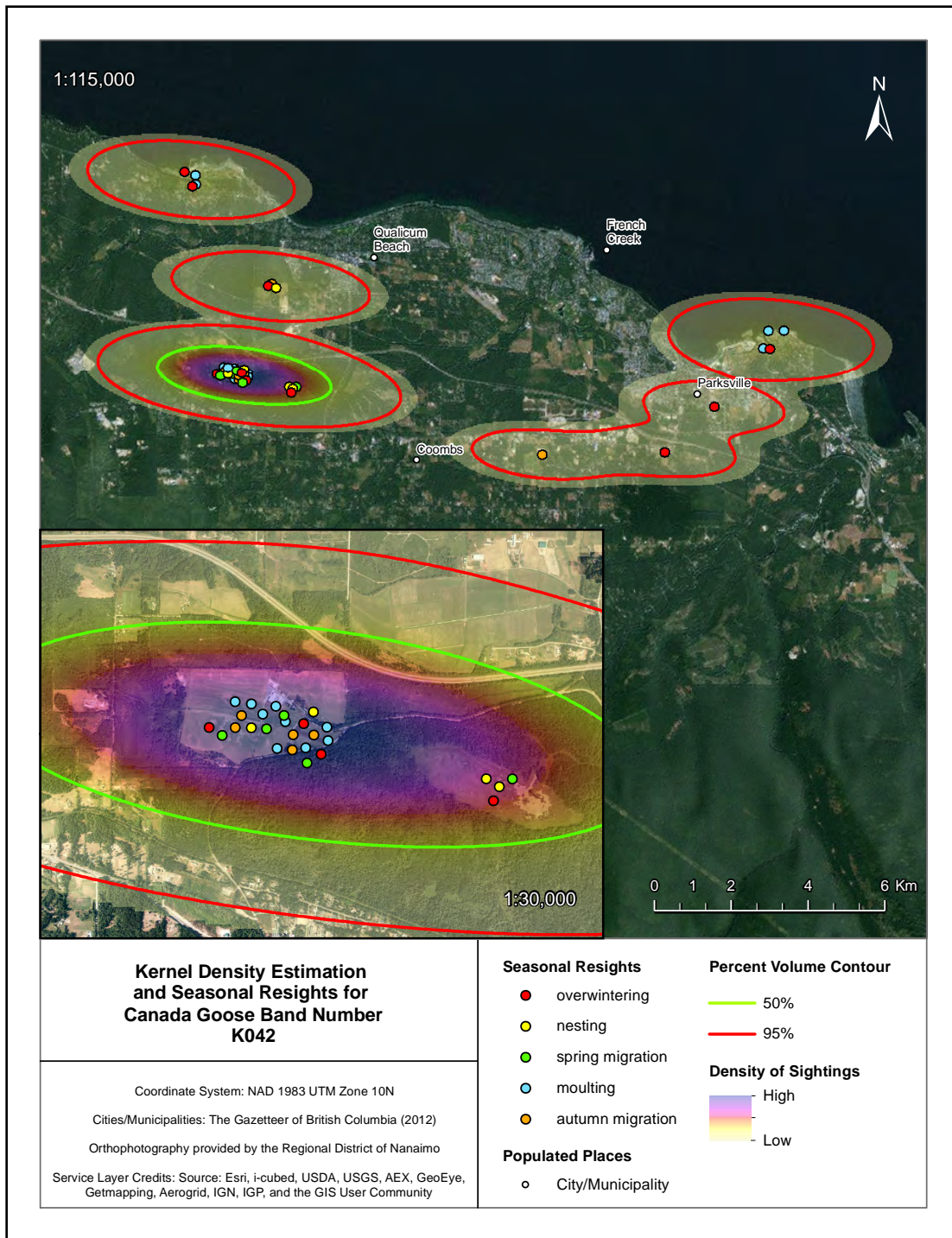
KDE map for Local Resident K050

Local Resident

K042 was banded at the LQRE in 2010. It was seen most frequently at Sunnymere Farm and Hamilton Marsh, and probably nested at Hamilton Marsh in 2013. It was observed at the LQRE in January 2014, and at the ERE in June and July, 2013.



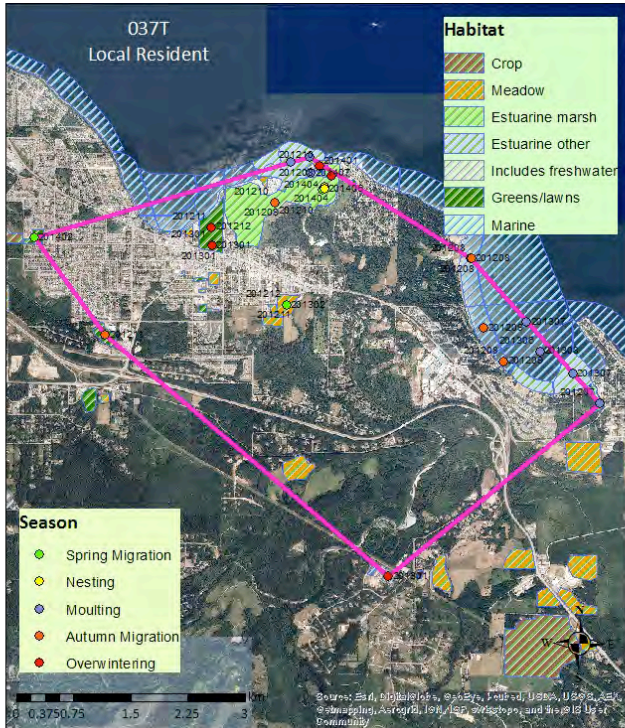
MCP map for Local Resident K042



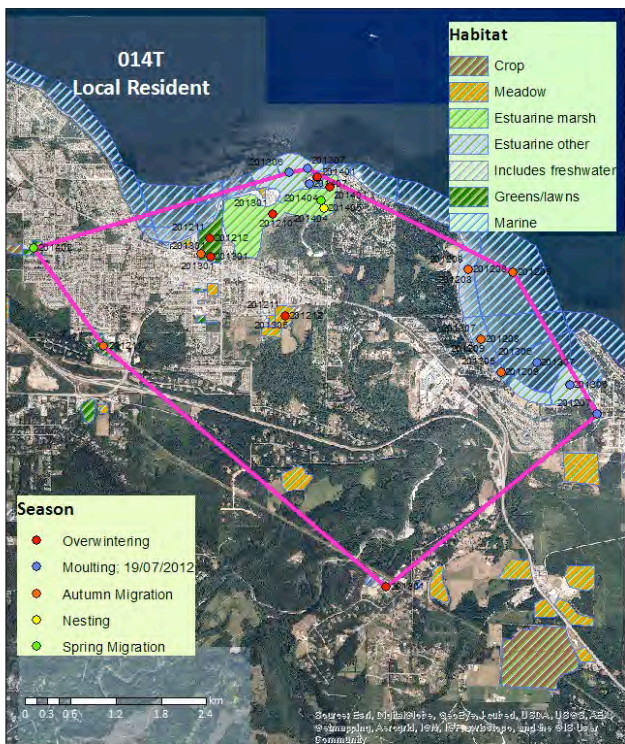
KDE map for Local Resident K042

Local Resident

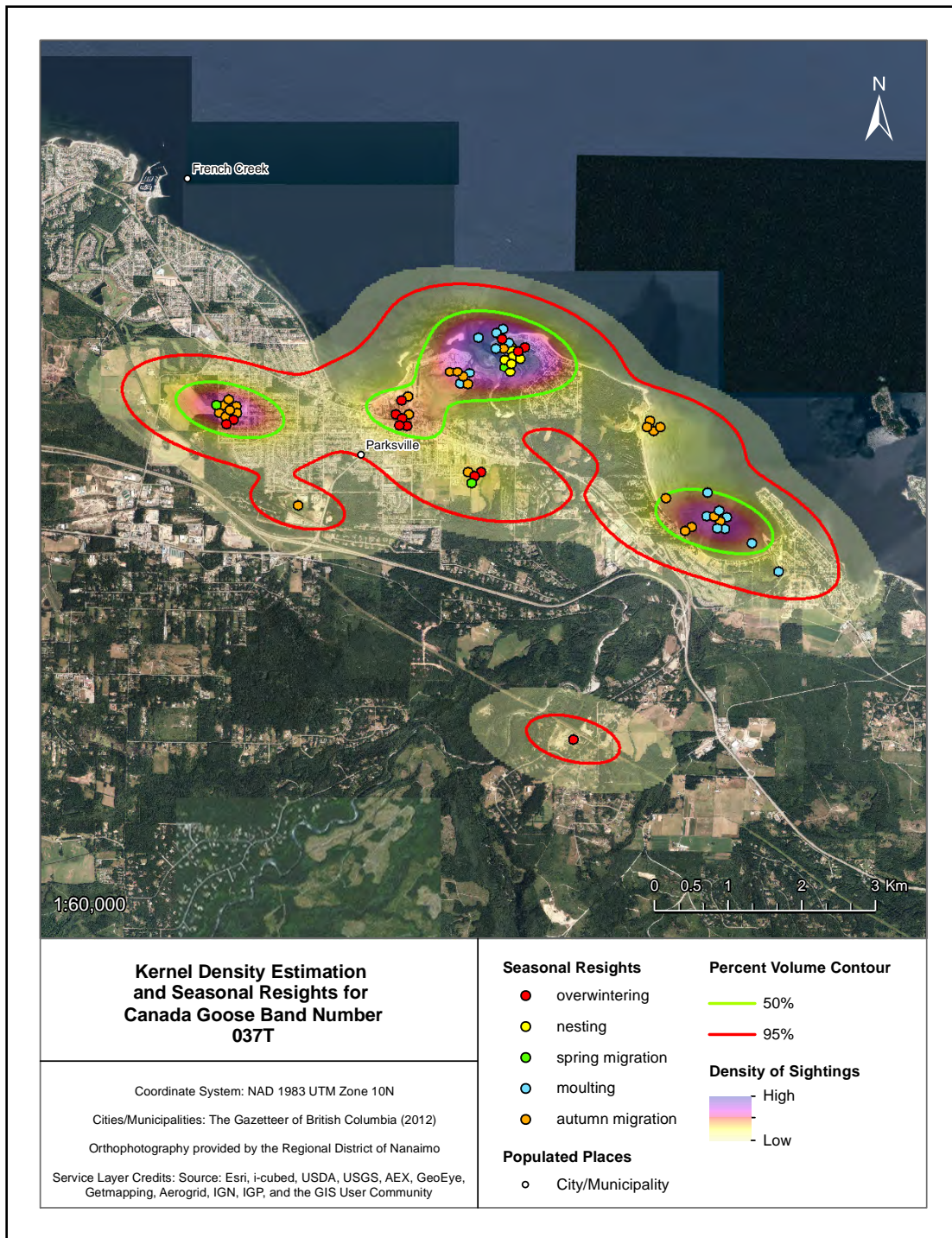
037T and 014T were local residents banded at the CCE in July 2012. Their ranges were identical, and they are included here to demonstrate how similar Canada Goose movements can be. 037T and 014T rarely ventured beyond the CCE and ERE and City of Parksville.



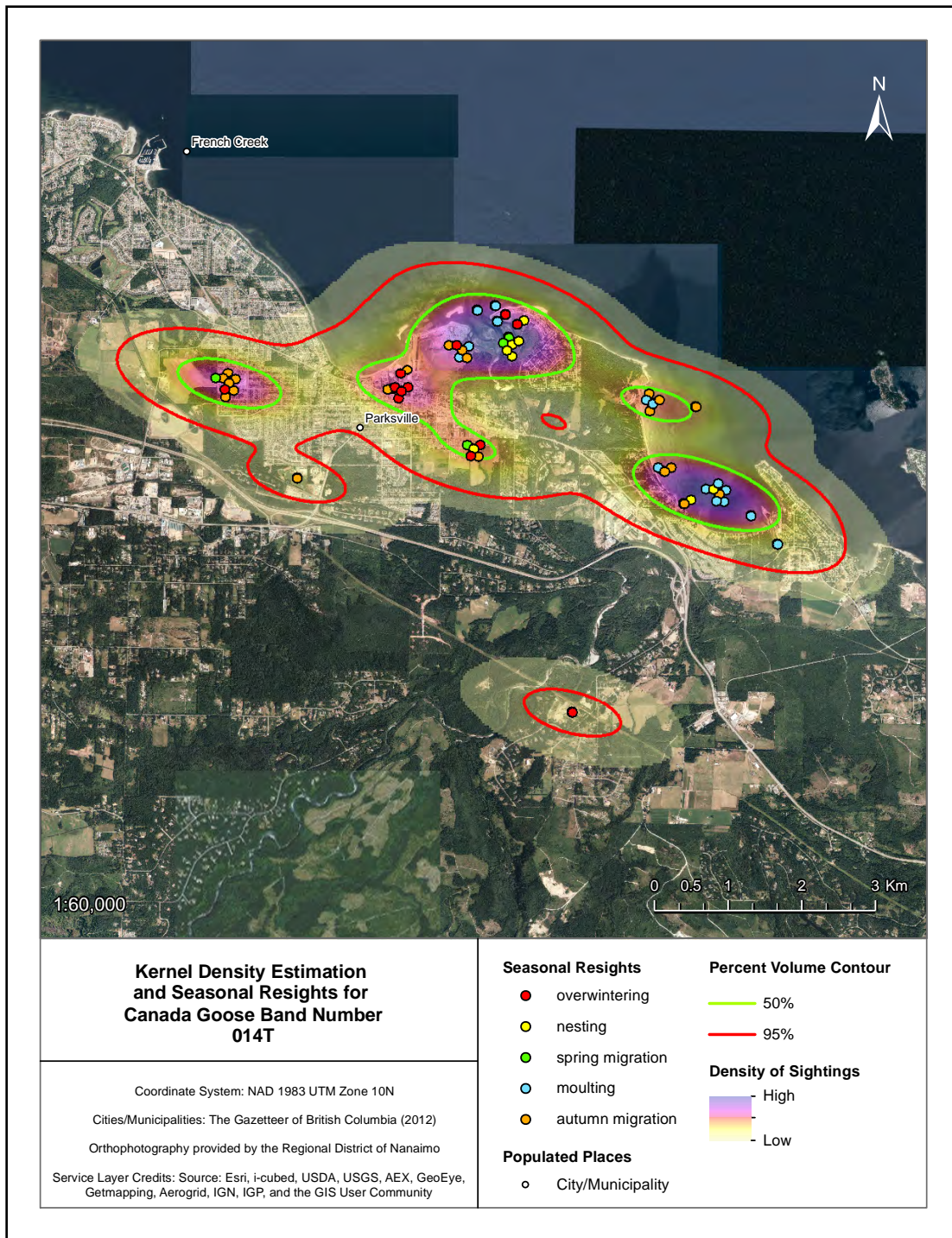
MCP map for Local Resident 037T



MCP map for Local Resident 014T



KDE map for Local Resident 037T



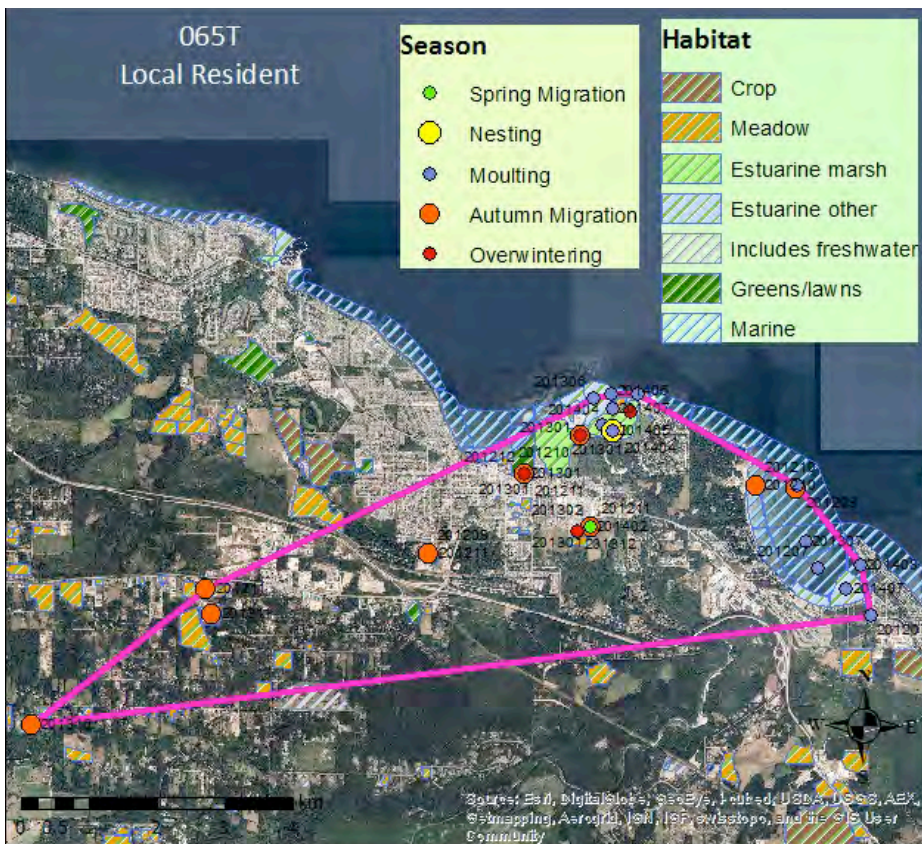
KDE map for Local Resident 014T

Local Resident

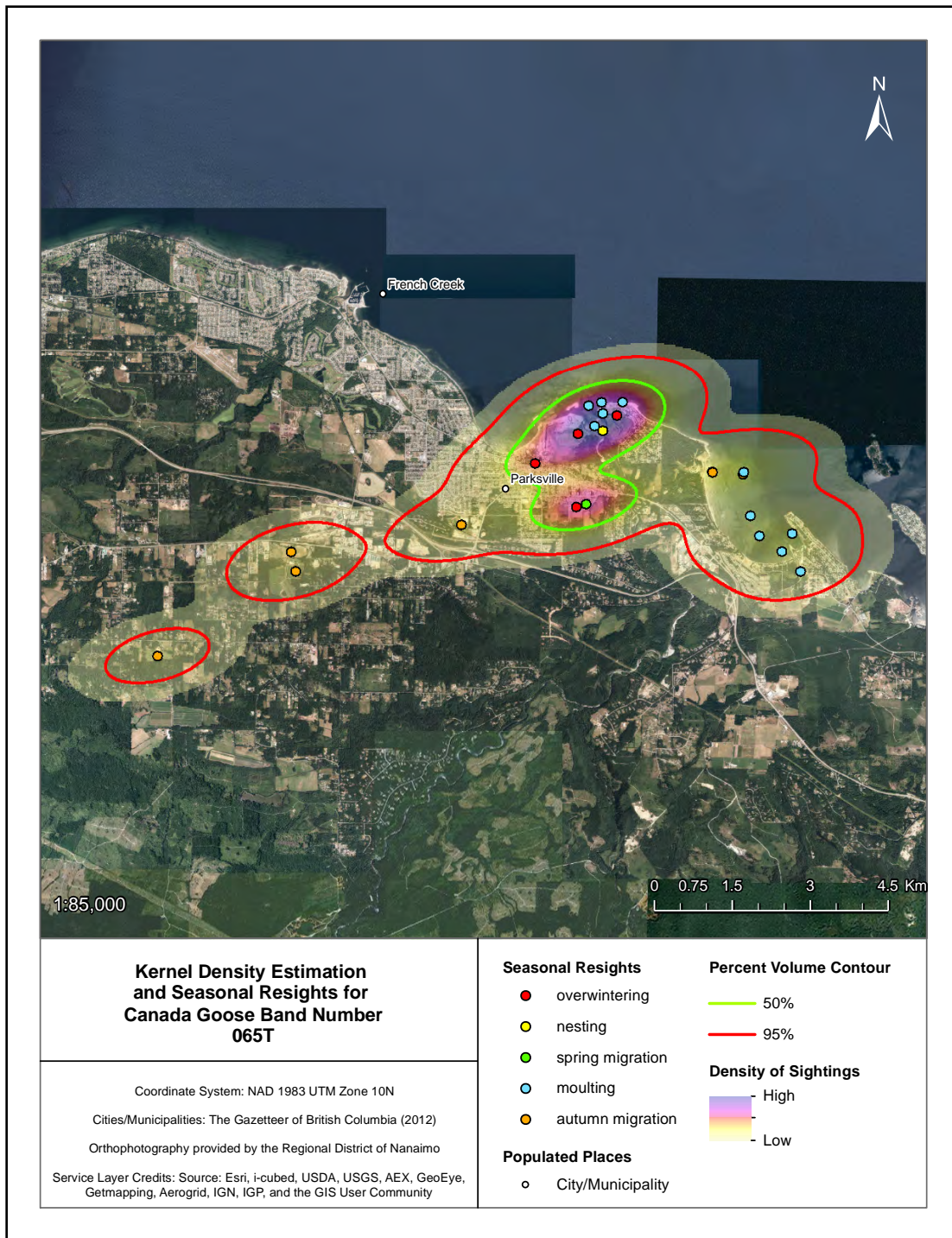
065T was also banded at the CCE in July 2012. It was on the ERE during the 2013 and 2014 nesting seasons, but was not observed nesting. During much of the autumn, it was found in Errington, as far as Belle Lake. In other seasons, it was found on the CCE, ERE and within city limits.



Local Resident 065T



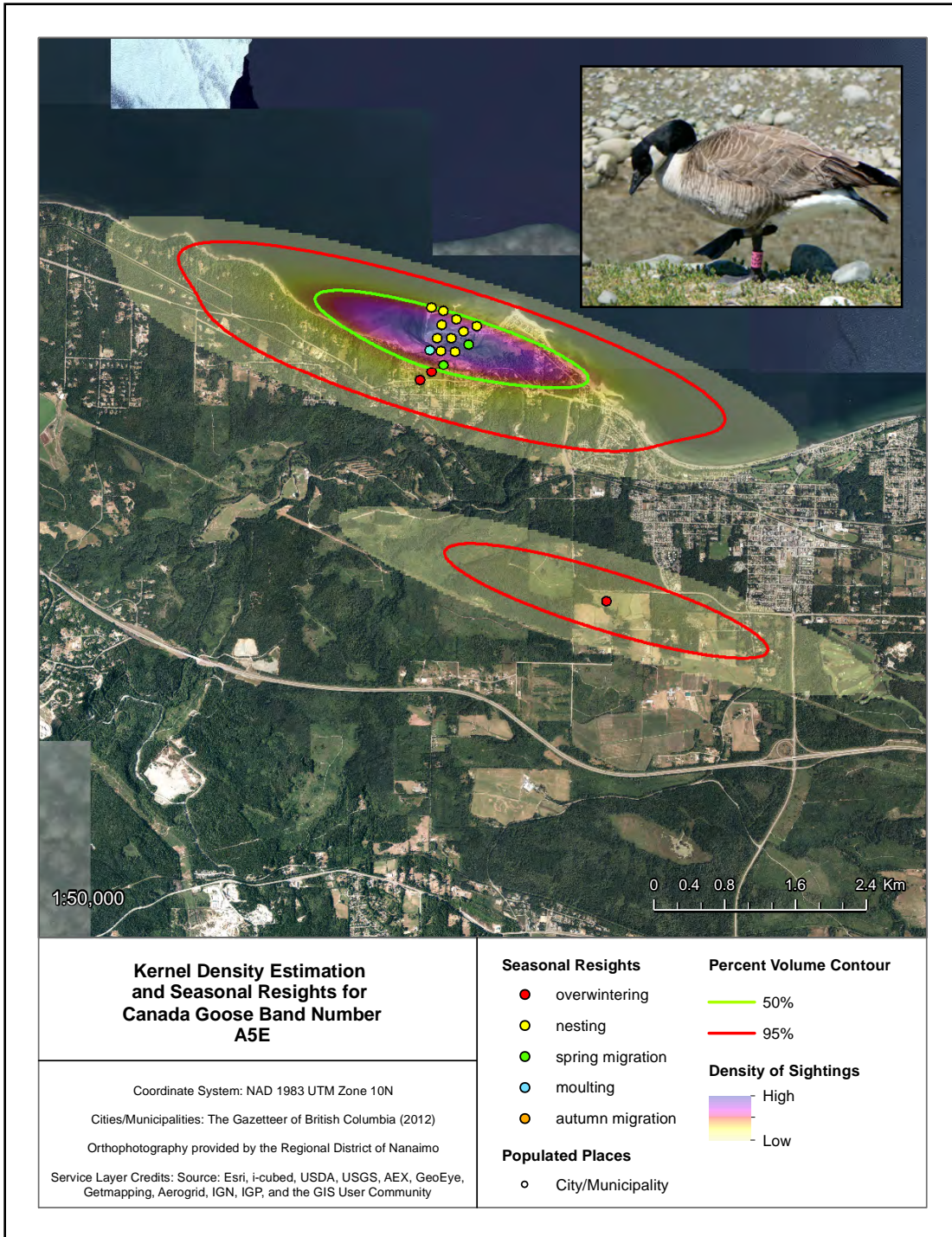
MCP map for Local Resident 065T



KDE map for Local Resident 065T

Local Resident Plus

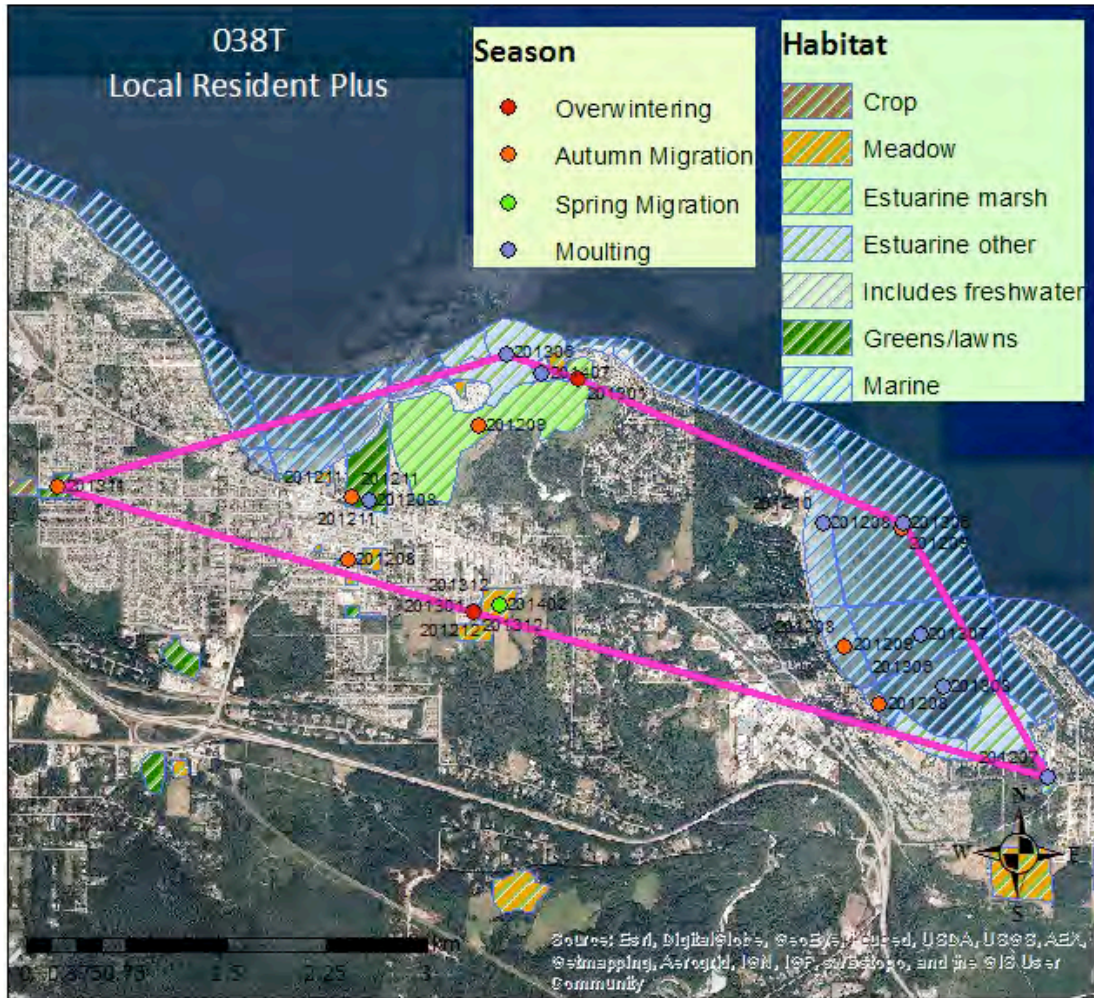
A5E was a female banded at the LQRE in May, 2009; she was incubating 5 eggs. She nested at the LQRE in 2010 (6 eggs), 2011 (8 eggs), 2012 (7 eggs), and 2013 (8 eggs). A5E has never been observed in the area in the autumn.



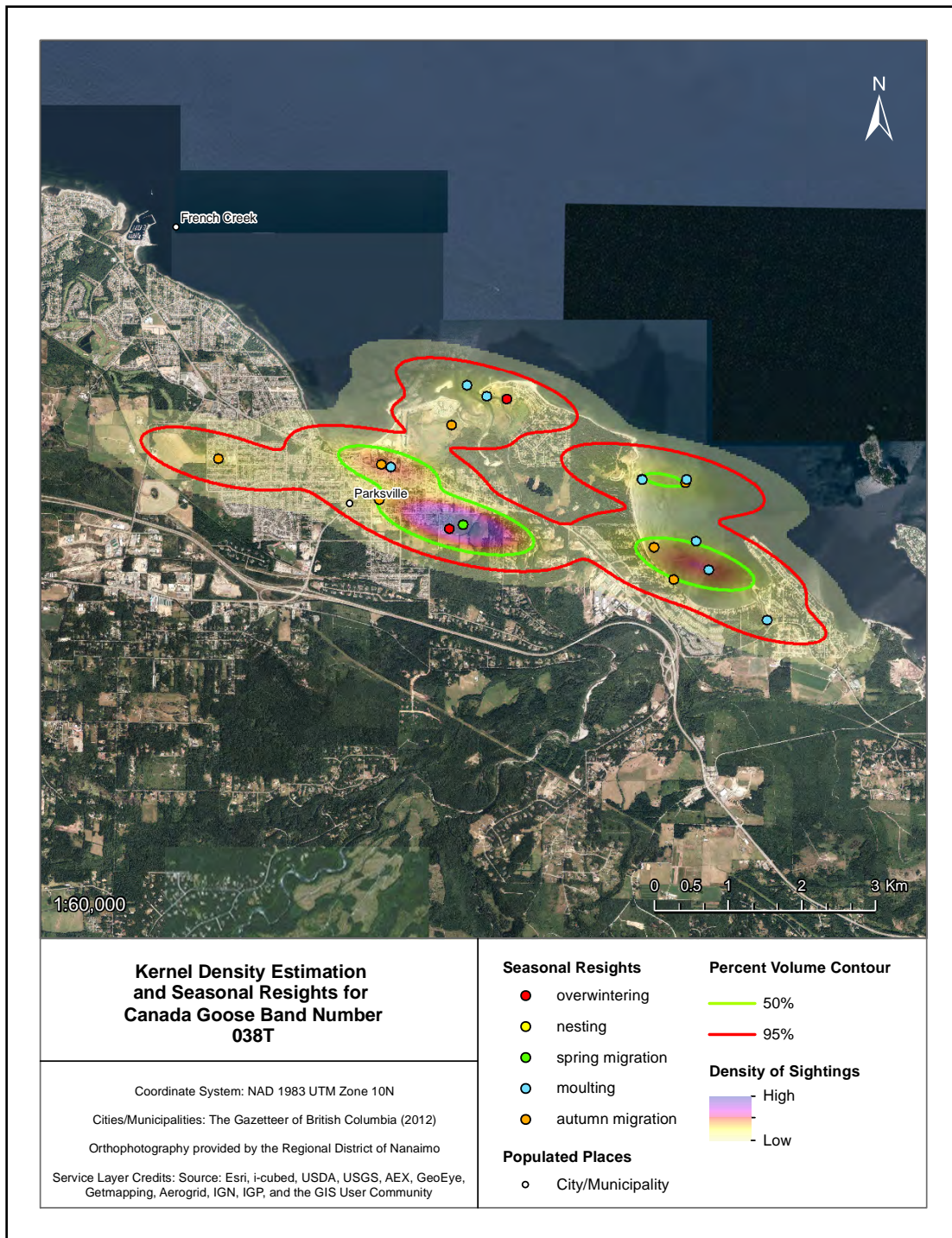
KDE map for Local Resident Plus A5E

Local Resident Plus

038T was banded at the CCE in July 2012. Its range during most of the year did not reach beyond the ERE and CCE estuaries and city limits. It used the estuaries for three consecutive moult seasons, and was not observed during the nesting seasons. 038T, and other Canada Geese that are absent only during the nesting season, may be local residents that nest outside of our search area.



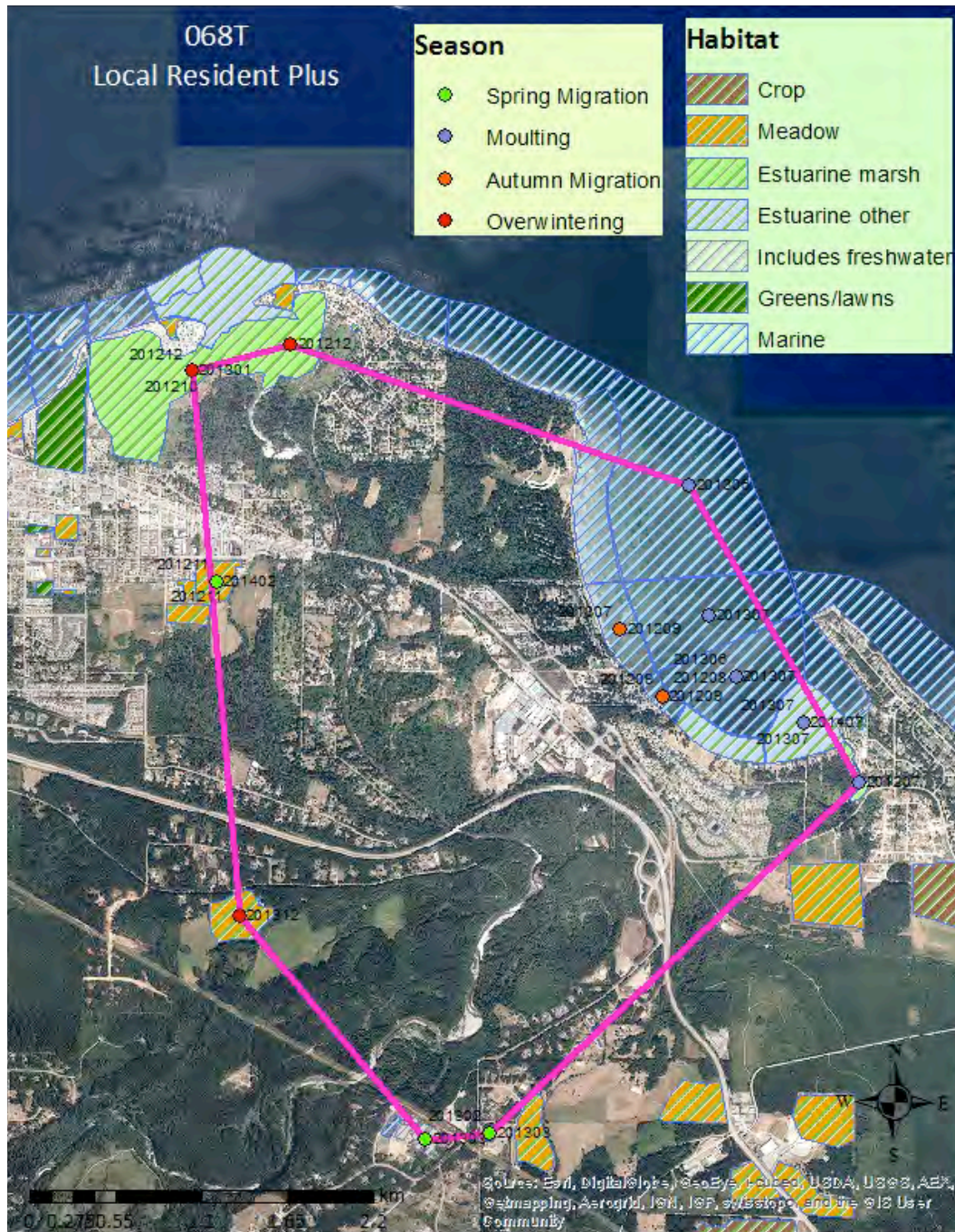
MCP map for Local Resident Plus 038T



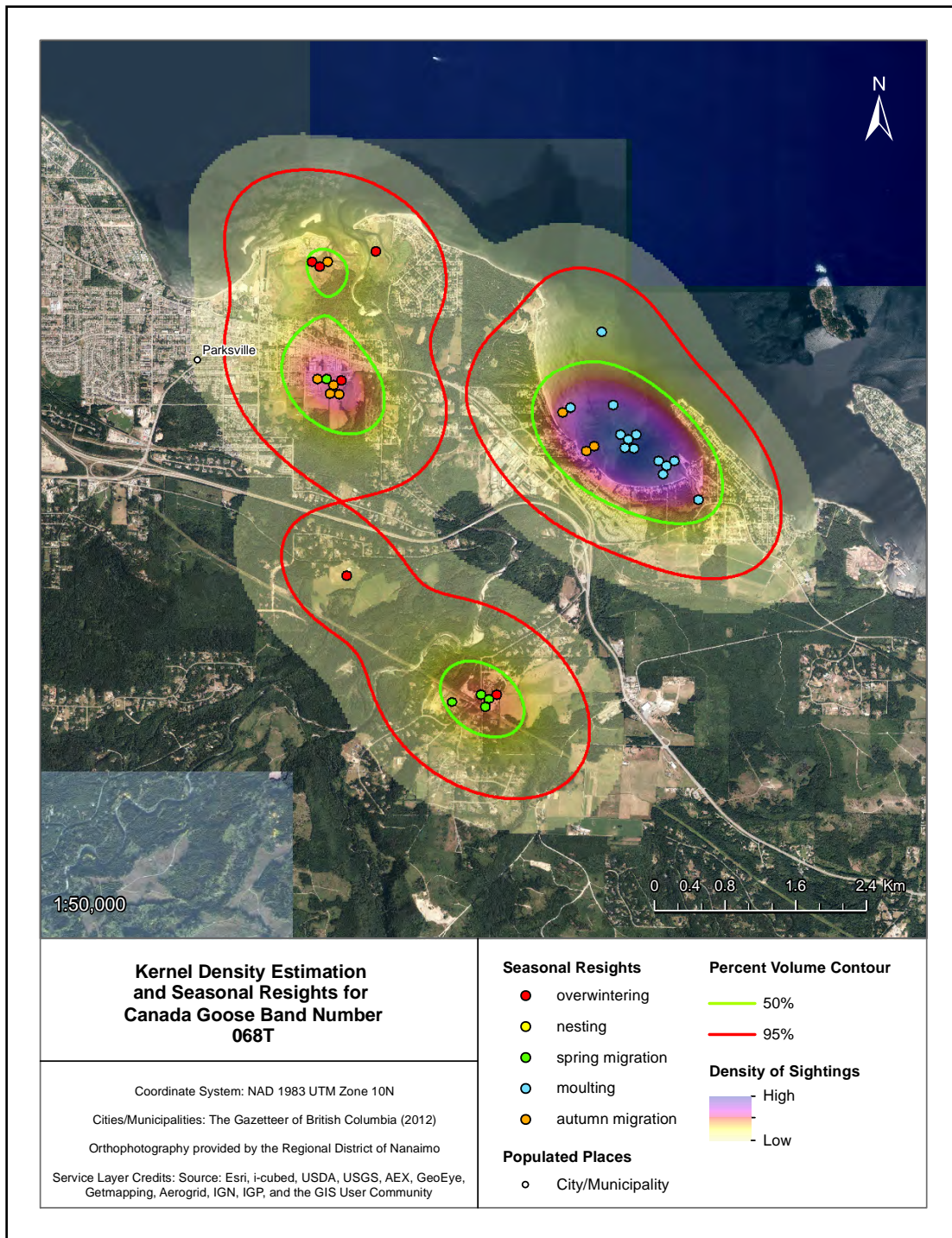
KDE map for Local Resident Plus 038T

Local Resident Plus

068T was banded at the CCE in July 2012. Aside from its frequent movements within the city and on the CCE and ERE, it was found in the River’s Edge community from January through March 2013, and in Errington in December 2013. There were no records for 068T during the nesting season.



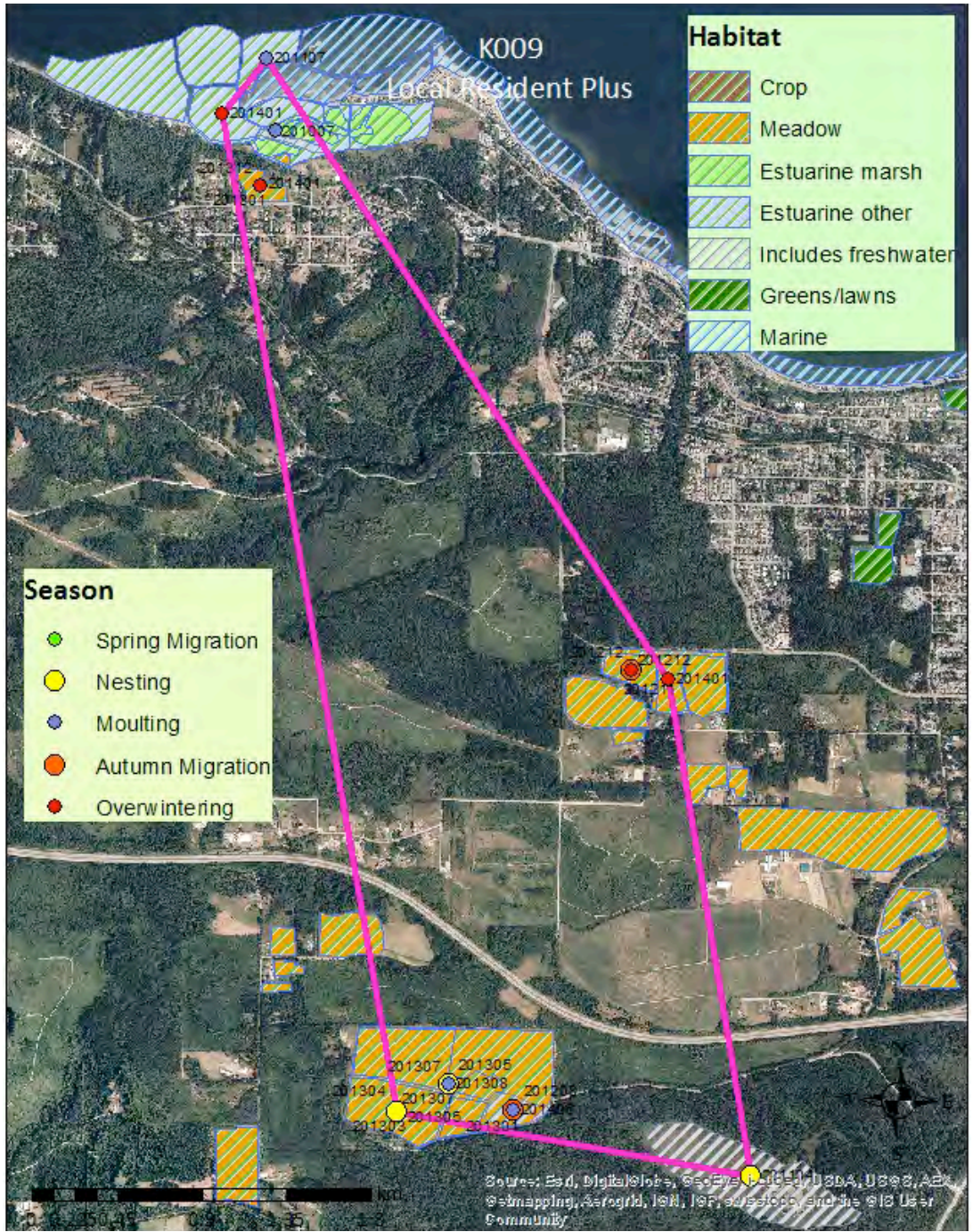
MCP map for Local Resident Plus 068T



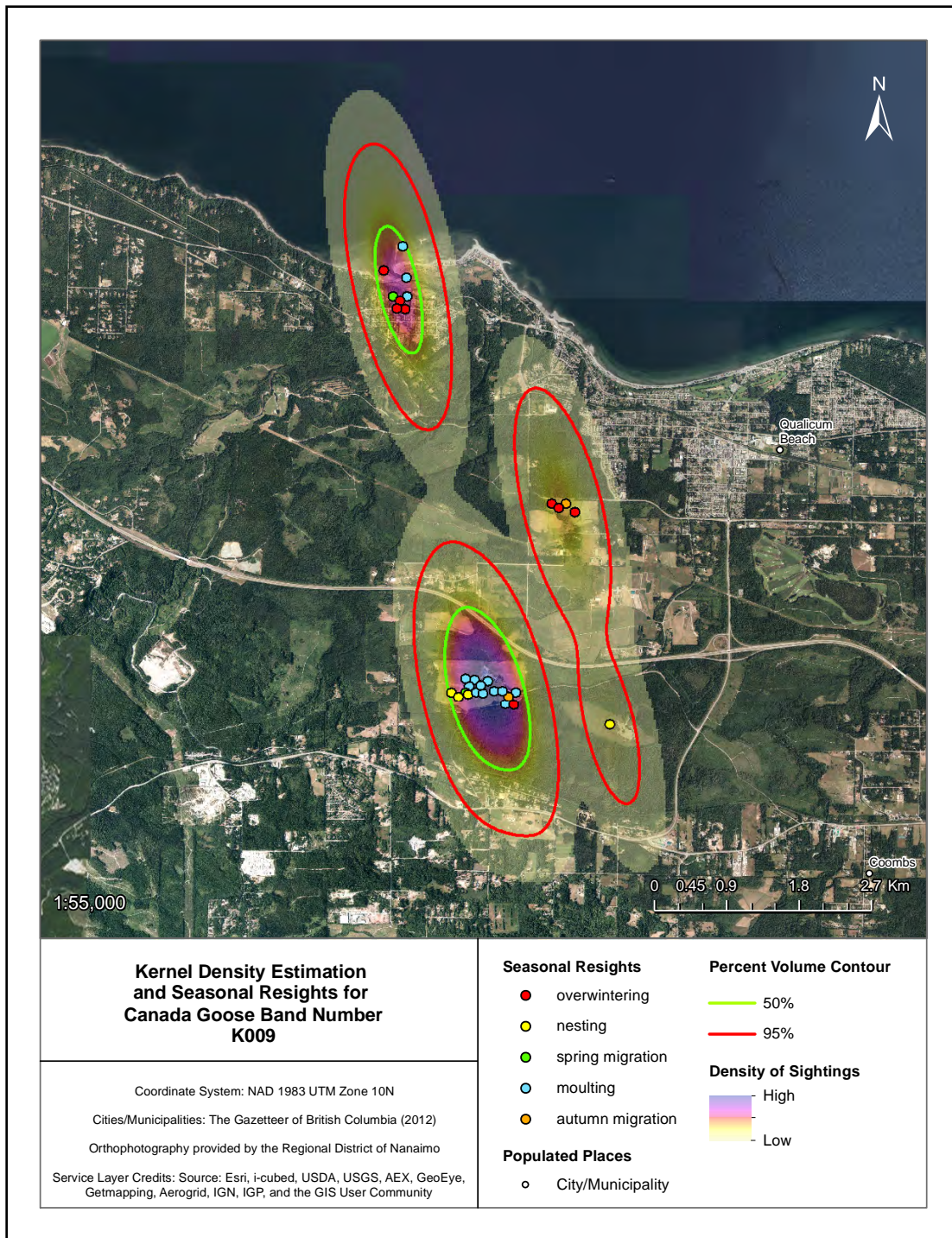
KDE map for Local Resident Plus 068T

Local Resident Plus

K009 was banded on the LQRE in 2010, and was observed at the LQRE again in July 2011 and January 2014. During most seasons, including the nesting seasons of 2011 and 2013, K009 was observed in the Hamilton Marsh/Sunnymere area.



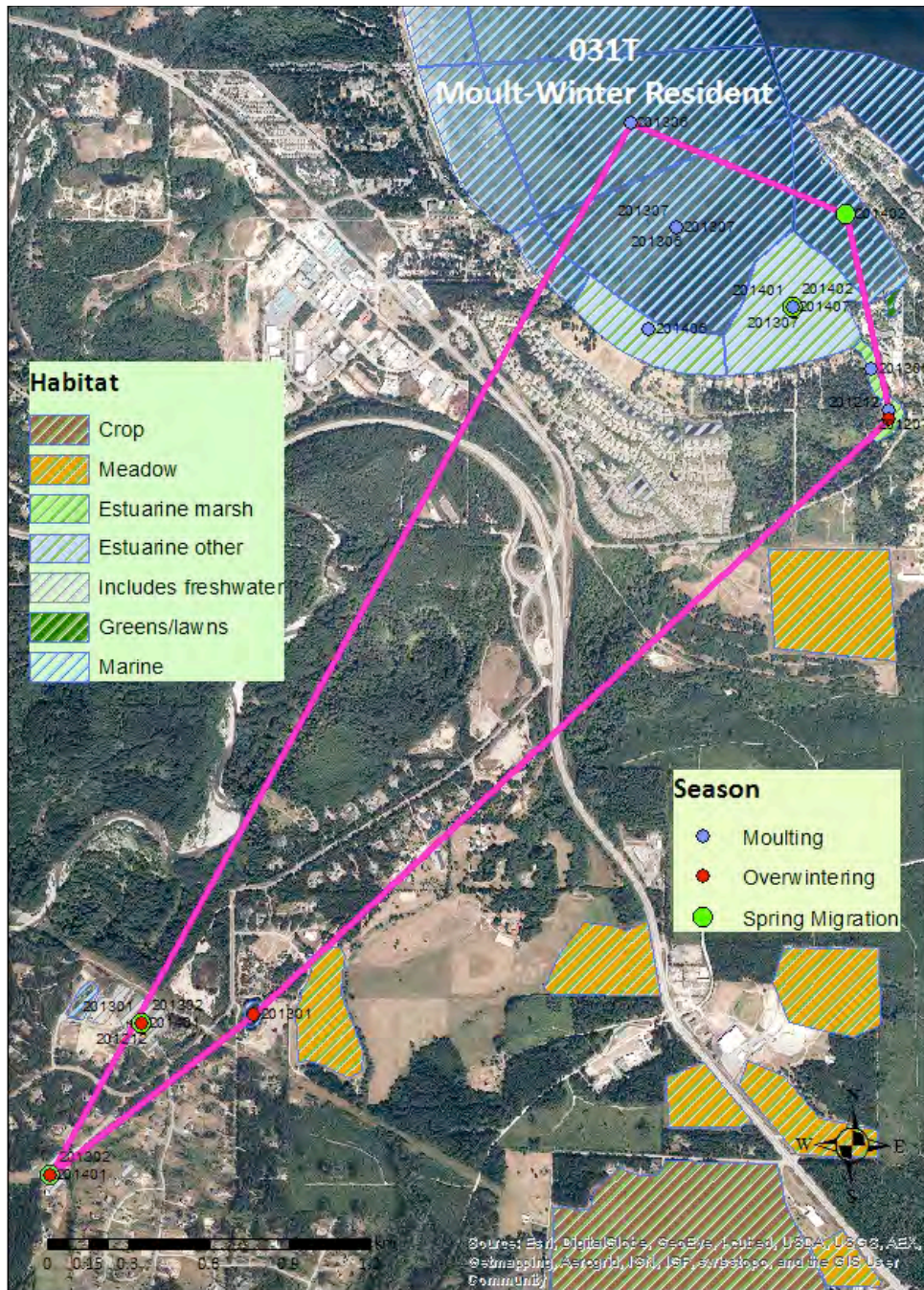
MCP map for Local Resident Plus K009



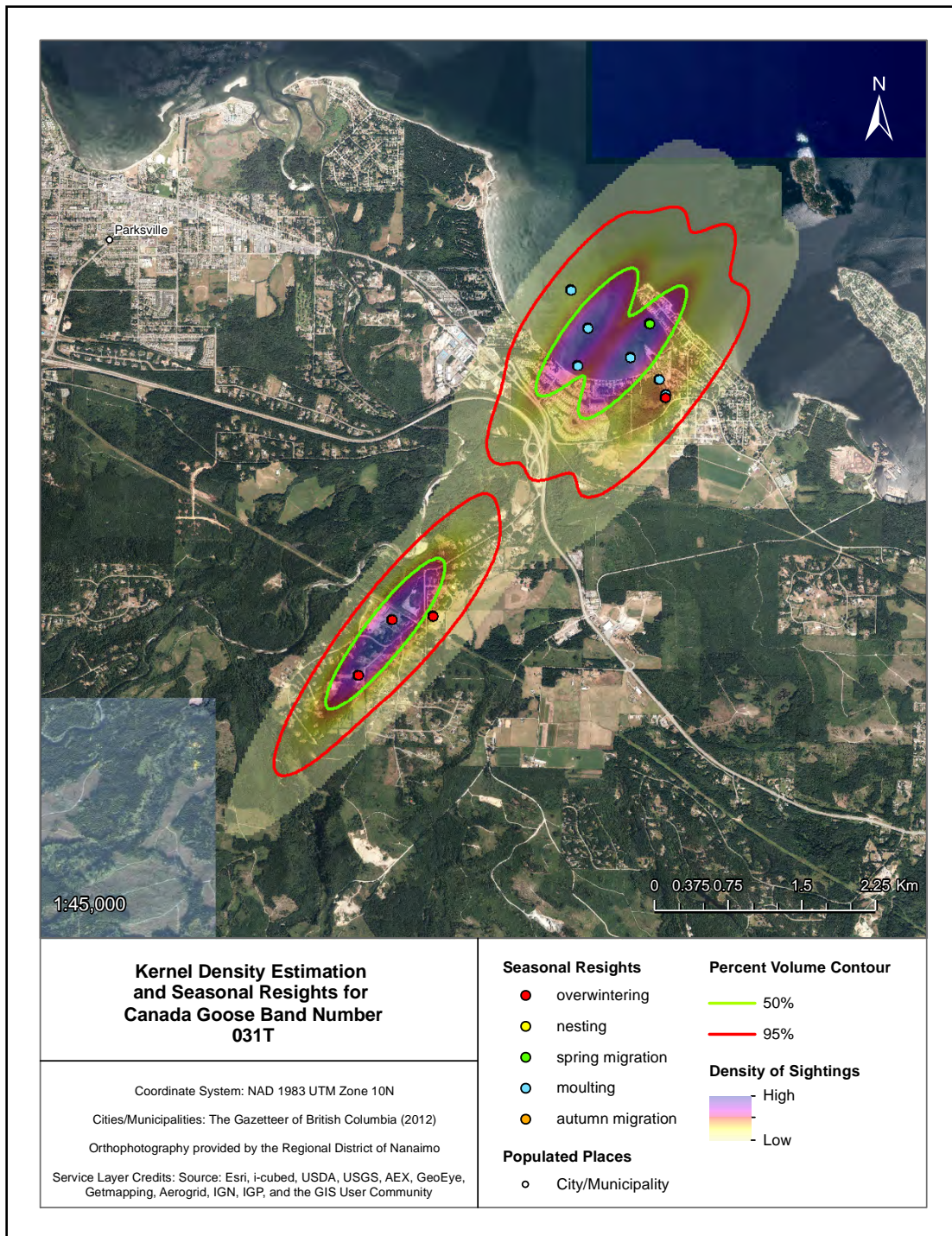
KDE map for Local Resident Plus K009

Moult-Winter Resident

031T was banded in July 2012 at the CCE. Since then, it has been observed in the area during the months of January, February, June, July, and December. In each of these months, 031T was found in the Craig Creek estuary/Craig Bay. It was also observed in Nanoose Bay’s River’s Edge community in December, January, and February.



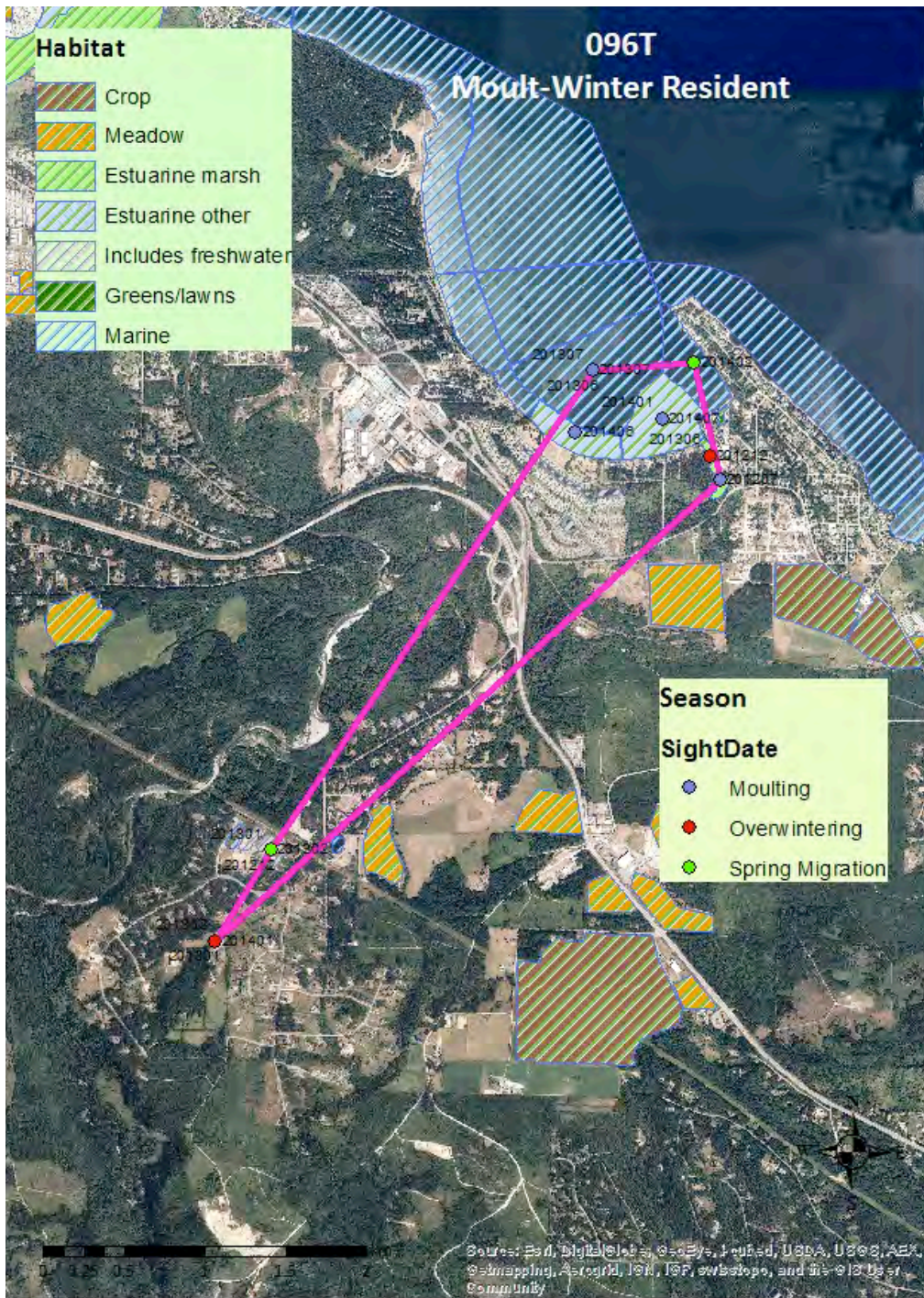
MCP map for Moulting-Winter Resident 031T



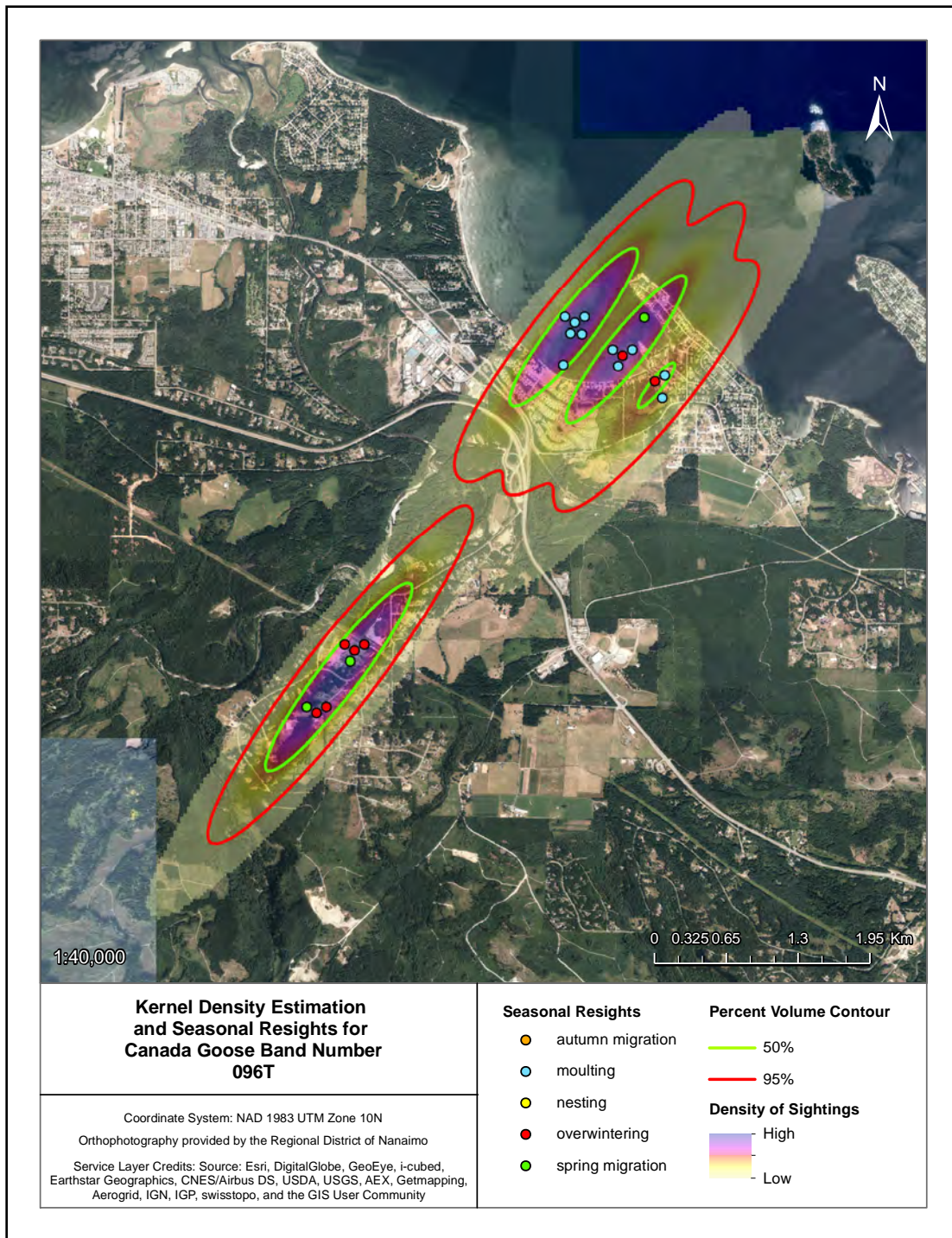
KDE map for Moulting-Winter Resident 031T

Moult-Winter Resident

096T was also a moult-winter resident. Its home range was similar to that of 031T.



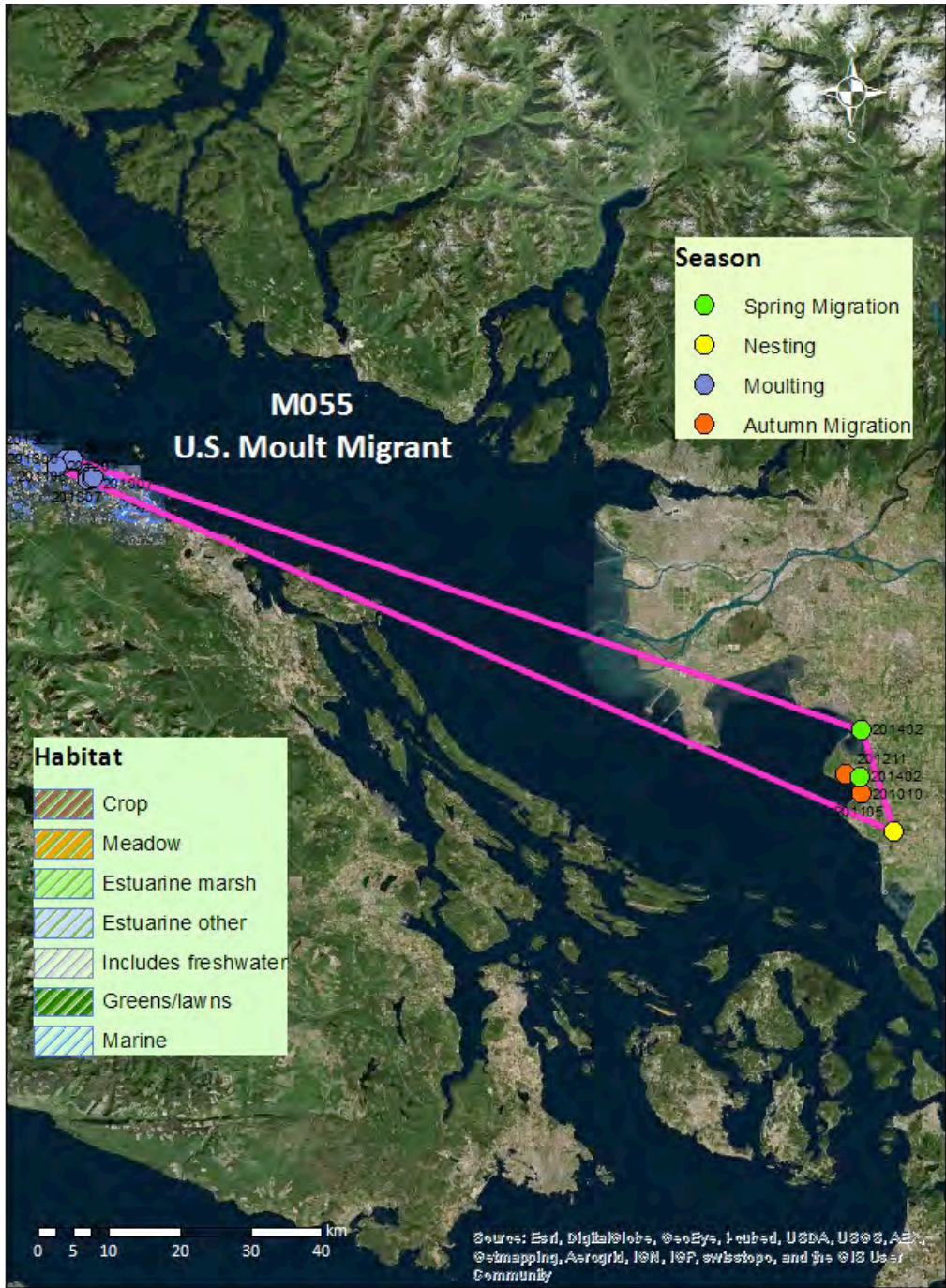
MCP map for Moulting-Winter Resident 096T



KDE map for Moulting-Winter Resident 096T

Moult Migrant

M055 was banded at the ERE in July 2010. It was spotted in Washington during the spring migration, nesting, and autumn migration periods. Still, it came back to the area (i.e., the ERE and CCE) to moult in 2011, 2012, and 2013.



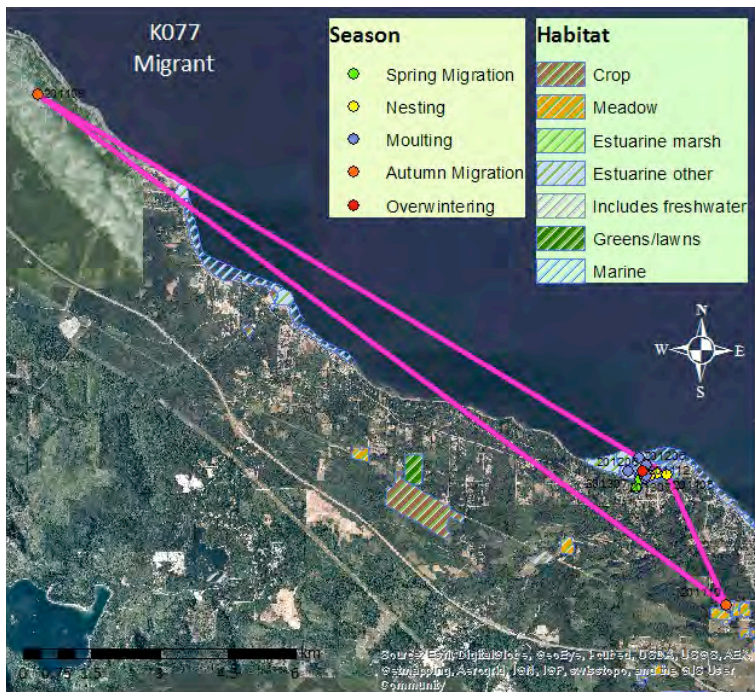
MCP map for Moulting Migrant M055



Re-sights for Moulting Migrant M055

Migrant

The movements of migrants were mostly unpredictable, and K077 is a good example of this. K077 was banded on the LQRE in July 2010. She nested on the edge of the mill pond at the LQRE in 2011, incubating 4 eggs. In September that year, she was observed northwest of Bowser, yet returned to the area in October. From mid-December 2011 through the end of May 2012, K077 was not encountered. She was seen regularly at the LQRE from June to October 2012, and then went missing until early March. In 2013, she returned and stayed on the LQRE from late March through July, but was not associated with an addled nest. K077 was last seen in the region at the LQRE in July 2013.



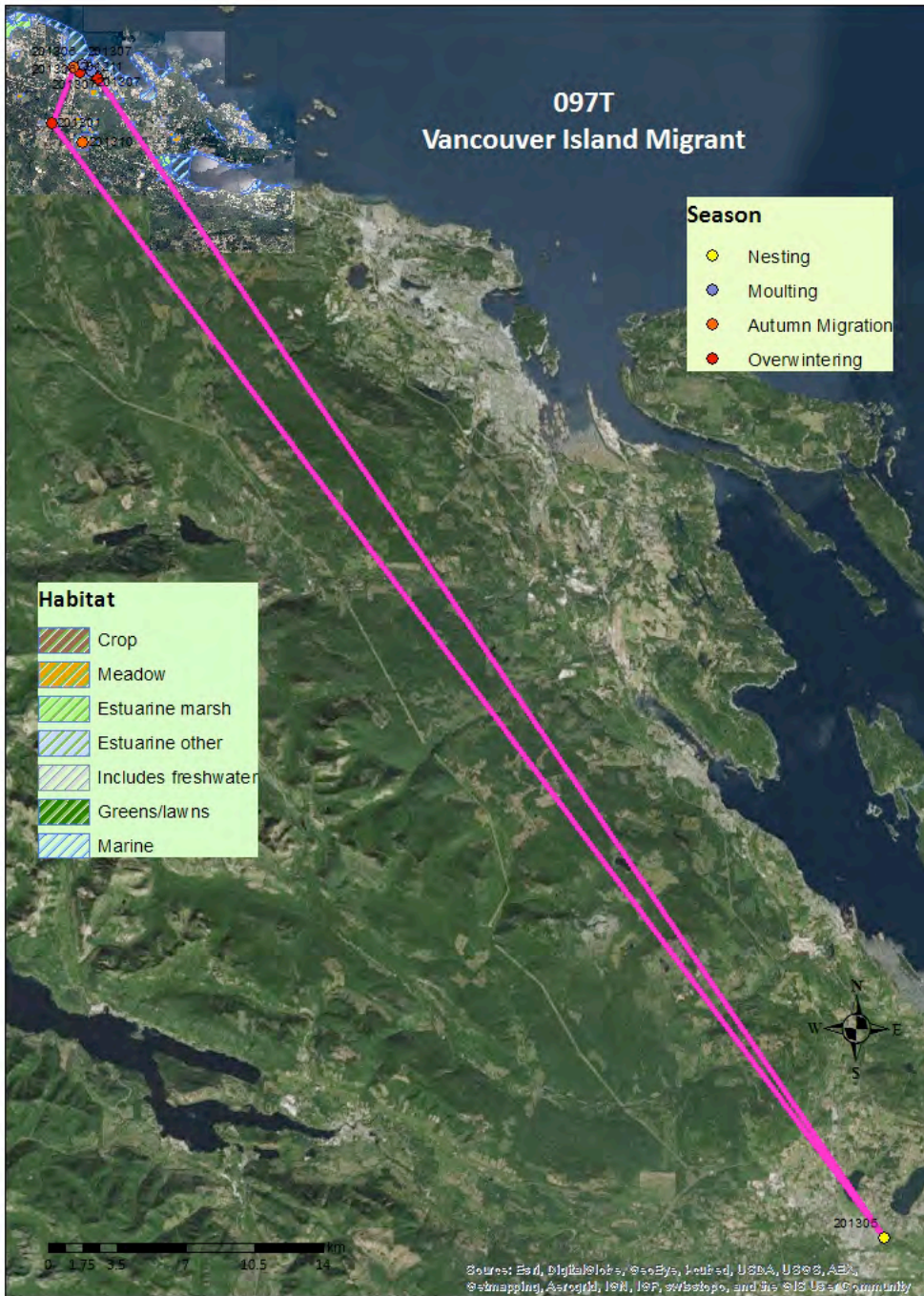
MCP map for Migrant K077



Re-sights for Migrant 097T

Migrant

097T was banded at the CCE in July 2012. It stayed in the area until at least January, then nested in the Cowichan Valley. By mid-June, it had returned to the CCE to moult. It was spotted in Nanoose Bay's River's Edge community in late October, 2013.



MCP map for Migrant 097T

U.S. Migrants and Moulting Migrants

Most of the 13 geese assigned a U.S. migrant type were re-sighted in America during the spring and fall migrations. Five were shot there, during all seasons aside from the nesting season.

CAGO	Spring Migration	Nesting	Moulting	Autumn Migration	Overwintering
022T - MM	California 2013	missing	CCE return 2013	NBCB 2012	NBCB Dec 2012-Jan 2013
024T	California 2013 shot	missing	banding only	NBCB 2012	NBCB, PBC 2012
066T - MM	California 2013	missing	CCE return 2013	NBCB 2012	NBCB Dec 2012-Jan 2013, Dec 2013
070T	Oregon 2014	NBCB end of May 2013	CCE return 2013	missing	missing
M027	missing	missing	Washington 2011 shot	Oregon 2010	missing
M042	missing	missing	banding only	Washington 2014 shot	missing
M043	missing	missing	banding only	missing	Oregon 2010 shot
M050	missing	missing	banding only	Washington	missing
M055 - MM	Washington 2014	Washington 2011	ERE return 2011, 2012, 2013	Washington 2010, 2012	missing
M058	missing	missing	Oregon 2011	missing	Oregon 2014 shot
M059	Oregon 2011	missing	banding only	Oregon 2010	missing
M063	Washington 2011	missing	banding only	Oregon 2010	Washington 2011 shot
M067	Washington 2011	missing	banding only	Washington 2010	missing