Sifton Bog White-tailed Deer Population Estimation Methods

"The most critical stage of implementing and completing an inventory or monitoring study is not data collection, presentation or interpretation, but rather design. Careful design will increase effectiveness, reduce costs and lead to improved interpretation." (Jones 1986)

There are three broad levels of intensity at which inventories are conducted: 1) presence/not detected (possible), 2) relative abundance, and 3) absolute abundance. Following is a brief overview of the characteristics of the three levels.

1) **Presence/Not Detected (Possible)** surveys are best suited for determining a species' occurrence in a given area. The usual goals of this type of survey are to create species lists for a given area and/or to determine species-habitat associations. This level of survey is probably the simplest measurement of a population but this by no means implies minimal effort. Methods at this level only involve the species present and related habitats; therefore, species and related factors that are not involved/captured/monitored in the study, but which may influence species dynamics, are not considered. (Cooperrider *et al.* 1986) Generally, making management decisions based on this type of survey can be detrimental to non-focal species because those non-focal species and their related factors will not be considered.

2) **Relative Abundance** surveys provide indices of population size that cannot be converted to an estimate of the total number of a species (i.e. absolute abundance). This level is best suited for conducting comparisons between locales and species and any temporal fluxes (i.e. species A is two times more prevalent compared to species B in area 1, but three times more prevalent in area 2). Usually surveys of this type involve units of time or distance traveled (deer/hour, monkeys/tree). In situations where indices are highly variable and where trends are required, multiple counts are required to achieve precision. (Harris 1986)

3) **Absolute Abundance** surveys refers to the density or total numbers of a species. Sampling methods are very similar to those used for relative abundance; however, these estimates are applied to the specific area. Of the three intensities, AA is probably the most costly and difficult to assess. Generally, data collected from AA surveys are used to relate population density to vital statistics (reproduction, survival, biotic growth, emigration and immigration) (Caughley 1977, Krebs 1989) and for developing harvest strategies.

Common strategies for developing AA surveys involve direct sampling via total counts or sampled counts or indirect sampling such as mark-recapture. Survey methods used in establishing AA will always have certain advantages and disadvantages associated with them (i.e. mark-recapture studies allow for inferences on a greater range of population parameters but have a strong reliance on statistical assumptions, not to mention high costs).

Table 1. Examples of questions that can be addressed at each level of inventory intensity.

Presence/Not detected	Relative Abundance	Absolute Abundance
Determine the types of species occupying various habitats within a defined study area.	Detect a change in population size and composition over time.	Set optimal harvest rates for a hunted population.
Delineate the distribution of a species within a larger geographic area.	Rank Study Areas within a larger Project Area based on the abundance of a particular species.	Determine the relationship between reproduction and species density.
Detect an expansion* in the distribution of a population or a species over time.	Determine population trend in managed and un-managed Study Areas.	Monitor the recruitment of an endangered species.

*Presence/not detected surveys cannot detect range reduction as they do not have the statistical validity to conclude extinction.
(Table from Species Inventory Fundamentals #1. Resource Inventory Standards. 1998)

An absolute abundance type survey is required to ascertain the total number of white-tailed deer in Sifton Bog. A presence/not detected (P/ND) type survey is not applicable because we already know that the deer are there. P/ND type sampling can show changes in demographics within the herd such as bucks, fawns and, more importantly, does (see population ecology below). Relative abundance indices (RA) are very useful for recording changes over temporal or spatial scale. For example, RA sampling can demonstrate shifts between food sources, even between neighbour A's and B's garden hedges as a food preference. In the future management of the Bog, RA techniques will effectively monitor the population.

Population Ecology

Population can broadly be viewed as the total population or the effective population. Total population refers to all the individuals of a given species (bucks, does, fawns) distributed over the given area, e.g. 25 deer in Sifton Bog. Effective population is linked to the number of breeding pairs or viable females in a population. If the population growth is based on the fecundity (the reproductive fitness of the female), then a population's growth is limited to the number of viable females in the population base given any number of males. A presence/not detected survey is suitable for assessing this aspect. If there are many breeding females in an area, the population growth rate (births minus deaths) is positive and the carrying capacity will generally be reached quickly. (Bookhout 1994)

Open and closed populations are terms usually used to describe the possibility of immigration to or emigration from an area. The terms can also be used to describe the sampling time interval. For example, is it possible that movement to or from the area (or births/deaths) during the count is making the population estimate inaccurate? If so, then the population would be considered open.

Most of the methods described below are conducted in a short time period of up to a few days. Therefore, the Bog's deer population can be considered closed as any changes will be insignificant to the population estimate. If the population is being assessed over many seasons or years, other factors take effect and the total population will vary. In this case, the total number can be considered an estimate of relative abundance.

Methods for Estimating the Absolute Abundance of White-tailed Deer in Sifton Bog

The Bog's total deer population can be determined by several absolute abundance sampling methods. However, for the Bog's purpose, several of the methods are not as applicable or are perhaps too costly to consider, such as using thermal or multispectral scanners. With every method, there are certain inherent assumptions that must be undertaken. All methods assume that the number produced is representative of what is really there.

Following is a description of seven complete count methods that could be applied in the Bog.

Complete Counts - All Individuals Observed

1) Drive Counts

This method involves people pushing or driving the deer through an area, possibly past counters at fixed counting stations. Drivers are evenly placed in a line across the given area. The drivers must remain within sight of each other as they evenly sweep through the area and push all the deer forwards towards the counters. If there are escape routes out of the area, additional counters may be placed to count those deer as well. Normally, the area needs to have well defined borders. As the Bog is surrounded for the most part by housing, this aspect takes care of itself.

A drive count census is "the sum of the number of animals moving out of the area ahead of the line of drivers, plus those moving ahead of the observers through the line, minus any moving into the area ahead of the drivers." (Bookhout 1994) This method assumes that all deer are counted and counted only once.

The count's accuracy can be affected by the deer doubling back through the line or slinking and fawns hiding. Experienced counters may ensure a more accurate count.

It has been determined that a drive count tends to underestimate the total number for low populations and overestimate the total number for large populations. (McCullough 1979) A repeat count may be conducted in the Bog two to three days later. If a repeat count is conducted, equal effort must be maintained between the first and the second counts.

This method, while not costly in the monetary sense, requires a large group of people as well as intense coordination and timing/scheduling. The results are usually a fairly accurate population estimation that can be conducted in virtually any season.

2) Aerial Photography

With the aid of either an airplane or helicopter, low altitude photographs are taken of groups of animals or of the area. In larger areas this method has been conducted along transects

or lines with these lines having a known area. Given the size of the Bog, it is plausible that the whole area be photographed. The images collected are later counted to obtain a total number.

This method assumes that all individuals are visible and have been counted. Timing of the count is important. Generally it is best conducted when forest canopy cover is at its lowest affording best view into the trees. Also, snow cover on the ground enhances the ability to discern individuals. The problem with this timing is that the gender of the deer may be unknown as the bucks shed their antlers in December or January and do not begin to grow them again until spring.

While this method is expensive (approximately $700-$1200/hour/helicopter), photo-evaluating requires little manpower and the product of such a census is usually of high quality. However, due to the location of the Bog within the City, this method may not be feasible.

3) Total Counts of Sample Plots

This method involves dividing the total area into smaller units or plots based on features such as habitat quality or forest type. In-depth censuses are conducted on ground or by air in representative plots and statistical inferences are conducted linking the plots to the rest of the area for a population estimate.

This method assumes that all the deer are visible and counted. It is also generally assumed that, as the animals would need to make large movements between plots, this sub-sampling of the area still satisfies the "closed" population concept. As the area of the Bog is relatively small (compared to the whole white-tailed range in London), this method may not be as feasible due to size of the plots and their proximity to each other. However, this type of sampling may be applicable combined with other methods (see #5 below).

<u>Complete Counts - All Individuals Not Observed</u>

4) Aerial Survey

This method involves using aircraft to fly along transects (lines) of know lengths and widths and counting all animals on the transects. The transects are considered to be representative of the area and easily converted to the total area for a population estimate. For example, if 10 deer are counted in a 4 km transect, and the total area to be estimated equals 40 km, then the population estimate would be 100 (40 x 10/4).

In most instances, at least two counters are used, one on each side of the aircraft. Whether the two communicate their count numbers or not, or if one checks the other's values or not, is part of this method and carries its own statistical significance.

This method has the same assumptions and problems as the above methods, with the additional assumption that the transect(s) is/are representative of the whole area.

5) Double Sampling

This method utilizes methods #2 and #3 above to reach a population estimate. First a transect is flown over the area as in #2 above. Then sample plot censuses are conducted on the ground as in #3 above but within the transect line area of the flight. Ideally, the ground census and the transect flight are both conducted at the same time. If this is not possible, then as little

time as possible should pass between the flight and the ground counts to minimize movement of the deer.

All of the assumptions above apply to this method. In addition, an important assumption is that the ground census counts all of the animals in the plot, without missing any. With this assumption, the total number estimate is basically comparing the air numbers to the ground and that value to the total area. For example, if it was shown that 2 deer spotted from the air represented 3 on the ground (2/3 = .667), and the air count was 10 deer for the total transect area of 4 km, then 10 deer counted from the air (based on ground correction) equal 15 on the ground (10/.667 = 15), and for 40 km the total number equals 150 (40x15/4).

This method produces a very accurate value, is only slightly cheaper than #4 above but is perhaps better suited to larger areas. However, it also works well in areas where there is a high degree of complex habitats such that a sweep may not be conducted as in #1 above.

6) Marked Sub-sample or Marked/Recapture

Statistically this method involves the highest understanding of the values collected in a census. In effect, a small number of individuals are captured and marked via different means (ear tags, paint markings, radio collars). They are then released back into the population and allowed a period of time to redistribute themselves over the area, after which various observation methods are employed to count the number of tagged deer relative to un-tagged deer in order to derive a population estimate. The calculation generally follows the corrected method in #5 above. For example, in a sample plot 5 un-tagged deer were observed for every tagged deer. As 10 tagged deer were released into the area, the total number equals 50 (5 x 10).

This method has a high degree of contact with the deer in that they must be captured and tagged by some means. The assumptions of this method are that the process does not affect the behavior or viability of the deer by any means. For example, if the deer was so adversely affected by being captured and tagged that it went into hiding and exhibited an even greater flight response than normal, it would, in effect, have removed itself from the population and not be available to be counted. In addition, a deer with a tag may be more vulnerable to predators than a "normal' deer.

7) Line Transects

Like #3 above, this method is a form of sample plot estimation but utilizes lines through the given area instead of plots. Distances of sightings perpendicular to the transect line are recorded as well. The distance-from-transect recordings are used to develop sighting probabilities. At some distance away from the transect line, observations will cease as deer cannot be seen due to obstructions or distance.

This method has a high degree of statistical dependance as well as having a high dependance on its assumptions, which are that all animals directly on the line are counted, the animals sighted remain in their exact location once sighted, no animals are counted twice, and all sightings are independent events (flushing of one animal does not cause another to flush). (Burnham *et al.* 1980)

This method is very similar to #4 Aerial Survey, but adds sighting probabilities. This method is low in manpower at the beginning but the work is end-loaded as there is a high degree

of statistics involved in generating the total number. While very "useable" in the Bog, this method works best where the area is great and cost is an issue (i.e. it is cheaper to pay someone to analyze data than to rent a helicopter to fly transects or take pictures). Line transects are also applicable as a presence/not detected method for determining sex ratio and herd demographics.

Relative Abundances (RA):

As discussed previously, relative abundance counts cannot be converted to absolute abundance estimations. However the power of a relative abundance estimation lies in its ability to note trends or develop relationships within the herd or area, or between areas. While there are many methods available and virtually every area has a unique situation requiring unique considerations, the following methods have been demonstrated to be most practical for determining relative abundance in the Bog.

1) Pellet Group Counts

This method involves counting groups of deer droppings (pellets) as a surrogate for deer numbers. Factors that must be taken into account while conducting this type of survey include the age of the pellet groups (decomposition) and defecation rate, which has been shown to vary with the season. While transects are the normal way of conducting this type of survey, circular bounded areas have been demonstrated to be a more realistic depiction of relative abundance.

In order to counter the pellet group age problem, Kuefeld (1968) developed a methodology in which older pellet groups were painted, then the area was left for a period of days, then all the non-painted groups were counted with a high degree of confidence that they were "new."

As this survey is an index of relative abundance, it will produce a value as follows. In 1999, in 13 circular plots of 5 metres each, 17 pellet groups per circle were counted for a total number of 221 (13x17). In 2000 in the same plots, 21 pellet groups were counted on the same day (total number = 273). In 2001, 3 pellet groups were counted over the same time and same plots (total number = 39). This is a dramatic example that one could infer a major population increase followed by a even more major decrease in numbers over a period of three years.

2) Spotlight Counts

This method is conducted at night with the aid of a powerful spotlight suddenly shining into an area such as a clearing or open road. As many ungulates become more mobile and less defensive at night, this method is very good at assessing the relative abundance in a given area. However, this method is also highly biased to certain locations as it is only applicable to larger open areas and not to tight bush. Therefore, only animals that utilize these open areas will be sampled while those that have adopted very secretive behaviours will never be represented in the sample. However, even so, spotlight counts are useful as a means of developing relative abundance as the majority of the individuals are likely to be sampled in this way. The total number calculation is very similar to the pellet group count above and easily shows trends.

Some lesser used but still applicable methods for determining relative abundance include:

3) Browse Counts

This method involves identifying the deer's food types and counting the number and/or degree of removed twig tips per bush or area, and then repeating those counts later in order to assess the relative abundance of browse intensity.

This method assumes that all the browse damage on a tree is caused by deer and there are no alternative feeding/browse sources new to the area that detract from this source. However, this method can suggest changes in population dynamics or food selection, population densities, and behaviour modifications based on population densities. This accuracy of this method is affected by changes such as deer browsing on less desirable food types in lieu of what they once preferred as the abundance of that preferred shrub becomes rarer and the population increases. This method can only be conducted on trees and shrubs not grasses and forbes as many animals utilize these easier to obtain food types.

4) Point Counts

This method involves identifying locations within a given area and standing or posting at the location over a certain time period and recording all observations and sightings within that time slot. Demographics and numbers can be recorded in this method.

This method is perhaps one of the less likely to produce anything dependable as far as relative abundance. There are so many factors that can determine the location of the animals at any given time, such as weather, predators, disturbance and year cycle of the deer (rutting bucks move greater distances than post rut), that this method is less likely to produce even marginal indices of population dynamics. However, this method is useful as an index of presence/not detected.

Literature Cited

Bookhout, T.A. editor. 1994. *Research and Management Techniques for Wildlife and Habitats.* Fifth edition. Allen Press, Inc. Publishers. Lawrence, Kansas.

Burnham, K.P. *et al.* 1980. "Estimation and density from line transect sampling of biological populations." *Journal of Wildlife Management* # 72: 202pp.

Caughley, G. 1977. *Analysis of Vertebrate Populations.* John Wiley and Sons Publishers. New York, NY.

Cooperrider, A.Y., Boyd, R.J. and Stuart, H.R. 1986. *Inventory and Monitoring of Wildlife Habitat.* U.S. Department of the Interior Bureau of Land Management. Washington, DC. U.S. Government Publications Office.

Harris, I.W. 1986. "Reliability of trend lines obtained from variable counts." *Journal of Wildlife Management* #50(1): 161-171pp.

Jones, K.B. 1986. "The inventory and monitoring process." Pages 1-10 in Cooperrider *et al. Inventory and Monitoring of Wildlife Habitat.*

Krebs, C.J. 1989. *Ecological Methodology.* Harper and Row Publishers. New York, NY.

Kuefeld, R.C. 1968. "Use of paint for marking deer pellet groups." *Journal of Wildlife Management* #32: pp. 593-596.

BC Resource Inventory Committee Standards (RIC). 1998. *Inventory Fundamentals. Standards for components of British Columbia's biodiversity. No. 1.* Ministry of Environment, Lands and Parks Inventory Branch.

BC Resource Inventory Committee Standards (RIC). 1998. *Ground-based inventory methods for selected ungulates: Moose, elk, deer. Standards for components of British Columbia's Biodiversity. No. 33.* Ministry of Environment, Lands and Parks Inventory Branch.

BC Resource Inventory Committee Standards (RIC). 1997. *Standardized inventory methodologies for components of British Columbia's biodiversity. Live animal capture and handling guidelines for wild mammals, birds, amphibians and reptiles.* Ministry of Environment, Lands and Parks Inventory Branch.