Population Estimate Survey of the Columbian Black-tailed Deer in Esquimalt, BC

Second annual report of the three-year study from 2017-19

Report Prepared for the Township of Esquimalt on Feb. 21, 2019

by Megan Sakuma

1 EXECUTIVE SUMMARY

Urban Columbian black-tailed deer have the potential to be a controversial topic among residents in a variety of communities. Management decisions need to be based on scientific evidence, including knowledge of the urban deer population estimate. This project aims to provide the Township of Esquimalt with a deer population estimate to help them with future urban deer management decisions.

The inventory method known as the mobile line technique was used and modified for the three habitat types in Esquimalt. The roads were surveyed while driving a car, the golf course path was surveyed while driving a golf cart, and the parks were surveyed while walking on the trails.

The bucks were individually identified based on photos and had the photo mark-resight Null Model applied to the data.

The results of the Null Model (for the bucks only) from the Fall 2018 survey (n=10) produced 95% confidence limits with a low of 26 to a high of 44 bucks, and an estimate of 35 bucks. Next, the herd composition ratio was extended to the buck estimate to extrapolate the total deer population estimate. This resulted in 95% confidence limits with a low of 100 to a high of 170 total deer, and an estimate of 135 deer.

Applying the same data analysis methods to the Fall 2017 survey (n=6), 95% confidence limits with a low of 13 to a high of 67 bucks, and an estimate of 40 bucks were produced. Again, the herd composition ratio was extended to the buck estimate to extrapolate the total deer population estimate. This resulted in 95% confidence limits with a low of 44 to a high of 226 total deer, and an estimate of 135 deer.

There was no statistical difference in the deer population estimates between 2017 and 2018 (as evident by overlapping 95% confidence intervals). However, the large range of values encompassed by the 95% confidence intervals for the 2017 deer population estimate limits the ability to draw any conclusions on population trends for Esquimalt deer. Increased sampling in 2018 (n=10) provided greater certainty around the buck estimate (and thereby total population estimate), and we therefore recommend future surveys to collect no less than 10 samples.

This study provides a robust estimate for the number of bucks in Esquimalt. Extending the observed herd composition ratios to the buck estimate provides an informed estimate for the total number of deer in Esquimalt. These estimates may be further refined through continued monitoring of urban deer population structure. Finally, identified localities where deer are observed at increased frequencies offer important insights into where to target future efforts for public education.

2 ACKNOWLEGDEMENTS

The completion of this project would not have been possible without the generous help of:

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- Gorge Vale Golf Course for allowing access to their property

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6 INTRODUCTION

There is very little information known about Columbian black-tailed deer (CBTD) populations in urban areas, including Esquimalt and surrounding Greater Victoria (see Figure 1). CBTD management decisions need to be made on scientific evidence, including knowledge of the urban deer population density. This project aims to provide the Township of Esquimalt with a population estimate, to help with future CBTD management decisions. This year's (2018) survey is the second of an ongoing, three-year program (2017-19), conducted each Fall.

Figure 1. Foraging deer in Esquimalt

7 BACKGROUND

7.1 Ecology

The rutting season for CBTD is generally late October to late November. At this time bucks will compete in order to breed with females. Fighting between males can be severe, resulting in broken antlers, scratches, puncture wounds and on rare occasions even death. It is at this time of year that deer are most active, and therefore most visible to count.

Bucks are capable of breeding as yearlings, but older, dominant bucks do most of the mating (Ministry of Environment, Lands and Parks, 2000). Bucks will follow does around for several days. Most bucks drop their antlers from January to March of each year; older bucks shed their antlers first. Bucks regrow their antlers from April through August each year, growing an inch every two days or so. Yearling CBTD almost always have unbranched "spike antlers"; 2-year-olds may have spikes, but may grow forked antlers with two or more branches. As shown in Figure 2, multi-branched antlers are common on older bucks.

Fawns are born primarily from late May through June. Before giving birth, does will drive away their offspring from the previous year. More than 90% of all does will give birth every year (Ministry of Environment, Lands and Parks, 2000). However, a large majority of fawns die in their first year, and few CBTD live more than ten years. Most does don't give birth until their second year, and don't give birth to twins until at least their third or fourth birthday. The main causes of death are natural causes and vehicle-deer collisions. Adults tend to be more cautious about crossing roads than young deer.

Figure 2. A mature buck with antlers

7.2 Previous Studies

2016 Esquimalt Community Survey
The response from this survey recommended that a population estimate should be conducted, in order to make management decisions (Nyberg, 2016).

2017 Fall DND Survey
The density at CFB Esquimalt was estimated as 40 deer/km^2 (Prentiss, 2017).

2017 Fall Esquimalt Survey
The previous survey to this one, with results of 95% confidence limits with a low of 44 to a high of 226 deer, and an estimate of 135 deer.

8 PROJECT RATIONALE

The 2016 Community Survey showed that the citizens of Esquimalt have mixed feelings about the presence of CBTD in their community (Nyberg, 2016). Some loved having wildlife around, while others considered the deer a nuisance, due to damage to some garden plants and vehicle-deer accidents. The 2016 Community Survey recommended that a population estimate should be conducted in order to help make management decisions, rather than just basing decisions on complaints.

This project selects and standardizes survey methods, in hopes that future surveys will be conducted with these same standardized methods in order to more accurately determine long term population trends, both within Esquimalt and in the surrounding areas.

9 OBJECTIVE

Determine the population size and trend of Columbian black-tailed deer in Esquimalt, BC.

10 SITE DESCRIPTION

Esquimalt
The Township of Esquimalt encompasses 7.08 km^2, including the 1.59 km^2 of land administered by the DND. This leaves 5.49 km^2 of a study site to be surveyed. Esquimalt is composed of residential areas, commercial areas, small parks, and a golf course. The small area of Esquimalt is somewhat enclosed by geographic features, primarily ocean shoreline, which restrict deer movement in certain directions.

For the purpose of surveying, Esquimalt was divided into seven different sub-zones:

Rockheights
Rockheights is primarily a residential area, and has one park called High Rock Park (see Figures 3-4).

<u>High Rock Park</u>

Figure 3. Kevin Pons taking notes at High Rock Park

Figure 4. Trail at High Rock Park

Esquimalt Village
Esquimalt Village is primarily a residential area. The houses are very close together. This zone has two parks, Macaulay Point Park and Saxe Point Park (see Figures 5-8).

<u>Macaulay Point Park</u>

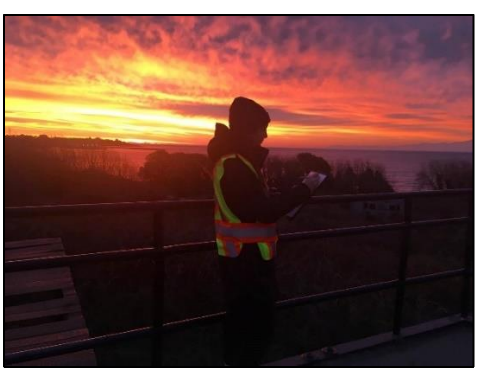

Figure 5. Megan Sakuma recording field notes

Figure 6. The view from Macualay Point Park

Saxe Point Park

Figure 7. The ocean view from Saxe Point Park

Figure 8. Trail at Saxe Point Park

Parklands

Parklands is primarily a residential area, and has houses with larger properties.

Gorge

Gorge is primarily a residential area, and is bound by the ocean and a main road. It has one park, Gorge Park (see Figures 9-10).

Gorge Park

Figure 9. Trail at Gorge Park

Figure 10. Gorge Park

Selkirk

Selkirk is primarily a residential area, and is bound by the ocean and a main road.

West Bay

West Bay is primarily a commercial area.

Golf Course

The Gorge Vale Golf Course is the largest green space in Esquimalt with 140 acres (see Figures 11-12). It is home to a variety of wildlife, including deer, rabbits, squirrels, racoons, and birds.

Figure 11. Deer trails at Gorge Vale Golf Course

Figure 12. Buck and doe sighting at the golf course

11 METHODS

11.1 SURVEY ROUTE DESIGN AND SAMPLE PROTOCOL

The exact same survey methods were used as last year, to ensure that the data would be consistent. The only difference was that with an increased budget, the samples were increased from 6 to 10, and surveys were always completed in a team of 3, rather than 2. (With the exception of the golf course, which only has room for 2 people in the golf cart.) Surveying was conducted during the rutting season. This was because deer are most active during this time of year, and bucks still have their antlers which makes them easier to identify. Surveys were conducted from Oct. 15 – Nov. 16 on Monday-Friday for the 5 weeks. Sampling was not conducted on weekends, to eliminate the variable of different traffic patterns during the weekend versus during the week. Two of the smaller sub-zones were paired with other sub-zones, so that the entire site could be sampled over 5 days. By splitting surveying the site over 5 days, the surveys would concentrate at the peak active hours at dawn and dusk (see Figure 13). These sub-zones were based on the zones assigned by Nyberg (2016).

1. Rockheights roads and Highrock Park
2. Esquimalt Village roads, Macaulay Point Park, and Saxe Point Park
3. Parklands roads, Gorge roads, and Gorge Park
4. Selkirk roads, West Bay roads
5. Gorge Vale Golf Course

Figure 14 shows an overview of all of the survey routes.

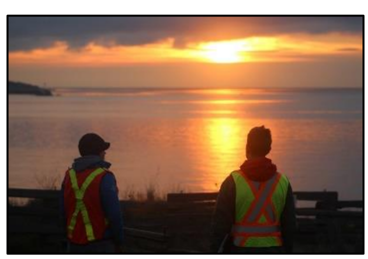

Figure 13. Sampling at sunrise

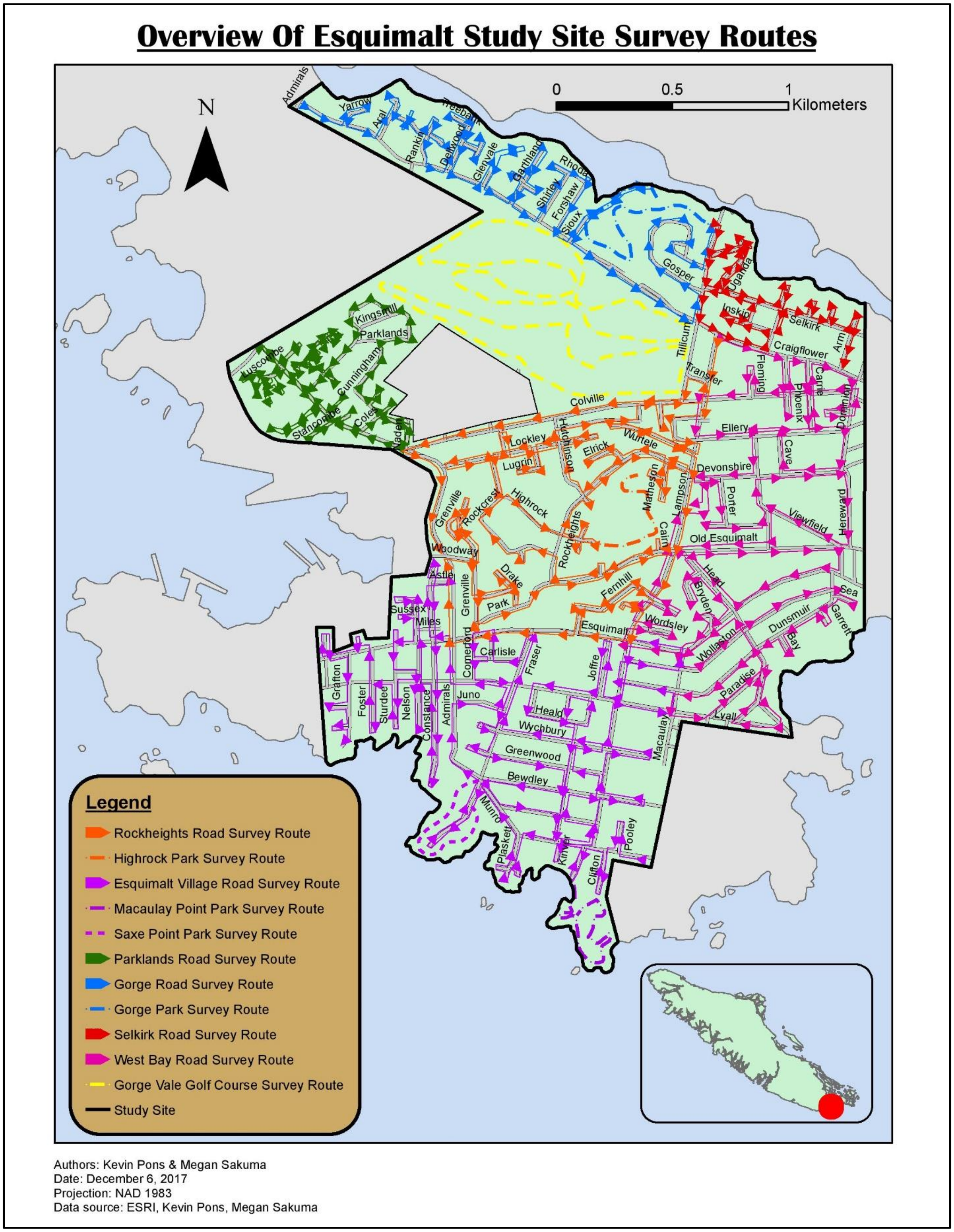

Figure 14. Map of Esquimalt Survey Routes

Each zone was surveyed for approximately one to two hours at both dawn and dusk on each sampling day. The surveys were repeated in the same order five times over the course of five weeks. This resulted in 25 sample days, sampling twice a day, for a total of 50 sampling times. The direction of the survey route was reversed on alternate days to allow each zone to be surveyed during the peak active hours of dawn/dusk.

This project was coordinated with DND to conduct our respective surveys on the same days. When possible, we started our survey routes at the same place and day, at points of access for deer along our boundaries, and then fanned out from there. This reduced potential double counting of deer.

The mobile line technique (Krebs, 2014) is a very cost effective, non-invasive survey method, and was used to survey the deer. It was slightly modified to adapt to the road, golf cart path, or trail. For the road zones, all roads were driven. For the golf course, all of the golf cart paths were driven (see Figures 15-16). For the parks, a short trail that stuck to the main trail and covered the majority of the area was walked. The four largest parks in Esquimalt were surveyed. By selecting the most easily accessible routes to survey in each of the three habitat types, consistency was provided amongst them.

Figure 15. Megan Sakuma surveying the golf cart

Figure 16. Megan Sakuma surveying the car

Surveying in a team of three people was required for both safety and quality data collection. For the road surveys, the driver drove as slow as safely and legally possible. The front seat passenger looked primarily right, and directed the driver using the survey route maps and tracked their location using google maps on a smartphone. The back-seat passenger looked primarily left. When a deer was sighted, the vehicle/golf cart/personnel pulled over to the side of the road/path/trail. The front seat passenger would take photos, then back seat passenger would collect GPS coordinates, distance and angle measurements, time/date, and the gender/age of deer seen (see Figures 17- 18). The driver would assist to collect the data if there was an opportunity to safely do so.

Figure 17. The survey equipment

Figure 18. Megan Sakuma taking pictures of deer from the car

Protocol for when <u>to</u> count or <u>not</u> count deer:

- Line of sight rule: If the deer was visible from the transect anywhere WITHIN the boundary of the sub-zone (i.e. Rockheights), it was counted, even if it was on the adjacent transect. If the deer was within line of sight, but was outside of the boundary of the sub-zone, it did NOT count.

- When a deer was sighted, our location on the map was checked to ensure that we weren't double counting deer that may have moved nearby from the last sighting, since the transects sometimes zigzagged.

- Doubling back on a road did not count as part of the survey. However, when doubling back on a road, if it appeared that the deer was highly likely there at the time when we were first driving by but just missed sighting it, it was counted.

- The spatial data (GPS location, bearing, distance) was collected from where the first deer was first sighted. After a few minutes if more deer appeared nearby (as if they are travelling together), those deer were grouped together with the spatial data from the first deer.

    - After each deer sighting, we waited 5 minutes before moving on. Often more deer accompanying the first deer sighted would come into view after waiting a short while. There was a delicate balance between waiting to see more deer, and staying on track of time on the survey, in order to stay in peak dawn/dusk hours.

11.2 Human Wildlife Conflict Safety Protocols

There are potential risks to taking photos of bucks during the rut. These risks and disturbance to all deer were minimized as much as possible, by following these protocols (WildSafe BC, n.d.):

- Giving the deer space.
- Remaining quiet, but did not surprise the deer.
- Avoiding eye contact.

- Never getting in between deer. (Had someone else always watching the photographers back. When the photographer was focussed on the camera, it would be easy for new deer to sneak up behind the photographer, placing them in between deer.)
- Watching for deer laying their ears back and lowering their head as these can be signs of agitation.

11.3 Photo Identification

One method to estimate the size of a population is to capture and mark individuals from the population, and then to re-sample to see what fraction of individuals carry marks. This is called the mark recapture technique. In this survey, photos were taken of each deer sighted to "mark" them.

"When trying to get photos of the deer, there are ideal ways to photograph them in order to ensure the highest amount of success when attempting to identify individuals later on… While the antlers are an obvious and easy way to identify an animal, ideally there will be some notable or distinguishing features somewhere on the body as well. These features will allow for the identification of the animal in future years, even after the current set of antlers have been shed… It should be noted that although these methods are ideal, in real life scenarios it is frequently difficult to get any or all of them to happen" (Bailey *et. al*, 2016, p.36).

Ideal criteria:

1. "Face and antlers facing forwards.
    a. This allows for potential identification of important facial features or distinctions, as well as noting antler size and shape.
2. Ears flared outwards facing forwards.
    a. Not only are the antlers and face important, but ears can also frequently exhibit specific colours or patterns, as well as small nicks or deformities that can be used for identification purposes.
3. Full body in the image.
    a. This is another important one, as it will show any distinguishing features along the length of the body or legs.
4. Multiple angles.
    a. Multiple angles of every deer strongly recommended, as it allows for the largest possibility of catching different markings on different sides of the deer."

(Bailey *et. Al*, 2016).

This year, a Canon Rebel T5i with a 75-300mm lens was purchased, which helped considerably with capturing the finer details that were key to identify individuals.

To identify individuals from photos we:

- Looked at the general shape of the antlers from the head on front profile shot.
- Compared this angle to the same angle of other individuals. If any appeared to match, we opened the folder to view more photos of different angles of that individual deer.
- Examined antlers carefully – looking for number of points and tines, shape, and coloration.
- Used facial features - scars, coloration, and nicks on ears and face - as a secondary confirmation.

12 RESULTS

12.1 Raw Data

During the 10 samples taken in 7 sub-zones over 50 sampling times, 178 deer were sighted (including multiple sightings of individuals). Table 1 shows the raw data collected in each sample in each sub-zone. Figures 19 and 20 represent this data in graph form, and compare it to the 2017 data. Note that in 2017, there were only 6 samples, and only had 2 observers, rather than 3 observers in 2018.

Sample	**Rock-heights**	**Esquimalt Village**	**Parklands**	**Gorge**	**Selkirk**	**West Bay**	**Golf Course**	**Total**
Week 1 Dawn	5	7	2	0	0	1	5	**20**
W1 Dusk	1	0	1	0	0	0	0	**2**
W2 Dawn	8	0	0	0	0	3	17	**28**
W2 Dusk	3	5	8	0	0	5	4	**25**
W3 Dawn	5	3	5	0	0	0	9	**22**
W3 Dusk	3	2	3	0	0	0	4	**12**
W4 Dawn	5	0	5	0	0	0	12	**22**
W4 Dusk	0	9	1	0	0	3	3	**16**
W5 Dawn	6	7	0	0	0	7	3	**23**
W5 Dusk	5	0	2	0	0	1	0	**8**
Total	**41**	**33**	**27**	**0**	**0**	**20**	**57**	**178**

Table 1. Number of deer sightings for each sample in each sub-zone

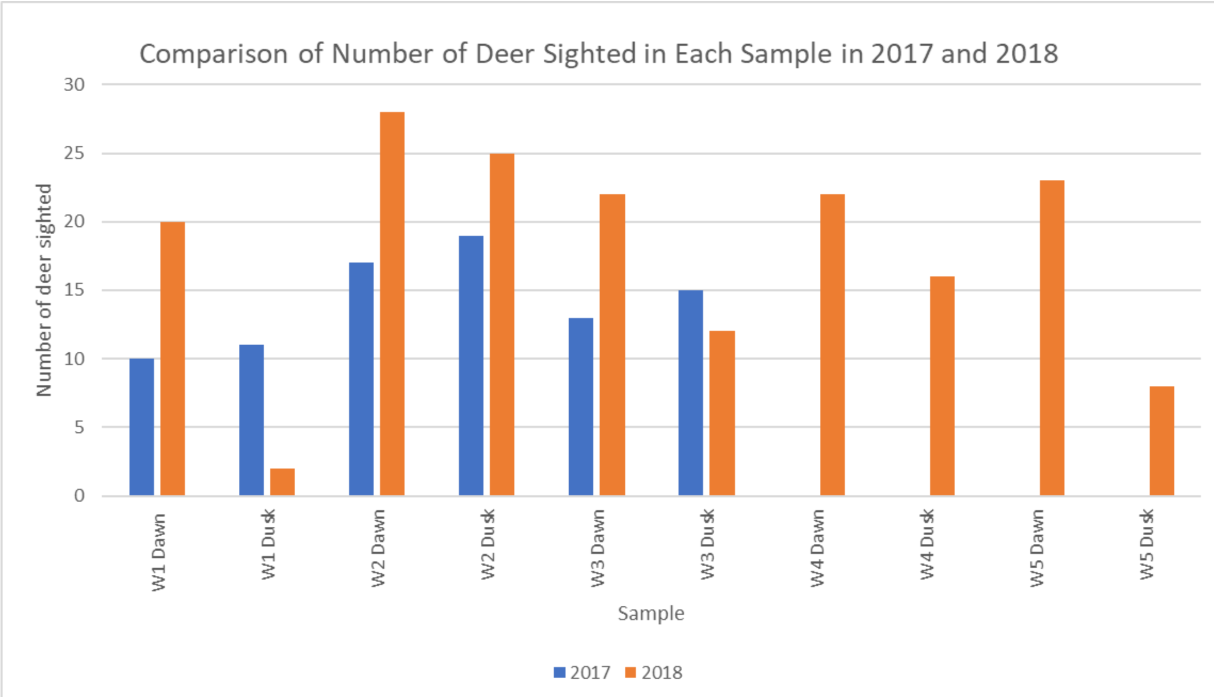

Figure 19. Graph of deer sightings in each sample in 2017 and 2018

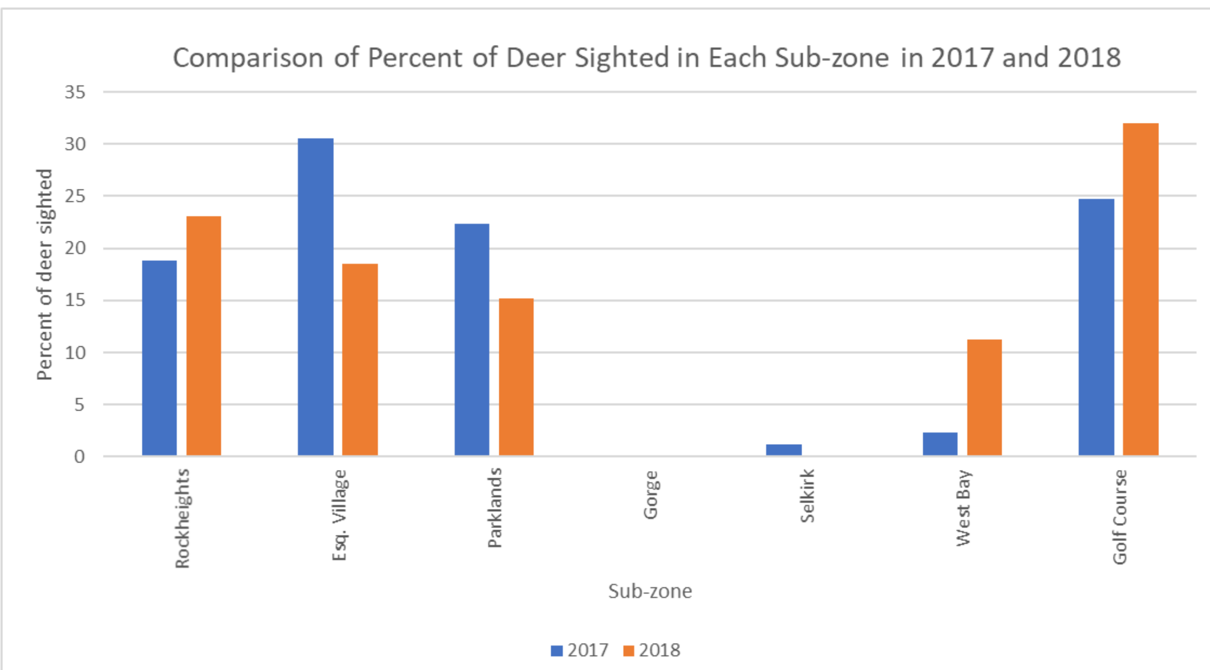

Figure 20. Graph of % of deer sighted in each sub-zone in 2017 and 2018

12.2 Spatial Distribution

Figure 21 shows the spatial distribution of all of the 178 deer sightings over the 10 samples in 2018 Fall. Figure 22 shows the spatial distribution of all of the 85 deer sightings over the 6 samples in 2017 Fall. The spatial distribution appeared very similar in both surveys.

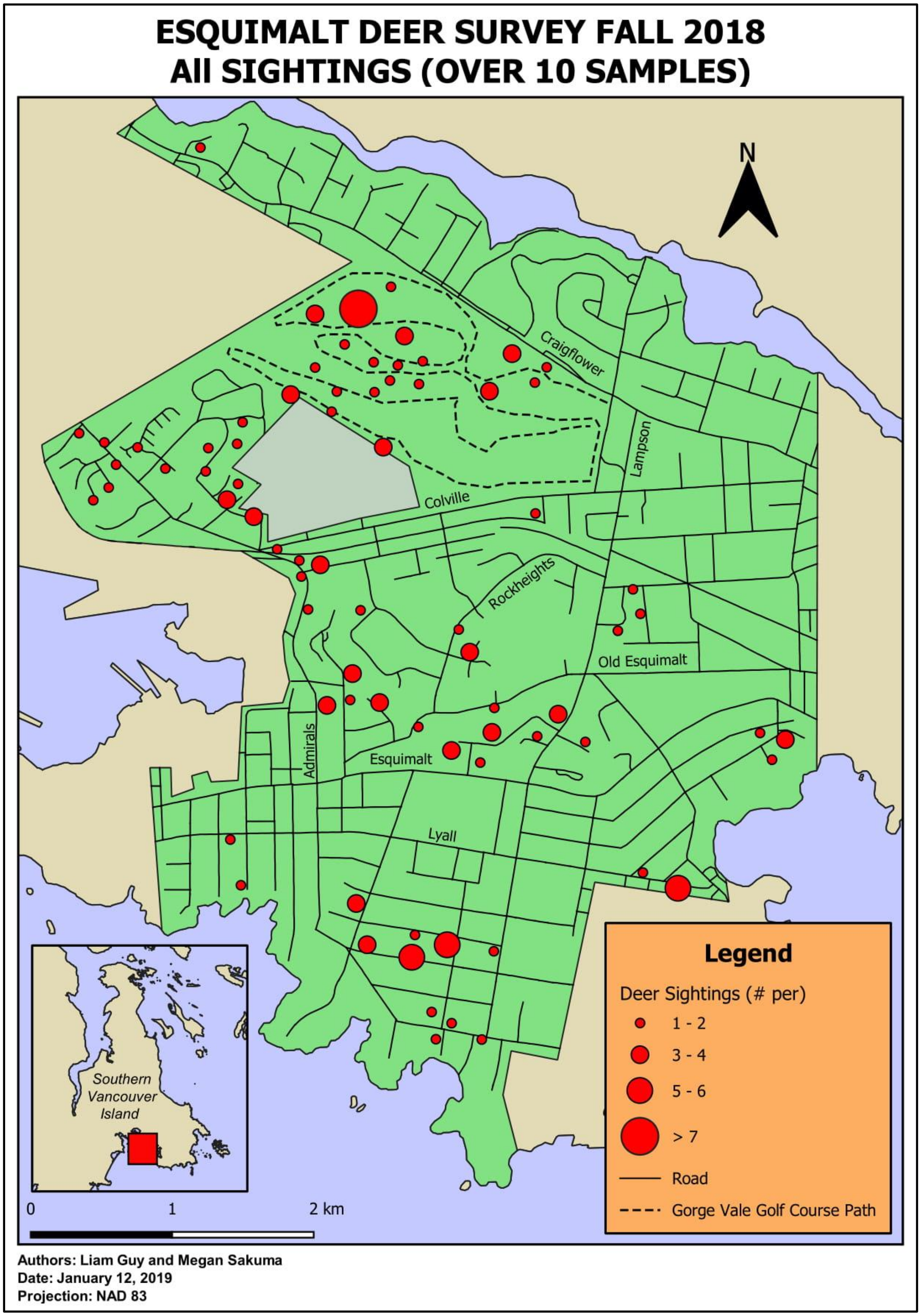

Figure 21. Map of Esquimalt deer survey Fall 2018 sightings

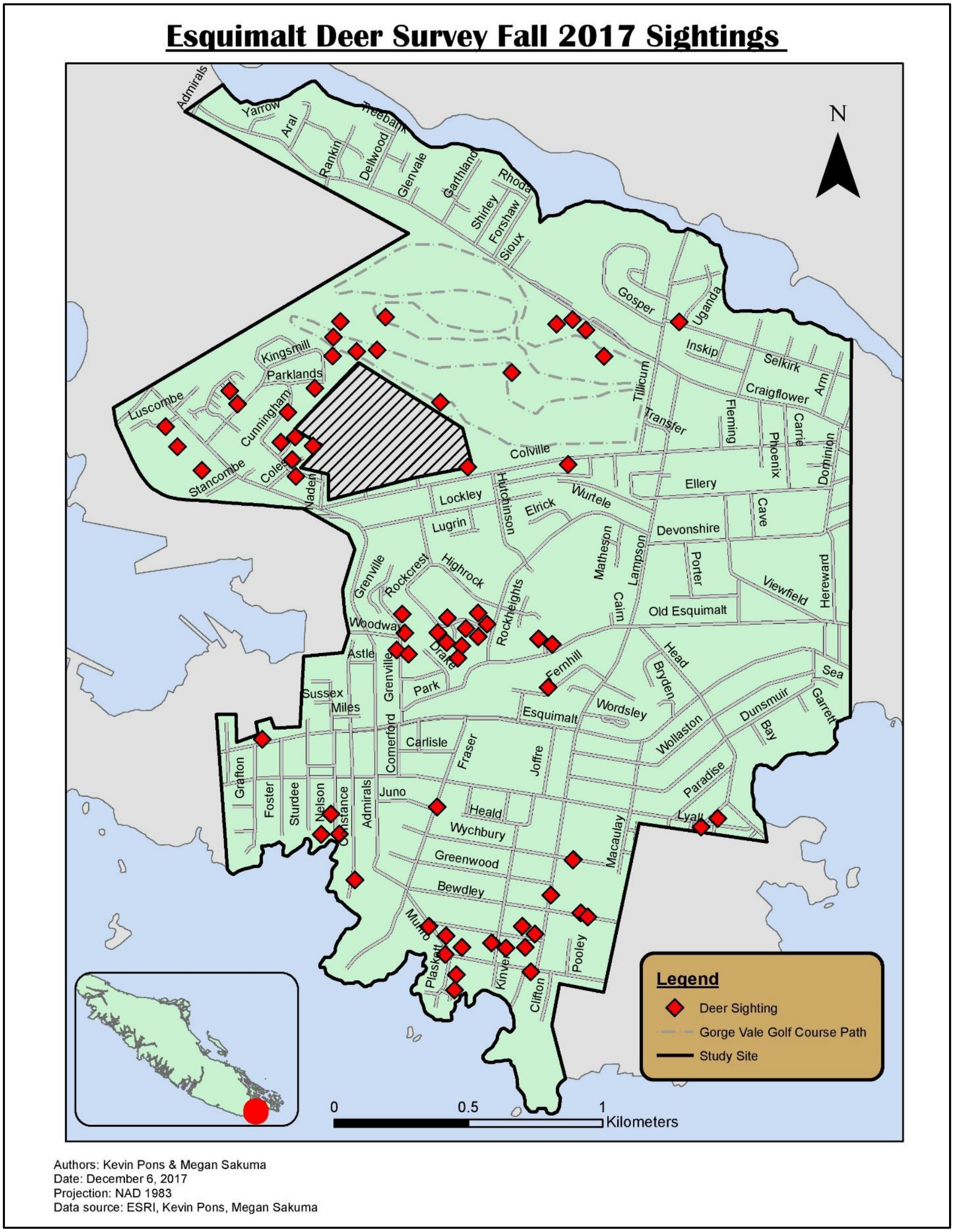

Figure 22. Map of Esquimalt deer survey Fall 2017 sightings

12.3 Herd Composition

Each deer sighted was placed into a category of either buck, doe, or fawn. For the purpose of this project, a fawn was considered a deer that had been born the previous spring of 2018, so approximately half a year old. Anything older than that was considered to be a mature adult, and was placed in either the buck or doe category.

Table 2 shows the herd composition percentages. Herd composition ratios are determined by the ratio between the number of bucks and does, and by the ratio of the number of fawns and does within the population. The ratios were calculated by dividing the total number of sighted *category X* by *category X* over all of the ten samples. Within the study area it was found that:

	Buck	Doe	Fawn	Total
Total number observed	46	74	58	178
Percentage	25.84%	41.57%	32.58%	100%

Table 2. Herd Composition in Esquimalt Fall 2018

Doe:buck = 1.61
Meaning that for every 1 buck, there are 1.61 does.

Fawn:doe = 0.78
Meaning that for every 1 doe, there are 0.78 fawns.

Figures 23 and 24 show herd composition percentages and ratios for all Fall 2017 and 2018 surveys in Esquimalt and DND. Note that the herd compositions are very similar.

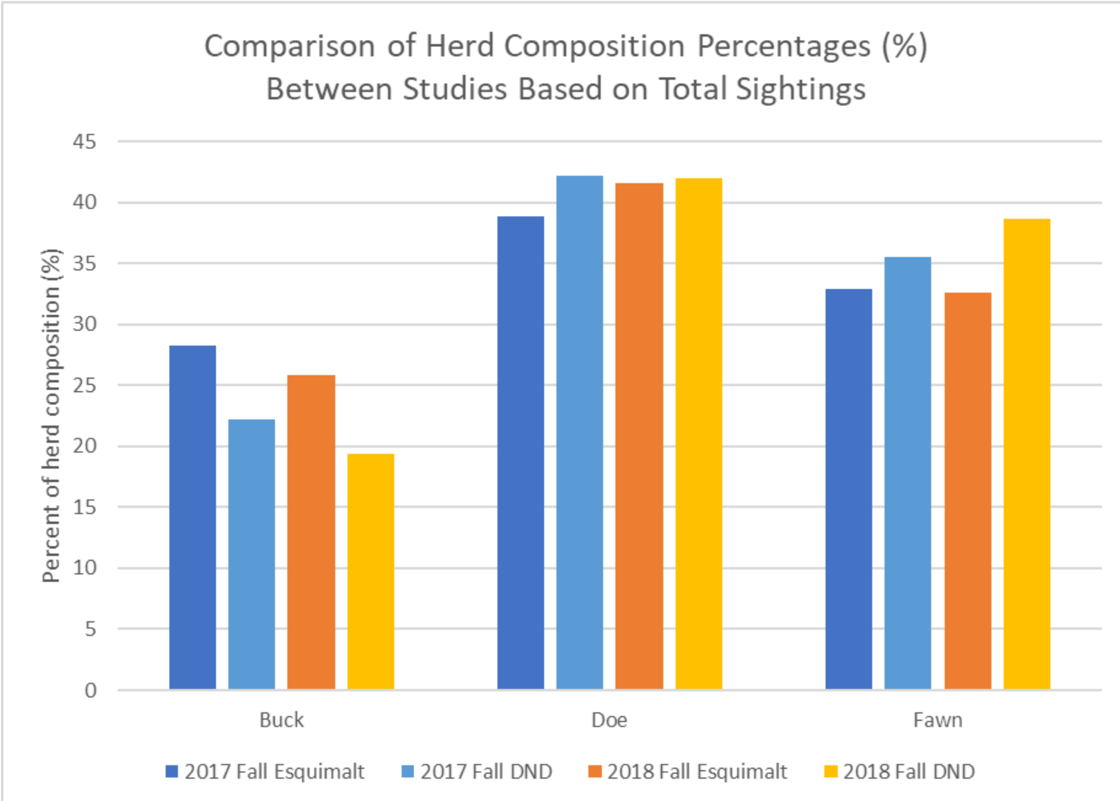

Figure 23. Graph of herd composition % between 4 studies

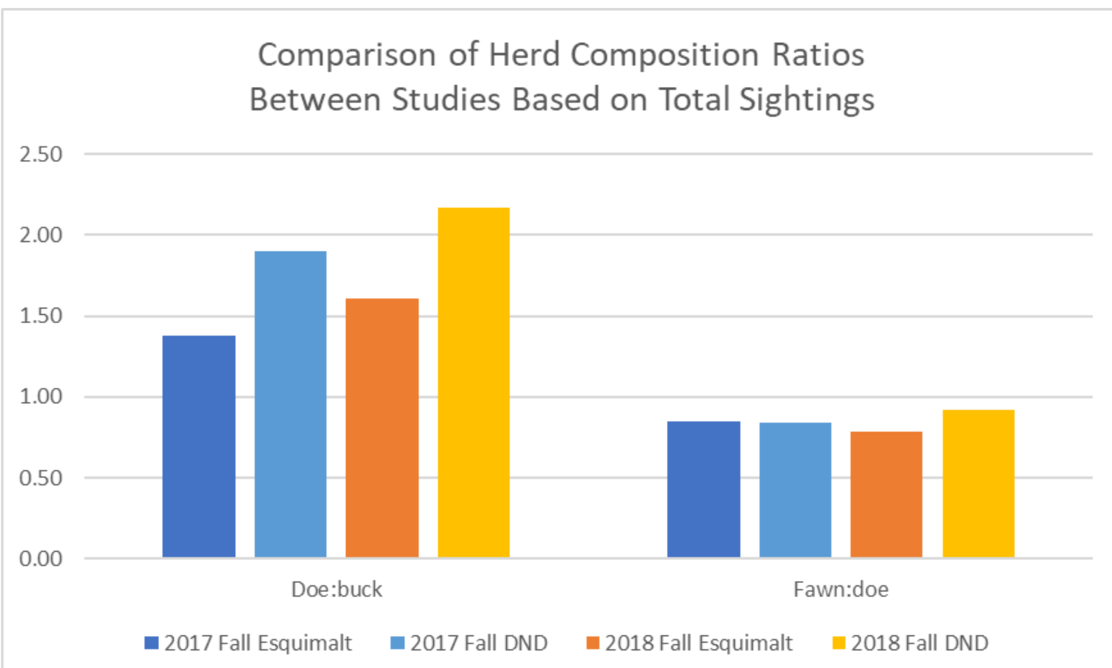

Figure 24. Graph of herd composition ratios between 4 studies

12.4 NULL MODEL

The Null Model is a variation of the Mark Recapture technique. It uses the maximum likelihood method to find the most likely population estimate size (Krebs, 2014).

"Assumptions:

1. The population is closed, so that N is constant.
2. All animals have the same chance of getting caught in the first sample.
3. Marking individuals does not affect their catchability.
4. Animals do not lose marks between the two sampling periods.
5. All marks are reported upon discovery in the second sample."

(Krebs, 2014, p.38).

This equation is solved by trial and error using a provisional range of estimates of population size.

$$L(\hat{N}_0, \hat{p}|X) = \ln\left(\frac{N!}{(N-M)!}\right) + (n)\ln(n) + (tN - n)\ln(tN - n) - (tN)\ln(tN)$$

$\hat{N}_0 = estimated\ population\ size\ from\ the\ null\ model\ of\ CAPTURE$
$N = provisional\ estimate\ of\ population\ size$
$\hat{p} = probability\ of\ capture$
$M = total\ number\ of\ different\ individuals\ captured\ in\ the\ entire\ sampling\ period$
$n = total\ number\ of\ captures\ during\ the\ entire\ sampling\ period$
$t = total\ number\ of\ sample\ days\ (e.g.\ days)$
$ln = natural\ log\ (log_e)$
$L = log\ likelihood\ of\ the\ estimated\ value\ \hat{N}_0\ and\ p, given\ the\ observed\ data$

Values from 0-100 were tested for *N* into the equation using Excel. Here is one example that used 35 for *N*:

$$L(\hat{N}_0, \hat{p}|X) =$$
$$\ln\left(\frac{35!}{(35-27)!}\right) + (46)\ln(46) + (10(35) - 46)\ln(10(35) - 46) - \big(10(35)\big)\ln(10(35)) = -54.65$$

Figure 25 represents the results of the repeated calculation for the values 27 - 50 as N:

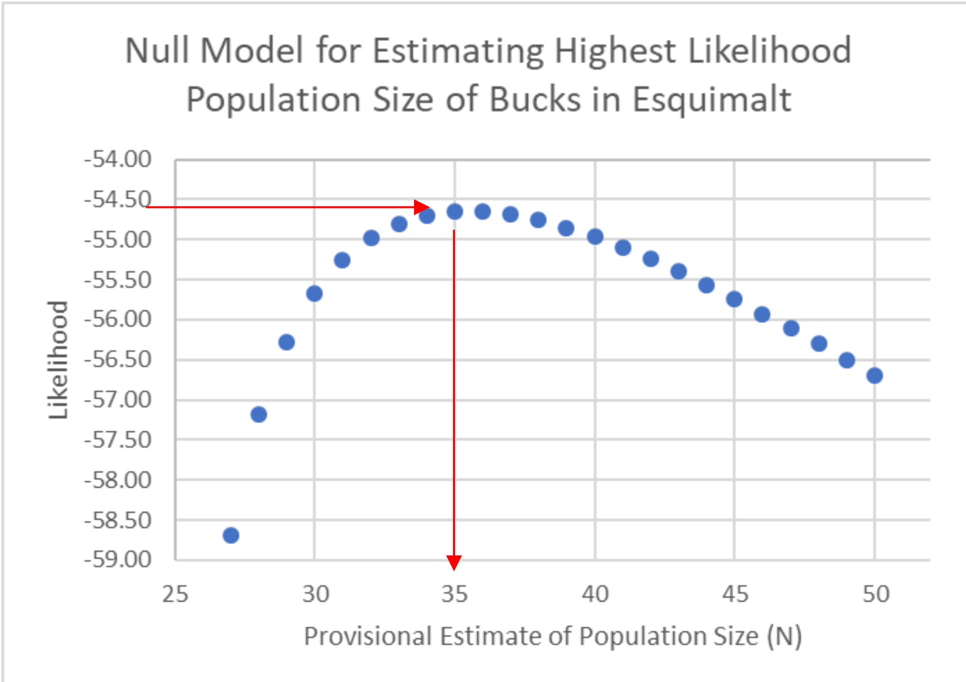

Figure 25. Graph of null model for estimating highest likelihood of bucks in Esquimalt for Fall 2018

The graph shows that the maximum likelihood of the buck population size is 35.

Next, the probability of an individual buck being sighted at any given sample period can be determined from the equation:

$$\hat{p} = \frac{n}{t\widehat{N}_0} = \frac{46}{10\ (35)} = 0.13$$

Given this probability we can now estimate the variance from the equation:

$$\widehat{Var}\left(\widehat{N}_0\right) = \frac{\widehat{N}_0}{(1-\hat{p})^{-t} - \left(\frac{t}{1-\hat{p}}\right) + t - 1}$$

$$\widehat{Var}\left(\widehat{N}_0\right) = \frac{35}{(1-0.13)^{-10} - \left(\frac{10}{1-0.13}\right) + 10 - 1} = 22.17$$

The resulting 95% confidence interval can be calculated from the equation (where z_α = standard normal deviate):

$$95\%\ confidence\ intervals = \widehat{N}_0 \pm z_a\sqrt{\widehat{Var}(\widehat{N}_0)}$$

$$\widehat{N}_0 \pm 1.960\sqrt{22.17}$$

$$\boldsymbol{35 \pm 9\ bucks}$$

There are 35±9 bucks in Esquimalt with 95% confidence intervals.

The results from the 2018 Null model estimate is compared to the 2017 Fall results, and represented in Table 3 and Figure 26.

Bucks only	2017 Fall	2018 Fall
Lower 95% confidence limit	13	26
Population estimate	40	35
Upper 95% confidence limit	67	44

Table 3. Null model population estimate for bucks

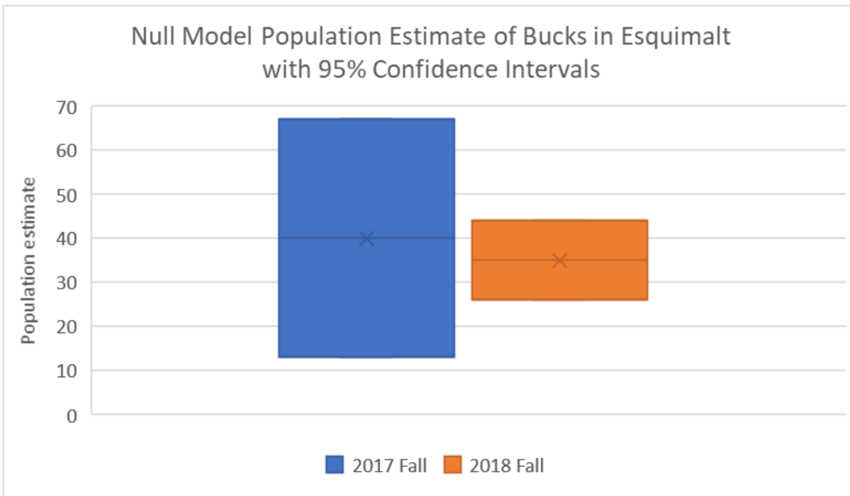

Figure 26. Graph of population estimate for bucks in Esquimalt for Fall 2017 and Fall 2018

For Fall 2017, the 95% confidence intervals encompassed a much larger range of values around the buck population estimate. This uncertainty is driven by the smaller sample size of conducted surveys (n=6). Increased sampling in Fall 2018 helped improve the precision around the buck population estimate, as indicated by the smaller range of values encompassed by the 95% confidence intervals.

Although all of the bucks were able to be individually identified, the does and fawns were not. Without antlers, it is much more challenging to identify unique features. In order to run the statistical model, all does and fawns had to be uniquely identified.

Using the ratio of the buck population estimate to the buck sightings (35/46 = 0.76), the doe and fawn sightings were extrapolated to a total population estimate of **135 deer** as shown in Table 4.

	Sightings	Percentage	Estimate
Bucks	46	25.84%	35
Does	74	41.57%	56
Fawns	58	32.58%	44
Total	178	100%	135 (35/46*178)

Table 4. Extrapolating buck estimates to total deer estimates

The ratios for the buck confidence limits were also extrapolated to 95% confidence intervals for all deer as shown in Table 5.

All deer	2017 Fall	2018 Fall
Lower 95% confidence limit	44 (13/40*135)	100
Population estimate	135	135
Upper 95% confidence limit	226	170

Table 5. Null model population estimate for all deer

13 DISCUSSION

13.1 Herd Composition

Unlike most wild populations of deer, there are no natural or human predators. In un-hunted populations, there tends to be a higher buck ratio (due to less hunted bucks), however it is still highly variable (Connolly, 1981). Therefore, it is not surprising to see a higher percentage of does than bucks. There were some studies on un-hunted populations, where buck to doe ratios were 45:100 (Hines 1975), 61:100 (Anderson et al, 1974), 74:100 (Longhurst et al, 1952), and 83:100 (Swank 1958) (as cited by Connolly, 1981, pp. 261). However, there was one very rare case discovered where the buck:doe ratio was 1:1 (White, 1973) (as cited by Connolly, 1981, pp. 261). These ratios fall in line with the Esquimalt 2018 data of 62:100. To explain this, Klein (1985) suggests that bucks are more prone than does to mortality over the winter, due to injuries obtained during the rut (as cited by Connolly, 1981, pp. 261).

The most influential factor on recruitment and therefore population growth is the juvenile survival rate (Hatter & Janz, 1994). Black-tailed deer have lower and more variable fawn survival than other ungulate species (Forrester & Wittmer, 2013). Hatter and Janz (1994) estimates that fawn survival rate is 45-69%. According to one study (Spalding 1968), a spring ratio below 33% fawns connotes low fawn survival, and good is 35-45% (as cited by Connolly, 1981, pp. 296). The 33% of fawns in this study was right on that border. The ratio of less than one fawn per doe (0.78) by November is not surprising, given the normal high mortality of newborn fawns, especially within crowded urban areas.

Healthy does in highly suitable habitats create 1.5 fawns per year (Bunnell, 1990). Under the best environmental conditions, fawn mortality rates may approximate adult mortality rate (Connolly, 1981).

13.2 Extrapolating Buck to Total Deer Estimate: Caveats and Assumptions

Herd composition data collected during the rutting season provide a more accurate representation. Bender (2006, p. 1226) states, “The breeding season is important because it represents the time when adults, especially adult males, are most likely to be freely intermixed with other population components and thus unbiased ASR [adult sex ratio] information collected from the population.” Additionally, “…because juveniles are not reliably seen with adults during the preweaning period, J/F [juvenile/female] ratios collected in this period potentially have great bias and little management significance” (Bender, 2006, p. 1227).

The total deer population estimate was derived by extrapolating the buck estimate to the observed herd composition ratios. The assumption is that the observed herd composition is accurate and representative of the true herd composition ratios in Esquimalt. The literature supports that the rut is the best time to collect the most accurate herd composition data. Nonetheless, the herd composition is dependent on how often bucks versus does versus fawns were seen, and assumes that does and fawns have the same probability of being detected as a buck. If bucks have a higher likelihood of being detected during a survey, then the observed herd composition ratios will be biased towards bucks. Any biases in the herd composition ratios would ultimately skew the total deer population estimate.

The total deer population estimate does not account for uncertainty in the observed herd composition ratios. It is therefore possible that the total deer population estimate may fall outside of he 95% confidence intervals. Continued monitoring of the Esquimalt CBTD population will help provide refined estimates of buck:doe:fawn ratios, lending greater confidence to the derived total deer population estimates.

Lastly, given that little is known about juvenile survival and recruitment rates for deer in urban environments, including fawns in the estimate of the total deer population overestimates the number of adults being recruited into the population. In reality, many of these fawns will likely die or disperse into areas outside of Esquimalt, and not actually be recruited into the population as a breeding individual.

13.3 Department of National Defence Deer Survey

DND initially conducted deer surveys on Canadian Forces Base (CFB) Esquimalt in 2003 and annually since 2016. Both the Esquimalt and DND sites have different habitats and available resources, which has resulted in different best suited methods for each area. For instance, DND has more open, green space than Esquimalt, which is mostly residential, which affects the probability of observing deer. In addition, dogs are not permitted at CFB Esquimalt and traffic volume is less on the DND property.

The Esquimalt surveys were coordinated with DND in 2017 and 2018 to conduct our respective surveys on the same days. When possible, we started our survey routes at the same place and days, at points of access for deer along our boundaries, and then fanned out from there. This reduced potential double counting of deer. There are some discrepancies in survey methodology between this study and that conducted by DND.

While this survey began at dawn, DND began their surveys at 8:00 am to limit surveying unstable terrain in the dark and avoid a safety incident. In addition, buck mark-recapture data collected by DND, and as used by Esquimalt to determine population estimates, were not sufficient for further analysis. Communication between Esquimalt and DND was frequent throughout the program and we provided each other with project updates. This year, Michael Muller, a co-op student with DND, came out and surveyed with us for one morning, and vice versa. This was a great way for us both to get a better understanding of what was happening on the ground.

During their Fall 2018 survey, DND estimated a deer population density of 44 deer/km^2 over the 1.59 km^2 CFB Esquimalt property (Muller, 2018). This value was slightly higher than the 40 deer/km^2 estimate from their Fall 2017 survey (Prentiss, 2017). Three individual deer were recognized from the Esquimalt survey in 2017, and one in 2018, in the photos in the DND report. This provides evidence that deer do travel between DND lands and the Township of Esquimalt.

In 2018, DND contracted Hemmera Environchem Inc. to analyse the local deer population using data from the Spring 2003, Spring 2016, Fall 2016, and Fall 2017 surveys. Deer density estimates were found to be very consistent between surveys ranging from at 38 to 43 deer/km^2. The population was concluded to be stable at approximately 40 deer/km2 and at biological carrying capacity (Hemmera, 2018).

13.4 Community Survey

The 2016 Community Survey Report divided Esquimalt into 6 zones based on relative deer density from the results of the survey (Nyberg, 2016). The ratings were:

- High: Parklands and Esquimalt Village
- Medium: Rockheights and Gorge
- Low: Selkirk and West Bay

Nyberg (2016) stated that "Deer or signs of deer were reported most frequently in the Parklands (100% of respondents), Esquimalt Village (90%), Rockheights (86%), and Gorge (85%) neighbourhoods; and least frequently in the Selkirk (52%) and West Bay (67%) neighbourhoods" (p.13).

He also states that "…the population density of deer appears to fall as one moves from west to east in Esquimalt, with substantially lower densities east of Tillicum Road and the portion of Lampson Street north of Esquimalt Road. The lowest density appears to be in the Selkirk area north-east of the intersection of Tillicum Road and Craigflower Road" (Nyberg, 2016, p.13).

And that "…more Parklands (27 percent) and Esquimalt Village (14 percent) respondents reported seeing deer on their properties 26-31 days/month than did the respondents from other neighbourhoods" (Nyberg, 2016, p.14).

"Survey results indicated that deer or their sign have been observed at one time or another on 17 of every 20 properties in Esquimalt that hold residences with outside entrances. West Bay and Selkirk neighbourhoods have experienced substantially lower levels of deer use than the rest of the Township. This is probably because deer movement into those neighbourhoods is restricted somewhat by barriers such as the busy streets (Lampson and Tillicum) forming their western borders and the water to the north and south; and by the unfavorable habitat associated with the high proportion of industrial and commercial properties in the West Bay area" (Nyberg, 2016, p.26).

The community survey results were very similar to the results from the data collected in this scientific survey. Taking the total number of deer sightings for each zone and dividing it by the length of its transect, I came up with a "density estimate". <u>The only purpose of this density estimate calculation was to compare the densities of each zone relevant to each other. It does not represent the actual density.</u> Table 6 shows the 2018 data, and table 7 shows the 2017 data:

Zone	Rockheights	Esq Village	Parklands	Gorge	Selkirk	West Bay
Deer Sighted	41	33	27	0	0	20
Length of transect (km)	16.8	15.7	4.7	7.6	2.7	11.5
"Density"	2.44	2.10	5.74	0.00	0.00	1.74

Table 6. Calculation of "density" of each sub-zone relative to each other in 2018

Relative to each other, the results from the 2018 survey placed the zones into the categories:

- High: Parklands
- Medium: Rockheights, Esquimalt Village, West Bay
- Low: Gorge, Selkirk

Zone	Rockheights	Esquimalt Village	Parklands	Gorge	Selkirk	West Bay
Deer Sighted	16	26	19	0	1	2
Length of transect (km)	16.8	15.7	4.7	7.6	2.7	11.5
"Density"	**0.95**	**1.66**	**4.04**	**0**	**0.37**	**0.17**

Table 7. Calculation of "density" of each sub-zone relative to each other in 2017

Relative to each other, the results from the 2017 survey placed the zones into the categories:

- High: Parklands
- Medium: Rockheights, Esquimalt Village
- Low: Gorge, Selkirk, West Bay

The density estimate ratings per sub-zone have only changed slightly over 2017-18 and agree with the subjective community survey results.

13.5 Sources of Error

- The slowest speed possible which was still safe was driven. This varied among roads, but an attempt to remain consistent was made throughout the study.
- Daylight savings time happened mid way through the survey, which affected our survey time in correlation to rush hour.
- More likely to double count does and fawns than bucks, as they are difficult to recognize.
- The golf course could not be sampled in reverse, as it would have disrupted the golfers too much.

14 CONCLUSIONS

The results of the Null Model (for the bucks only) from the Fall 2018 survey (n = 10) produced 95% confidence limits with a low of 26 to a high of 44 bucks, and an estimate of 35 bucks. Next, the herd composition ratio was extended to the buck estimate to extrapolate the total deer population estimate. This resulted in 95% confidence limits with a low of 100 to a high of 170 total deer, and an estimate of 135 deer.

Applying the same data analysis methods to the Fall 2017 survey (n = 6), 95% confidence limits with a low of 13 to a high of 67 bucks, and an estimate of 40 bucks were produced. Again, the herd composition ratio was extended to the buck estimate to extrapolate the total deer population estimate. This resulted in 95% confidence limits with a low of 44 to a high of 226 total deer, and an estimate of 135 deer.

Total deer population estimates were based on the observed herd composition ratios and assumes equal probabilities for sighting bucks, does, and fawns.

There is no statistical difference in the deer population estimates between 2017 and 2018 (as evident by overlapping 95% confidence intervals). However, the considerable uncertainty around the 2017 deer population estimate limits the ability to draw any conclusions on population trends for Esquimalt deer. Increased sampling in 2018 (n=10) provided greater certainty around the buck estimate (and thereby total population estimate), and we therefore recommend future surveys to collect no less than 10 samples.

This study provides a robust estimate for the number of bucks in Esquimalt. Extending the observed herd composition ratios to the buck estimate provides an informed estimate for the total number of deer in Esquimalt. These estimates may be further refined through continued monitoring of urban deer population structure. Finally, identified localities where deer are observed at increased frequencies offer important insights into where to target future efforts for public education.

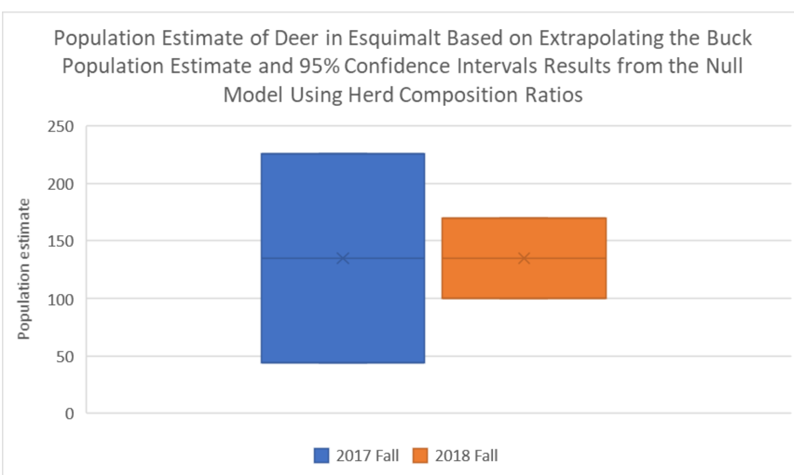

Figure 27. Graph of population estimate of deer in Esquimalt in Fall 2017 and Fall 2018

15 RECOMMENDATIONS

- Repeat the survey in Fall 2019.
- Assess if it is worth the resources to continue surveying the parks, and how it would affect the data analysis.
- Compare deer population demographics observed for Esquimalt to those observed in Oak Bay to provide further certainty to the herd composition ratios applied to the buck estimates to derive the total deer population.
- Focus public education efforts in areas with higher densities of deer, as identified by this survey and the Community survey.

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