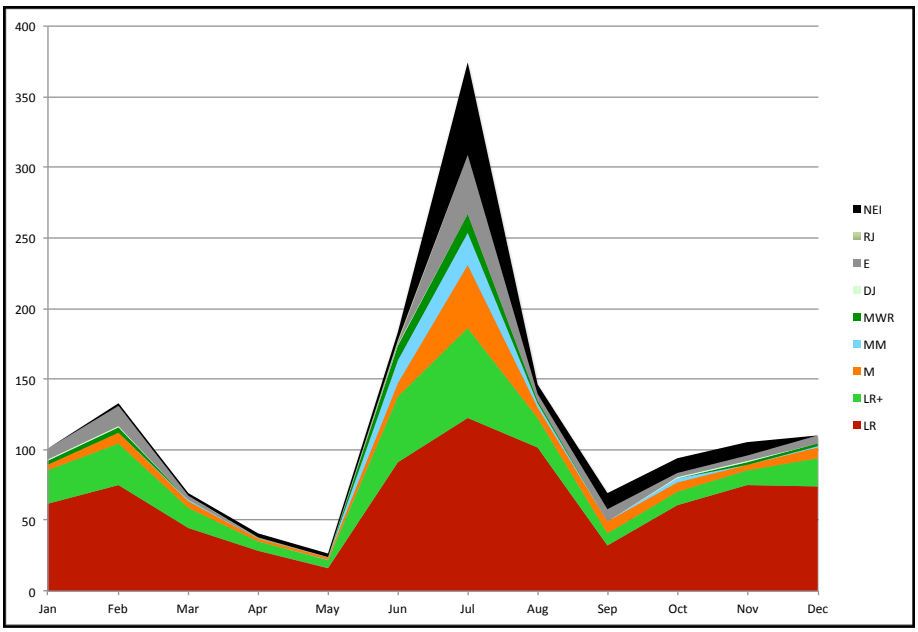
6.5 Relative Abundance of Migrant Types and Subpopulations

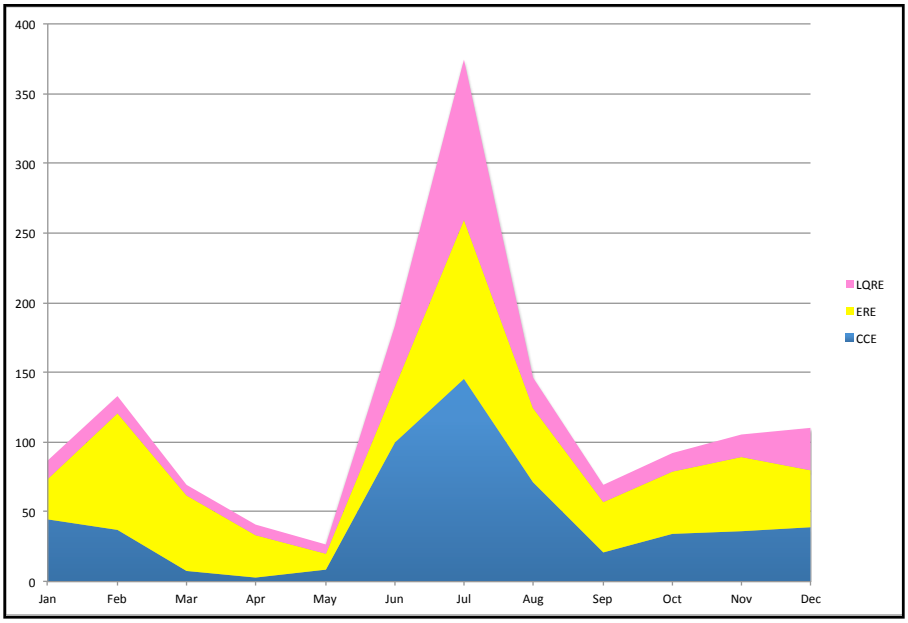


Local residents (LR) are the foundation of our year-round regional Canada Goose population, but other migrant types are always present (Figure 6-10).

Limitations

Limitations related to seasonal detection and sampling intensity/ survey effort are described in Appendix C.

Figure 6-10. Marked Canada Geese re-sighted each month, by migrant type, 2008-2014, corrected for sampling intensity (n = 4,731). Numbers along the "y" axis are relative, not absolute.



Compared to the other estuary-based subpopulations, fewer birds returned to the LQRE after the winter and to nest (Figure 6-11). Canada Geese marked at the ERE included a local resident cohort present throughout the year. CCE-marked birds were most plentiful in our area during the moult period.

Figure 6-11. Temporal distribution of Canada Geese banded at the Craig Creek estuary (CCE) (n=106), Englishman River estuary (ERE) (n=93), and Little Qualicum River estuary (n=97) (n marked Canada Geese = 296), corrected for sampling intensity. Numbers along the "y" axis are relative, not absolute. Counts have been summed for all years (2008-2014).

Chapter 7 - Canada Goose Seasons

Highlights

This chapter describes five Canada Goose 'seasons' that delimit the temporal distribution of marked geese, underpinning Goal 2 (setting temporal management objectives).

Although there is considerable overlap among Canada Goose seasons, we have delimited them as follows: spring migration = February/March, nesting = April/May, moulting = June to middle of August, fall migration = middle of August to end of November, overwintering = December/January.

Canada Goose Seasons

Canada Geese overwintering in the Craig Creek estuary, January 8, 2005

The Canada Goose life cycle consists of a series of 'seasons', including spring migration, nesting, moulting, fall migration, and overwintering. Finer life cycle descriptions include pre-nesting and brood-rearing periods. Table 7-1 divides the year into life cycle seasons; the first row shows hard boundaries between each period. In reality, these seasons overlap, as some birds begin nesting earlier than others, some linger at the moulting areas while others move on, and so forth. These 'true' seasons are also shown in the table.

Seasons were delimited mainly by examining the movements of marked birds. The nesting season was derived from observations made over 7 years of egg addling on the estuaries. Brood-rearing was determined based on a 25-28 day incubation period.

Table 7-1. Canada Goose seasons. The first row divides the year into an annual cycle encompassing overwintering, spring migration, nesting, moulting, and fall migration periods. In the rows below, entire, overlapping seasons have been delimited wherever possible.

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Over-wintering	Spring Migration		Nesting		Moulting		Fall Migration				Over-wintering
	Spring Migration: ends Mar 22										
	Pre-nesting: begins Mar 8										
			Nesting: Mar 30 - May 30		Laying (B.C.): March 13 to July 6 (*Birds of British Columbia,* Campbell et al. 1990). Peak laying April 1-14 (Dawe & Davies 1975).						
			Brood-rearing (hatch): April 24 - Jun 27		Brood-rearing from hatch to fledging (B.C.) April 15 to August 24 (*Birds of British Columbia ,* Campbell et al. 1990). Peak hatching May 6-19 (Dawe & Davies 1975).						
				Moulting: May 17 - Aug 22, most May 31- Aug 16							
Over-wintering: ends Feb 22									Overwintering: begins Oct 26, most after Dec 6		

Chapter 8 - Seasonal Distribution

Highlights

This chapter describes the seasonal distribution of marked geese. This information is instrumental for Goal 2 (setting temporal management objectives) and Goal 3 (setting spatial management objectives).

During the spring migration period, 11 of our marked birds were observed or shot outside of the region: in Victoria, the Saanich Inlet, Lower Mainland, Washington, Oregon, and California. During the nesting season, 5 marked birds were observed elsewhere: Campbell River, Bowser, Cowichan Valley, Maple Ridge, and Washington. During the moulting period, 4 marked birds were observed elsewhere: just outside of the biosphere region in Qualicum Bay, and in Campbell River, Washington, and Oregon. During the autumn migration period, 16 marked birds were observed elsewhere: Comox Valley, Gabriola Island, Chemainus, Saltspring Island, Lower Mainland, Alberta, Washington, and Oregon. In winter, 10 marked geese were found elsewhere: Courtenay, Denman Island, Bowser, Cowichan Valley, Washington, and Oregon.

The distribution of Canada Geese differs by season. During the spring migration, Canada Geese were widely dispersed over many different habitats, in mostly small flocks. There was very little overlap among subpopulations. During the nesting season, geese were paired or in small flocks on the estuaries, or on other sites with freshwater, such as Hamilton Marsh. Again, there was very little overlap among subpopulations. During the moult, geese were found almost exclusively in estuarine, marine, and freshwater habitats. While the other subpopulations were observed mainly in 'usual' areas (e.g., LQRE-banded birds at the LQRE, Qualicum Beach, Hamilton Marsh, and Sunnymere Farms; ERE-banded birds at the ERE and in Parksville), CCE-banded birds were widely distributed along coastlines from north Lantzville to Qualicum Beach. In autumn, Canada Geese were more scattered and the subpopulations more mixed than they had been earlier in the year. In autumn, the greatest daytime concentrations of geese were on agricultural fields. Many geese also fed in urban and peri-urban fertilized grassy habitats, particularly those associated with freshwater. Distributions in winter were similar, yet flocks were more frequently observed in the estuaries during the day. In both fall and winter, estuaries were preferred roosting and loafing/ resting sites.

Birds arrive on the nesting grounds in family units and quickly disband. Older, more dominant females nest earlier than young ones, and pairs that nested the previous year typically reclaim the same nest site. If suitable sites are unavailable, other breeding geese may forego nesting rather than venture far from the place where they were hatched. Yearlings and juveniles gather at the edge of the nesting territories. One and two-year old females may attempt to pair-bond or mimic older birds by building and tending nests. Juvenile ganders often disperse.

Citations, excluded here for brevity, can be found in the text of the document's chapters. Please do not cite highlights without consulting the chapters.

Chapter 8 - Seasonal Distribution

More Highlights

If the first clutch is destroyed, pairs may re-nest. From 2008 through 2014, only 3 marked pairs were known to re-nest. Then in 2015, 3 re-nests were discovered. Rather than re-nest, failed nesters may linger near the nest site and then form flocks with non-breeding geese, and still others may leave the area before moulting.
Prior to the moulting period, some Canada Geese leave their nesting grounds and travel considerable distances north (40 to 2,500 km or more) to favoured moulting sites in what is known as a moult migration. Most moult migrants are believed to be non-breeding geese, unsuccessful nesters, and pairs that have lost their broods. Thirteen of our marked birds were moult migrants from other areas, (e.g., from the Cowichan Valley, Victoria, Washington, and California), and one marked bird migrated to Campbell River to moult. Management techniques that cause nest failure, such as addling, may induce moult migration, reducing pressure on local moulting habitat but potentially increasing nuisance populations in other areas.
Migratory geese are attracted to areas where local residents gather, and within a few days can have a major impact on those habitats.
Estuaries are critical habitat for Canada Geese and other waterfowl when other areas are frozen.

Citations, excluded here for brevity, can be found in the text of the document's chapters. Please do not cite highlights without consulting the chapters.

8.1 Spring Migration and Pre-nesting

During the spring migration, northern-breeding migrants travel from overwintering areas, mainly in the continental U.S., to nesting grounds in arctic and sub-arctic regions (CWS 2010). They typically leave their wintering grounds in late February and early March, linger in southern Canada to feed, and arrive in northern Canada in mid-May and early June (Howard Breen 1990; CWS 2010). This potentially places them in our area from late March to the end of April (Campbell et al. 1990; CWS 2010). Our understanding of these birds is limited, as they would not be nesting on the estuaries, nor present during the moult; none should have been banded during our study.

During the spring migration/ pre-nesting season, 11 of our banded birds, marked during the nesting and moult periods, were observed or were shot by hunters on other parts of Vancouver Island (052T in Victoria, 006T and 053T in the Saanich Inlet), on the Lower Mainland (120T in Pitt Meadows), and in Washington (M055, M063, M067), Oregon (070T, M059), and California (022T, 066T) (Figure 8-1). There were no re-sights north of the study area. The earliest arrival date for these birds was May 20, suggesting none of them were northern-breeding migrants (Table 8-1).

Figure 8-1. Spring migration (February/March) re-sights of marked Canada Geese, 2008-2014.

Table 8-1. Arrival dates of marked birds found outside of the region during the spring migration/pre-nesting period.

Canada Geese	Earliest Arrival Dates in the Region	Observed Elsewhere
006T	May 20, 2014	Saanich August 22, 2012 and March 16, 2013
022T	June 14, 2013 (was here until January 26, 2013 - local sightings in July, September, December 2012)	California March 2 and 22, 2013
052T	June 14, 2013	Victoria February 11, 2013 and West Saanich/Saanich Peninsula October 10 and 18, 2014
053T	no evidence of arrival/return since banding	Saanich August 22, 2012, Saanich Inlet March 2013, and October 10, 2014
066T	June 11, 2013	California March 2 and 22, 2013
070T	no arrival recorded after OR sighting	Oregon February 28, 2014
120T	N/A, shot in Pitt Meadows	Pitt Meadows February 26, 2013
M055	June 16, 2011; June 26, 2012; June 14, 2013	Washington October 23, 2010; May 6, 2011; November 12, 2012; February 5 and 6, 2014
M059	no arrival recorded after OR sighting	Oregon September 30, 2010; February 5, 2011;
M063	N/A, shot in Washington	Oregon September 30, 2010; Washington March 2 and December 21, 2011
M067	N/A, shot in Washington	Washington October 23, 2010; November 6, 2010; March 18, 2011

Although our migratory birds were too few to detect weather-related patterns, the timing of spring migration is known to closely follow weather variations. This has been shown to be most evident in migrants that travel only short distances (Lehikoinen, Sparks, & Zalakevicius 2004).

Increasingly, earlier arrival dates in the majority of migratory species are attributed to climate change (Lehikoinen, Sparks, & Zalakevicius 2004). Birds are known to react quickly to environmental changes, and to precipitate further changes in ecosystems by spreading seeds, diseases, etc. (Böhning-Gaese & Lemoine 2004). Our data do not cover a sufficient time period to detect shifts in arrival dates.

Within the study area, Canada Geese were found at all estuaries during the spring migration/pre-nesting period (Figure 8-2). LQRE and CCE birds were widely distributed, yet there was relatively little overlap among subpopulations. ERE birds were concentrated in the City of Parksville.

Spring migrants, in contrast to fall migrants, travel in smaller flocks over a longer period of time (Howard Breen 1990). The flocks are family units comprised of goose, gander, last year's goslings (i.e., yearlings), two or three year-old juveniles, and individuals that have lost their mates or had failed to pair-bond (Howard Breen 1990). They may migrate during the day or at night (Granholm 1988).

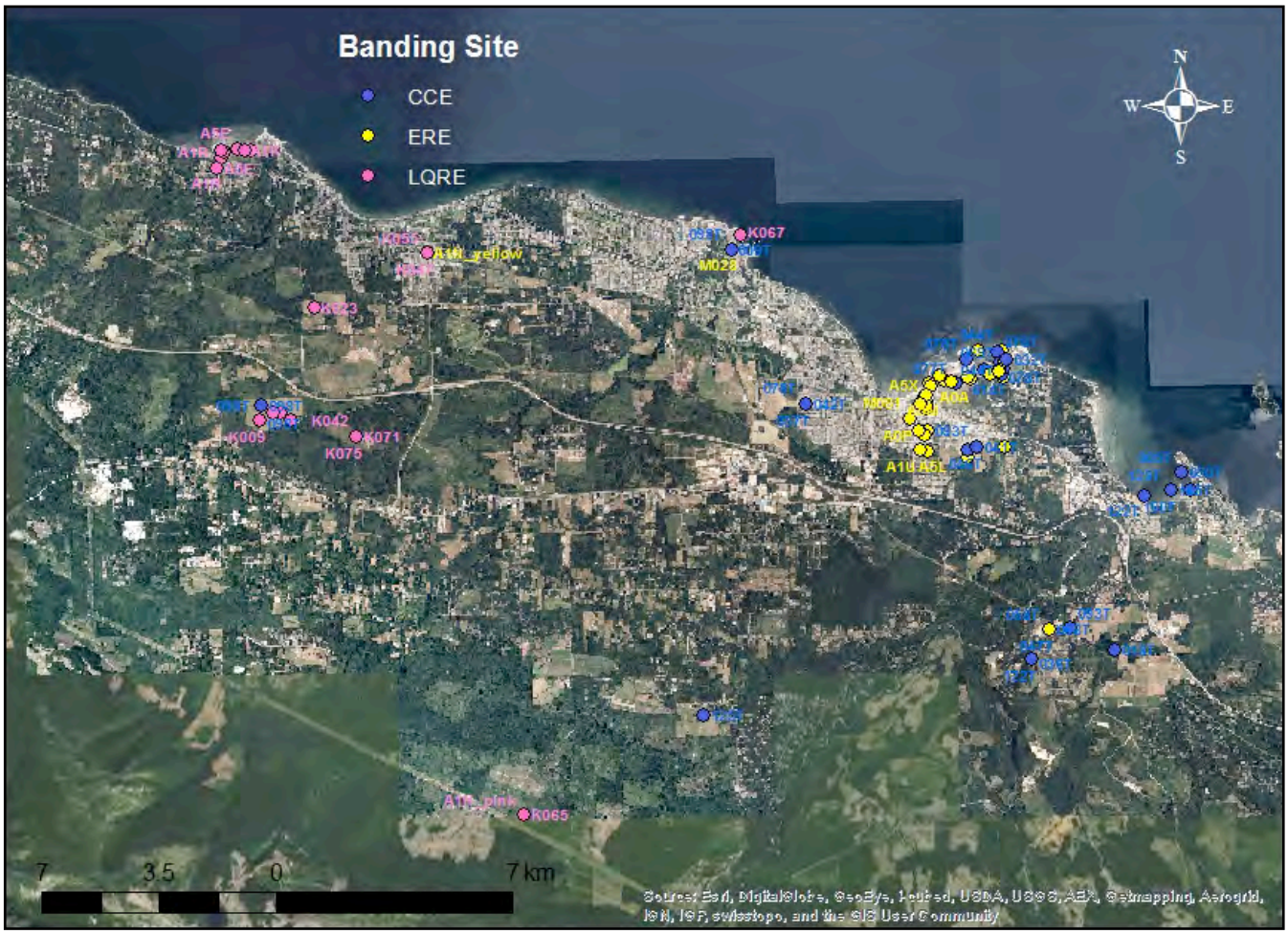


Figure 8-2. Spring migration/pre-nesting (February/March) re-sights of marked Canada Geese in the study area, 2008-2014

Local resident Canada Geese act as decoys, drawing long-distance migrants into the area (Smith, Craven, & Curtis 1999). Pairs, which typically mate for life, home to the female's natal area to breed (Bellrose 1976; Cooper 1978; Johnson et al. 1992, and many others). By the time the birds arrive on their nesting grounds, they have completed courtship, pairing, and copulation (Howard Breen 1990). Family units disband within a day or two of arriving (Brakhage 1965).

During spring migration (and possibly during the overwintering period), migratory Canada Geese alter their diets to change their body composition and gain body weight (Krapu & Reinecke; Martin & Guignion 1983). The goose acquires most of the protein needed for reproduction at these times. Krapu and Reinecke (1992), synthesizing data from many different sources, reported that spring migrants spend about 80% of their daylight hours feeding to build up fat reserves which will progressively deplete during the nesting season.

Early on, food availability may be restricted primarily to the underground portions of plants (USFWS 2002). Importantly, grubbing and subsequent damage to the estuarine marsh platform is more likely to occur when palatable, aboveground vegetation is unavailable.

In a study of migrating geese in Prince Edward Island, Martin and Guignion (1983) noticed a distinct feeding pattern in the spring. During the first two weeks of their stay, the birds were more confined to the estuary, lingering for 1-4 hours after sunrise before flying elsewhere. After the two weeks, they congregated near the centre of their estuarine roosting site just after dawn, and began leaving in small groups to feed in nearby fields. Flocks moved from one field to another at least once each day, progressively inland as food resources were depleted. After many fields were cultivated, they returned to the estuary by midmorning to loaf and feed on the marshes (Martin & Guignion 1983).

In our region, there were many small flocks, with concentrations at the LQRE, ERE, Nanoose-Bonnell estuary, and Sunnymere fields - suggesting many Canada Geese had arrived on their nesting grounds (Figure 8-3). Large flocks were observed in a variety of habitats, including meadow (Windhaven Farm adjacent to the LQRE, Sunnymere fields, Stanford Avenue field), estuarine marsh (French Creek), marine (Craig Bay east), and greens/lawns (Ballenas Secondary sports fields, lawn adjacent to the Nanoose estuary).

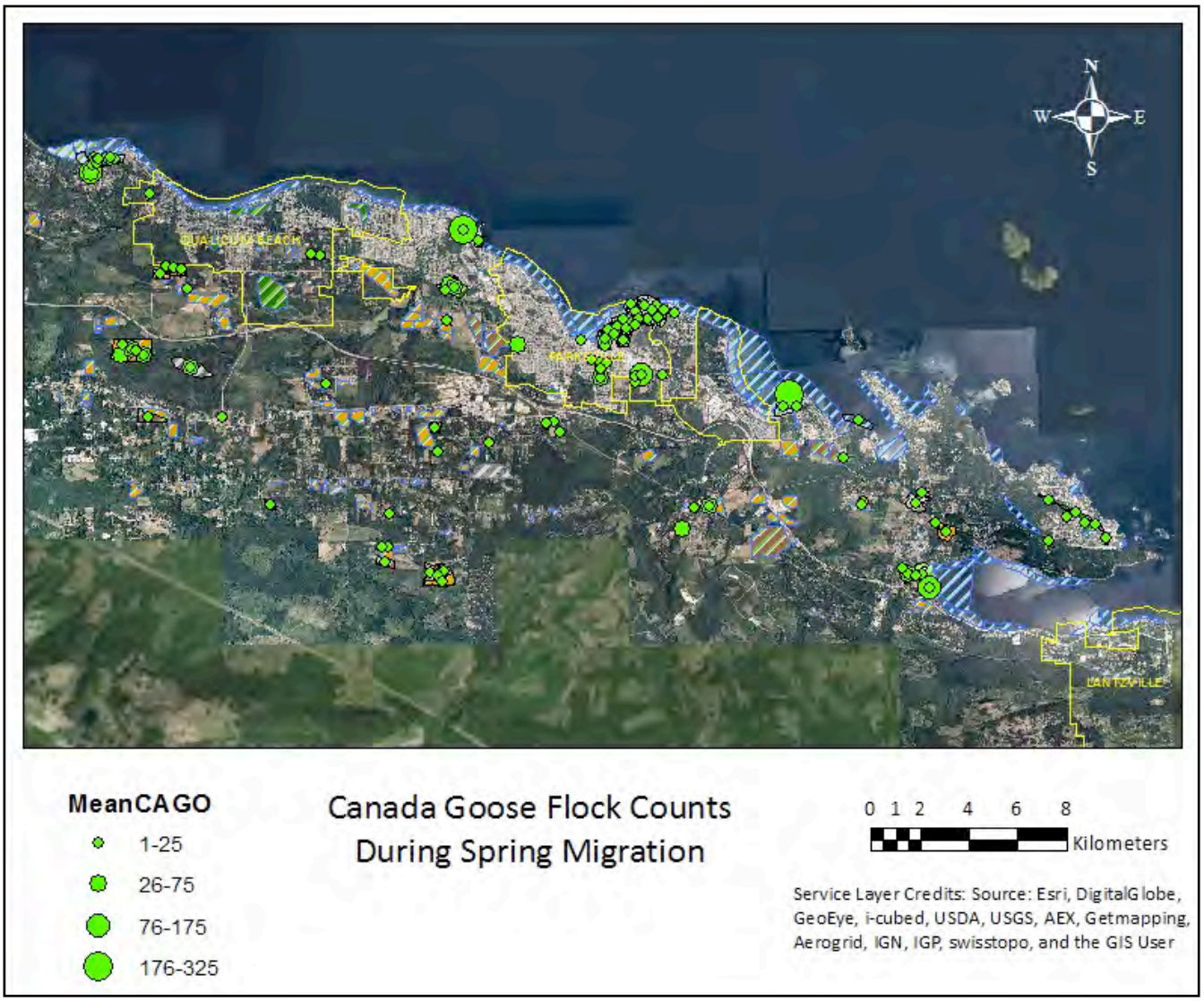


Figure 8-3. Canada Goose flock counts during spring migration, weighted for number of surveys (n=875).

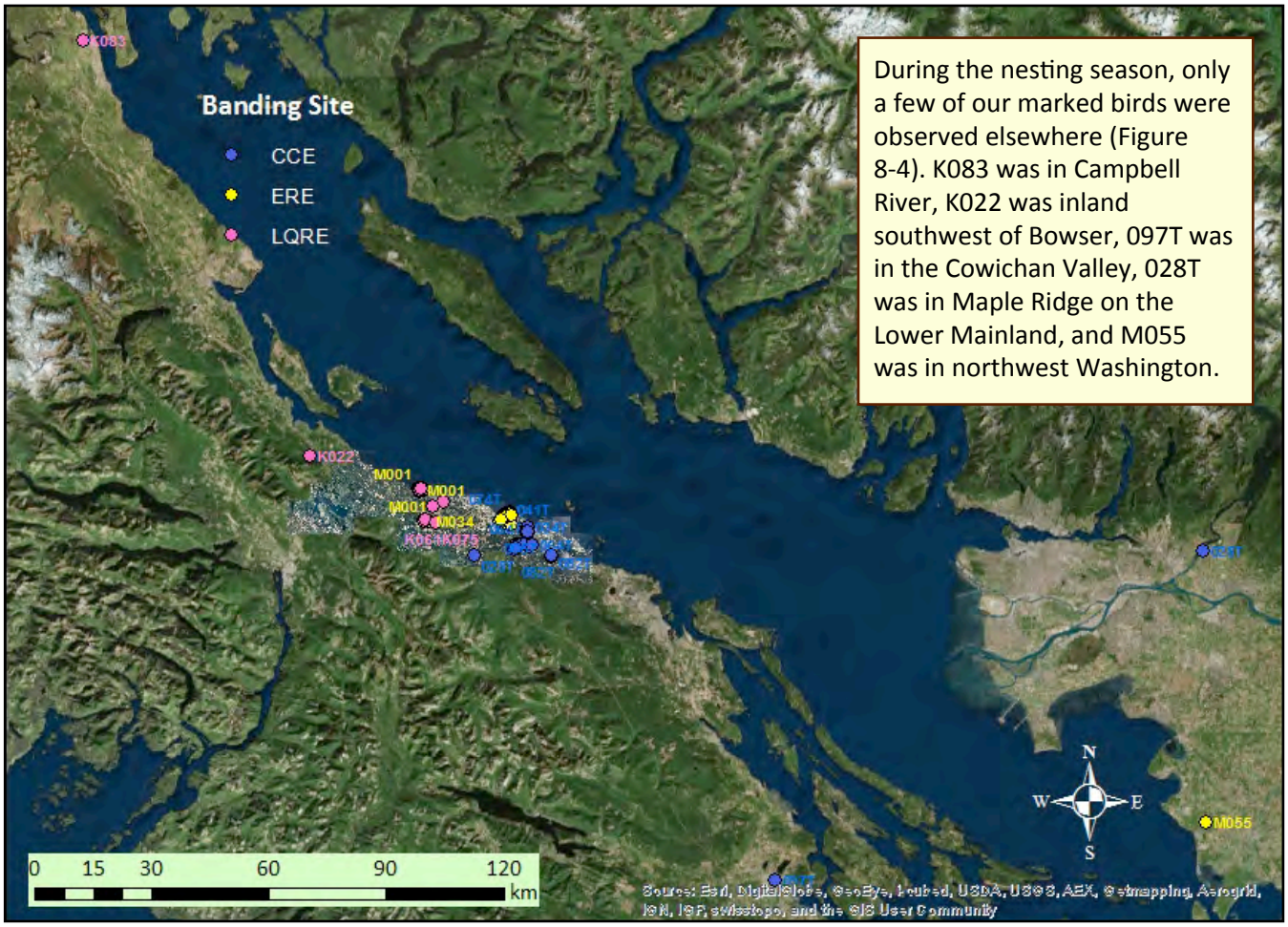
8.2 Nesting

Canada Geese are the earliest of all waterfowl to breed (MoE, 1979). They may begin defending territories up to 6 weeks prior to egg laying (Brakhage 1965). Canada Geese that nested in southwestern B.C. typically established nesting territories by mid-March (CWS 2010).

Conflict over nest sites begins as soon as the flock arrives on the nesting grounds (Howard Breen 1990). The most aggressive birds hold the largest territories (Brakhage 1965). Brakhage (1965) found that territory size decreased as incubation progressed; Cooper (1978) disputed this, albeit anecdotally.

Pairs that nested the previous year typically reclaim the same nest site. Other breeding females try to nest near the place where they were hatched (Granholm 1988). If suitable sites are unavailable, geese may forego nesting that season, rather than venture far from the original site (Howard Breen 1990).

Young or inexperienced geese begin nesting later than older females, perhaps because of the time taken to establish territories, or because older birds are in better condition, as the condition of the female is known to influence the timing of nesting (Perrin & Birkhead 1983; Johnson et al. 1992). Brakhage (1965) found that females 5 years and older arrived on the nesting grounds earliest, and began laying first; laying followed an age-based hierarchy of dominance among females. The size of family groups is also linked to hierarchical position (which is probably correlated to the age of the dominant female) (Raveling



During the nesting season, only a few of our marked birds were observed elsewhere (Figure 8-4). K083 was in Campbell River, K022 was inland southwest of Bowser, 097T was in the Cowichan Valley, 028T was in Maple Ridge on the Lower Mainland, and M055 was in northwest Washington.

Figure 8-4. Nesting season (April/May) re-sights of marked Canada Geese, 2008-2014.

1970 in Anderson & Titman 1992). Weather (e.g., cold or hot temperatures, wind, rain) also affects the timing and occurrence of nesting (Johnson et al. 1992).

Yearlings and juveniles gather at the edge of the nesting territories (Granholm 1988). One and two-year old females stay near the natal area (Johnson et al. 1992). They may try to mimic older birds, attempting to pair-bond or build and tend nests. The next year, they may return to the same site to nest in earnest (Granholm 1988). Yearlings and unpaired males often disperse (MoE 1979; Johnson et al. 1992).

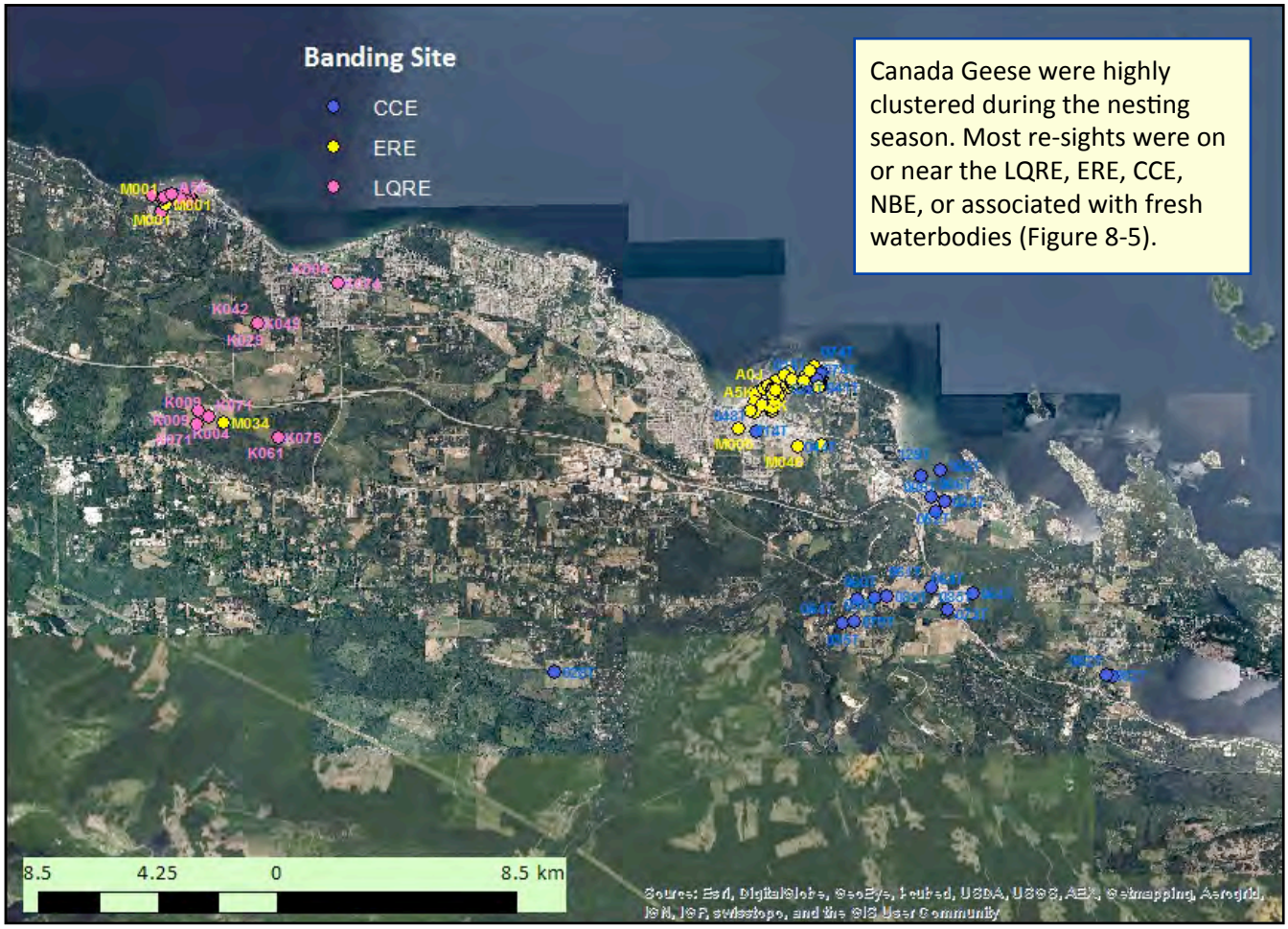


Figure 8-5. Nesting season (April/May) re-sights of marked Canada Geese in the study area, 2008-2014.

Nesting Canada Goose, April 21, 2011. Photo by Danielle Morrison.

Figure 8-6. Nesting season (April/May) re-sights of marked Canada Geese at the Little Qualicum River estuary, 2008-2014.

Aside from M001, which was banded at the ERE, all marked birds observed at the LQRE had been banded there, i.e., they were marked with K-collars or pink leg bands (Figure 8-6).

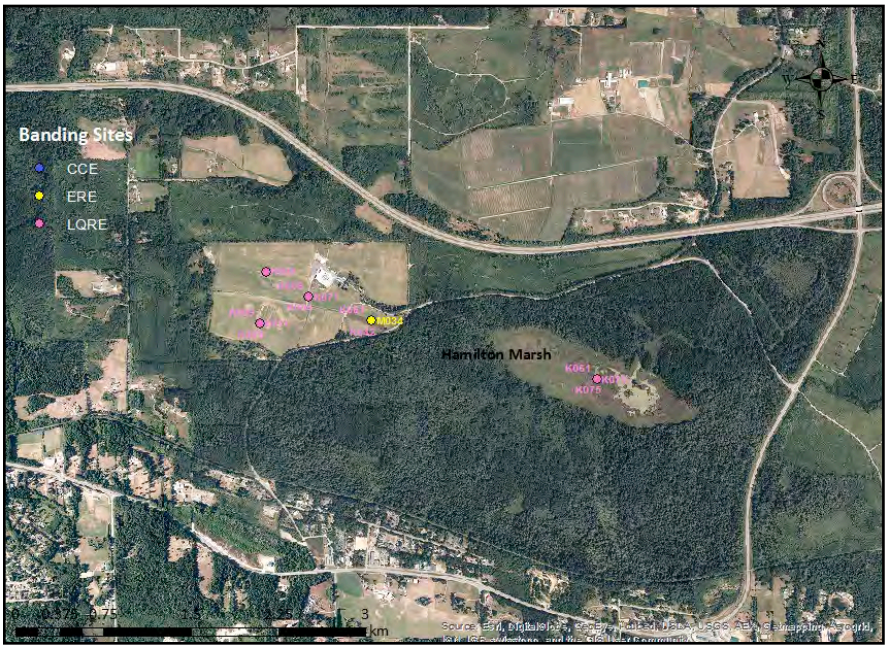


Figure 8-7. Nesting season (April/May) re-sights of marked Canada Geese in the vicinity of Hamilton Marsh, 2008-2014.

LQRE-banded Canada Geese were also found at Hamilton Marsh and Sunnymere pond during the nesting season, together with a single ERE-banded bird (Figure 8-7).

Figure 8-8. Nesting season (April/May) re-sights of marked Canada Geese at the Englishman River estuary, 2008-2014.

At the ERE, most observations were of M-collared or yellow leg-banded Canada Geese (Figure 8-8). Thirteen CCE-banded birds also nested at the ERE, including 6 paired with one another, and one paired with an ERE-banded bird. The lone LQRE-banded bird found on the ERE during the nesting season was a returned juvenile; it was observed April 17, 2013 at the ERE, then found at the LQRE on May 2, 2013. Outliers, e.g., Canada Geese found in downtown Parksville, were comprised of local resident, emigrant, migrant, U.S. moult migrant, and perhaps other migrant types.

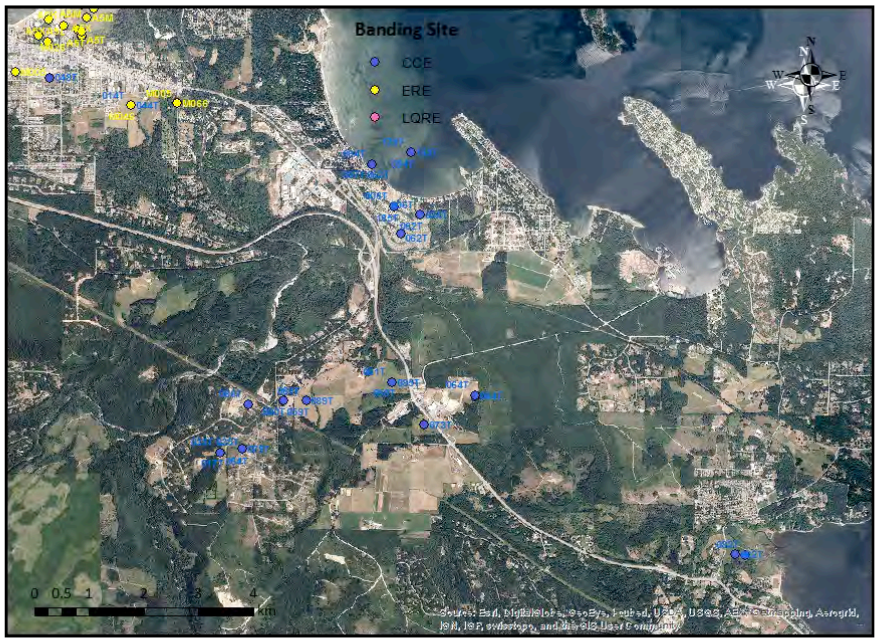


Figure 8-9. Nesting season (April/May) re-sights, 2008-2014, of Canada Geese marked at the Craig Creek estuary estuary.

CCE-banded Canada Geese were also found near the CCE, at the NBE, within Nanoose Bay's River's Edge community (Figure 8-9), and at the French Creek estuary.

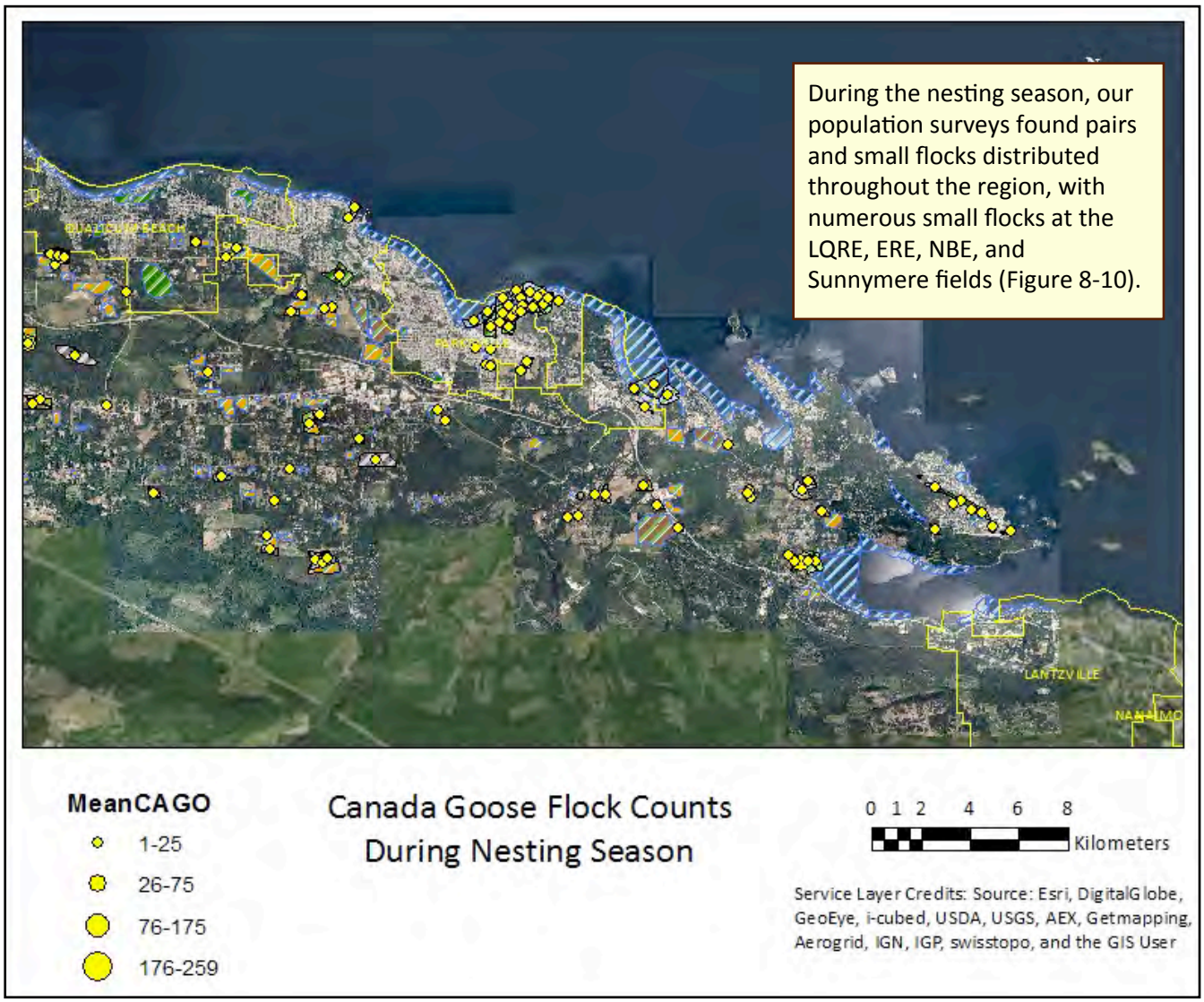


Figure 8-10. Canada Goose flock counts during the nesting season, weighted for the number of surveys (n=570).

Pair of Canada Geese defending their nest, Englishman River estuary, April 21, 2011

Goose nest in a stump at the Little Qualicum River estuary, 2013

Typically, egg-laying begins by the end of March and continues into late May (CWS 2010). In our area, new eggs were observed from March 30 to May 30. For 1,405 clutches in B.C., laying was found to occur from March 13 to July 6, with 52% recorded between April 18 and May 2 (Campbell et al. 1990); the June and July records were probably from northern B.C.

It takes about a week to lay a complete clutch (Howard Breen 1990; CWS 2010), or 1-2 days to lay each egg (Cooper 1978). Once laying is completed, the goose incubates the eggs for 25 to 28 days, while the gander stands guard nearby. He vigourously defends the nesting territory from intruders (MoE 1979; Howard Breen 1990; CWS 2010).

Once nesting, foraging usually occurs near the nest. However, geese tending a nest may take 'recesses' to forage and drink; these have been recorded as far as 8 km away (Cooper 1978; Granholm 1988). Brakhage (1965) observed that pairs left their nest together, usually during the first and last 2 hours of daylight; the goose fed ravenously and occasionally preened briefly while the gander rarely fed. Cooper (1978) found that females had a fixed routine, which included drinking, bathing, preening, and feeding, always at a hurried pace. Feeding areas consistently supported an abundance of new plant growth and were absent of dense, decadent vegetation. Back at the nest, the goose preened water from her breast to moisten the down around the eggs, likely to increase humidity. Cooper also noted that pairs had days without recesses, and days that included up to 5 recesses. Time away from the nest varied from 1 to 68 minutes, with an average of 15 minutes (Brakhage 1965; Cooper 1978). With each additional egg, time spent away from the nest was reduced (Brakhage 1965).

The hatch peaks in early to mid-May (CWS 2010). On average, it takes approximately 24 hours for the clutch to hatch, but hatching time can range anywhere from 8 to 36 hours (Kossack 1950; Brakhage 1965; Cooper 1978). Depending on the timing of the final emergence, goslings may be off the nest by the next morning (Brakhage 1965; Cooper 1978). They are closely guarded by both parents. Initially, the new family stays near the nesting grounds (MoE 1979; Howard Breen 1990; CWS 2010), but the adults do not defend the nest site or territory (Brakhage 1965). If forage and water are

To avoid being seen, a nesting goose lowers her profile, while the gander stands guard a short distance away. Photo by Guy Monty.

limited, they may move several km to a more suitable rearing area (Kossack 1950; Granholm 1988).

If the first clutch is destroyed, pairs may re-nest. Over the period 2008-2014, three different pairs re-nested, in 2012, 2013, and 2014, all on the ERE. Eggs in two of the original nests had not been addled, and one had been visibly predated. In 2015, there were two confirmed re-nests on the ERE and one on the LQRE.

Atwater (1959) found that unsuccessful nesting pairs in Montana moved away from the nest sites and were quite solitary, often wandering from one waterbody to another. Cooper (1978) found unsuccessful pairs in Manitoba remained within 500 m of the nest site for 2 days to 4 weeks, with an average of 2 weeks. In Quebec, females that had lost their nests or abandoned their young left the area before moulting and returned in November (Beaumont, Rodrigues, & Giroux 2013). Unsuccessful nesters in South Dakota formed flocks with non-breeding geese that had remained in the nesting area until mid to late May (Dieter & Anderson 2009).

8.3 Brood-rearing

The moulting season encompasses the latter part of the brood-rearing period, as the parents are replacing their flight feathers (i.e., moulting) while their goslings are growing, developing flight feathers, and learning to fly (CWS 2010). For 2,076 Canada Geese broods in B.C., brood-rearing (hatching to fledging) occurred between April 15 and August 24 (Campbell et al. 1990).

A pair with its brood may be solitary for 5-7 days, then loosely associates with other pairs with similar-aged young (Brakhage 1965). Broods may mix for several (e.g., 3 to 6) weeks before reorganizing into their original families (Bellrose 1976; Dieter & Anderson 2009). They may also form crèches (sometimes called gang broods). One might see 10-20 goslings under the care of a single pair of adults, typically when young females give up their goslings to older birds (Bellrose 1976; Howard Breen 1990). Crèches may also be accompanied by 2-5 productive pairs and additional, non-breeding females (Brakhage 1965). Brakhage (1965) found that pairs which gave up their broods returned to the vicinity of their nesting territories.

Pair with large brood at the Little Qualicum River estuary, May 21, 2009

8.4 Moulting

Flightless Canada Geese make their way from the main trail in Rathtrevor Beach Provincial Park to the foreshore.

During the summer, adult Canada Geese replace their flight feathers and are unable to fly, or fly well, and are more vulnerable to predation (Howard Breen 1990; CWS 2010). Non-breeding juveniles and adults, and adults whose nests have been destroyed, are usually the first to moult (Smith, Craven, & Curtis 1999). Successful nesters begin to moult when the goslings are about two weeks old; both parents and young are able to fly at approximately the same time, 4-6 weeks later. Initially, they confine their movements to secluded areas near their nesting grounds. Later, they move to prime grazing areas where they can better address the high nutritional demands required for feather production, and to mudflats or riverbanks where they can find grit for digestion (Bellrose 1976; Howard Breen 1990; CWS 2010). As the young reach adult-size, the family may venture further and join other flocks. Near the end of the moulting season, the combination of warm temperatures, high quality food resources, and decreasing nutritional demands allow more time for loafing and preening (Winn 2001).

Although CWS (2010) delimited the moult period from mid-May to late July, and we defined a moulting season from June 1 to August 15, a few birds were flightless as late as August 22.

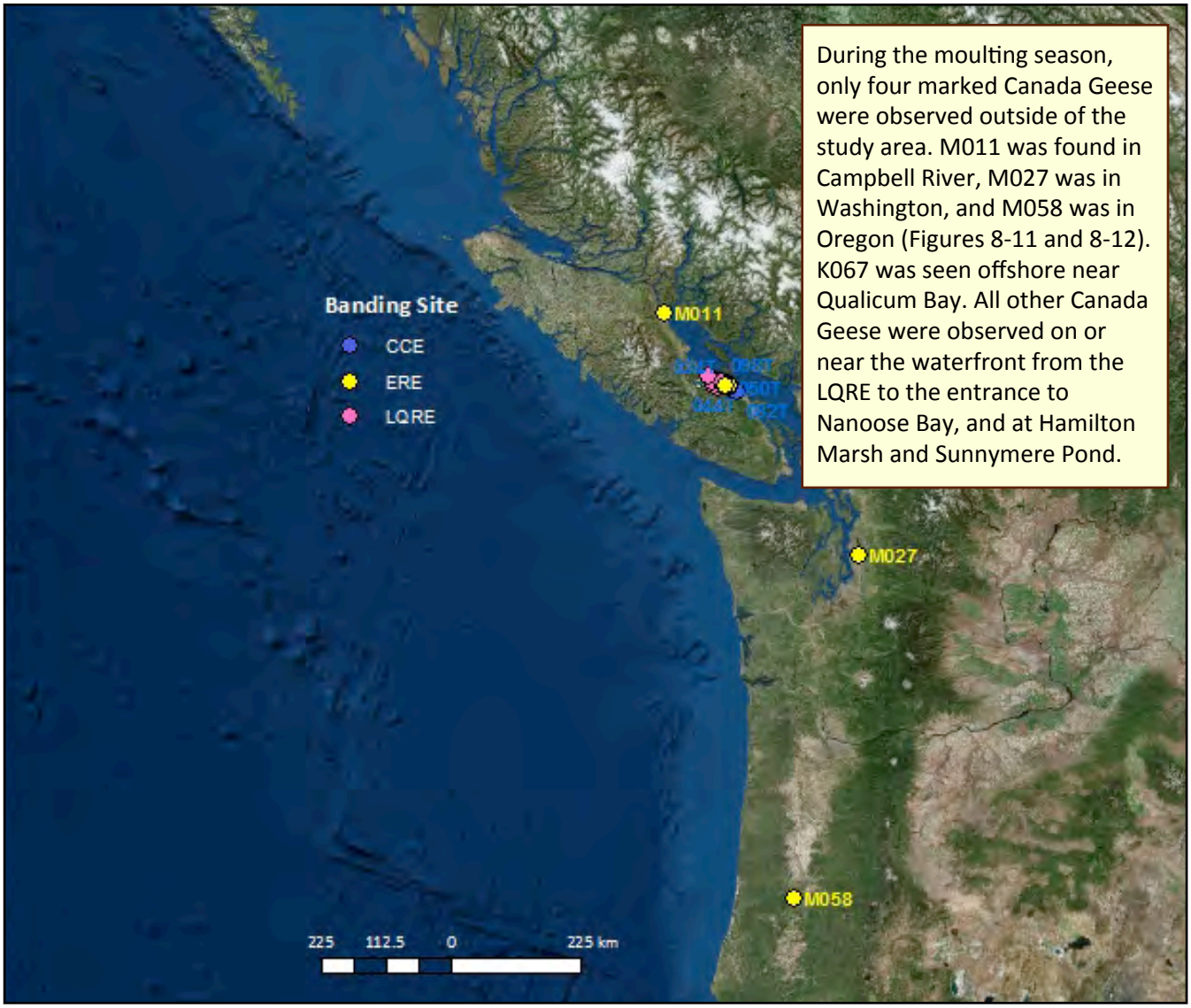
7.41 Moult Migration

Canada Geese that leave the nesting grounds and travel considerable distances to return to favoured moulting areas year after year are known as moult migrants. Both Arctic/sub-arctic and temperate-nesting Canada Geese populations may undertake moult migrations (cf. Sheaffer, Malecki, Swift, & Dunn 2004). Distances recorded have ranged from 40 km to more than 2,500 km (Dieter & Anderson 2009). Most moult migrants are believed to be juvenile, non-breeding Canada Geese (Salomonsen 1968; Sheaffer et al. 2004). However, some are unsuccessful nesters or pairs that have lost their broods to predation or gang broods (Sheaffer et al. 2007; Dieter & Anderson 2009). Moult migration tends to occur in June (Sheaffer et al. 2007).

Annette Lucas of Blonde Ambition Communications films Canada Geese loafing on the sandstone near Pearl's Rock in Craig Bay for the Guardians' video *Mitigating Impacts of [Locally] Overabundant Canada Geese.*

Management techniques that cause nest failure, such as egg addling, may induce moult migration (Sheaffer et al. 2007; Dieter & Anderson 2009), reducing pressure on local moulting habitat and perhaps exposing more birds to hunting, but potentially increasing nuisance populations in other areas. In a variety of studies of satellite-tracked Canada Geese in the eastern U.S., up to 73% of females whose nests had been destroyed subsequently moult-migrated. However, nest-failed females from rural areas were more likely to moult migrate than their coastal counterparts; authors attributed this to an abundance of good quality moulting habitat in coastal near-urban landscapes (Sheaffer et al. 2007).

Moulting Canada Geese on Craig Bay near Rathtrevor Park, summer 2014



During the moulting season, only four marked Canada Geese were observed outside of the study area. M011 was found in Campbell River, M027 was in Washington, and M058 was in Oregon (Figures 8-11 and 8-12). K067 was seen offshore near Qualicum Bay. All other Canada Geese were observed on or near the waterfront from the LQRE to the entrance to Nanoose Bay, and at Hamilton Marsh and Sunnymere Pond.

Figure 8-11. Moulting season (June/July) re-sights of marked Canada Geese, 2008-2014.

Moulting geese at Craig Bay estates, June 11, 2014

Most Canada Geese were distributed along the coastline during moult counts and routine population surveys over the moulting season (Figure 8-12 and 8-13). Geese were concentrated at the LQRE, along Qualicum Beach, at the French Creek estuary and shorelines north of the estuary, Parksville Bay east to Rathtrevor Beach, Craig Bay and nearby ponds, NBE, Sunnymere pond, and along the Snaw-naw-as First Nation reserve. Geese often congregated along the foreshore where there were freshwater flows (e.g., stormwater outfalls), presumably to drink.

Figure 8-12. Moulting season (June/July) re-sights of marked Canada Geese, 2008-2014.

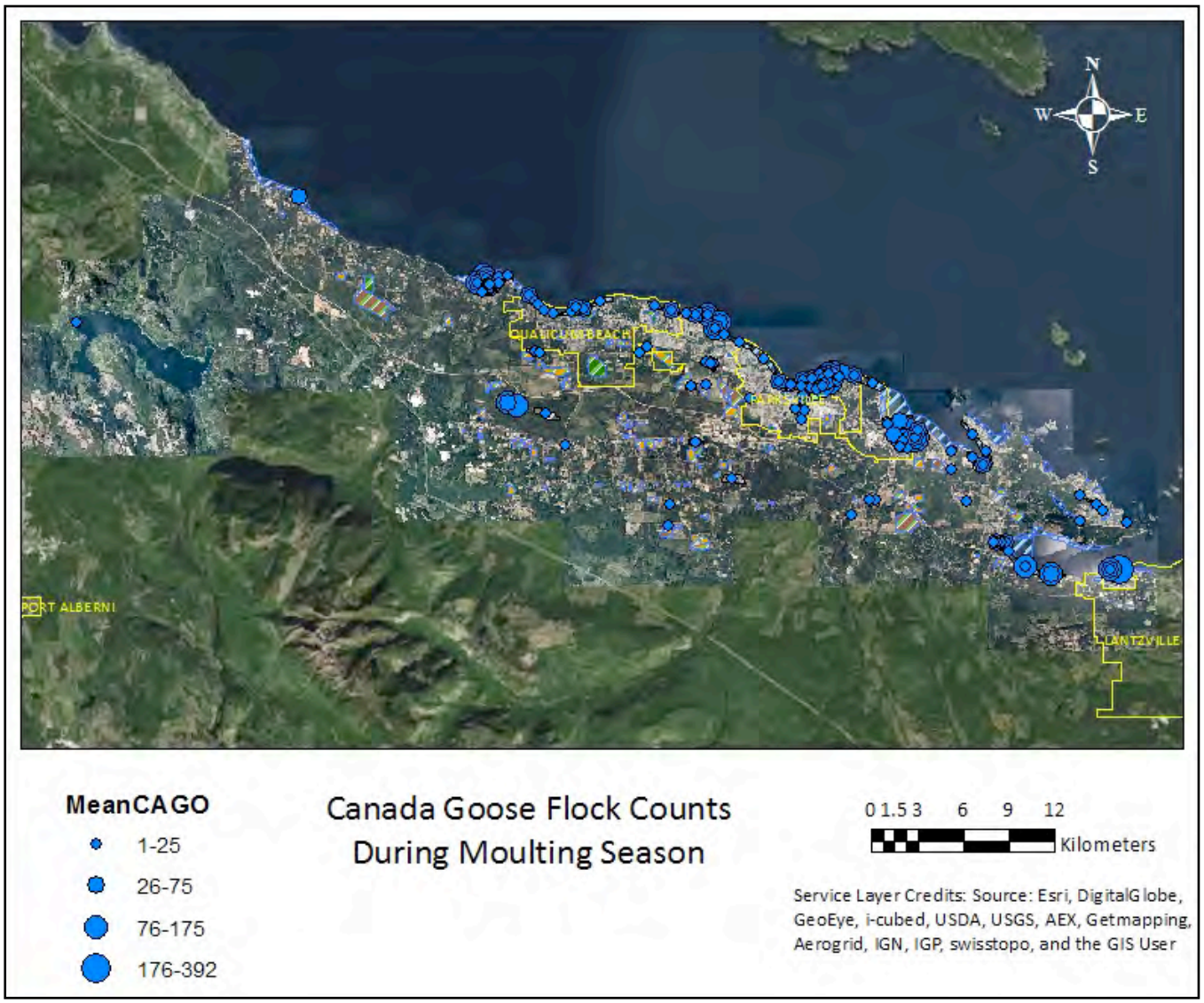


Figure 8-13. Canada Goose flock counts during the moulting season, weighted by the number of surveys (n=2,018).

In our study, 13 Canada Geese (4.4% of all marked Canada Geese, 6% of all Canada Geese assigned a migrant type) were assessed as moult in-migrants. (Moult in-migrants come to our region to moult, whereas moult-out migrants leave the region to moult.) Three were U.S. moult migrants; two of these were sighted in California in March, and the other was observed in Washington in October, November, February, and May. Two were Vancouver Island moult migrants; one was seen in the Cowichan Valley in January, and the other was in Victoria in February. The others fit the definition of a moult migrant (i.e., present during at least 2 consecutive moult periods, not seen during nesting and in winter), but their whereabouts in other seasons were unknown. A 14th bird, assigned a Vancouver Island migrant type, moulted in Campbell River in 2011. All are consistent with a body of literature that suggests **moult migrants typically migrate north to moult** (MoE 1979; Sheaffer et al. 2007).

Because most marked birds were captured during the moult, our data were heavily skewed to identifying in-migrants.

Annual moult counts found the greatest densities of Canada Geese were at the ERE, French Creek estuary, and LQRE (Figure 8-14). However, goose numbers (not considering the size of sites) were highest in the Craig Creek estuary/Craig Bay east area (Figure 8-15). A 2014 moult count that included Nanoose Bay east towards Lantzville boosted Canada Geese counts for Nanoose Bay sites.

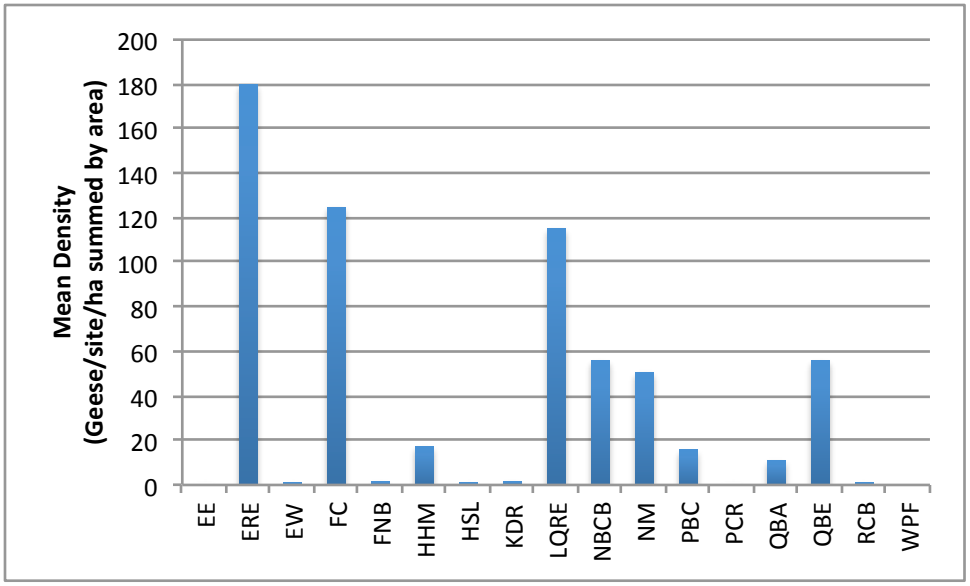


Figure 8-14. Canada Goose density (Canada Geese/site/ha summed by area) during the moulting period, 2011-2014 (n=581 sites). FC=French Creek, NBCB=Northwest Bay/Craig Bay East. See Table 6-1 for other area descriptions.

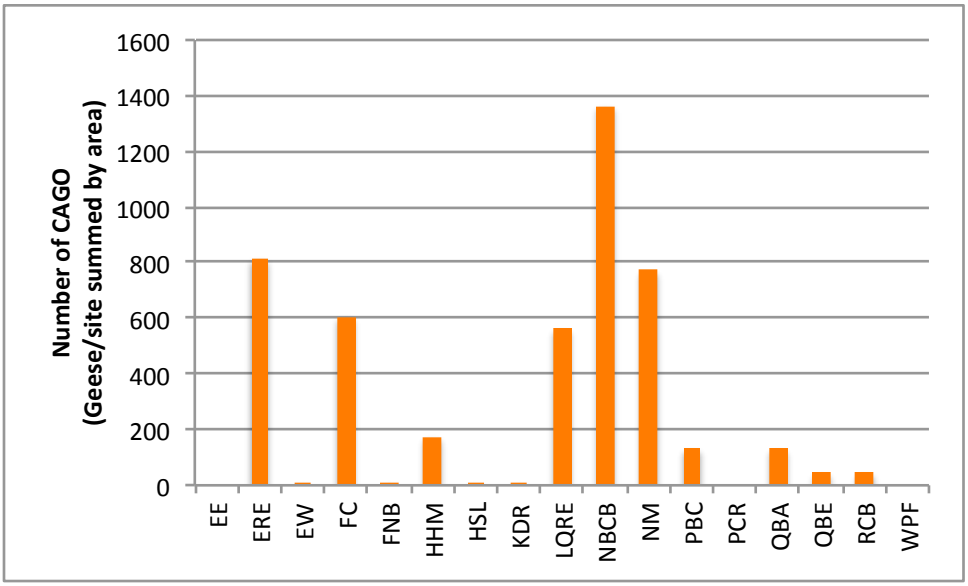


Figure 8-15. Mean Canada Geese counted during the moulting period, 2011-2014 (n=581 sites). NM=Nanoose/ Morello. See Figure 8-14 and Table 6-1 for other area descriptions.

During the moult, Canada Geese were found almost exclusively in estuarine, freshwater, and marine habitats (Figure 8-16). In marine and outer estuarine habitats, geese were either clustered or spread out over large areas; when goose numbers were tallied without consideration for density, totals were highest in these areas (Figure 8-17).

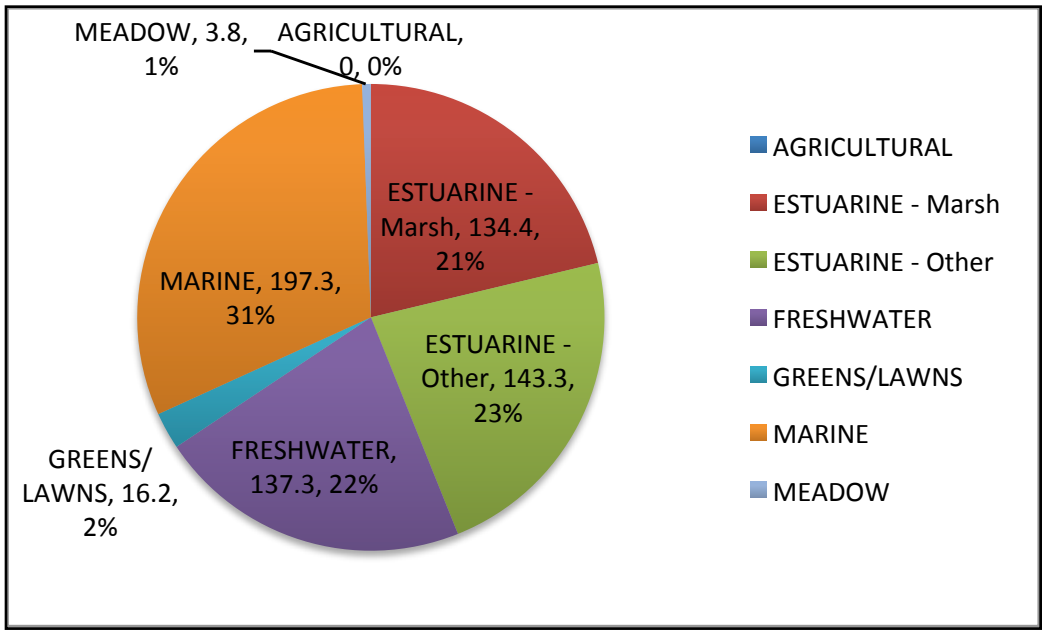


Figure 8-16. Canada Geese density during the moulting period, by habitat type, 2011-2014 (ha, %) (n=581). Area is in hectares (e.g., marine = 197.3 ha, 31% of total area used during the moult).

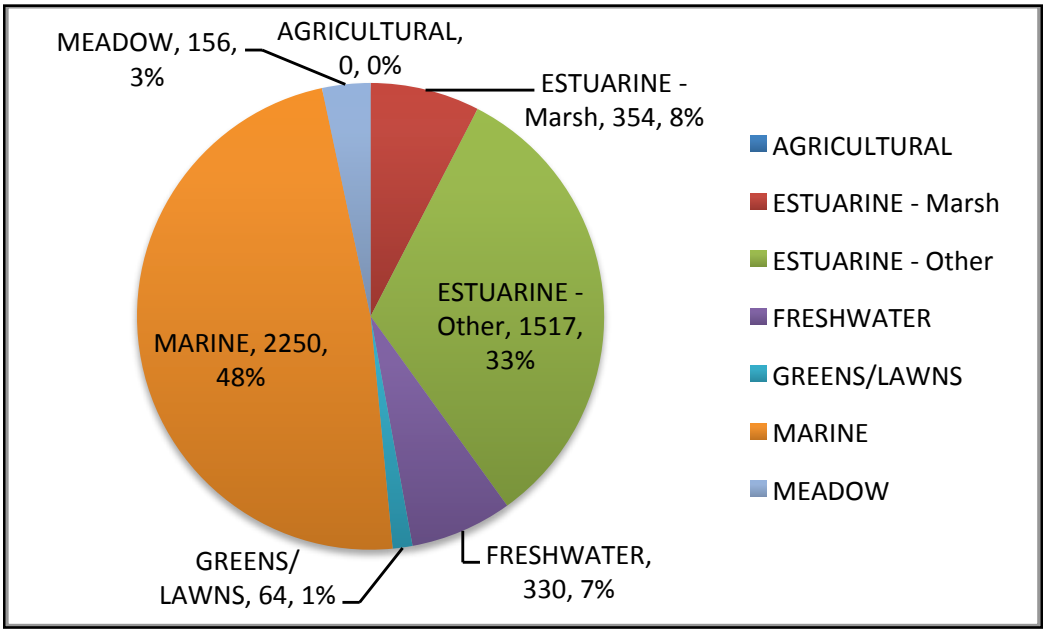


Figure 8-17. Canada Geese use of habitats during the moulting period, 2011-2014 (ha, %). (n=581).

8.5 Transition - Moulting to Autumn Migration

In August, many marked birds remained in their moulting areas (Figure 8-18). Although the second half of August is characterized as a migration period, only two marked birds were observed outside of the study area; 006T and 053T were spotted on the Saanich Peninsula. Most Canada Geese were mobile by this time, feeding beyond the moulting areas but returning to roost.

Canada Geese enjoying a leaking hose at a building site in Parksville, August 17, 2009

Figure 8-18. August re-sights of marked Canada Geese in the study area, 2008-2014

8.6 Autumn Migration

Autumn migration along coastal routes peaks in the first week of November and declines by the end of the month (Campbell et al. 1990). Most temperate-breeding geese do not migrate long distances, typically staying in the region or neighbouring regions (Smith, Craven, & Curtis 1999). If weather conditions are harsh or high quality food is unavailable, they will head south (CWS 2010).

Seven Canada Geese were found beyond Vancouver Island. K021 was observed in *Alberta*; M027, M059 and M063 were seen in Oregon; M055 and M067 were found in Washington; and 028T was shot on the Lower Mainland (Figure 8-19).

On Vancouver Island, there were 9 Canada Geese observed or shot outside of the study area: K010 at Cowichan Bay; 048T and 071T near Saltspring Island; 001T and 088T at Chemainus; 067T at Gabriola Island; and K011, M007 and M045 in the Comox Valley.

Migratory geese are attracted to areas where local residents gather, and within a few days can have a startling impact on those habitats (Smith, Craven, & Curtis 1999). One survey respondent spoke of hosting 200 birds in the autumn, where there had been ~30 during the rest of the year.

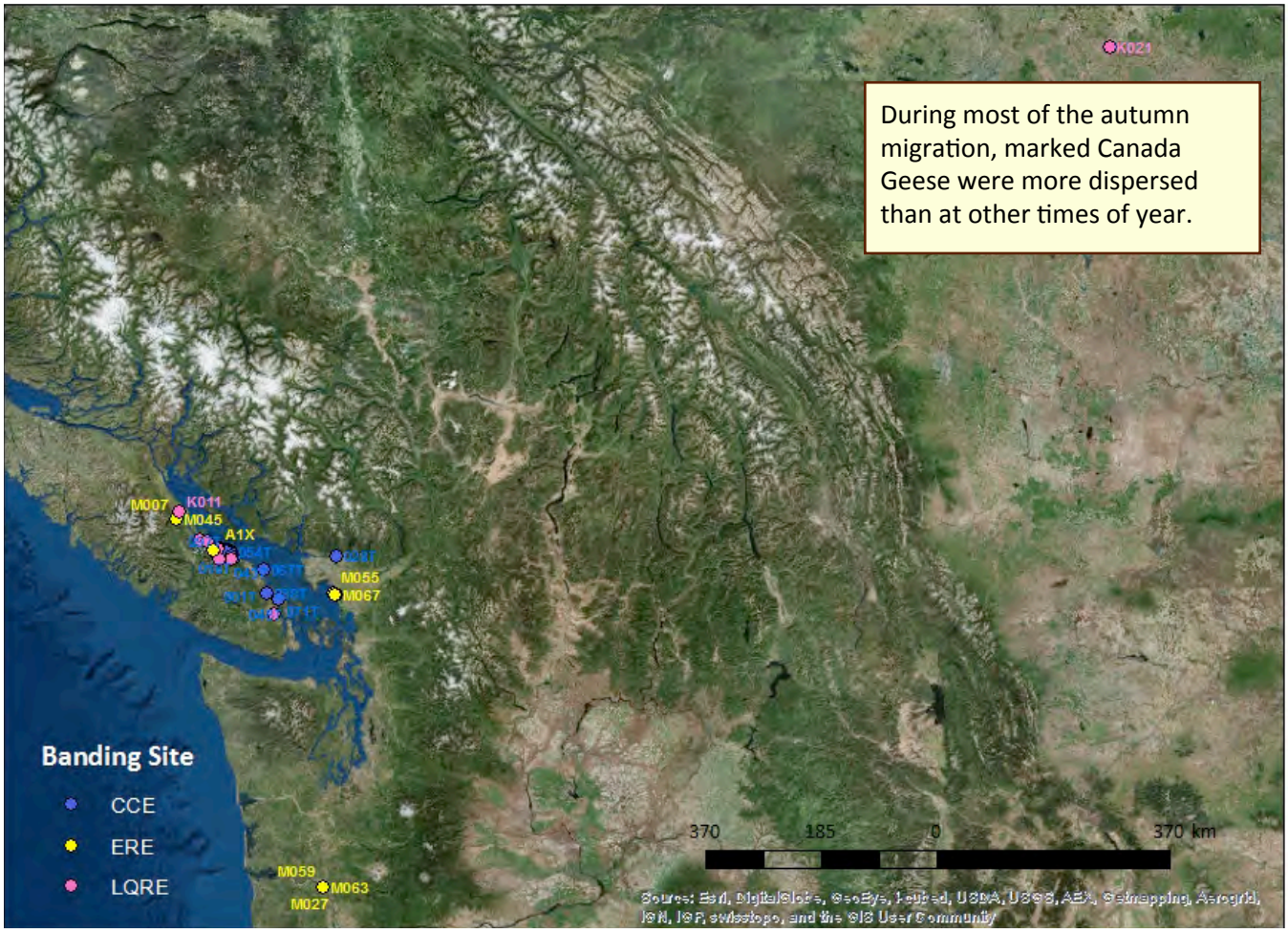


Figure 8-19. Autumn migration (September, October, November) re-sights of marked Canada Geese, 2008-2014.

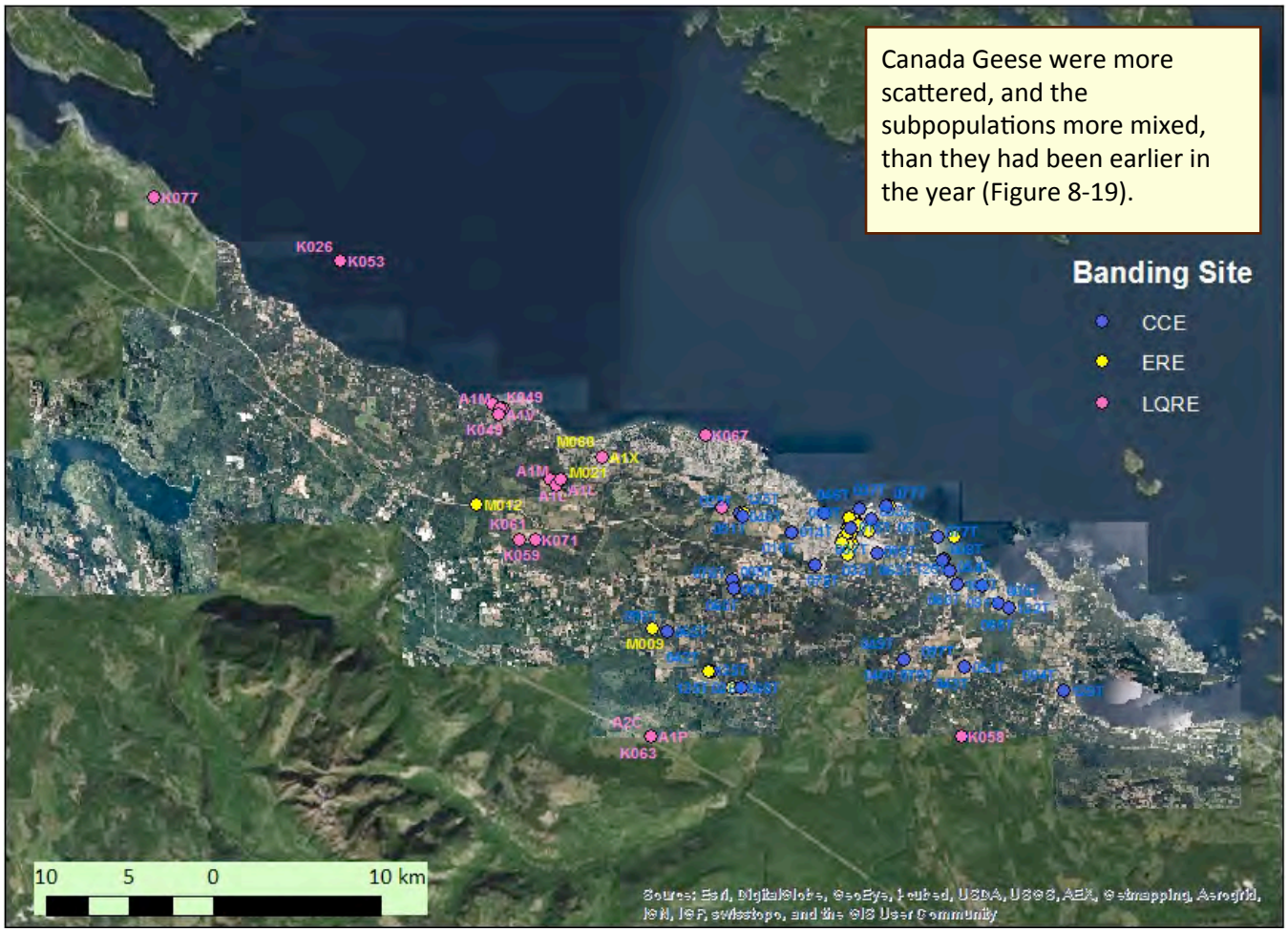


Figure 8-19. Autumn migration (September, October, November) re-sights of marked Canada Geese, 2008-2014.

Researchers in Prince Edward Island found no evidence of the regular daily movements observed during the spring. Instead, autumn movements were determined by hunting pressure, weather, and agricultural activities. Geese foraged primarily on tidal flats once fields were cultivated, and during the hunting season, many geese loafed and fed in areas inaccessible to hunting (Martin & Guignion 1983).

Quebec researchers found that the movements of radio-collared local resident geese were restricted to smaller areas once northern migrants arrived (Beaumont et al. 2013).

Some geese, particularly those accompanying juveniles, moved into areas with little or no hunting pressure *several weeks before* hunting season began in September (Beaumont et al. 2013). The effect of hunting on Canada Goose movement is further discussed in Chapter 12.12, Hunting.

Migrants are generally more wary and easily startled, and so may be differentiated from more resident birds at this time of year (cf. Smith, Craven, & Curtis 1999).

Canada Geese drinking from a puddle in a Parksville parking lot, September 28, 2015

Canada Geese were as widely distributed in the autumn as they had been in spring (Figure 8-20). The large flocks observed at the French Creek and Craig Creek estuaries in spring were comparatively smaller in the fall. In autumn, the greatest concentrations of geese were on agricultural lands in Nanoose Bay, Errington, and HIlliers.

Canada Geese grazing in a Nanoose Bay farm field, September 28, 2015

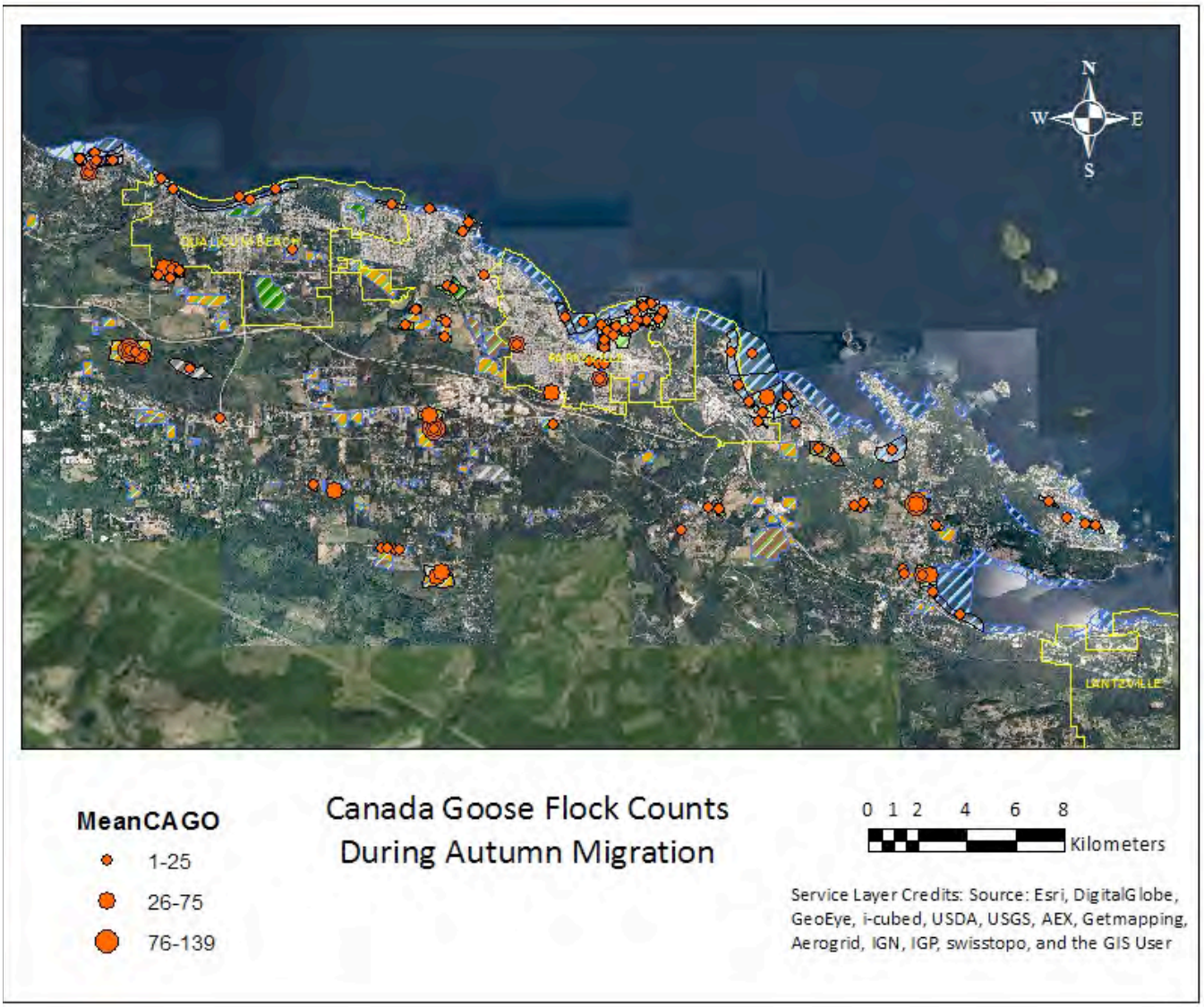


Figure 8-20. Canada Goose flock counts during autumn migration, weighted by the number of surveys (n=827).

Canada Geese were dispersed over the rarely flooded high marsh of the Craig Creek estuary, as well as the mid-marsh and low marsh at 1:43 p.m., November 13, 2014.

November 2014 was cold. The temperature at the Springwood Middle School weather station in Parksville was -6.3 degrees Celsius on November 30, 2014, the coldest November day since the station was installed in 2006. Minimum temperatures from November 12-18 ranged from -1.1 to -3.4 degrees, and from November 29-30 they ranged from -1.6 to -6.3. The mean monthly minimum was 2.5, and the daily average was only 5.8 degrees Celsius (Victoriaweather.ca 2015).

8.61 *A Cold Day in November*

In mid-November, 2014, more than 100 Canada Geese were loafing each afternoon at the Craig Creek Estuary. A cold snap lasting several days began on November 13th; the weather station at Springwood Middle School reported a low of -3.4 degrees Celsius that night. To assess how geese used the partly frozen estuary during a period when there was ice on freshwater sources and hunting was open (hunters had been on a nearby farm on November 14th), we surveyed the estuary every two hours from 1 p.m., November 16th to dusk, and from dawn, November 17th to 1 p.m.

November 16

1:00 p.m. Temperature 5 degrees C., mainly sunny, estuary partly frozen. Twenty-two geese were on Craig Bay, offshore from Pearl's Rock at Pacific Shores Nature Resort.

3:00 p.m. Temperature 4 degrees C., sunny and clear. No geese.

4:15 p.m. A resident of Craig Bay estates observed 141 geese, including 7 collared geese, on the south shore of the Three Bridges Pond. Two of the collared birds were moult-winter migrants, three were local residents plus, and two were local residents. He noted that the birds had been using the ponds and neighbouring grassy areas for the last four days. They generally left the ponds at ~4:30 p.m., returning ~8:30 a.m. each day.

4:35 p.m. Dusk

4:56 p.m. Temperature 1 degree C., nearly dark. From 4:56 to 5:15, geese flew into the estuary in small flocks (7, 54, 27, 3, 23, 2, and 12 birds), a total of 138 in 7 groups.

November 17

7:00 a.m. Temperature -3 degrees C., sunny and clear, estuary partly frozen, upper marsh has thick frost. A total of 122 geese were mostly clustered at the entrance to Craig Bay (near Pearl's Rock).

7:30 a.m. dawn

7:15 to 8:17 a.m. Geese left in small flocks, 21, 3, 18, 10, 4, 1, 23, and 22 geese flew towards the direction of Craig Bay estates, 12 geese flew through the estuary towards Springford's farm, 3 more geese flew towards Craig Bay estates. Ten of the birds that had flown were collared. Five geese remained.

9:00 a.m. Temperature 0 degrees C., sunny and clear. No geese.

11:00 a.m. Temperature 5 degrees C., sunny and clear. No geese.

1:00 p.m. Temperature 5 degrees C., mainly sunny. No geese.

These observations provided several insights:

1) In autumn, fertilized, green lawns and fields were preferred feeding areas, as the quality of food in the estuary deteriorated. Yet, the estuary was favoured for loafing and especially roosting, regardless of icy conditions. (In past years, as cold snaps progressed and ice spread down the estuary, we found geese moved with the ice sheet, clustering just beyond the covered areas on open water.)

2) Hunting pushed the geese into non-huntable areas. It is

Fifty-five Canada Geese were counted at Craig Bay estates ponds, at 9:39 a.m., November 17, 2014. Photo by Mike Ingledew.

notable that moult-winter migrants were present, ahead of the overwintering period (December - January); if not for the cold weather, this might suggest that both the late November counts from 1989 to 2005, and the January winter counts thereafter, were indicative of overwintering populations.

3) Importantly, the exercise provided evidence that ***the predominance of daytime surveys grossly underestimated the presence of Canada Geese in our estuaries.***

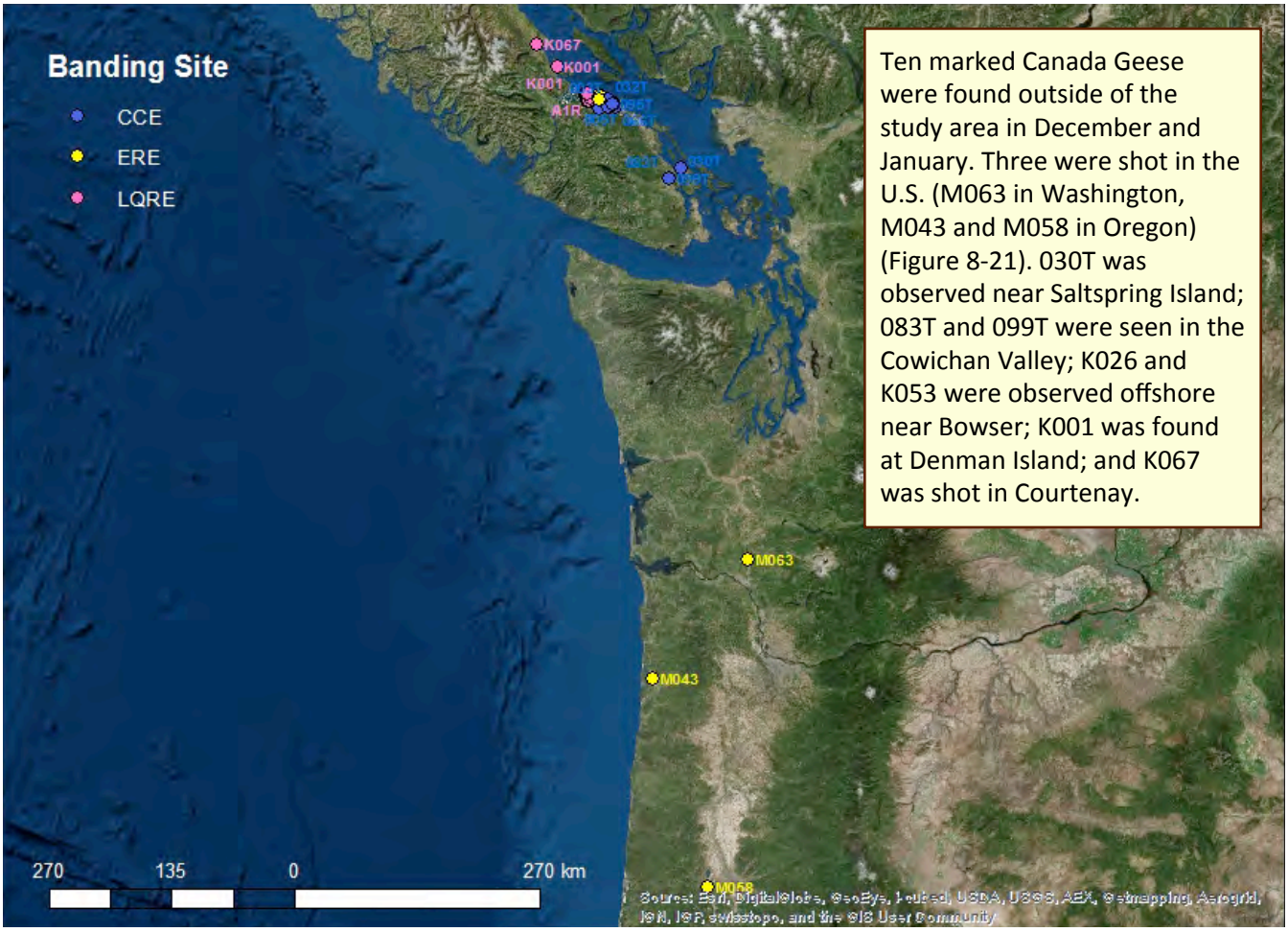
8.7 Overwintering

In winter, estuaries are preferred roosting sites. Geese will undergo daily excursions to feeding areas, such as farm fields and urban grassy areas (cf. Campbell et al. 1990). They generally make two foraging trips each day from their roosting sites, one shortly after sunrise and the other later in the afternoon, depending on temperature and light intensity (USFWS 2002). Flocks may forage up to 48 km away from their roosting sites (Granholm 1988).

Ray (2011), who observed marked geese in Phoenix, Arizona, found she could differentiate migrants from local residents by their early morning behaviour; migrants left the overnight roosts at first light for daytime feeding sites, while residents began grazing after sunrise or continued to rest.

Warmer conditions may cause migrants to winter further north than usual (Hestbeck, Nichols, & Malecki 1991; Böhning-Gaese & Lemoine 2004). Despite known fidelity to overwintering sites, Canada Geese have been vacating southern wintering areas in favour of northern ones for decades (Reeves et al. 1968 in Hestbeck, Nichols, & Malecki 1999; USFWS 2002). With climate change, this trend is expected to continue.

Canada Geese roosting/resting with Mallards, scaup, and other waterfowl at the mouth of Craig Creek. Much of the estuary was frozen, early February, 2014



Ten marked Canada Geese were found outside of the study area in December and January. Three were shot in the U.S. (M063 in Washington, M043 and M058 in Oregon) (Figure 8-21). 030T was observed near Saltspring Island; 083T and 099T were seen in the Cowichan Valley; K026 and K053 were observed offshore near Bowser; K001 was found at Denman Island; and K067 was shot in Courtenay.

Figure 8-21. Overwintering (December, January) re-sights of marked Canada Geese, 2008-2014.

Canada Geese in the frozen Craig Creek estuary, January 8, 2005

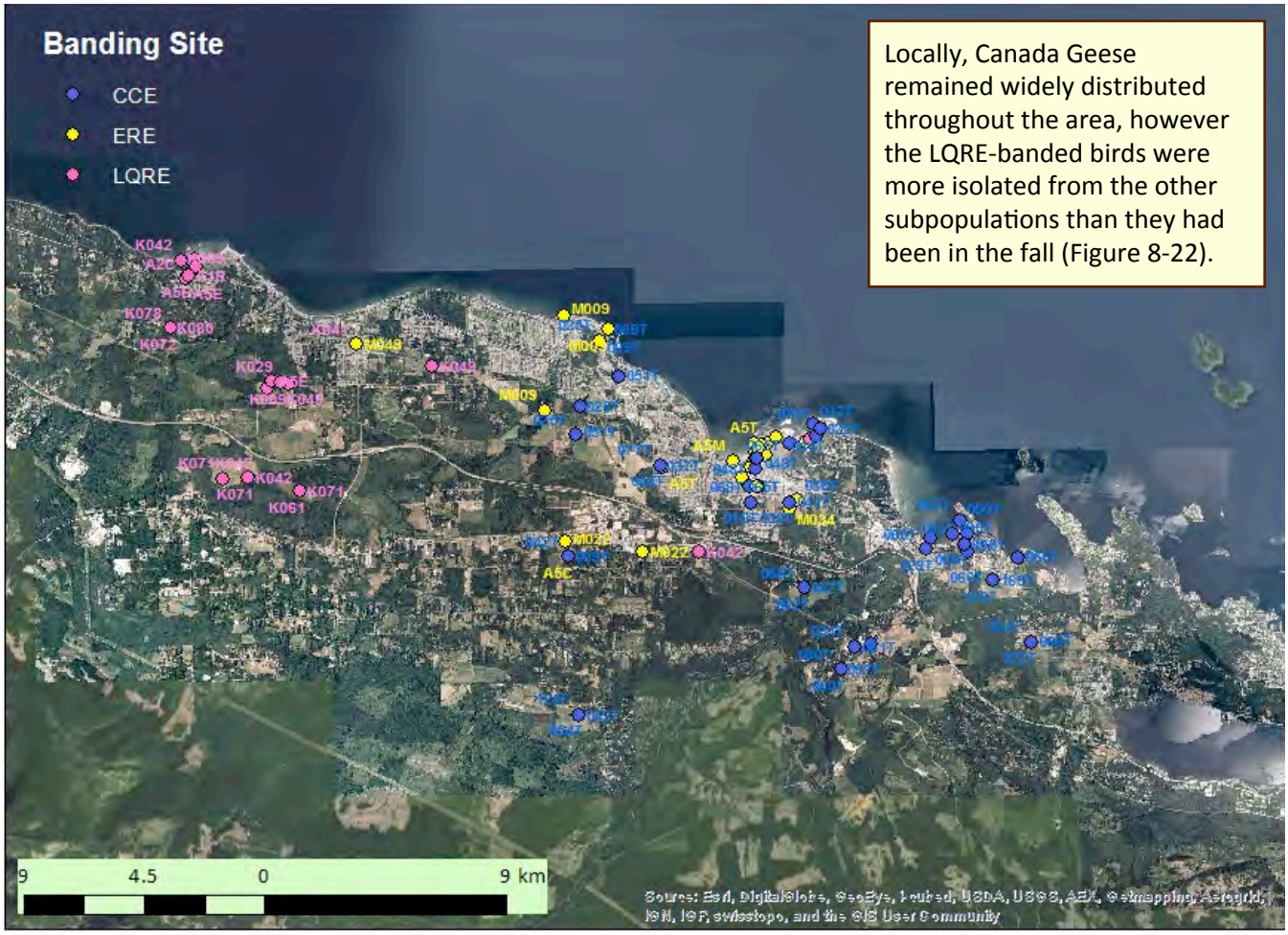


Figure 8-22. Overwintering (December, January) re-sights of marked Canada Geese in the study area, 2008-2014.

Canada Geese in the Craig Creek estuary, January 8, 2005

Population surveys and annual winter counts found large flocks at the Big Qualicum River estuary, LQRE, CCE, and NBE; smaller flocks occurred at the French Creek estuary, and there were many small flocks at the ERE (Figure 8-23). At the same time, large flocks of Canada Geese were using agricultural fields in Qualicum Bay, Qualicum Beach, French Creek, Errington, Hilliers, and Nanoose Bay. Smaller flocks were distributed over other farm fields, sports fields, golf courses, and other sites.

Canada Geese roosting/resting with Mallards, scaup, and other waterfowl at the mouth of Craig Creek. Much of the estuary was frozen, early February, 2014

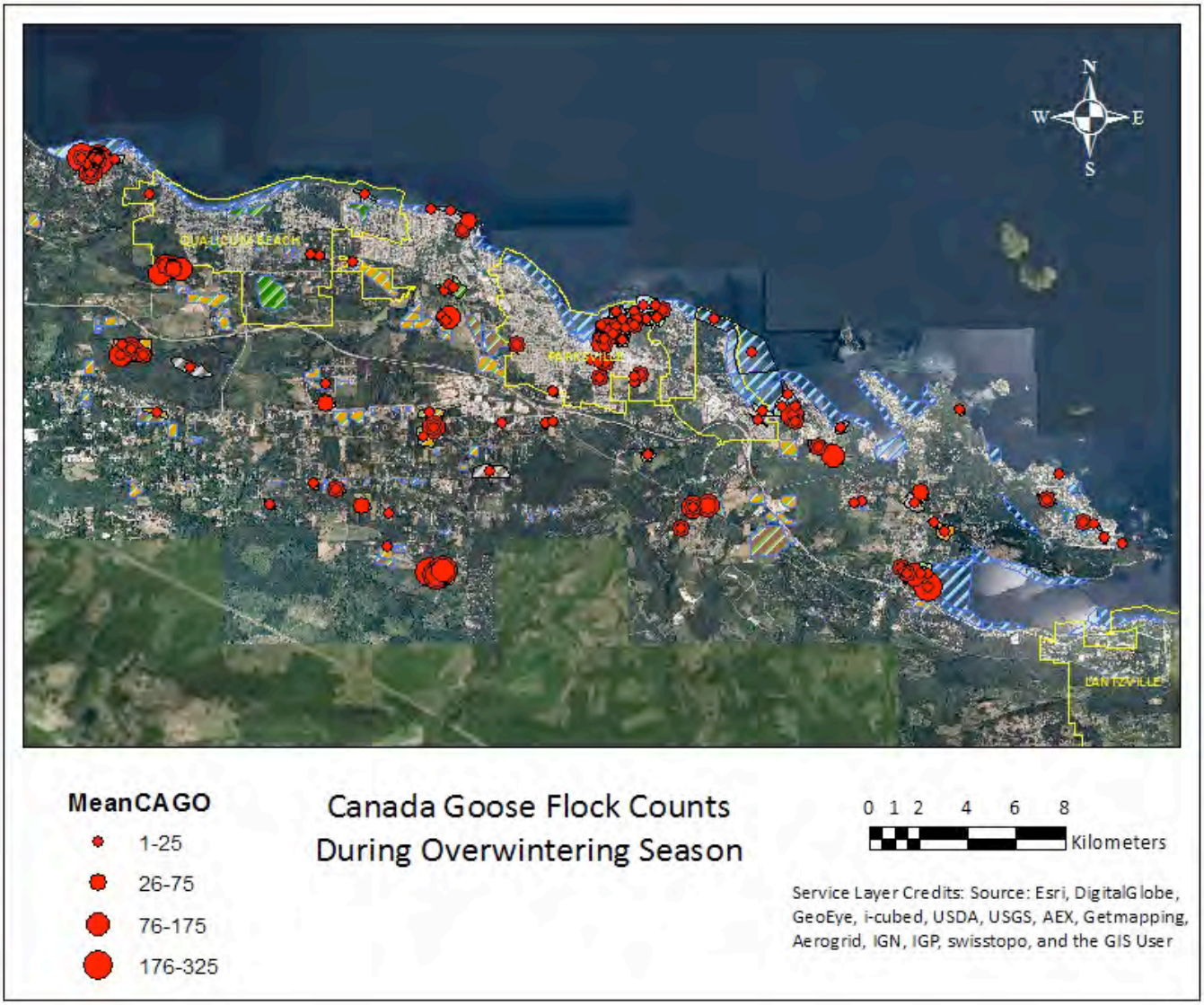


Figure 8-23. Canada Goose flock counts during the overwintering season, weighted by the number of surveys (n=1,757).

Winter counts revealed high densities of geese in Nanoose Bay (Figure 8-24), and high numbers of Canada Geese in agricultural areas throughout the region (Figure 8-25).

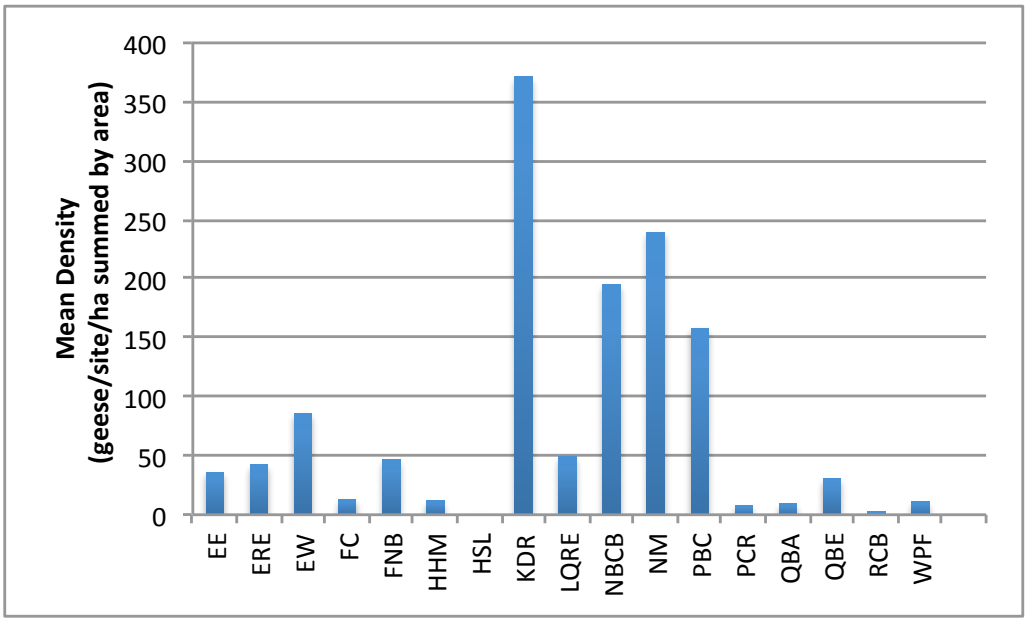


Figure 8-24. Canada Goose density during the overwintering season, 2012-2014 (Canada Geese/site/ha summed by area)(n=651 sites). KDR=Kaye Road/Dawson Road, NBCB=Northwest Bay/Craig Bay East, NM=Nanoose/Morello, PBC=Parksville Bay/City. See Table 5-1 for other area descriptions.

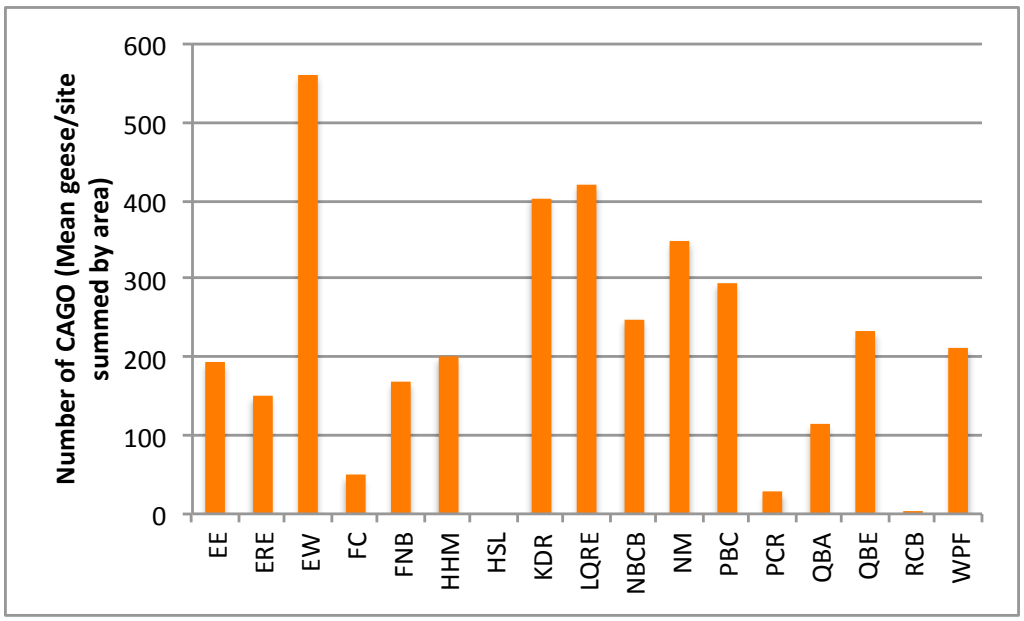


Figure 8-25. Canada Geese counted during the overwintering season, 2012-2014 (n=651 sites). EW=Errington West. See Figure 8-24 and Table 6-1 for other area descriptions.

Meadows and greens/lawns associated with freshwater were important overwintering sites (Figures 8-26 and 8-27). Marine sites were used far less in the winter than in other seasons.

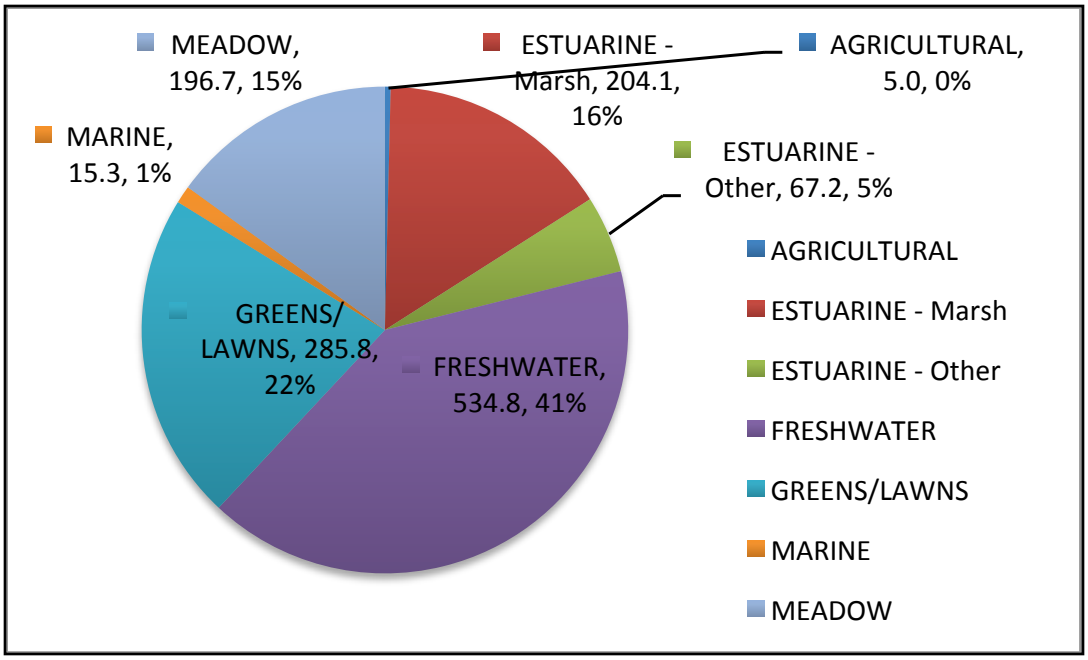


Figure 8-26. Canada Geese density during the overwintering season, by habitat type, 2012-2014 (ha, %)(n=651). Area is in hectares (e.g., marine = 15.3 ha, 1% of total area used during the overwintering period).

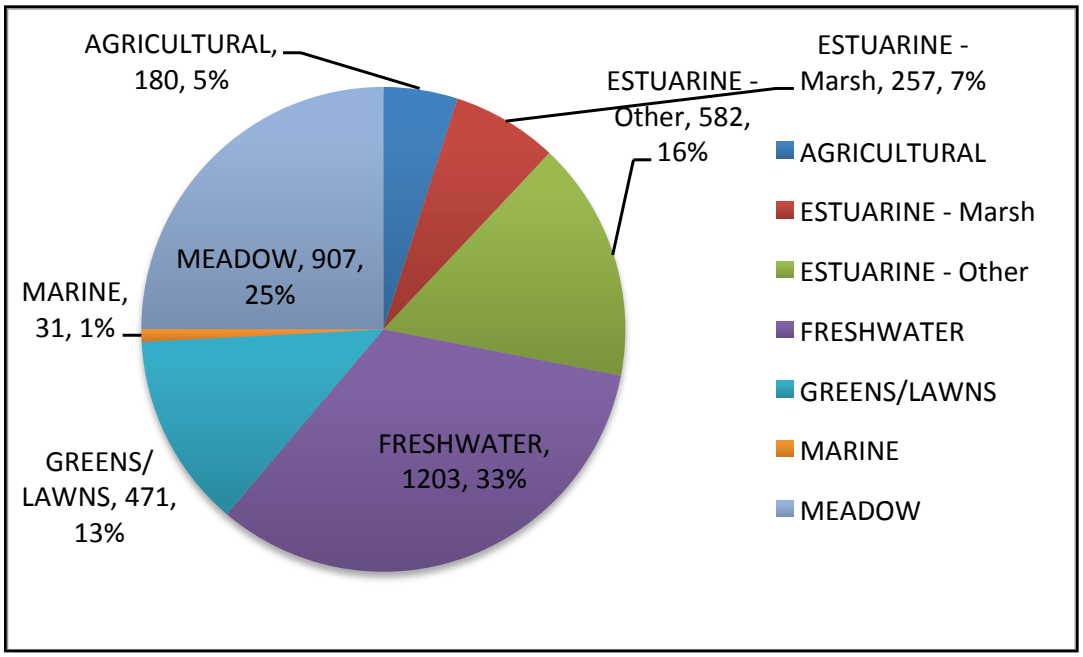


Figure 8-27. Canada Geese use of habitats during the overwintering season, 2012-2014 (n=651).

Chapter 9 - Spatial Trends
Highlights

This chapter discusses spatial trends, including hotspots (i.e., places where geese are frequently present or in high densities), site fidelity, and nest density. These contribute to Goal 3 (setting spatial management objectives).

The three main hotspots for Canada Geese were the LQRE, ERE, and CCE/Craig Bay. Across all seasons, goose counts were highest at the estuaries, particularly the 'hotspot' estuaries and the Nanoose/Bonnell Creek estuary.

Daytime goose densities were highest in the Parksville Church Road and Parksville Bay/City areas, and on sites with access to freshwater in particular.

Canada Geese return again and again to favoured sites. Seasonally, fidelity was strongest on nesting sites, and on sites used during the spring migration/pre-nesting period. With respect to habitats, geese had strong fidelity to croplands, sites with freshwater, and estuarine marsh sites.

Nest densities were highest at the LQRE, on the spit and the lower parts of the estuary that still support vegetation.

Citations, excluded here for brevity, can be found in the text of the document's chapters. Please do not cite highlights without consulting the chapters.

9.1 Hotspots

Canada Geese can be found in many grassy and aquatic habitats in Mount Arrowsmith Biosphere Region's lowlands (Figure 9-1), they tend to concentrate in specific areas. The three hotspots for geese were on our estuaries: the LQRE, ERE, and CCE/Craig Bay.

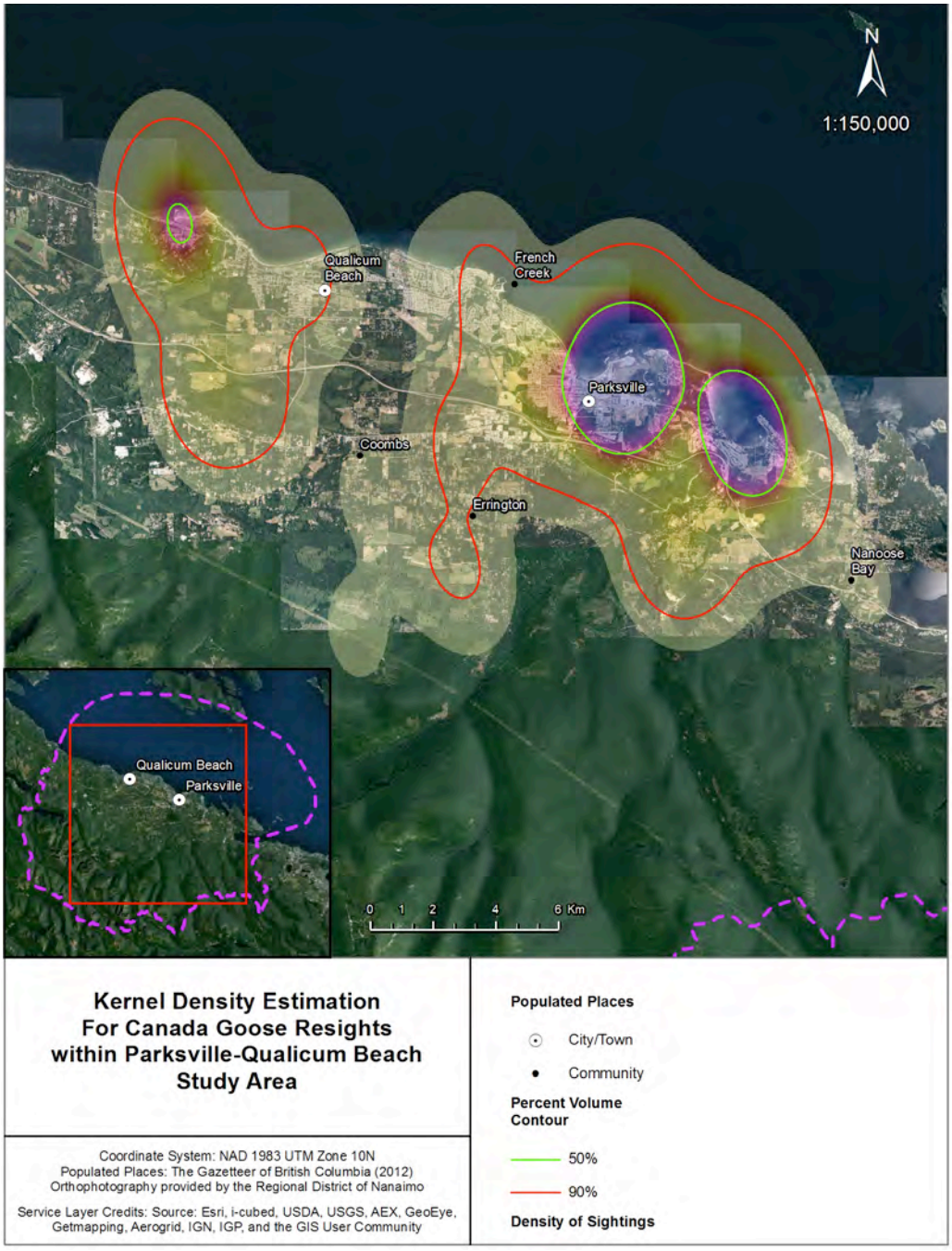


Figure 9-1. Canada Goose hotspots (n=4,692). All re-sight data were included (i.e., addling counts, routine population counts, moult counts, winter counts, waterfront counts), across all seasons.

Across all seasons, goose counts were highest at the estuaries. The greatest numbers were observed at the LQRE, ERE, in the Northwest Bay-Craig Bay east area encompassing the CCE, and in the Nanoose Morello area including the NBE (Figure 9-2).

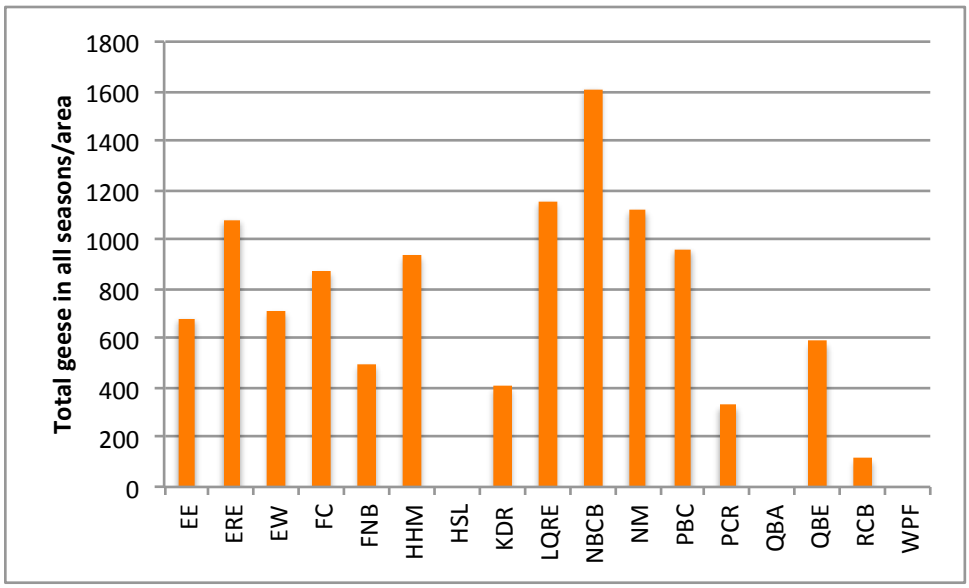


Figure 9-2. Total Canada Geese counted during routine population surveys, across all seasons, 2011-2014 (n=2,963). See Table 6-1 for site descriptions.

When the size of the sites were taken into account, Canada Goose densities were highest in the Parksville Church Road, and Parksville Bay/City areas (Figure 9-3).

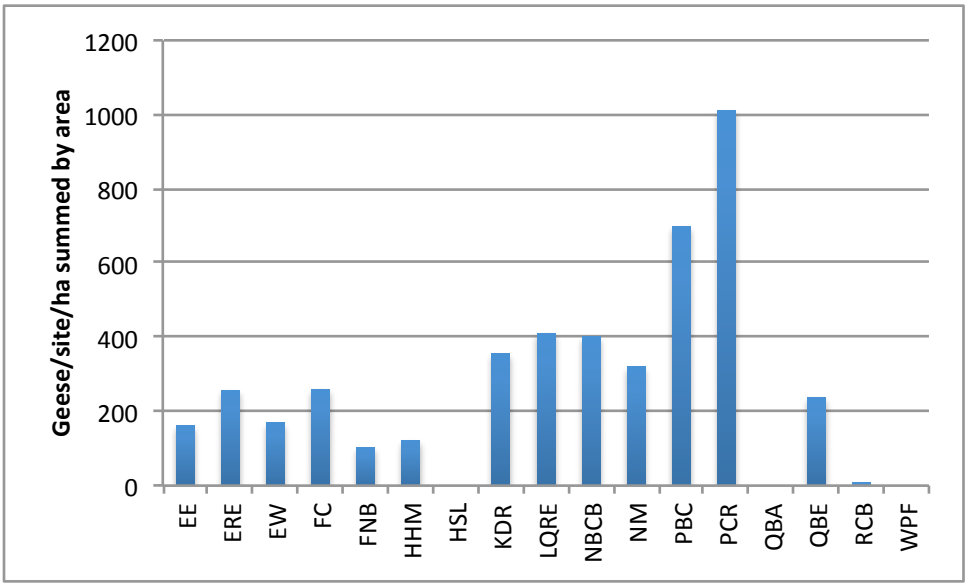


Figure 9-3. Canada Geese density (Canada Geese/site/ha summed by area) over all seasons. Based on population surveys, 2011-2014 (n=2,963).

During daytime population surveys over a four-year period, sites with access to freshwater supported the greatest densities of Canada Geese. In our area, these sites are few and most are small. They are generally associated with greens/lawns or meadow (Figure 9-4).

During the fall migration and overwintering seasons in particular, geese used estuaries primarily in the early morning, evening, and night, outside of most survey periods. Densities on estuarine marshes were higher than other estuarine and marine habitats, because of their relative sizes; marsh areas are smaller than most other estuarine sites (e.g., mudflats) and marine sites. Densities were also low on agricultural areas, which are typically large fields.

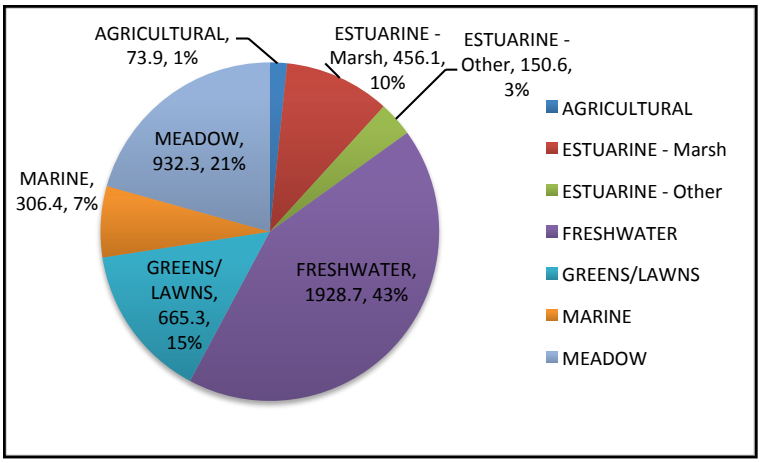


Figure 9-4 Sum of Canada Goose densities per site (Canada Geese/ha) by habitat type. Based on routine population counts, 2011-2014 (n=2,963).

When goose populations were considered irrespective of the size of survey sites, habitat use was more widely distributed (Figure 9-5). Estuaries and marine sites were used 43% of the time.

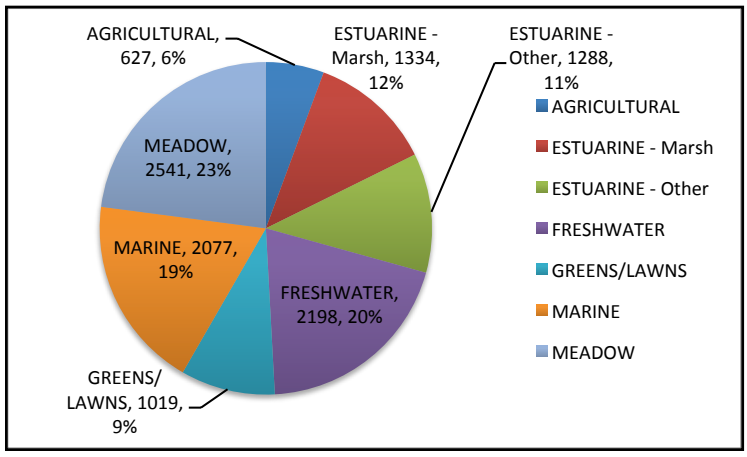


Figure 9-5. Mean Canada Goose numbers per site, for each habitat type. Based on routine population counts, 2011-2014 (n=2,963).

Preferred habitats in limited supply, such as estuarine and freshwater moulting areas, tend to support dense populations. Canada Geese were observed on 100% of the region's estuarine marsh sites, yet those sites represented less than 5% of all available sites. Sports fields and other greens/lawns in the City of Parksville represented only 1% of all available goose habitat.

9.2 Site Fidelity

This nest on the Englishman River was used every year until the log was removed in a storm event.

Measuring Site Fidelity

Fidelity is best determined by complex modeling, taking into account re-sight rates, sex, age, year, and various population, habitat, and management parameters (cf. Beston et al. 2014). Lacking appropriate data for some of these variables, we used Groepper et al.'s (2008) measure of site fidelity, which simply divided the number of times a marked goose was observed at a site by the total number of observations of that goose.

Hunting, weather, habitat modification, and management activities such as egg addling and hazing all affect site fidelity and have not been taken into account in these estimates. The data are also subject to the same limitations described for surveys.

Canada Geese are known to return, again and again, to nesting, moulting, staging, and overwintering sites (Bellrose 1976; Cooper 1978; Hestbeck et al. 1991; CWS 2010; Huang 2010 and many others). The fidelity of Canada Geese to nesting, feeding, loafing, and roosting areas is strong, even with heavy hunting pressure (Shultz et al. 1988). This fidelity, in concert with the propensity of young birds to return to their original nesting and rearing places (MoE 1979; CWS 2010), can have a profound effect on habitats. In fact, it is this trait that was used to successfully establish new breeding populations (MoE 1979).

The steady northerly shift of overwintering ranges, emigration (mainly by young males), and moult migration (mainly by sub-adults) create movement away from sites to which geese have fidelity (MoE 1979; Reeves et al. 1968 in Hestbeck, Nichols, & Malecki 1999; USFWS 2002; Sheaffer et al. 2007; Beston et al. 2014). Still, the site fidelity phenomenon must be considered when managing Canada Geese.

Sex and age affect fidelity (and directly affect vital rates), but fidelity also influences vital rates (Huang 2010). Hatch-year geese, which have lower site fidelity (67.9% for females and 48.1% for males) than after-hatch-year geese (90.4% for females and 86.9% for males) (Beston et al. 2014), are typically more vulnerable to disturbances than older birds that home to familar territories and preferred nesting sites.

Migrant type is also linked to fidelity. Groepper et al. (2008) found overall site fidelity for female resident geese in Nebraska was 75%.

Site fidelity will also factor into the speed at which sites may repopulate if vacated through management (e.g., culling).

In our area, total re-sights of marked geese were highest at Northwest Bay/Craig Bay sites (746 observations), Parksville Bay/City sites (706 observations), ERE sites (693 observations), and LQRE sites (350 observations).

In general, fidelity was strongest on nesting sites (75%) and spring migration sites (65%) (Figure 9-6).

Geese exhibited strong fidelity to some sites while showing less loyalty to others (Figure 9-7). They had strong fidelities to most nesting and some moulting sites, and to a smaller number of autumn migration and overwintering sites.

With regard to habitat types, fidelity was strongest to croplands (64%), sites with freshwater (62%), and estuarine marsh sites (59%) (Figure 9-8).

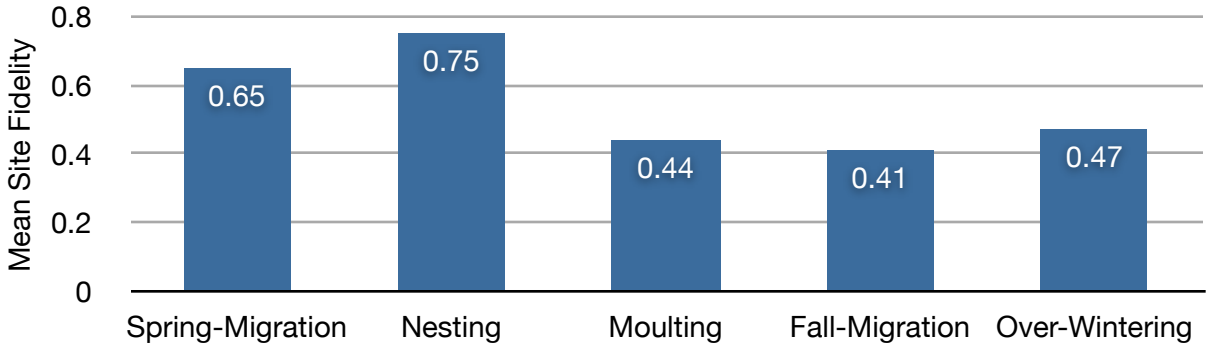


Figure 9-6. Seasonal mean site fidelity (%), 2008-2014 (n=2,387). Sites visited only once were excluded from the analysis.

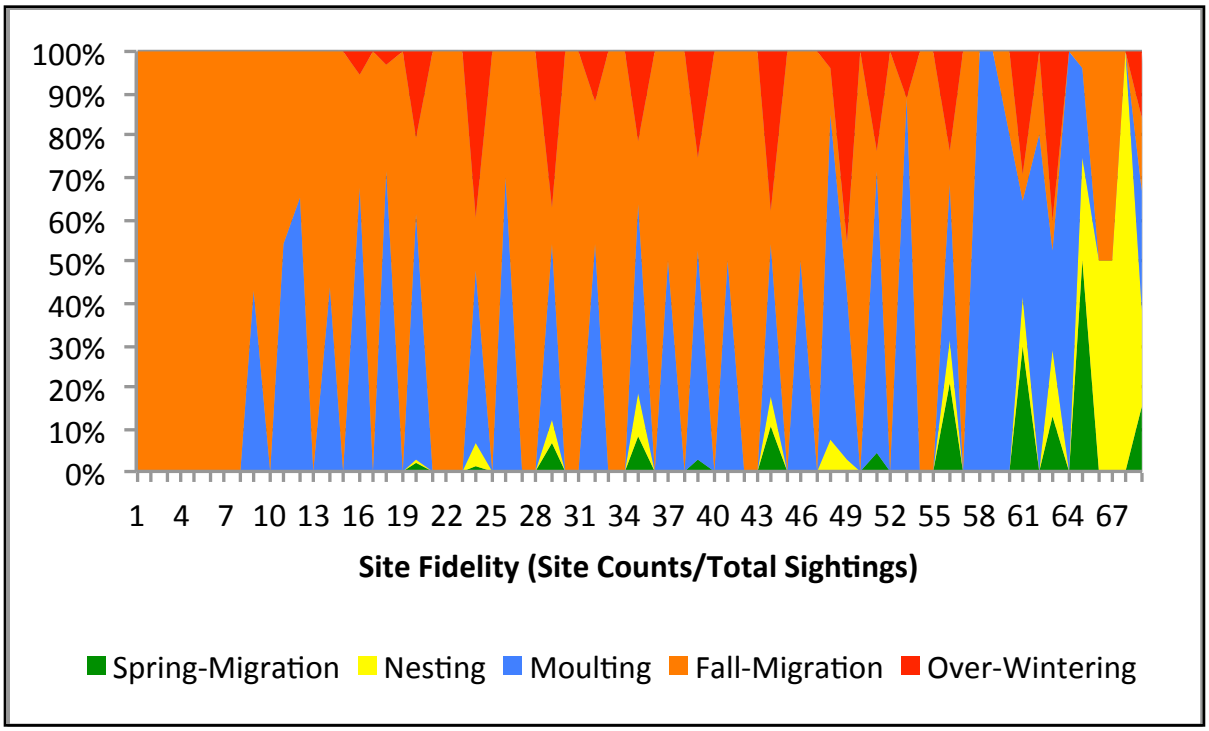


Figure 9-7. Seasonal site fidelity of Canada Geese, 2008-2014 (n=2,387). Sites visited only once were excluded from the analysis. This 100% stacked area graph shows the fidelity of geese to individual sites allocated to each type of seasonal habitat. For example, a thick yellow band on the right side of the graph shows there was strong fidelity to most nesting sites. Smaller yellow 'peaks' to the left of this band indicate there were nesting sites that were visited less frequently.

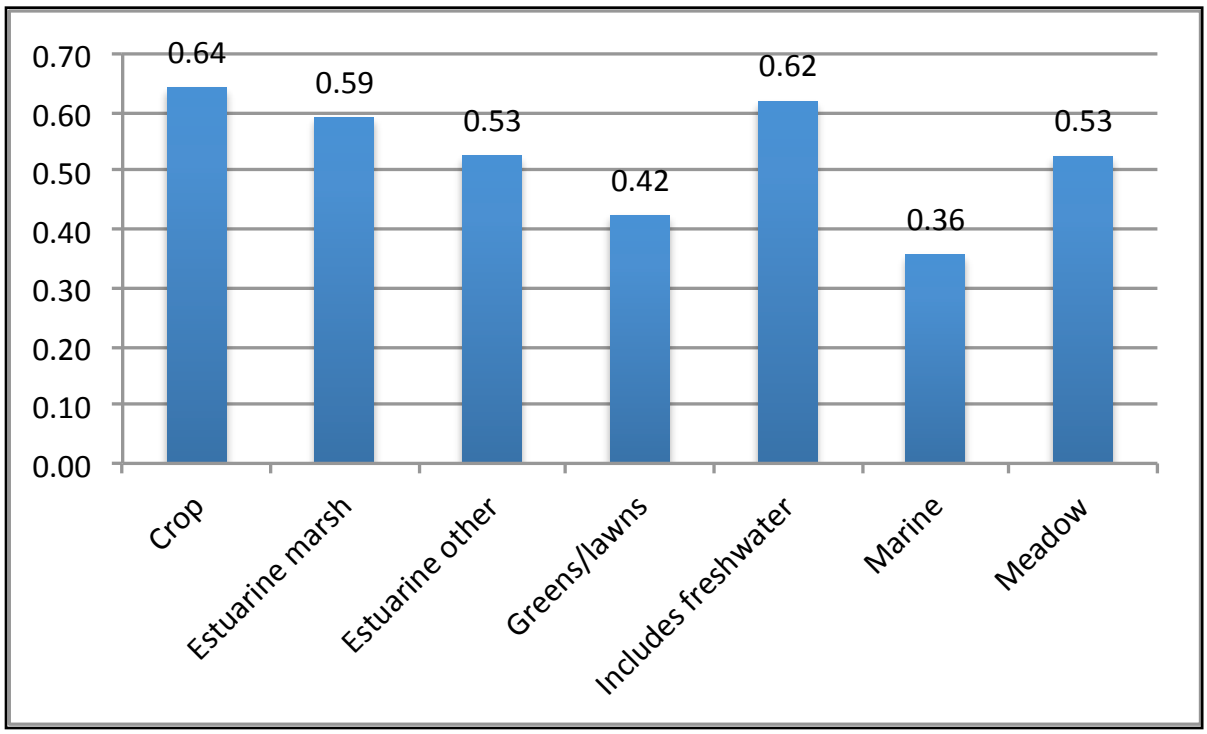


Figure 9-8. Mean site fidelity to habitat groups (%), 2008-2014 (n=2,387). Sites visited only once were excluded from the analysis.

9.3 Nest Density

Although Canada Geese are not colonial nesters, nest densities may be so high on favoured sites that they look like colonies (Granholm 1988; Anderson & Titman 1992). Authors have reported densities as high as 150 and 155 nests/ha (Campbell et al. 1990; Naylor 1953 in Granholm 1988, respectively). Allan et al. (1995) documented Canada Goose nests within 6 to 10 feet of each other, Dow 1943 in Granholm (1988) found nests spaced as little as 2.7 m or 9 feet apart, and Palmer 1976 in Howard Breen (1990) reported 4 geese nesting on an 12 x 30 foot island and 11 nests on a large haystack.

Nest densities in our area, calculated using the sum of nests for all years (2008 through 2014, rather than individual years), and divided by the area of survey sites, were nowhere near 150 nests per hectare. We calculated densities up to 31.5 nests per hectare (Figures 9-9 and 9-10); this number is probably low, as the sites included areas that could not support nesting, such as the water in the LQRE mill pond. The highest nest densities were observed on the LQRE around the mill pond, on other areas of the spit, and on the parts of the lower estuary that still support vegetation. On the ERE, the greatest nest densities occurred on the island; predation is often lower on islands (Johnson et al. 1992). Where nest densities were highest, nests were often found only a few metres apart.

High nest densities may be beneficial or detrimental to geese, depending on whether habitat is limited. High densities may offer some protection against predation, while simultaneously offering a

bonanza for predators (cf. Sherwood 1968). Yet, if densities are too high, females may 'dump' eggs in other nests (Ogilvie 1978 in Ray 2011). Intense competition and attacks by neighbouring ganders may lead to nest abandonment (Munro 1958; Brakhage 1965; Weigand, Pollok, & Petrides 1968; Howard Breen 1990). The proportion of geese in the population that breed may decline, as some pairs move to other areas, or remain as non-breeders (Johnson et al. 1992).

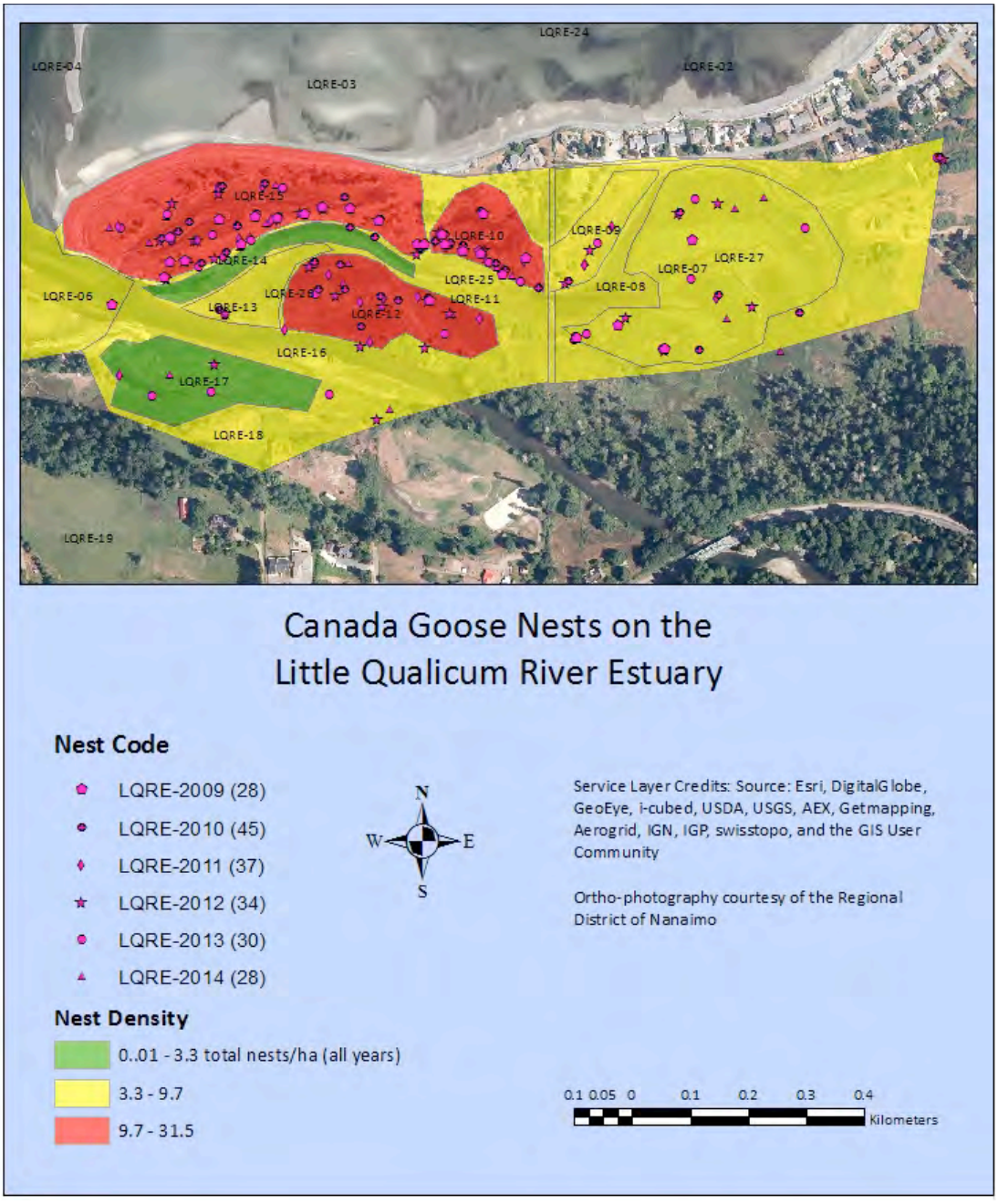


Figure 9-9. Canada Goose nests on the Little Qualicum River estuary, 2009 to 2014 (n=202).

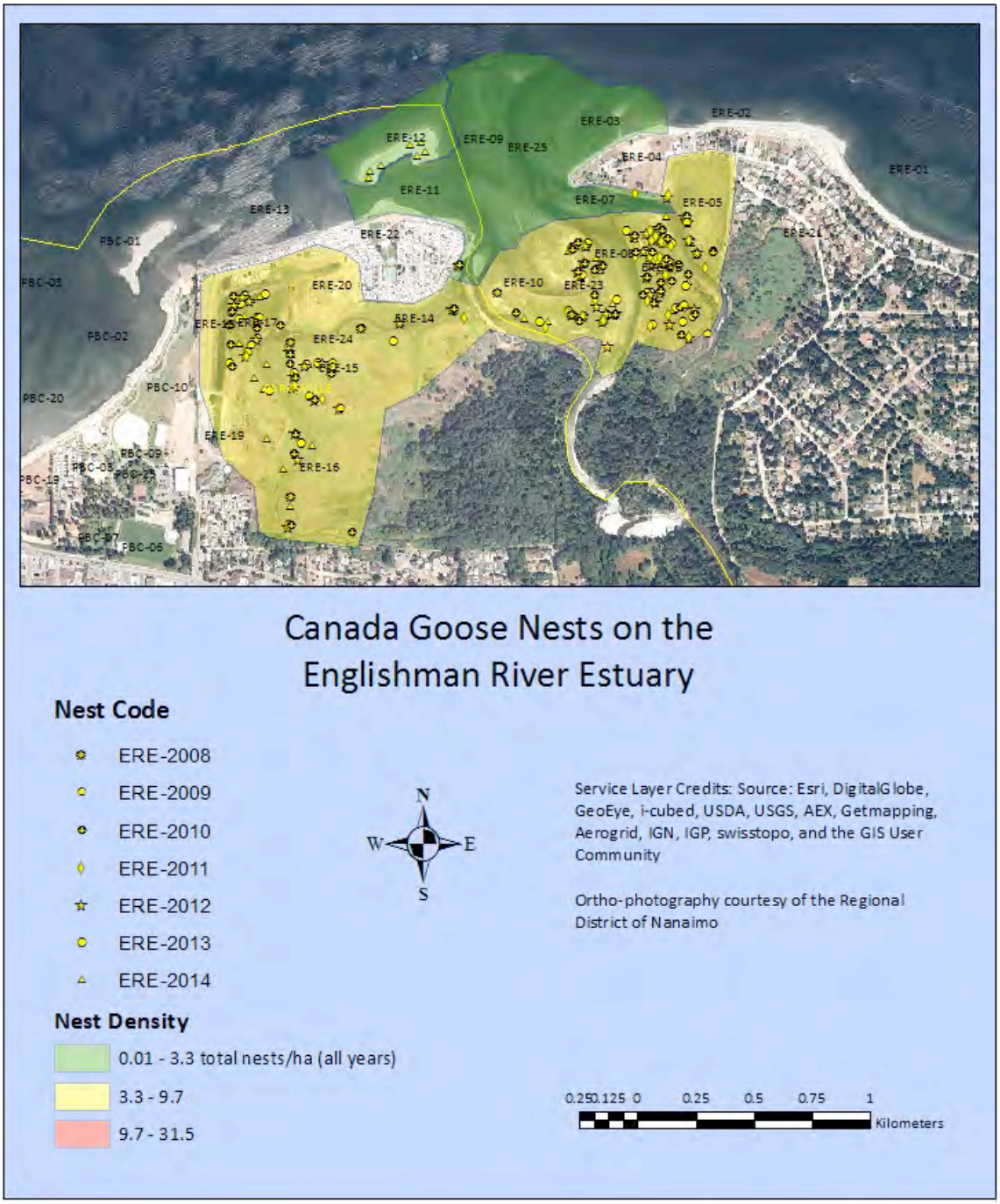


Figure 9-10. Canada Goose nests on the Englishman River estuary, 2008-2014 (n=318). Some data were unavailable (i.e., locations for 43 nests in 2009, re-nest locations).

Chapter 10 - Population Trends

Highlights

This chapter discusses population trends derived from our data and compares them with external datasets. With Chapter 6, Population Structure, it contributes to Goal 1 (setting population objectives).

Multiple types of analyses were used to assess population trends, yet we were unable to determine whether Canada Goose populations are increasing or decreasing. Even when goose surveys from 1989 to 1993, and 2005/2006 were included, there was no obvious trend. External datasets, the Coastal Waterbirds Survey and Christmas Bird Count showed weakly increasing or possibly cyclic trends.

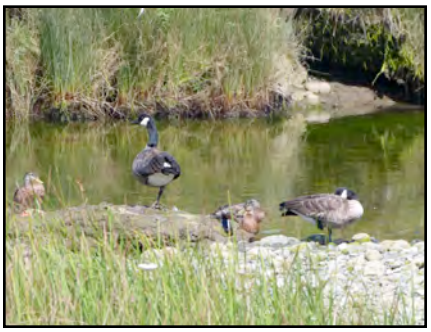
As there is probably the least amount of mixing between local residents and other types of migrants during the nesting season, routine population counts during the 2012 and 2013 nesting seasons were used to estimate the size of the local resident population. The maximum count was 443 in 2013. Missing were undetected nesting birds and geese that left the region to moult.

Peak overwintering and moult counts were considerably higher than counts in other seasons, ~1,500 birds in 2014. However, both peak counts included additional survey areas. The highest count during the spring migration period was 1,018 in 2013. During the autumn migration, it was 948 in 2012.

From 2011 to 2014, Canada Goose densities during the moulting period significantly increased at the ERE while they remained flat at the LQRE. These reflect the numbers of nests found on the estuaries over that time period, which have increased at the ERE and decreased at the LQRE.

Citations, excluded here for brevity, can be found in the text of the document's chapters. Please do not cite highlights without consulting the chapters.

10.1 Statistical Analysis



Although other species were sometimes present, surveyors counted only geese.

10.11 Methods

A variety of statistical methods were applied to Canada Goose survey data to examine annual trends and seasonal differences from moult, winter, and routine population counts, from June 2011 to July 2014. Waterfront counts were excluded.

The number of surveys and survey sites visited differed among survey types, years, and seasons. To maximize the number of surveys included in analysis, the survey year was adjusted from a typical calendar year to a June to May 'Canada Goose year'.

Site-specific population counts were factored by area surveyed (derived from GPS and GIS mapping) to account for the size differences among survey sites. The resulting goose densities (birds per ha) were averaged by year, area, habitat, and season, weighted by the frequency of site visits to accommodate differences in observer effort between seasonal and spatial factors. This process gave more weight to the counts from the most frequently visited sites within a season. Non-parametric analysis of mean and scale (ANOM), based on the Kruskal-Wallis chi-square test, were applied to the weighted mean densities for comparisons tests.

Bird count data were characterized by a high proportion of zero counts; **during most surveys, geese were found on only 10% of the approximately 340 available sites** identified for routine population counts. These data more closely fit a skewed Poisson-type distribution than a Guassian or 'normal' distribution due to the high frequency of zero or low counts and low frequency of very high counts (Ter Braak et al. 1994). Missing values (i.e., under-sampling due to sites not routinely surveyed), over-sampling (of known or easily accessible sites), over-dispersion (high variance in relation to the mean), and serial correlation in the time-series introduce other problems into statistical analysis of trends for count data. These must be accounted for to correctly quantify variability (Pannekoek & Van Strien 1994; Van Strien et al. 2004).

Therefore, to examine the nature of inter-annual differences in mean goose densities for population counts, a log-linear trend analysis was performed via Poisson-type 'maximum likelihood' regression techniques (Pannekoek & Van Strien 1998; Van Strien et al. 2004; SAS Institute Inc. 2011), that are insensitive to deviations from normality in the data. These included three models:

1.Standard Poisson regression for count data, optimized for dispersion correction;

2.'Zero-inflated' Poisson (ZIP), to accommodate the high frequency of zeros in the data; and

3.'Zero-inflated' negative binomial (ZINB), to account for the uncorrected over-dispersion of the data by the Poisson model.

Because these count data statistical methods are inappropriate for density calculations (M. Drever, pers. comm. 2014; A. Van Strien, pers.

John Cooper, cradling a goose captured and collared at the nest, Englishman River estuary.

Multiple types of analyses were used to assess population trends. Inconsistencies in any one dataset matter less when other types of data are exhibiting significant trends in the same direction. Due to conflicting and mostly statistically insignificant results, we cannot report that Canada Geese in the region are increasing or decreasing at a given rate.

comm. 2014), population trend analyses were based on the natural logarithm of individual (unaggregated) site survey counts, utilizing the site-specific area estimates as an 'offset factor' to account for differences in area surveyed. In this way, the resulting population count variable emulated a density variable.

Goodness of fit statistics such as the 'corrected Akaike Information Criterion' (AICc) and the 'deviance ratio' (i.e., deviance value/degrees of freedom) were used to identify the most parsimonious model and the resulting coefficients for the slope of the trend line, if significant. The presence of a dispersion parameter significantly different from zero ($p<0.05$) in the ZINB model is indicative of a persistent uncorrected dispersion issue, which, if present, determines the ZINB model to be most parsimonious.

A significant trend is obtained when the Wald Chi-Square statistic is significant at an alpha = 0.05 level. The trend estimate is obtained from exponentiating the slope (i.e., the parameter estimate for the year variate in the model) and its standard error to obtain 95% confidence limits. The exponentiated slope parameter indicates the predicted change in the count variable given a one-unit change in the year variable. For example, an exponentiated slope estimate of 1.15 + or - 0.05 indicates an increase (i.e., positive trend) of 1.15 times the number of geese per year (i.e., a 15% annual increase) plus or minus 5%, indicating a range of increase of 10 to 20% per year.

10.12 Results

Within- and Between-Year Goose Abundance and Densities

When total goose counts and densities were examined by survey dates over the calendar year, they largely mimicked those for marked birds, with peaks in the moulting period and in the late winter and early spring (Figures 10-1, 10-2, and Table 10-1, see Chapter 6.5, Relative Abundance of Migrant Types and Subpopulations). Low numbers in the nesting and autumn migration periods were due, in part, to lower detectability (see Appendix C). Notably, there were record tallies for 2014.

Geese may be widely distributed over a large site, lowering densities; this is often the case with marine and agricultural sites. On the other hand, large numbers of geese can be found in very small areas; for example, 91 birds were found in a 0.09 ha pond in the Parksville Church Road area (site PCR-04) during a routine population count in the winter of 2012. Removing these outliers did not affect between-year statistical significance.

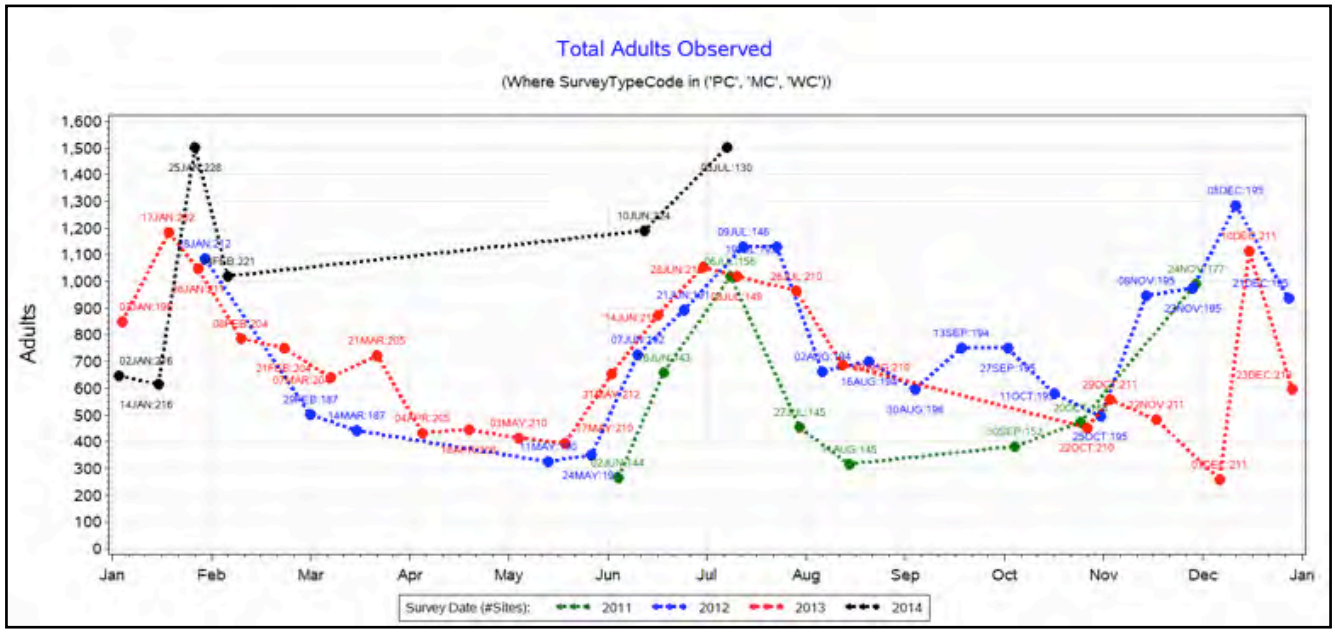


Figure 10-1. Total numbers of Canada Geese surveyed in the study area. Only AHY or unknown aged birds were included; juveniles were excluded. Tallies included moult, winter, and routine population counts across all sites, by survey date. Each data point is identified by survey date and the number of sites visited during the survey.

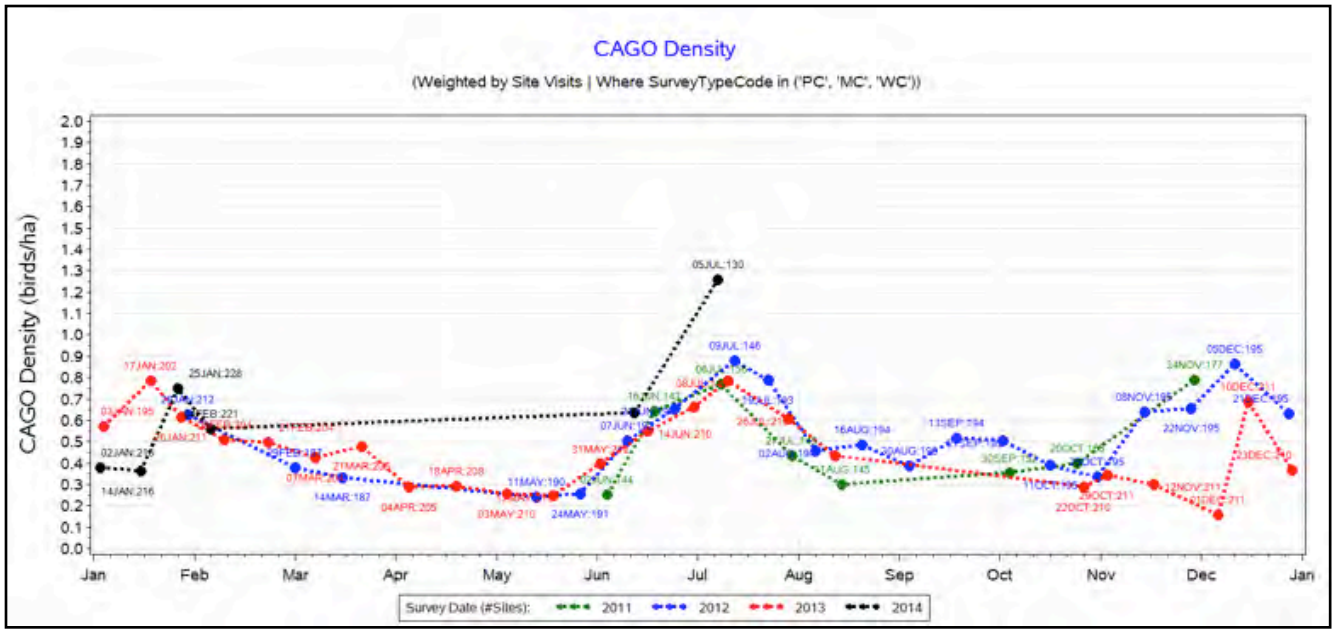


Figure 10-2. Canada Goose density (birds/ha) during moult, winter, and routine population counts, by survey date.

Table 10-1. Summary statistics for Canada Goose counted by survey type, season, and year. RPC=Routine Population Count. The lowest minimum and highest maximum number of geese per survey for each season are shown in red, for each season.

Survey Type	Year	Minimum CAGO/Survey	Maximum CAGO/Survey	Mean CAGO/ Survey	Mean CAGO/ Survey SD
Moult Count	2011		1020		
	2012		1129		
	2013		1020		
	2014		1502		
RPC - Moult	2011	264	661	423.5	177.5
	2012	662	1130	852.8	208.9
	2013	688	1053	894.8	156
	2014	1188	1188	1188	
Winter Count	2012		1084		
	2013		1046		
	2014		1501		
RPC - Overwintering	2012	992	992	992	
	2013	848	1285	1045.6	181.3
	2014	258	1113	645.2	305.1
RPC - Spring Migration	2011	443	503	473	42.4
	2012	642	786	725.5	61.3
	2013	1018	1018	1018	
RPC - Nesting	2012	326	350	338	17
	2013	395	446; 654 May 31	468.4	105.5
RPC - Autumn Migration	2011	169	472	284.6	163.7
	2012	497	948	688.8	148.2
	2013	453	559	498.3	54.6

Goose Densities Among Years

A non-parametric analysis of mean and scale (ANOM), applied to weighted mean Canada Goose densities, found significant differences (pKW<.0001) when site-specific goose density values were averaged across all surveys, aggregating all survey types and seasons (Figure 10-3). When partitioned by survey type however, density comparisons among years indicated strong significant differences only for routine population counts, not for moult or winter counts, whether aggregated across seasons or partitioned by seasons.

Importantly, the level of error within a given moult or winter count was high, given these counts were only conducted annually. Yet, moulting birds cannot fly and are easier to count, and the precision of winter counts benefits from many experienced observers counting over a short period.

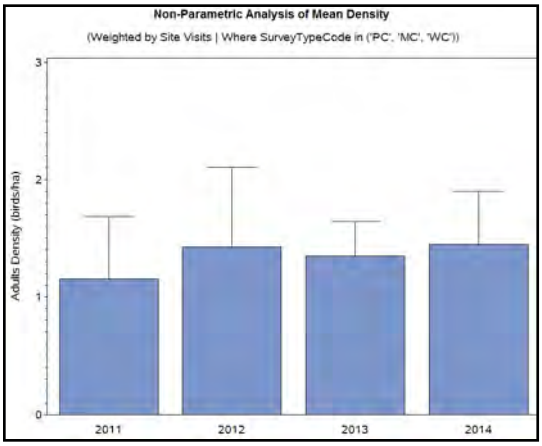


Figure 10-3. Comparison of annual mean Canada Goose densities (birds/ha), from moult, winter, and routine population counts across all seasons. Non-parametric Analysis of Means (ANOM) Kruskal-Wallis Chi-Square test (pKW<.0001). Only AHY or unknown aged birds were included; juveniles were excluded.

Population Trends

Although successful model convergence on parameter estimation occurred in all cases for all model types, the three model trend estimates did not always agree in significance or even in direction, indicating weak support for model fits.

For example, the ZINB linear trend models indicated there were significant, positive trends for moult counts and spring migration routine population counts, and significant, negative trends for nesting and overwintering routine population counts (Table 10-2).

The negative nesting period trend was based on only two years of data and therefore does not provide a reliable indicator. Nesting trends on the estuaries, apparent in the egg addling data, were gathered over a longer period (see Chapter 12.11, Egg Addling Program).

Table 10-2. Linear trend statistics for moult, winter, and population counts, 2011-2014.

Survey Type	Season	Selected Model	Based On	Slope	Std Error	Trend	Min	Max	Prob	Direction
MOULT	Moulting	ZINB	AICc & Over-Dispersion	0.308	0.135	1.36	1.05	1.77	0.022	+
WINTER	Over-wintering	ZINB	AICc & Over-Dispersion	0.115	0.243	1.12	0.70	1.81	0.632	0
POPULATION	Moulting	ZINB	AICc & Over-Dispersion	-0.119	0.100	0.89	0.73	1.08	0.234	0
POPULATION	Fall Migration	ZINB	AICc & Over-Dispersion	0.049	0.222	1.05	0.68	1.62	0.827	0
POPULATION	Over-wintering	ZINB	AICc & Over-Dispersion	-0.633	0.163	0.53	0.39	0.73	0.001	-
POPULATION	Spring Migration	ZINB	AICc & Over-Dispersion	0.418	0.198	1.52	1.03	2.24	0.035	+
POPULATION	Nesting	ZINB	AICc & Over-Dispersion	-0.515	0.214	0.60	0.39	0.91	0.016	-

The significant increase of moulting Canada Geese in the region from 2011 to 2014 (Figure 10-4), including a linear trend coefficient showing an average rate of growth of 36% over those years, may be deceiving. It is largely attributed to a single survey, i.e., the 2014 moult count which exceeded 1,500 birds; an observer extended the search area to include large flocks of geese along Nanoose Bay towards Lantzville, whereas this area had not been surveyed in earlier years. There was no similar trend for routine population counts during the same period (Figure 10-5). From 2011 through 2013, the moulting population was relatively stable at 1,000-1,200 geese.

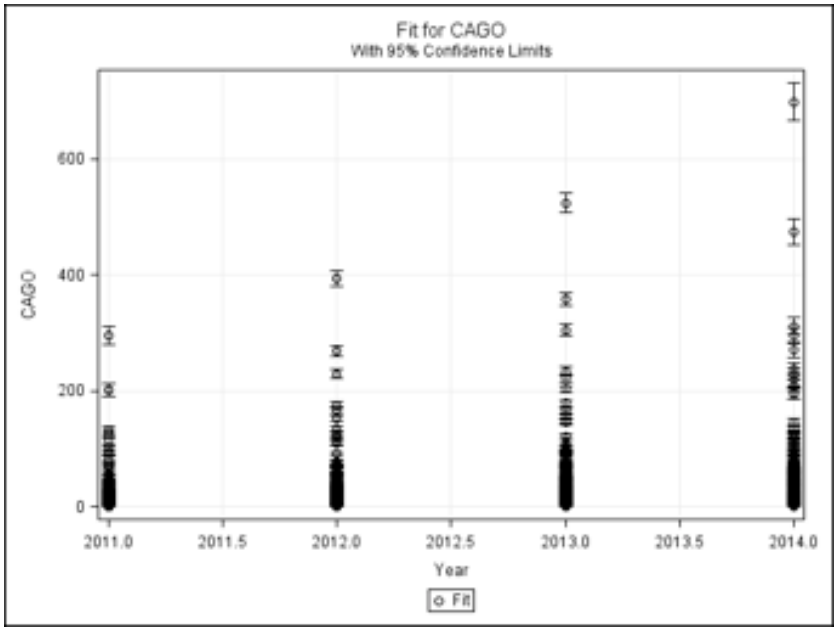


Figure 10-4. Poisson model results for moult count data, 2011 to 2014.

Limitations

The number of sites surveyed increased over time, as geese were discovered in new areas and permissions were granted to survey private properties. The number of site visits also increased. Therefore more sites were surveyed, more often, as the study progressed. Statistical significance in some analyses was attributed to these changes in survey effort, rather than to changes in goose populations, despite concerted efforts to incorporate effort in the analyses. This is explained in more detail in Appendix C.

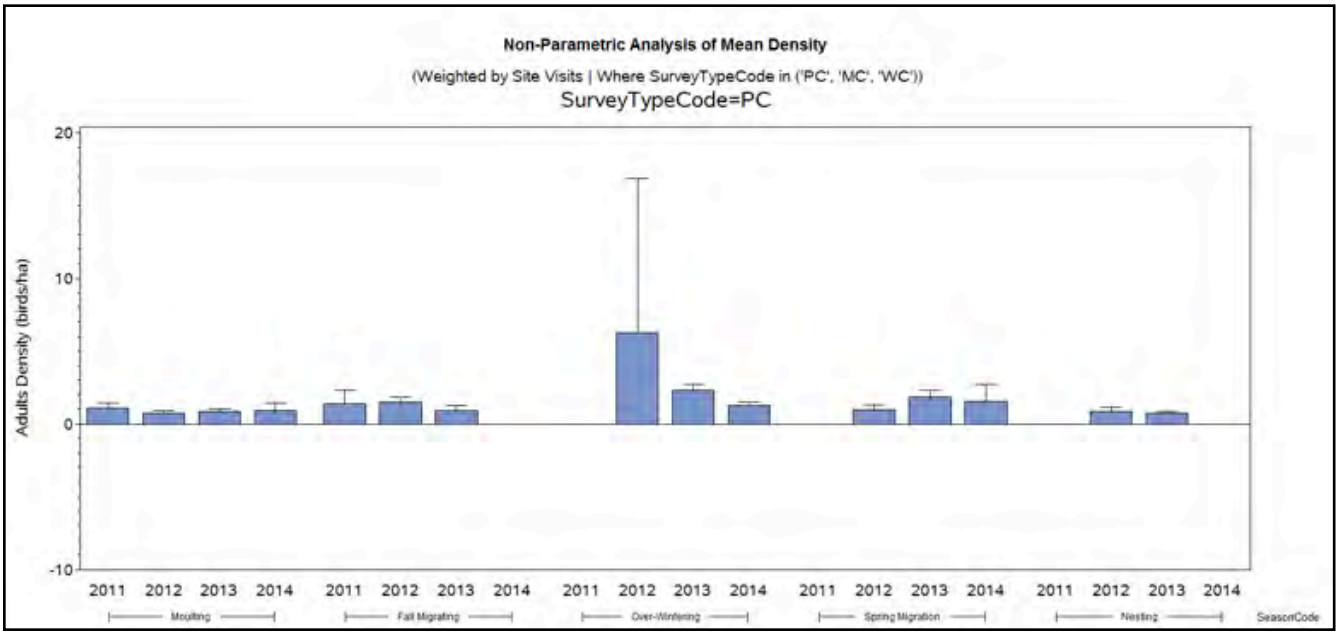
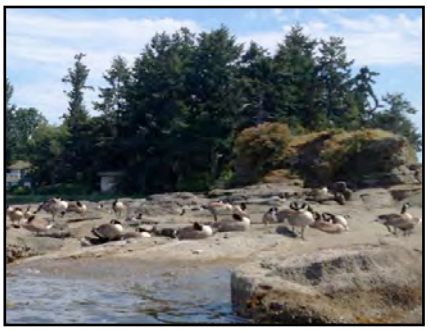


Figure 10-5. Mean Canada Goose density (birds/ha) for seasonal population counts.



Loafing geese at the mouth of the Craig Creek estuary. The CCE subpopulation does not nest at the CCE estuary; without this link their trends are more difficult to assess.

Similarly, routine population counts during the overwintering period showed a significant decrease over time (Figure 10-5), whereas the winter counts did not. The decline observed in population counts was attributed to a single outlier in 2012, where densities were inflated by a large flock observed on one small site. When the 2007 winter count was included, there was no significant trend.

There was a significant, positive trend in the number of geese present during routine population counts over the spring migration period. Yet, a significant negative trend was observed at the ERE over the same period ($p=0.017$), and the trend at the LQRE was insignificant ($p=0.341$).

When the population data were partitioned by banding estuary, there were trends indicative of the effectiveness of goose control and restoration efforts, or the lack thereof.

During the moulting period, the densities of Canada Geese at the ERE significantly increased from 2011 to 2014 ($p=0.021$), while numbers were flat at the LQRE. This is reflected to some degree in the numbers of nests found and eggs addled at each estuary, which have risen over time at the ERE, but decreased at the LQRE (see addling graphs in Chapter 12.2, No Action).

In the fall migration and overwintering periods, densities significantly increased at the LQRE ($p<0.001$ and $p=0.002$, respectively), whereas densities were static or slightly decreased at the ERE. The daytime use of these estuaries in seasons outside of the nesting and moulting periods may be dependent, in part, on the availability of preferred forage, which is improving at the LQRE and probably declining at the ERE. However, there are many other variables that could play a role, such as proximity and use of other feeding areas, levels of disturbance, and weather. This trend requires further investigation.

Insignificant trend model fits might be attributed to insufficient length of time-series, outliers in the data, unidentified model components (i.e., missing co-variates), or, barring those likely factors, no evident trend in the data. In addition, population trends may be non-linear, and therefore not apparent from these linear trend analyses. Initial analysis of trends using TRIM software (Van Strien et al. 2004) indicated apparent nonlinear effects in some (but not all) cases, and were inconclusive due to insufficient data (namely brevity of time-series in the contemporary population count dataset, and insufficient spatial resolution in historic data for inclusion for analysis and detection of long-term linear or non-linear time trends).

Overwintering Time Series

For an overview of population trends, we explored data for which we had a relatively long time series. There were nine surveys of 'overwintering' Canada Geese from 1989 through 2014. The CWS and MoE led six counts from 1989 through 2006, and the Guardians conducted surveys from 2012. This amalgamation of historical and contemporary data found a prominent spike in 2006 followed by a return to lower numbers in 2012 (Figure 10-6). Population growth in the early years was indicative of an increasing goose population as well as additional survey effort with new areas added over time. Foggy conditions in November 2005 prompted a second survey in January 2006, revealing greater numbers and motivating a shift to January overwinter counts in later years. 2005 also marked the opening of River's Edge in Nanoose Bay, a new rural subdivision with grassy areas, ponds, and pastures. A spike in goose numbers in January 2014 was attributed, in part, to additional survey areas in Nanoose Bay. No long-term, statistically significant trend was evident in this data.

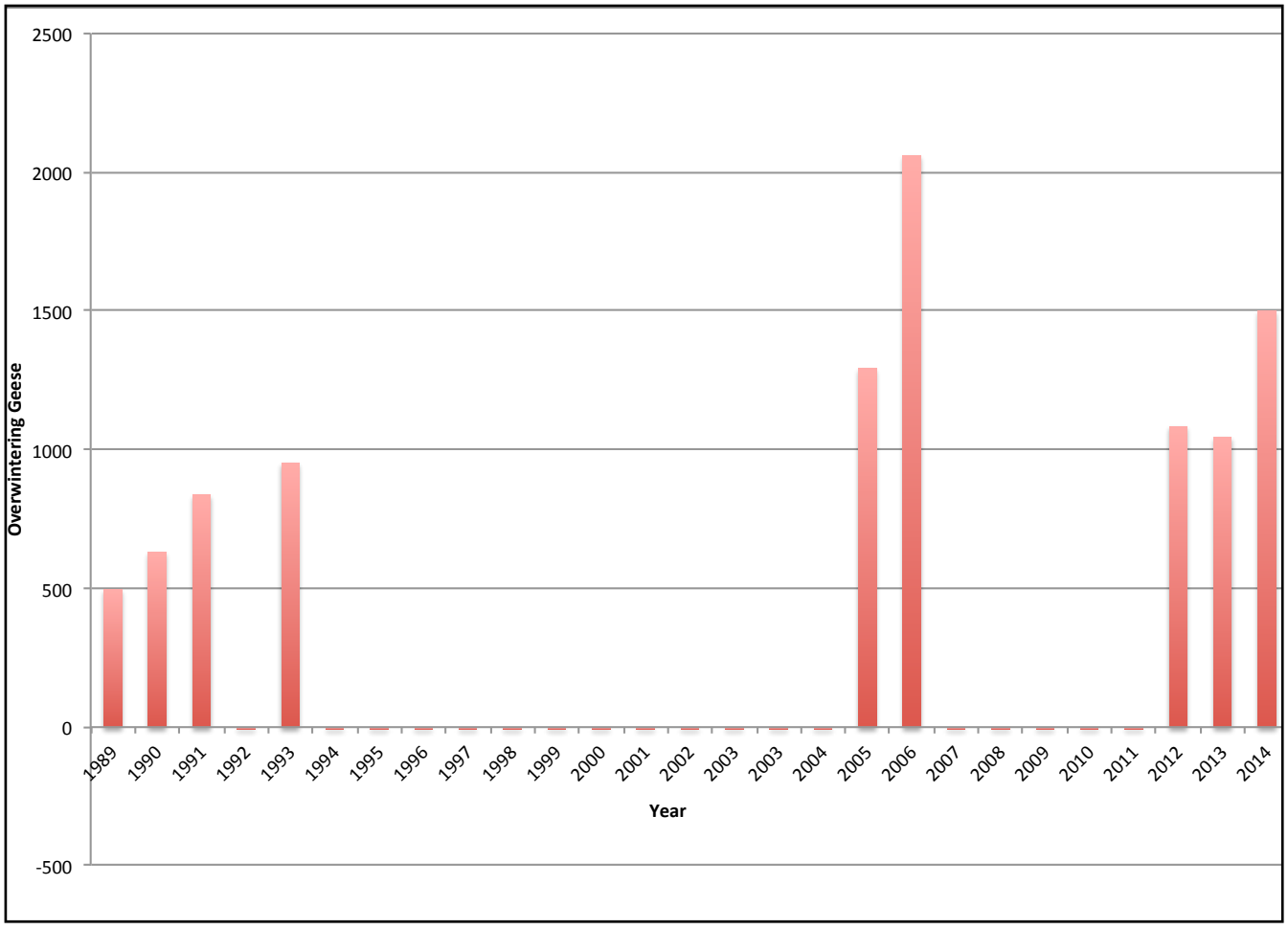
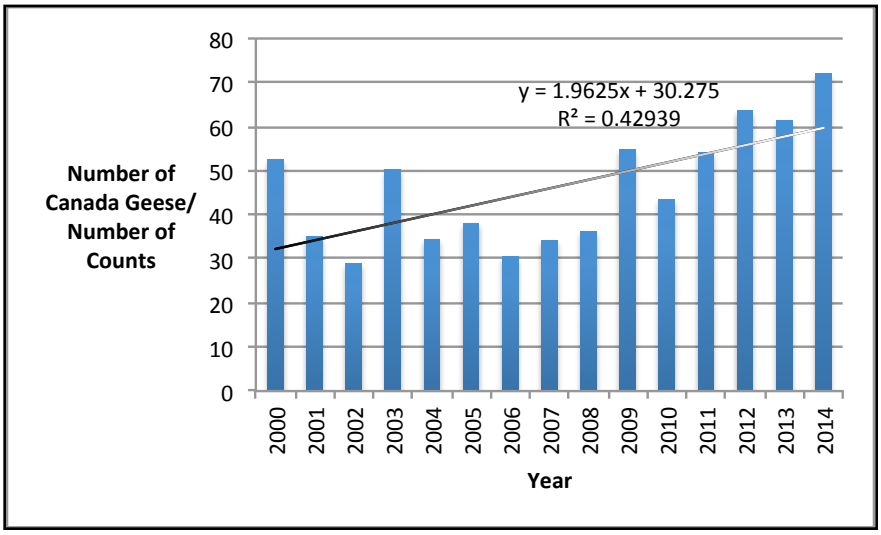


Figure 10-6. Autumn and January Canada Goose counts, 1989 to 2014 (n=9). Counts were conducted in late November for 1989 to 1991, 1993 and 2005, in mid-January in 2006, and late January from 2012 to 2014. Data were grouped by survey area. Effort was directly comparable for 2012 and 2013 counts only.

10.2 External Data Sources

10.21 B.C. Coastal Waterbirds Survey

While data for the Vancouver Island, Parksville - Qualicum Beach region showed an increasing trend, adding approximately 2 birds per year from 2000 through 2014, less than half of the variability in Canada Goose numbers was explained by year. Numbers were lowest in 2002 and 2006, whereas the 2006 CWS-led winter count was one of the highest ever recorded (see Figures 10-6 and 10-7). In a closer examination, using counts for the month of January only, numbers were very low and there was no significant linear trend (Figure 10-8).



B.C. Coastal Waterbirds Survey data were compiled by Karen Barry. These data are also available from Bird Studies Canada (see http://www.bsc-eoc.org/volunteer/bccws/index.jsp?targetpg=bccwsdata). The data were collected by volunteers trained to follow a standardized protocol. This protocol asks that volunteers count birds from September through April, and preferably monthly. Birds are located in three habitats: inland = above high tide (e.g., a pond, field), nearshore = from high tide out to 500 m from shore, and offshore = beyond 500 m from shore (K. Barry, pers. comm. April 4, 2014). To more accurately compare this data with our own, we selected only January surveys and contrasted these with our winter counts.

Figure 10-7. B.C. Coastal Waterbird Survey data for Canada Geese in region VIPQ (Vancouver Island, Parksville - Qualicum Beach), 2000 to 2014. September to April counts were summed and divided by the total number of counts. Surveys with zero Canada Goose counts were not included (K. Barry, pers. comm. April 4, 2014).

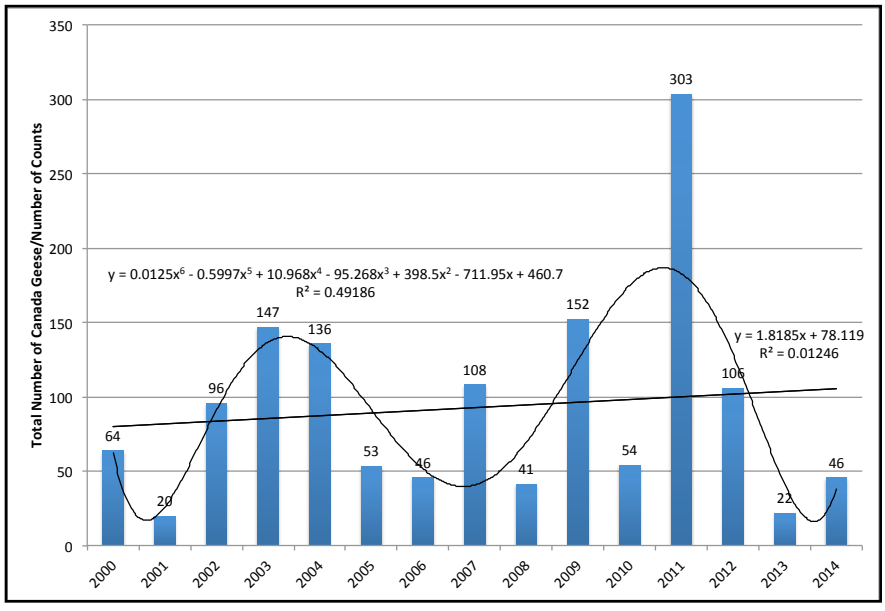


Figure 10-8. B.C. Coastal Waterbird Survey data for January, 2000 to 2014.

10.22 Christmas Bird Count

The Christmas Bird Count (CBC) is an annual one-day, volunteer-based survey coordinated by local naturalists and reported by the Audubon Society. Weather is known to strongly influence the number of birds observed. Prior to about the mid-1990s, the data collected for the BCPQ count circle was scant, the map was poor, and the circle centre was not described accurately. Since ~2000, counting effort has been more, but not entirely consistent. Over the last decade, data collection has been more detailed (S. Gray, pers. comm. January 16, 2015).

There are two CBC 'counting circles' within our region, i.e., BCPQ (Parksville-Qualicum) (Figure 10-9) and BCNB (Nanoose Bay). The numbers of Canada Geese observed in the BCPQ circle have consistently increased since 2009, after fluctuating for many years (Figure 10-10). The linear trend line shows a mean increase of 20 birds per year from 1991 through 2014, yet the coefficient of determination is low (r^2=0.18), suggesting that only 18% of the variability in CBC goose counts is accounted for by year. Counts exceeded 1,400 birds in 1998, 1999, 2002, 2004, 2013, and 2014. Our regional counts over the overwintering period exceeded 1,400 only in 2014. No data were available for the BCNB circle (Audubon Society 2015).

To the northwest is a third counting circle, the Deep Bay circle (BCDB), which extends south to the Big Qualicum River. Interestingly, CBC numbers in the BCDB circle did not reach 400 until 2003, and have been increasing since 2005 (Figure 10-11). The linear trend line showed an increase similar to the BCPQ circle (i.e., 20 birds per year), but the coefficient of determination was much higher (r^2 =0.47). The trend was better explained by a polynomial line that was largely flat through the 1990s and early 2000s (order 3, r^2=0.57).

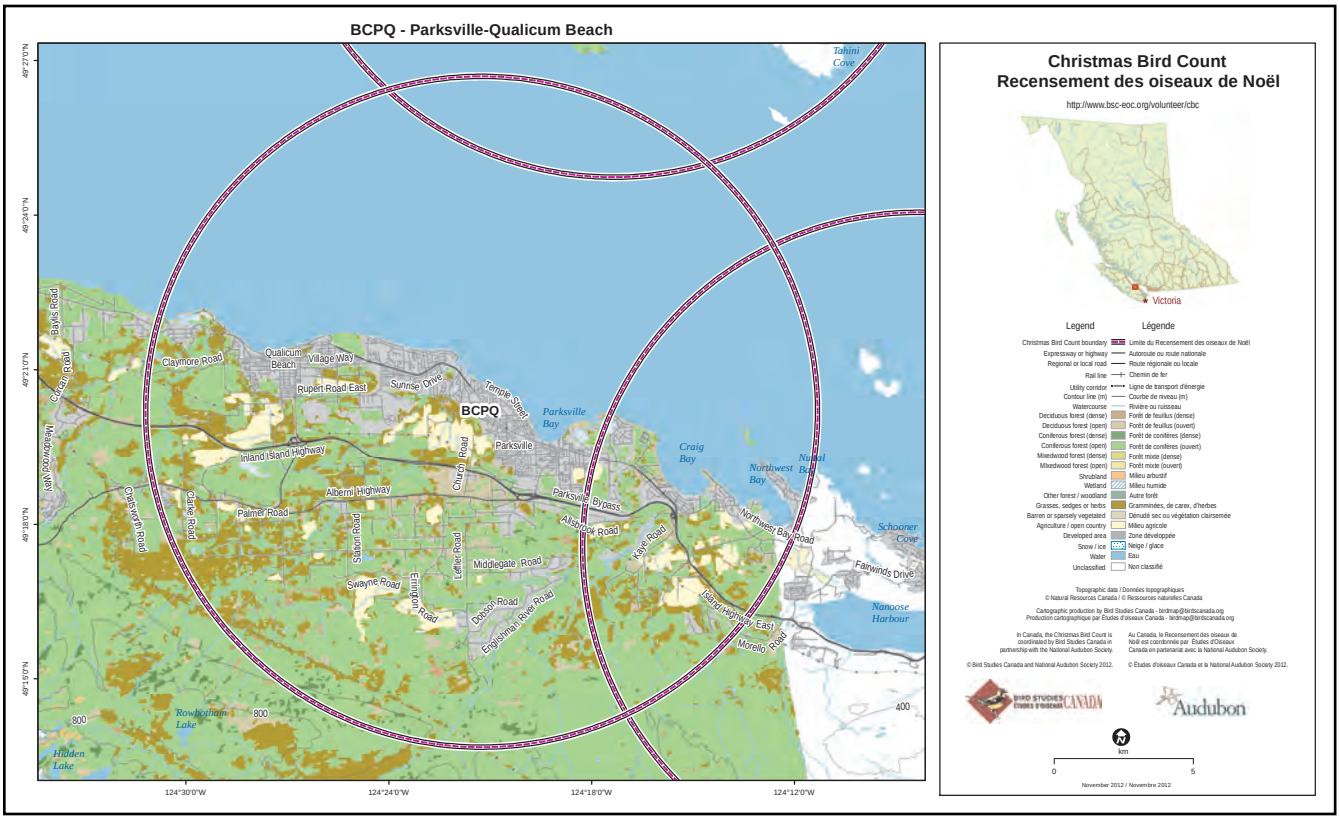


Figure 10-9. Christmas Bird Count circle BCPQ (Parksville - Qualicum Beach).

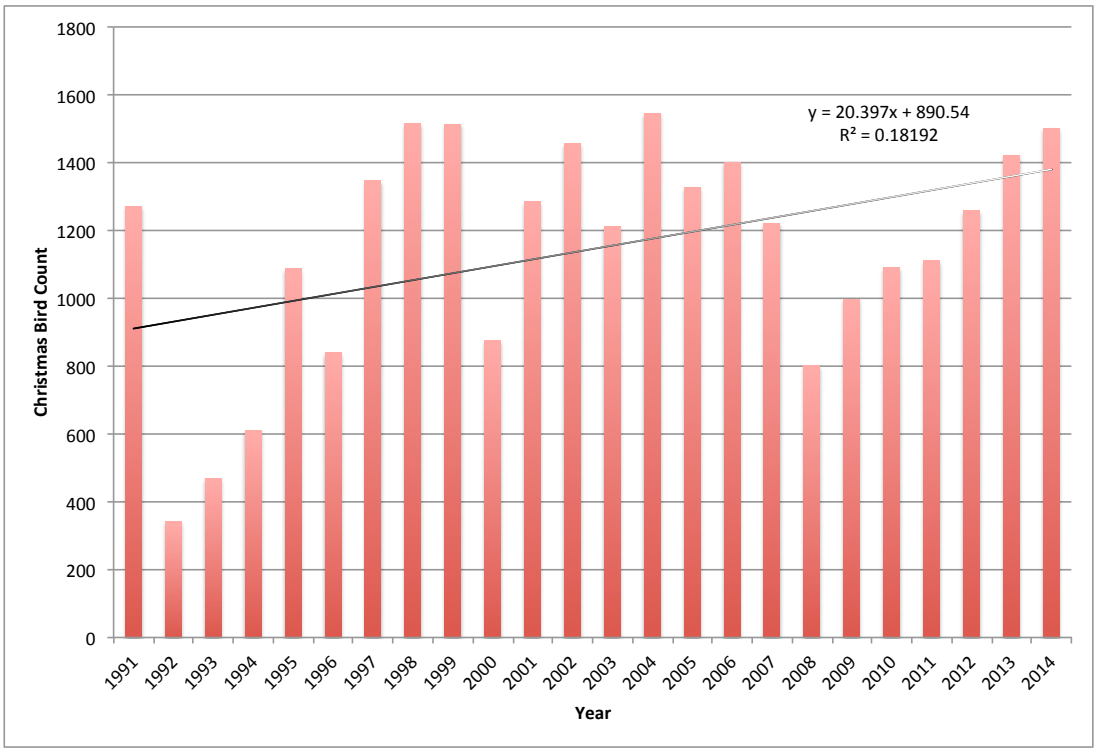


Figure 10-10. Canada Geese observed during the Christmas Bird Count in the BCPQ circle, 1991-2014.

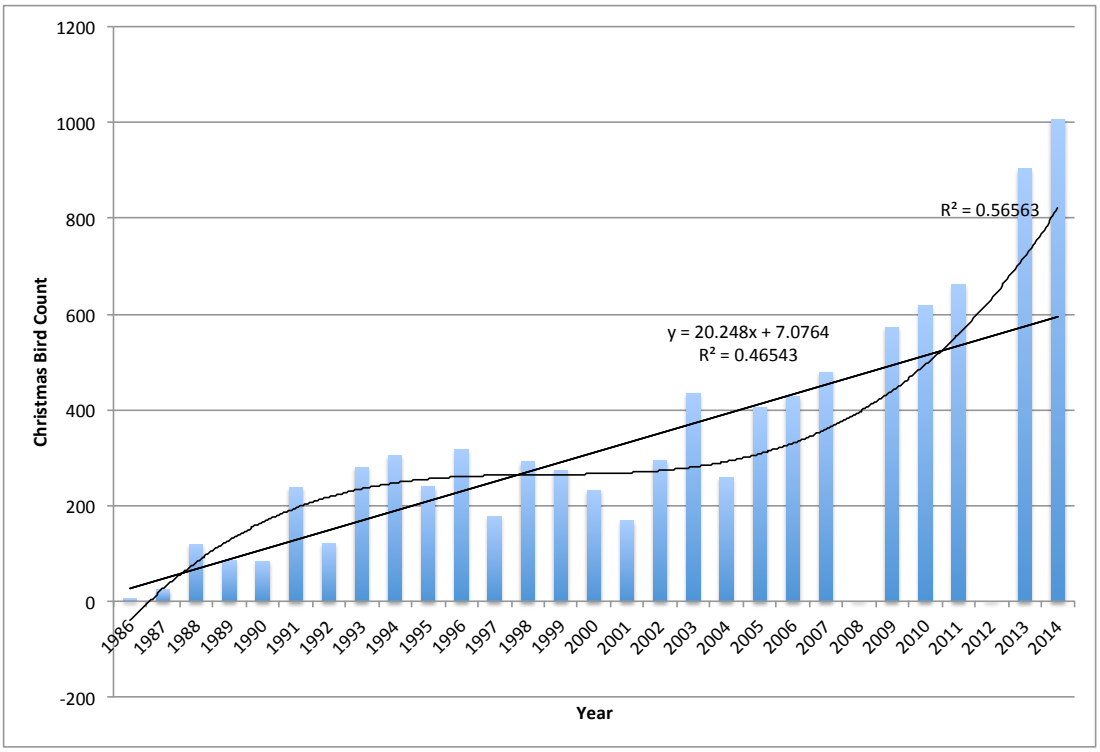


Figure 10-11. Canada Geese observed during the Christmas Bird Count in the BCDB circle, 1986-2014.

Aaron Ritchie, conducting surveys for the Guardians near the Snaw-naw-as First Nation reserve in Nanoose Bay, 2014

10.23 Study of Canada Geese in Parksville

Ritchie (2013) estimated the goose population in Parksville to be 678 ± 112 (SD), based on surveys conducted from July 2012 to January 2013. Counts fluctuated from 383 in late October to 1,480 in late December. More geese were found during morning surveys (mean = 262 ± 127 SD) than afternoon surveys (mean = 166 ± 63), although time of day did not significantly affect population estimates (Ritchie 2013). The high in December 2013 is consistent with our winter count in 2014 and with 2013 CBC data, confirming that this was a peak for overwintering Canada Geese.

Ritchie (2013) conducted weekly goose surveys and recorded marked birds within the City of Parksville and the San Pareil area of the RDN from July 2012 to January 2013, as part of his undergraduate degree program at Vancouver Island University. He estimated the resident population size using program MARK 6.2, and assessed whether the time of day that surveys were conducted (i.e., morning or afternoon) affected the statistical significance of the population estimate.

10.24 Other Data Sources

Several other data sources were considered in the development of this strategy.

B.C. banding records were examined to determine whether Canada Geese banded elsewhere had been recorded in our region from 2008 to 2014. No such records were found.

Breeding bird surveys were found to be poorly suited to the study of Canada Geese. They occur in June, when the birds are beginning to moult. The surveys occur along a predefined route, 24.5 miles (39.4 km) long, with 50 three-minute stops, each 0.5 miles (0.8 km) apart. At each stop, volunteers record the total number of each bird species seen or heard within about 400 m (Bird Studies Canada n.d.).

eBird was also explored for Canada Goose data in local and nearby Important Bird Areas. There were few data based on a small number of sites.

As part of her undergraduate degree program at the University of Victoria, Spillette (2015) explored the use of several mark-re-sight models (i.e., Cormack-Jolly-Seber Model, Jolly-Seber Model, Brownie M1 Model, and Burnham Model) to assess survivorship of CCE-banded birds. Some of the statistical challenges she identified or examined included **tag loss**, homogeneity (migrant types), homogeneity (banding location), study range and emigration, and defining re-sight intervals. This work may serve a future Master's or PhD student in the University of Victoria's Department of Mathematics and Statistics (L. Cowen, pers. comm. May 26, 2015).

Other sources are described in Chapter 12, Management Options.

Tag loss was a factor in this study. Several LQRE and ERE-banded birds managed to free themselves of their collars. We used glue to secure the collars of CCE birds.

10.3 Life History by the Numbers

The key factors contributing to a larger regional population and greater Canada Goose densities include: a higher natality or birth rate, lower mortality rate, more immigration from other areas, and/or less emigration out of the region. Similarly, a smaller regional population and lower densities can be achieved by lowering the birth rate, increasing the mortality rate, limiting immigration, or encouraging emigration. This section explains how these factors affect population size, drawing from our own data wherever possible.

10.31 Natality

The natality or birth rate, sometimes referred to as reproductive output, is directly influenced by the number of breeding birds, breeding success, and the rate of re-nesting. The average clutch size of a Canada Goose population is a measure of its potential for reproduction (Brakhage 1965). (Eggs laid sequentially in a single nest are referred to as a 'clutch'.)

Breeding Birds

The proportion of birds that attempt to breed is determined by the age at which Canada Geese become capable of breeding. Canada Geese will choose mates at the age of two or three years (Howard Breen 1990). Some Canada Geese that nest successfully in earlier years do not attempt to nest later on (Johnson et al. 1992).

The age structure of the population affects egg and gosling production. There are fewer young produced if there are fewer birds of breeding age. The number of breeding birds in any given year is dependent on the population size during the previous nesting season, the number of young they produced that have reached breeding age, the survival rates of breeding adults between the previous and current breeding season, and the likelihood that the birds will return to the nesting grounds (Johnson et al. 1992).

Brakhage (1965) suggested that certain females were dominant and others were subordinate. In his study, males determined the territories, but females determined the nest sites; the female hierarchy affected proximity to other nests, size of clutches, and even whether subordinate females laid eggs at all. It appears likely that dominance is age-related.

Our marked Canada Geese were not systematically aged. Of the 296 birds that were marked, only 26 were aged as juveniles/'hatch-year' (HY), 110 were adult/'after-hatch-year' (AHY), and 160 were of unknown age.

Breeding Success

Breeding success' is self-explanatory in circumstances where managers have used various forms of birth control to limit goose production. However, most often it is a broad term encompassing egg success,

hatching success, and/or nest success. Cooper (1978) defined egg success as the percentage of eggs that hatch, hatching success as equivalent to nest success (unless referring to artificially incubated eggs, in which case it is a measure of fertility), and nest success as the percentage of nests producing one or more goslings.

In nature, some eggs do not hatch, due to infertility, breakage, displacement from the nest, chilling, desertion, or predation (Johnson et al. 1992). When populations are dense, the number of infertile eggs among subdominant birds may be greater (Johnson et al. 1992). Overcrowding and conflicts between nesting pairs can lead birds to abandon their nests (Ogilvie 1978 in Ray 2011). Losing eggs has less effect on the size of a population than losing goslings or adults, because the chance of an egg becoming a breeding adult is lower (Perrins & Birkhead 1983).

Cooper (1978) reported nest success rates close to 80% for first nests, in an area of Manitoba not subjected to excessive predation or flooding. Nesting success was 84% at George C. Reifel Migratory Bird Sanctuary in Delta, B.C., in 1973 (Dawe & Davies 1975).

Breeding success is linked with nest site selection, or more specifically, the availability and quality of nest sites. Good sight lines and vegetative cover help protect nests from predation (cf. Miller, Abraham, & Nol 2013), while nearby high quality forage and drinking water minimize the length and number of recesses (cf. Cooper 1978). The tenacity of the parents likely plays a role as well.

Re-nesting

After an earlier clutch is destroyed or abandoned, or a brood is lost, Canada Geese may re-nest (Johnson et al. 1992). A re-nest differs from a 'continuation nest', where a female continues laying in a second nest, after losing eggs from the original nest before her clutch is complete (Brakhage 1965).

From 9 years of records for Canada Geese in a captive breeding program in Michigan, 70% of geese re-nested after their first clutch was removed (Weigand, Pollok, & Petrides 1968). Among Canada Geese breeding in Manitoba, 92% of pairs that lost their first nest made a second attempt, as either a re-nest or continuation nest (Cooper 1978). Of pairs that lost a nest at two days of incubation, 70% re-nested. None of the pairs that lost nests late in incubation made another attempt (Cooper 1978). Continuation nests are generally nearer original nests than re-nests (Brakhage 1965; Cooper 1978). Brakhage (1965) observed most continuation nests were within 100 m, while Atwater (1959) found a re-nesting bird had moved 24 miles. In Missouri, Weigand, Pollok & Petrides (1968) calculated an average re-nesting interval (between the termination of the first nest and the start of the second) of 16.7 days, Not surprisingly, re-nesting

Clutches with 9 eggs were unusual. From 2008 through 2014, only 10 were found: one on the LQRE and 9 on the ERE. This one was found on April 26, 2010 (above). However, there were at least 93 nests with 8 eggs over the same period (below).

rates are higher where nest success rates are lower (Johnson et al. 1992).

Re-nest clutch sizes are reportedly smaller for all species of waterfowl, a consequence of hen exhaustion and diet (Johnson et al. 1992). Yet Cooper (1978) and others found that re-nest clutch sizes for Canada Geese were not significantly different from first nest clutches, and in some cases were larger.

Prior to 2015, there were three re-nests discovered among our marked birds, all at the ERE, one in 2012, one in 2013, and one in 2014. In 2015, there were two re-nests at the ERE and one at the LQRE (T. Clermont, pers. comm. 2015).

Clutch Size

Canada Geese are determinate layers, e.g., if eggs are removed, a goose will not lay more (or fewer) eggs than they would if eggs had not been removed (Cooper 1978). Therefore, clutch size is a measure of egg success. In *Birds of British Columbia*, clutch size ranged from 1 to 14 eggs, with 55% having 5 or 6 eggs, for 1,374 clutches (Campbell et al. 1990). The CWS (2010) reported that nests may contain 10 or more eggs, with an average of 5-6 eggs, and the MoE (1979) documented an average of 5 with a range of 4 to 7. Bellrose (1976) noted that nests with more than 8 eggs probably included some dumped by intruding females.

In our region, the mean clutch size, with 95% confidence, was 5.2 ± 2.2 eggs/clutch, for all nests found during the estuary-focused egg addling program since 2002. As nests outside of the ERE and LQRE were a lesser priority, they were often searched later in the season, some after they had been predated; therefore this value is probably low. In fact, variability prior to 2010 was largely a reflection of 'survey' effort, as early egg addling crews visited the estuary only once or twice each nesting season. For nests discovered on the ERE and LQRE from 2011 through 2014, addling crews were consistently onsite when eggs were fresh, and mean clutch size was higher, 5.83 ± 0.94 eggs/clutch (95% confidence).

Annual mean clutch sizes varied from estuary to estuary (Figure 10-12), suggesting each subpopulation has a different age structure. The average clutch size from 2010 through 2014 was 5.6 for the ERE, and 5.8 for the LQRE. At the NBE and other sites, mean clutch sizes from 2012 to 2014 were 5.3 and 4.6, respectively; these lower values reflect a later egg addling schedule coupled with higher levels of predation, particularly on the outer islands.

Mean clutch sizes for the ERE and LQRE have risen since 2010, suggesting that these subpopulations are aging. Brakhage (1965) found older birds had larger clutches and greater nest success. Cooper (1978) linked clutch size to time of nest establishment. Later in the nesting season, clutches are smaller, perhaps due to the age of late nesters; younger birds of all species tend to lay smaller clutch sizes and many nest later (e.g., Cooper 1978; Johnson et al. 1992).

As clutch sizes are limited by protein reserves, they may reflect preferential nesting of older birds in better habitats (Johnson et al. 1992). As high levels of disturbance may deplete reserves, the increase in clutch size at the ERE suggests that the City of Parksville canine goose control program, which ran from 2009 through 2011, did not have a detrimental effect on the condition of the ERE population. Clutch size may also be related to individual genetics, photoperiod, and hormone levels (Johnson et al. 1992).

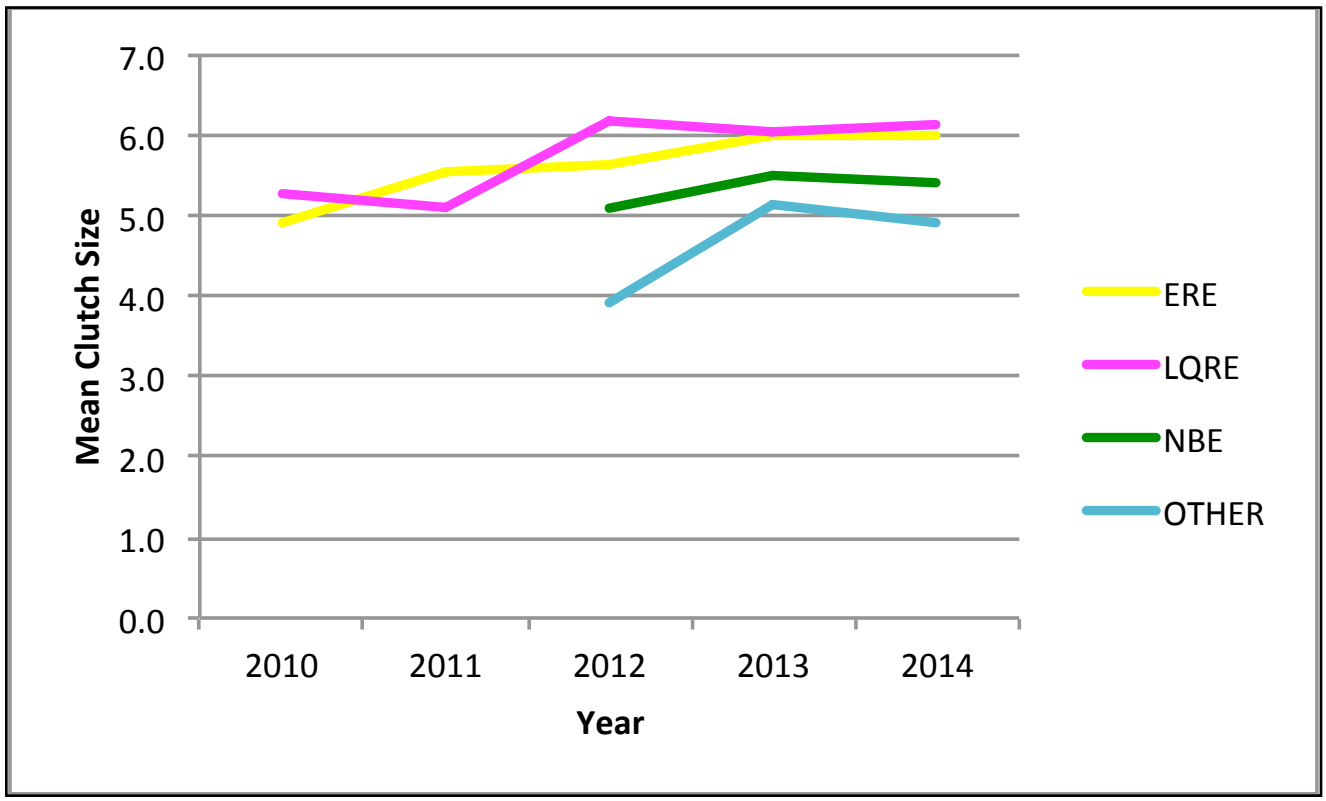


Figure 10-12. Mean clutch size by estuary, 2010-2014 (n=3,163).

Egg Size

Larger eggs may produce larger birds which may have higher survival rates (Johnson et al. 1992). Egg size can vary within clutches and between years for the same goose. However, there are notable relationships. Brakhage (1965), using a 1949 index by Romanoff and Romanoff (width/ length*100), discovered that mean egg size rose until age 5, then became variable, but never as high as age 5. Cooper (1978), using the same index, found that egg size increased with the age of the female up to year 5, then stabilized until extreme age (e.g., 18 years), when it declined. Cooper (1978) also found that egg size was correlated with the time of nest establishment, which is linked to the age of the female. (See also Chapter 8.2, Nesting).

In our study, egg size was examined to explore a link between egg size and estuarine marsh productivity; the data will be analyzed in a later publication.

Calipers were used to measure eggs.

10.32 Mortality

Mortality is the death rate of the population, and the converse of survivorship (Perrins & Birkhead 1983). In general, larger birds have greater survivorship, although there is little evidence of lower survival rates for females relative to males (Johnson et al. 1992). And authors disagree whether juvenile/HY or adult/AHY geese have greater survivorship (or lower rates of mortality), with some reporting higher rates for one or the other. Higher rates of HY survival have been credited to a lack of reproductive costs, especially in urban habitats (cf. Smith, Craven, & Curtis 1999), and to parents escorting young into no hunting areas (Pilotte 2012 in Beaumont 2013). Lower rates of survival among AHY birds have been attributed to increased exposure to hunting pressure during moult migration (cf. Heller 2010). Lower rates of HY survival are attributed primarily to naivety during hunting seasons (Beston et al. 2014).

Most, but not all authors agree that urban, resident Canada Geese enjoy better survival rates than rural and migrant geese due to less hunting pressure and predation (USFWS 2002; Balkcom 2010; Beston et al. 2014). In an urban Arizona setting, Ray (2011) calculated a mortality rate of just over 6%, although this was based on just two years of data.

Known predators of Canada Goose eggs and goslings include river otters, mink, weasels, raccoons, Bald Eagles and other raptors, gulls, crows, dogs, and humans (e.g., Sherwood 1968). Die-offs due to disease have occurred but are uncommon (Sherwood 1968; Howard Breen, 1990).

Hunting is not allowed at any of the banding sites, because of their conservation lands status, firearm discharge restrictions, or both. However, marked birds were targeted by hunters (as noted by a local hunter). See more on hunting in Chapter 12.12.

In jurisdictions exposed to severe weather conditions, survivorship and productivity have been known to fluctuate with thermal stresses (Beston et al. 2014). However, our weather is typically mild and likely has little effect on mortality rates.

Gosling Survival

Gosling survivorship is highly variable. Johnson et al. (1992) defined gosling survivorship as the probability that an individual hatchling will survive to fledge, while some other authors look at survivorship over the entire first year. Higher rates of gosling survival is linked to older parents and earlier hatch times (Johnson et al. 1992).

Bellrose (1976) found 70% of breeding pairs fledged an average of 4 young, representing a rate of production of 2.8 young per nesting pair (MoE 1979). Mortality rates were highest in the first year (39 to 65%), and less in subsequent years (32 to 52%) (Bellrose 1976). In B.C., 2,033 broods included 1 to 27 young, with 56% having 4 to 6; mixed broods were considered 10 or more (Campbell et al. 1990); Campbell et al. (1990) did not indicate whether the young lived to fledge. Smith, Craven, and Curtis (1999) reported mortality rates for urban-born juveniles ranging from 77% (23% survival) to the first moult, to more than 90% to the first hunting season. In contrast, Brakhage (1965) reported gosling mortality ranged from 20 to 36% annually, averaging 32% over 3 years; 90% were lost within the first two weeks of life. Beston et al. (2014) reported a survival rate of 66% for rural HY geese in New Jersey, and a rate of 83% for urban HY birds. Pilotte et al. (2014) reported survival rates of 82% for juveniles, and 76% for yearlings in Quebec. Heller (2010) found juvenile survival rates for juveniles ranged from 63 to 95%, with a grand mean of 78%. High survival rates were attributed to the social structure of Canada Goose populations (Howard Breen 1990); family groups generally stay together for nearly a year (Johnson et al. 1992).

Adult Survival

Population growth rates for long-lived species like Canada Geese are most sensitive to the survival of breeding-aged birds (Beston et al. 2014). Adults can live for 20 years or more (Douville & Friley 1957; Bellrose 1976; CWS 2010).

The oldest known wild goose was banded as an adult and recaptured 28 years and 5 months later (Klimkiewicz 2000 in USFWS 2002). Yet, Howard

M033, paired with M046, laid 6 eggs in 2012, 7 eggs in 2013, and 6 eggs in 2014. While M033 was seen only at the Englishman River estuary and in Parksville each season, M046 was also observed at the Craig Creek estuary.

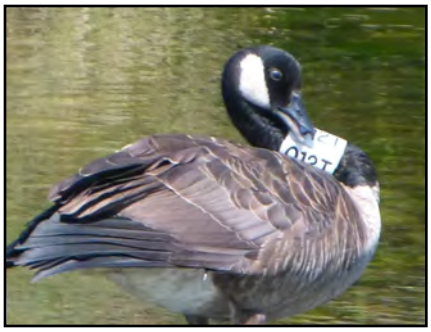
Breen (1990) noted that most die before their tenth year and only a few survive to fifteen. Of 1,600 Dusky Canada Geese recaptured on the Copper River Delta in Alaska, four were found to be more than 17 years of age, and one of them was still reproductively active (Campbell 1991). Two others were at least nineteen. As suggested in Chapter 7.25, Local Residents and Long-distant Migrants, northern-breeding Canada Geese probably have shorter lifespans than their temperate-breeding counterparts.

Adult survival is supported by strong social structures, including pair bonds (Heller 2010). Pair bonds are formed prior to the first breeding season and typically last for life. Only when a mate dies, will a goose or gander seek another mate (MoE 1979). Mates stay close together when feeding, resting and flying. When a mate is lost, the remaining bird is more vulnerable. It calls, searches, and spends time away from the flock, until it mates again before the next breeding season (Howard Breen 1990).

The USFWS (2002) amalgamated various studies to find adult survival rates ranging from 65 to 85%. In New Jersey, Beston et al. (2014) recorded average survival rates for both urban and rural AHY geese of 72%. Pilotte et al. (2014) reported survival rates were 82% for adult Canada Geese in Quebec. Heller (2010) found rates from 67 to 76% in Iowa, with a grand mean of 72%.

10.33 Immigration and Emigration

Young ganders are more likely to disperse from nesting and rearing areas (Beston et al. 2014). Ray (2011) reported emigration rates of 36 to 38% for urban geese in Scottsdale, Arizona, based on the number of collared geese not seen a year later, excluding known mortalities. She also found immigration rates ranging from 2 to 13%, based on the the number of new geese collared in the second year.



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

Chapter 11 - Management in Other Jurisdictions

Highlights

This chapter documents management approaches for nuisance Canada Geese in certain international, national, and regional jurisdictions, contributing to Goal 4 (examining management in other jurisdictions and identifying options appropriate for this region). For brevity, it does not provide a complete history associated with goose management in these jurisdictions. Recognize that management approaches may change; please check with individual jurisdictions for more up-to-date information.

Canada Geese are considered nuisance animals in many jurisdictions. In 18 of 20 countries participating in the European Network on Invasive Alien Species, the Canada Goose holds one of two top spots among 9,511 invasive species and is considered a serious threat to biodiversity. In some European countries, Canada Geese outnumber native goose populations. In certain countries, destruction of eggs and birds is allowed, while in others, calls for hunting, egg sterilization, and culling are underway. The Network adheres to the slogan, “If you can’t beat ‘em, eat ‘em”.

In New Zealand, egg sterilization and culls during the moult were conducted by the Wildlife Service between 1976 and 1987. A 1995 management plan proposed culling where hunting could not maintain populations. By 2000, control measures were shown to be moving birds to other areas.

The Pacific Flyway Council had requested the western United States be excluded from some U.S. regulations to control Canada Geese. An airport control order, nest and egg depredation order, and public health order are available to Pacific Flyway states, but orders to control overabundant migratory bird populations and to control resident Canada Geese - which would allow culling of goslings and adults, are only available to states along the Atlantic, Central, and Mississippi Flyways. Nonetheless, U.S. cities have considerable latitude to deal with urban goose problems under U.S. Fish and Wildlife Service (USFWS) depredation permits. For example, Anchorage, Alaska and Seattle, Washington conducted a series of annual culls beginning in 1996 and 1997, respectively.

In 2014, the Pacific Flyway Council proposed, and the USFWS agreed to combine interior and coastal frameworks for Canada Geese, noting that harvests alone would not completely address agricultural depredation. The hunting seasons, dates, and limits were to be altered in several states to encourage greater harvests. Quotas were to be increased on Dusky Canada Geese in Washington and Oregon.

The USFWS maintains an e-permits website, whereby anyone in the conterminous U.S. can register for federal authorization to destroy resident Canada Goose nests and eggs. Some states do not participate in this program and/or have additional or similar requirements.

Citations, excluded here for brevity, can be found in the text of the document’s chapters. Please do not cite highlights without consulting the chapters.

Chapter 11 - Management in Other Jurisdictions

More Highlights

U.S. Department of Agriculture (USDA) Wildlife Services has provided support in many aspects of goose management, including capture and euthanasia. Where geese could not be captured or otherwise controlled, small numbers were selectively removed with a pellet gun or shotgun. Culled geese suitable for human consumption were donated to qualified charitable organizations. Wildlife Services personnel were also responsible for hazing, nest destruction, addling, and relocations.
The National Wildlife Research Center, an arm of the USDA Wildlife Services program, was instrumental in developing a chemical repellant to discourage geese from using grassy areas. The Center also tested drugs to inhibit bird reproduction.
USDA Wildlife Services provides goose management services on a cost-reimbursable basis. Funding has been provided by resource owners, private businesses, and local, state, or federal funding agencies.
There are a variety of State-funded Canada Goose control programs. For example, the Wisconsin Department of Natural Resources provides grants to local and tribal governments, to reimburse damage abatement and control projects (i.e., 50% reimbursement up to a maximum of $5,000). In Michigan, the Department of Natural Resources conducts nearly half of Canada Goose roundup activities. The state's resident Canada Goose program is financed by hunters and permit fees.
The Patuxent River tidal marshes in Maryland were restored by allowing hunting in a wetland sanctuary, removing ~1,700 Canada Geese over a 4 year period, and by planting and fencing.
Washington's Seattle Goose Program was launched as a pilot project by non-profit groups in 2006. The program was designed to help Seattle Parks and Recreation resolve its human-goose conflicts without culling. Volunteers located nests for addling and oiling; hazed geese with lasers, kites and dogs; and cleaned feces from beaches and recreation areas.

Citations, excluded here for brevity, can be found in the text of the document's chapters. Please do not cite highlights without consulting the chapters.

Chapter 11 - Management in Other Jurisdictions

More Highlights

The Capital Regional District on Vancouver Island commissioned the production of a technical report and strategy to manage Canada Geese. Population trends and seasonal abundance and distribution were estimated using historical data and monthly goose surveys conducted by volunteers. Goose exclosures were erected on area farms to assess crop losses. Funding from the Agricultural and Environmental Initiative supported much of the work. A threshold and population target of 1,000 geese was set, based on the number of geese in the region in 1985. The regional working group collaborated with CWS and the Province to conduct the first goose cull on Vancouver Island in summer 2015.

The Campbell River Environmental Committee began monitoring Canada Geese in 2013 in response to grazing pressure on the Campbell River estuary. Exclosures were installed in spring 2014, and with the help of the Guardians, 199 birds were banded during the summer of 2015. The Campbell River Indian Band may harvest moulting birds on reserve lands to help reduce the goose population.

A problem analysis published in 1991 documented stakeholder concerns and efforts to control Canada Goose populations in the Fraser Valley. Relocations to areas where geese could be hunted had taken place from 1987 through 1990. Egg addling programs had begun at key breeding sites in 1988. In the analysis, farmers asserted that scare permits did not work and they were too busy to chase birds.

In 2013, the Vancouver Airport Authority led the first annual Canada Goose workshop on the Lower Mainland and created an informal partnership, the Lower Mainland Canada Goose Working Group. Group members, including staff from CWS, began mapping population abundance and distribution using existing data. A Google Earth-based Conflict Mapping Project was launched in 2014 to engage communities and document where human-goose conflicts were occurring. A Terms of Reference was drafted to formalize the group's existence, along with a problem statement, goals and objectives, research questions, a list of potential stakeholders, and a communications strategy. The communications strategy noted that Environment Canada is not responsible for dealing directly with the birds or their actions, or mitigating damage that the birds may cause.

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Chapter 11 - Management in Other Jurisdictions

More Highlights

The Okanagan Valley Goose Management Committee was formed in 1995, and an action plan with strategies to manage Canada Geese was endorsed in 2006 following public meetings in Vernon, Kelowna, Penticton, and Osoyoos. Of greatest concern was the level of contamination on area beaches. The Okanagan Valley Goose Management Program was established in 2007 as a partnership among local governments and an Irrigation District. The City of Kelowna contributed $75,000 to the $136,000 program, and committed to spending an additional $90,000 to control and clean-up after geese on City-owned properties. The program conducted aerial population surveys during the moult in 2011 and 2014, banded birds in 2012, and estimated gosling production with post-nesting ground surveys in 2014. Banding was largely funded by the Western Canada Turfgrass Association. The flagship of the program was annual egg addling, with a goose hotline to coordinate goose sightings and addling crews.

One of the Okanagan Valley Goose Program partners, the Town of Osoyoos, requested the Union of B.C. Municipalities (UBCM) endorse a resolution for more Canada Goose kill permits from senior governments, as addling had limited effect. The UBCM endorsed the resolution in 2013. That year, CWS permitted the Town to kill up to 10 adult birds per week at two sites: a horse racing facility and a golf course, with no blinds or decoys, and the geese could not be kept by the hunter. A owl rehabilitation centre in Oliver agreed to take some of the birds.

Citations, excluded here for brevity, can be found in the text of the document's chapters. Please do not cite highlights without consulting the chapters.

11.1 International

Other jurisdictions struggle with the same issues we experience here. See http://www.telegraph.co.uk/news/earth/wildlife/9160190/Canada-goose-cull-is-scrapped.html

Canada Geese are native to North America (i.e., Canada, U.S., Mexico, and Greenland), and are considered nuisance animals in many jurisdictions. Beauty of Birds.com (2011) noted they are also native to eastern Siberia, eastern China, Japan, and a number of Caribbean islands (i.e., Bahamas, Cayman Islands, Cuba, Haiti, Puerto Rico, Saint Pierre and Miquelon, Turks and Caicos), although other authors dispute this (cf. Jansson, Josefsson, & Weidema 2008).

They were deliberately introduced to Great Britain in 1665, to New Zealand in 1905, Germany in 1928, Sweden in 1929, Denmark in 1930, and Norway in 1936 (Thomson 1922 in Winn 2001; Jansson, Josepfsson, & Weidema 2008). Other early introductions were unsuccessful in establishing populations (e.g., Dawes 2008).

Today, Canada Geese are observed in most countries around the North Sea and along the Atlantic coast, in parts of central and eastern Europe, northern Russia, and New Zealand (Campbell et al. 1999; Banks et al. 2004; various authors in Jansson, Josefsson, & Weidema 2008). In some European countries, Canada Geese now outnumber native goose populations (Jansson, Josefsson, & Weidema 2008). New introductions of Canada Geese are regarded as a serious threat. Dawes (2008), for example, warned that Canada Geese had entered Australia and called for immediate eradication.

Interestingly, Canada Goose populations in Scandinavia are believed to have originated from only 5 individuals, four from a zoo in Germany and one from North America, and despite losses in genetic variation over time, the species has continued to increase its range (Jansson, Josefsson, & Weidema 2008).

11.11 United States

Regulations

Legislation for managing resident Canada Geese in the U.S. is found in the Code of Federal Regulations, Title 50 (Wildlife and Fisheries), Chapter 1, Subchapter B, Part 21 (Migratory Bird Permits), Section 21.26 (Special Canada Goose permit), 21.49 (Control order for resident Canada Geese at airports and military fields, 21.50 (Depredation order for resident Canada Geese nests and eggs), 21.51 (Depredation order for resident Canada Geese at agricultural facilities), 21.52 (Public health control order for resident Canada Geese), and Subpart E (Control of Overabundant Migratory Bird Populations), 21.61 (Population control of resident Canada Geese). Sections 21.49, 21.51, and 21.52 allow culling of goslings and adults, in addition to other lethal and non-lethal controls. These regulations cover states along the Atlantic, Central, and Mississippi Flyways only. The USFWS may issue depredation permits in situations that do not fall under the depredation orders (J. Sands and T. Smith, pers. comm. February 17, 2015).

The Pacific Flyway Council requested the western states not be included in all of the regulations due to fewer issues with resident

Directed management vs. 'vigilante bird justice'. See http://www.thestar.com/life/2010/07/15/deadly_summer_for_canada_geese_in_the_us.html

Canada Geese; only the airport control order, the nest and egg depredation order, and the public health control order are available to the Pacific Flyway States (USFWS 2006).

Section 21.61 regulates a population control program, "implemented under the authority of the Migratory Bird Treaty Act to reduce and stabilize resident Canada Goose populations when traditional and otherwise authorized management measures are unsuccessful, not feasible in dealing with, or applicable, in preventing injury to property, agricultural crops, public health and other interests from resident Canada Geese". Managed take allows hunting August 1-31, extends shooting hours, and removes daily bag limits. Following one full operational year of Sections 21.49 through 21.52, any of the states or tribes may request approval for the population control program. Once approved, the government may "without permit, kill or cause to be killed under its general supervision, resident Canada Geese" under a suite of conditions (e.g., no baiting, no live decoys, etc.).

The USFWS maintains an e-permits website, whereby anyone in the conterminous U.S. can register for federal authorization to destroy resident Canada Goose nests and eggs (see https://epermits.fws.gov/ercgr/gesi.aspx). Some states do not participate in this program and/or have additional or similar requirements (e.g., WA, OR).

In 2014, the Pacific Flyway Council proposed, and the USFWS agreed to combine interior and coastal State frameworks for Canada Geese, to increase the hunting season length in WA, OR, and CA from 100 to 107 days, to change opening date in these states from the Saturday closest to October 1 to the Saturday closest to September 24, to increase bag limits in CA to 10, to increase bag limits in OR on hunt days on or before the last Sunday in January to 6, and to increase quotas on Dusky Canada Geese In WA and OR, among other things. The Service acknowledged that harvests alone would not completely address agricultural depredation issues and encouraged the States in the Pacific Flyway to work towards implementing other approaches detailed in the Flyway's Canada Goose depredation plan (Federal Register 2014).

Management Actions

Along the Atlantic Flyway at least, hunting has been liberalized, egg treatments are widespread, and culling operations have grown. In some jurisdictions, goose numbers have peaked and are falling, while in others populations continue to grow (Best et al. 2014).

The USDA Wildlife Services assists the USFWS, State governments, and many others with goose management. The USDA (1999) reported that its Wildlife Services personnel were trained and certified in the use of a capture drug to contain geese outside of the moulting period, 30 days in advance of or during the hunting season. Where geese could not be captured or otherwise controlled, small numbers were selectively removed

with a pellet gun or shotgun. Geese captured and euthanized that were suitable for human consumption were donated to qualified charitable organizations. Wildlife Services personnel also assisted with hazing, nest destruction, addling, and relocations (USDA, 1999).

The Patuxent River tidal marshes in Maryland (introduced in Chapter 5.2, The Need for Action, Estuaries) were restored by allowing hunting in a wetland sanctuary, thereby removing approximately 1,700 Canada Geese over a 4 year period, and re-establishing wild rice through a large-scale fencing and planting program (Haramis & Kearns 2006).

In general, U.S. cities have had considerable latitude to deal with urban and resident goose problems. The City of Seattle is a case in point. In 1987, the Seattle Waterfowl Committee was formed to deal with the growing numbers of Canada Geese. A year-long study by the University of Washington recommended 90% reductions in 1990, 80 to 90% reductions in 1991, and smaller reductions later on, as necessary. From 1989 to 1994, the USDA Wildlife Services program facilitated the translocation of 7,342 geese to eastern Washington and Idaho. From 1992 to 1998, Wildlife Services addled more than 6,000 eggs, but numbers continued to grow. In 1997 and 1998, Wildlife Services captured and euthanized 578 geese from the city and area (USDA, 1999). Culling continued annually for several years, in public parks, private golf courses, and on the University of Washington campus. This motivated Paws and the Humane Society of the U.S. to launch the Seattle Goose Program, a program to help Seattle Parks and Recreation explore more humane methods of resolving human-goose conflicts. A pilot project from 2006 to 2008 provided volunteers who located goose nests for addling and oiling; hazed geese with lasers, kites, and dogs; and cleaned goose poop from beaches and recreation areas (Paws n.d.).

To reduce populations of 'urban' Canada Geese in Anchorage, Alaska, a similar program was undertaken from 1996 to 1998. The USFWS, USDA Wildlife Services, Alaska Department of Fish and Game, municipalities, and conservation groups formed a working group to plan culls and other activities, and senior governments carried out various facets of the plans (T. Smith, pers. comm. February 17, 2015).

The National Wildlife Research Center, the research arm of the USDA Wildlife Services program, was instrumental in developing the chemical repellant methyl anthranilate, used to discourage geese from using grassy areas. It also tested drugs to inhibit bird reproduction (USDA 1999).

Funding

USDA Wildlife Services programs are not federally funded; a congressional mandate requires they help with goose management, however no monies are available to do so. Therefore, controls undertaken by USDA Wildlife Services personnel are implemented on a cost-reimbursable basis (USDA 1999; T. Smith, pers. comm. February 17, 2015). Funding was usually provided by resource owners, private businesses, or local, state or federal funding agencies (USDA 1999).

Some State governments have taken the lead, funding and/or implementing goose management. The Wisconsin DNR (2007) provided $25,000 worth of annual grants to towns, cities, villages, counties, or tribal governments in urban areas, to help develop wildlife plans and/or implement specific damage abatement/and or control measures for Canada Geese. The program provided 50% project reimbursement up to a maximum of $5,000 (Wisconsin DNR 2007). In Michigan, the Department of Natural Resources (DNR) conducts ~46% of the goose roundup activities in the state, while others manage the rest. Half of the costs of Michigan's resident Canada Goose program come from hunter dollars, and the other half from permit fees (Michigan DNR 2015).

11.12 Europe

The Canada Goose is registered in 18 of 20 countries participating in the European Network on Invasive Alien Species (NOBANIS), holding one of two top spots among 9,511 species. (The other is Canadian Waterweed *(Elodea canadensis)*, Oh Canada!) This organization adheres to the slogan, "If you can't beat 'em, eat 'em" (NOBANS Secretariat 2013).

Canada Geese in Britain are widespread, and deemed responsible for destruction of bank-side vegetation, eutrophication of waterbodies, and aircraft strikes at Heathrow Airport, among other things (Owen et al. 1998 in Winn 2001). They are a recognized game species that can be shot throughout the year (British Association for Shooting & Conservation 2013). Special licenses designed to protect public health and air safety, prevent crop damage, and to conserve wild bird populations allow destruction of eggs and birds (Owen et al. 1998 in Winn 2001).

In France in 2011, Canada Geese were not hunted but agencies and scientists were calling for hunting, egg sterilization, and culls. There, geese are a threat to wetland biodiversity, primarily by excluding other species from nesting territories. They had also caused closures of outdoor swimming pools, and other typical urban nuisance problems. From several hundred birds at the end of the 1990s, populations had increased to more than 5,000 by 2011, with half in the Paris area. "For reasons that remain obscure, their numbers have started increasing very fast" (Vincent 2011). Vincent (2011) noted that Canada Geese are on a list of 100 invasive species posing a serious threat to biodiversity in Europe.

11.13 New Zealand

In New Zealand, 'sedentary' [nonmigratory] Canada Geese are established on the South Island. They were protected until 1931, when farmers were allowed to disturb and destroy geese on their pastures. The species was declared a game bird in 1973. Between 1976 and 1987, the Wildlife Service conducted moult-culling drives and egg-pricking operations in certain areas. The South Island Canada Goose Management Plan was developed in 1995, whereby organized culls were to be used if recreational hunting could not maintain populations at target levels. By 2000, only two areas were at target levels, as control measures were simply moving the birds to other areas (various authors in Winn 2001).

The New Zealand population of Canada Geese is primarily descended from an importation of 50 birds in 1905 (New Zealand Birds Online, from http://nzbirdsonline.org.nz/species/canada-goose

11.2 National

In just a few years, the views and policies of our regulatory agencies have shifted, partly because of news coverage and a growing awareness of the problems.

The position of federal regulators in Canada has changed significantly from the inception of this project in 2007, when grave concerns for endangered Dusky Canada Geese outweighed any urgency to address the impacts of 'resident' Canada Geese. The Guardians were instructed to avoid using the term 'overabundant', in favour of 'locally overabundant', as the former was a 'legal' term. We were asked not to mention culling (the 'C' word) as a potential management tool, as this was viewed as highly unpopular. And we were instructed to gather the supporting science for mandatory management planning.

Fast forward to 2014. Distinguishing resident birds from migratory birds, and from Canada Geese migrating to and from the lower 48 states in particular, is of little concern, as nearly all temperate-breeding populations are perceived as 'locally overabundant'. Applications for kill and cull permits are encouraged (e.g., I. Whitehorne, pers. comm. June 18, 2014). CWS is engaged with several working groups (e.g., Capital Region, Lower Mainland, Okanagan) that are attempting to manage nuisance Canada Goose populations. CWS staff have provided timely and forthright information as well as advice regarding data analysis for this strategy.

The agency's involvement in Snow Goose and cormorant management is described elsewhere in this document (Chapters 4 and 12, respectively).

11.3 Regional

11.31 Capital Region

The Capital Region's Regional Canada Goose Management Strategy Working Group was formed in May, 2010 and has met monthly. It has focused on understanding and mitigating crop loss and damage, and health and environmental impacts to parks and recreation areas, as well as improving aviation safety at the Victoria International Airport. The group has learned from the regional deer management program and has examined sharing resources and integrating program activities (Canada Goose meeting in Central Saanich, March 14, 2013).

A 2012 technical report (see https://www.crd.bc.ca/docs/default-source/regional-planning-pdf/regional-canada-goose-management-strategy-technical-report-.pdf?sfvrsn=0) informed the group's management strategy in the same year (see https://www.crd.bc.ca/docs/default-source/regional-planning-pdf/regional-goose-management-strategy-.pdf?sfvrsn=0). The technical report, commissioned by the Working Group and developed by EBB Environmental Consulting, examined historical data, conducted a crop loss impact analysis with goose exclosures on area farms, and mapped potential goose habitat using Landsat satellite imagery, Capital Regional District (CRD) ortho-photography, the Sensitive Ecosystem Inventory (SEI), and field surveys. Volunteers conducted monthly goose surveys which informed a series of population models. Maps and charts were created depicting seasonal abundance and distribution.

The strategy outlined three management scenarios and a