Deer Browsing at the Millard Learning Center:

An Analysis of Current Data and Recommendations for Future Deer Monitoring and Management

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CONTENTS

ABSTRACT:

Columbian Black-tailed deer, (*Odocoileus hemionus columbianus),* are considered hyper-abundant by some people in locations where intense human activities have affected their natural habitat and population controls. Efforts to preserve or restore the native plant communities and biodiversity of the Coastal Douglas-fir ecosystem in these areas are challenged by excessive browsing by Black-tailed deer. Attempts to determine the population sizes of Black-tailed deer that will allow for all species of the Coastal Douglas-fir ecosystem to persist are a subject of research. One method suggested by Martin *et al.* (2011) uses the palatable oceanspray shrub (*Holodiscus discolor*) as a region-wide indicator of browsing pressure by deer (Martin 2011). Continued browsing limits the recruitment of new shoots, thus changing the shape of the plant from a bushy shrub to an umbrella shape over time. By measuring the foliar width at 2m and 1m in height, a quantitative indicator (2:1 ratio) of browsing pressure can be obtained. A survey of oceanspray on the Millard Learning Centre property on Galiano Island BC was first done in 2015 using a transect approach to obtain such measurements. These oceanspray transects were repeated in the Galiano Field Course in 2021 with the goal of comparing the results obtained in 2015. With comparative data recorded for 8 of the 34 transects in 2021, an analysis was made between the available data from 2015 and 2021. The 2:1 ratio's change was inconsistent between transects, and no conclusions could be drawn on changes in deer density and browsing intensity between 2015 and 2021. An additional method for determining deer populations combined with continued monitoring of browsing could aid the current data in establishing deer management protocols for Galiano Conservancy land and possibly the other Gulf Islands.

1.0: INTRODUCTIONS AND BACKGROUND:

1.1 Location and Context

Galiano Island is one of the Southern Gulf Islands in the Salish Sea of British Columbia. The Land lies within the traditional territories of the Hul'qumi'num Treaty Group (Chemainus, Cowichan Tribes, Halalt, Lake Cowichan, Lyackson and Penelakut), the Hwlitsum Nation, and the Tsawwassen First Nation. (Galiano Learning Centre Management Plan 2013*)*.

The Southern Gulf Islands lie within the endangered Coastal Douglas-fir (CDF) and Associated Ecosystems Biogeoclimatic Zone. This zone continues along the southern coast of British Columbia, and south-eastern coast of Vancouver Island. It is the smallest and rarest of the 16 biogeoclimatic zones in BC, and the least protected (Centre for Forest Conservation Genetics, University of British Columbia). 80% of land in the CDF Zone is privately owned, 9% held as provincial Crown land, and 11% is under protection by other levels of government (Curran 2013*)*. In the rain shadow of the Vancouver Island and Olympic mountains, the Mediterranean-like climate is the mildest in Canada resulting in one of the most densely populated regions in the country. The pressures of urbanization and intensive land uses have altered the habitat for native herbivores and their predators resulting in localized excessive herbivory and trophic cascades. The BC Conservation Data Center (2019) lists 48 ecological communities and 270 species of wildlife, plants, and fungi at risk in the CDF ecosystem.

Protecting and restoring intact ecosystems is a human endeavor that has ecological, cultural, and economic value. Where human densities are high, like Southern BC, sustainable land use planning that balances the needs of human economies with the necessary ecological features that support all species will help preserve biodiversity. Ecosystem protection in Southern BC involves collaboration between local, regional, public, and private entities to preserve intact landscapes and their connectivity. This may include the acquisition of damaged landscapes for the purpose of restoration (Curran 2013). The restoration of damaged landscapes provides early seral stages of vegetation that are both palatable and vulnerable to native herbivores. This can undermine the success of restoration efforts and give the impression that the herbivores are the problem. Successful restoration of biodiversity includes native herbivores whose populations and habits have been altered by human activities (Arcese 2014).

1.2 Galiano Conservancy Association (GCA) and The Millard Learning Center (MLC)

Since its creation in 1989, the Galiano Conservancy Association has been committed to ecological and cultural restoration, education, research, and innovation. The Millard Learning Center is a 76-hectare property owned by the Galiano Conservancy Association on the southwestern coast of Galiano Island. The acquisition of this property in 2012 completed a 500-hectare corridor of jointly protected lands from coast to coast on central Galiano Island (Fig.1)

Figure 1. Map of Mid-Island Protected Areas Network produced by the GCA

The MLC contains the remnants of intensive land use and extraction of resources. Prior human settlement, logging, and agricultural activities have altered the landscape, offering many opportunities to learn and practice ecological restoration of the CDF ecosystem.

1.3 Columbia Black-tailed deer (*Odocoileus hemionus columbianus*)

Three subspecies of deer (*Odocoileus spp.*) that range in Canada are Mule deer, Sitka deer, and Columbia Black-tailed deer. Each has adapted to specific geographical locations. The Columbia Black-tailed deer (BTD) have been native residents of North America for 2 million years and range along the entire coast of BC west of the summits of the Coast and Cascade ranges. Population densities of BTD vary depending on location but are highest in the southern coastal regions of Vancouver Island and the islands of the Georgia Strait, where human densities are also high. Deer (*Odocoileus* spp.) populations have been increasing rapidly in the urban areas of southern BC while non-urban populations have been in decline for at least 30 years (Ministry of Forests, Lands, Natural Resource Operations, and Rural Development 2014). BTD buck harvest has decreased by about 50% since the early 1990's while hunting efforts increased by more than 30%, suggesting an overall population decline despite their relative densities in urban areas. The most recent range-wide estimates of BTD population in BC are 98,000-155,000 (Mule Deer Working Group, 2020). Urban deer can demonstrate behaviour patterns that differ from their non-urban cohorts. For example, urban male Mule deer translocated to non-urban areas exhibit wider seasonal ranges, lower survival rates, and a tendency to return to urban sites (Wright 2020). A five-year research project in the southern interior of BC began in 2018 to look at mule deer responses to differing landscapes and ecological conditions. (BC Wildlife Federation Southern Interior Mule Deer Project 2018). Knowledge gained from this project may help in developing wildlife management techniques in the future.

For thousands of years prior to the arrival of Europeans, Indigenous people took care of the landscape and managed the deer population. Using fire to maintain oak savannas they enhanced the persistence of their food staples of roots and fruiting shrubs. These meadow-like areas also attracted BTD who were valued as a significant source of protein and other products (Arcese 2014). Colonization by Europeans led to a reduction in the traditional land management methods of Indigenous people. Fire suppression has reduced the prevalence of meadow-like landscapes and their associated plant species. Reduction of natural predation and hunting have also caused an abundance of BTD populations in areas of altered and oversimplified landscapes. (Arcese 2014). Identifying modern day BTD densities that allow for the conservation of all native species is a subject of research. It has been suggested that a threshold density of no more than 1 deer per 10 hectares would allow for recovery of native vegetation that supports a diversity of bird species (Martin 2011). With roughly 6,000 ha of space, Galiano Island would ideally support no more than 600 deer for proper establishment of native plant species. Using the same threshold, the Mid-Island protected areas network would support no more than 50 deer, translating to fewer than 8 deer for the Millard Learning Centre (Galiano Conservancy Association, 2021).

1.4 Current management of deer browsing pressure at the MLC:

Browsing pressure from BTD is an ongoing concern for conservation and restoration efforts at the MLC. Excessive browsing over long periods of time changes the understory and can cause trophic cascades that lead to local extinctions of native plants and animals, especially ground nesting songbirds (Martin 2011). A recent report by University of Victoria students (Khan and Howse 2020) provided an excellent review of the current challenges, causes, and management of deer at the Millard Learning Centre. They reviewed the methods currently in use at the MLC: fencing, experimental exclusion plots, and coordinated hunting. They also reviewed other methods such as aversion and immunocontraception (being studied in Oak Bay and Esquimalt). They compiled a literature review and made recommendations to further the research on deer management directions for the GCA and MLC. (Khan and Howse 2020). Objective 6 of the Stewardship goals of the MLC recognizes that management of BTD populations may be necessary to achieve successful ecological restoration and avoid trophic cascades. (The Galiano Learning Centre Management Plan 2013).

Indigenous people have a long history of hunting deer on Galiano Island. A coordinated hunting program with the Penelakut Nation on the MLC property was initiated as a 2-year trial in 2019. Healthy ecosystems are known to contain apex predators. Therefore, one of this program's goal is to "achieve a better ecological balance for the deer population and ecosystem at the MLC by simulating natural predation through hunting" (Facilitating Traditional Food Harvesting, 2019, pp. 2-3). Hunting venison is also promoted as a protein that can be ethically harvested, a practice that can also support cultural resurgence for Indigenous peoples (Facilitating Traditional Food Harvesting, 2019). While hunting could theoretically take place anytime between September and March, there have only been 2 coordinated hunts so far. In 2019, two hunters took 10 deer and in 2020 one hunter took 4 deer (see Appendix MLC Hunting and Deer History). Hunting was localized to open areas near the roads on the property. (Personal communication, Adam Huggins 2021). It remains to be seen if coordinated hunting will significantly change the browsing pressure at the MLC. Methods to assess both deer numbers and browsing pressure are needed for an informed and adaptive approach of active wildlife management.

1.5 Research and monitoring of deer density and browsing pressure

The MLC has five deer exclosure plots of various ages already installed on the property. Plant species richness, composition, and percent cover in these plots are compared to corresponding open plots provides site specific information about deer herbivory. Khan and Howse (2020) analysed data collected in 2019 and 2020 from 3 of these plots. They found that species composition was relatively similar between open and closed plots for both years. Species composition was highest in the oldest exclosure at the Mill site, which was fenced in 2014. Total percent cover in the plots was generally greater in the exclosures, but there was more variability in this relationship between the sites. Incomplete data prohibited cross-site comparisons of browsing assessments, but they did notice some trends indicating preferential browsing of certain plant species. For example, oceanspray was present in exclosure plots but was never observed in the open plots suggesting high palatability and a lack of new recruits. (Tables 2,3,4 Khan and Howse 2020).

Research on deer browsing pressure around the San Juan and southern Gulf islands was first conducted by Martin et al. (2011). Oceanspray is known to be a palatable species for deer, which they may prioritize over other plant species for browsing. As deer continually browse on the same shrubs, all the leaves under 1.5m in height are removed. Instead of a full bush, an umbrella-like shape forms from the weight of the untouched leaves. The ratio between the shrub's diameter at 2m and 1m in height (2:1 ratio) helps display this structural change (Martin et al., 2011). Acrese et al. (2014) add that the 2:1 ratio can work as an index for both deer density and shrub species richness. A protocol for sampling oceanspray 2:1 ratio along transects of the entire MLC site was developed and implemented by University of Victoria students in 2015.

A recommendation was made in the report by Khan and Howse (2020) to repeat the transect sampling as done in 2015 and make comparisons. In June 2021, 11 University of Victoria students taking the Galiano Field course (ES 471), taught by Professor Eric Higgs and Teaching Assistant Alina Fisher, emerged from their pandemic-induced isolation to live, and learn at the MLC. The main field component of this year's course was to learn the method of transect sampling vegetation and add to the existing data for compilation and analysis.

2.0 GOALS AND OBJECTIVES:

1. Assess the transect method as a tool for determining BTD populations and herbivory over time on GCA property and the MLC.
   <u>Objectives:</u>
   - Repeat sampling of transects done at the MLC in 2015.
   - Compile past and current oceanspray transect data onto one source.
   - Analyse available transect data over time and draw conclusions on changes in deer density and herbivory if possible.
   - Compile data from coordinated hunting events.

2. Make recommendations for future monitoring of BTD populations and herbivory for use in adaptive wildlife management and research at the MLC.
   <u>Objectives:</u>
   - Discuss limitations and strengths of the current transect method.
   - Provide alternative monitoring methods for deer browsing.
   - Expand methods for estimating and monitoring deer density at the MLC in combination with current observations of browsing pressure.

3.0 APPROACH AND METHODS:

3.1: Method

We used the 2015 oceanspray transect protocol along the MLC's property for the 2021 field work: (See Appendix 9.2 for detailed, original protocol)

Materials: Compass, measuring tape, GPS unit, worksheet
Definitions:

- **Individuals:** A single plant separated by more than 10m from its nearest neighbour
- **Patch:** A group of individuals whose foliage is contiguous or overlaps
- **Distribution:** 9-class description of spatial arrangement ranging from single individuals to continuous dense patches. ("Few" refers to 2-4 individuals; "Several" is more than 5 plants)

Thirty-four transects are conducted at the Galiano Conservancy, starting at their respective coordinates [Figure 2]. Transects run due south from the starting coordinates, finishing on the coast of Galiano Island. Each transect line has a 25m radius to sample oceanspray. Each individual or patch of oceanspray found along the transect must have its characteristics measured on a data sheet.

The oceanspray are given a code from 1-9 depending on their distribution with other shrubs in the area [See Appendix 9.2]. The GPS coordinates are designated a special letter code, which are followed by the oceanspray's distribution code (ex: D3). The shrub's Northing and Easting coordinates are recorded from the GPS on the data sheet. The shrub's diameter is also measured at 1m and 2m above ground along the stem line. These measurements of diameter should be divided to create the 2m/1m ratio. This value serves as an indicator of browsing pressure. If the sample is a patch, measurements are only performed on the northernmost individual.

Each individual or patch must also be categorized based on canopy cover: O (Open), P (Partial), F (Full); Slope (to the nearest 5 degrees with an inclinometer); Aspect (Direction of the slope to the nearest 1/16 cardinal direction (ex: NEE)).

If shrub height is below 1.5m, browsing pressure is measured by counting the number of stems coming from the base without living foliage (dead stems), the number of stems that have been browsed, and the number of live stems with a diameter below 0.5cm.

3.2: 2021 Revisions to the protocol

It was found that some oceanspray individuals grew on uneven surfaces. This led to some confusion on the base point from which the heights were measured. It was decided that these uneven surfaces measurements would be measured starting from where the deer would be standing while browsing (for example, if a shrub was growing through a fallen log, measure from the exit point at the base of the log).

Previously there was also a gap in the protocol for measuring shrubs whose maximum height is between 1.5m and 2m. Within this range, the shrubs are taller than the required height for measuring the number of stems. Therefore, the shrub's width at 1m is measured, but no measurement is possible at 2m. This leads to a zero value in the 2m width and the 2:1 ratio, removing any indication of browsing pressure. For these cases, it was decided that the shrub's highest point would be measured as an alternative to the 2m measurement.

3.3: Selecting data for comparison

For evaluating changes in deer browsing intensity between time, the 2015 data was restricted to only the area where 2021 data are also available. This should give a more direct comparison and could possibly serve as an indicator for change along the rest of the property. Comparisons are also made for each available transect area. While the 2021 data retains their transect IDs for each data point, there are no transect IDs present in the original 2015 sheet. The 2015 data points are therefore placed into "transect-equivalent" groups based on their easting values. Assuming the width of each transect stops at the middle point between neighboring transects, the easting range for each 2015 "transect equivalent" is based on the middle value between neighboring start points (see "Transect Boundary Lines" on Figure 2).

However, the easting ranges are noticeably different between 2015 and 2021 transects. The 2021 ranges are based on the coordinates from recorded data points per transect. As stated earlier, the 2015 eastings range is decided by the middle points between starting coordinates. Had the 2015 transect groups been created following the ranges provided by the measured 2021 data, certain ranges would risk overlapping past transect boundaries. The transect analysis would therefore include data points belonging to different transects, or risk double-counting data points. This overlap could have been caused by factors like human error or inaccuracies in the devices used.

Some data points were removed for the analysis. In the 2015 sheet, there were multiple points that measured the width at 1m but did not provide a 2m measure. It is likely due to the previous lack of protocol for shrubs whose maximum height did not reach 2m. This leads to a zero value at 2m and the 2:1 ratio. Even if these shrubs received some level of browsing pressure, it would not be indicated by the zero-value provided. Therefore, a calculation of mean browsing pressure through the 2:1 ratio would be undervalued if these zero values were included in the calculation. These zero values were removed from the analysis to prevent any biases created by these data points.

3.4: Analysis of statistical significance

In the comparison of 2015 and 2021 browsing pressure, the null hypothesis (H_0) is that the mean 2:1 ratio is unchanged. The alternate hypothesis (H_A) is that the mean 2:1 ratio for the two years is different.

H_0: $M_1 = M_2$

H_A: $M_1 \neq M_2$

Where:

M_1 = Mean 2:1 ratio for 2021; M_2 = Mean 2:1 ratio for 2015
SD_1 = Standard Deviation of 2:1 for 2021; SD_2 = Standard Deviation of 2:1 for 2015
n_1 = Number of 2021 data points; n_2 = Number of 2015 data points

Since the samples have a different number of data points, a 2-sample T-test with unequal variances is conducted. This test is calculated as:

T-test = $[M_1-M_2]$ / Standard Error (SE)

Where: $SE = \sqrt{(SD_1^2/n_1 + SD_2^2/n_2)}$

The P-value is calculated to test if the null hypothesis can be rejected. The null hypothesis can be rejected if the P-value is less than 0.05.

4.0 RESULTS:

4.1: Overview

From the data collected in 2021, the mean 2:1 ratio across all transects was 3.44. In this area between transects 00-3A, the mean 2:1 ratio in 2015 was 4.24. According to Martin (2011), high deer browsing intensity requires a 2:1 ratio greater than 3.33. While overall deer browsing intensity seems to have reduced, it is still within the high intensity range. However, the level of deer browsing intensity is different between the transects. In 2021, the only transects whose deer browsing intensity reached Martin's (2011) definition of "high intensity" were 00, 01, and 03A. On the other hand, three other transects (0A, 02A, 03) had a 2:1 ratio of less than 2.00 (Figure 5). These 2:1 ratios align with Martin's (2011) findings for low deer density: 1.54 (2.27-1.12 95% CI).

The changes in deer browsing intensity are also not the same between transects. Only transects 0A and 03 had statistically significant reductions in the 2:1 ratio, going from averages of 6.41 and 7.72 to 1.31 and 1.99 respectively. However, transects 01 and 02 had an increase in their 2:1 ratio. Notably, transect 1A displayed no change in the 2:1 ratio, and contained the most combined data points between 2015 and 2021.

When comparing the aggregate data collected, the average 2:1 ratio was lower in 2021, but the p value (0.45) did not indicate statistical significance. Furthermore, the changes in the 2:1 ratio are inconsistent between transects; there were both increases and decreases in deer browsing. The transect containing most data points showed no change in the 2:1 ratio. We conclude that there is no statistically significant difference in the overall browsing pressure between 2015 and 2021. While more transects could be conducted to provide a larger sample size for comparison, alternative methods of research may be preferred.

4.2: Discussion

There were certain aspects in the process of measurement and evaluation that could have led to variance in the analysis of deer browsing intensity. When conducting measures of shrub width at 1m, the width is usually between the many stems originating from one plant. However, there were some shrubs who only contained one stem at 1m, giving a much smaller width measurement. These measurements are often in the two-decimal range (0.01m-0.09m) and give a significantly larger 2:1 ratio. This can be seen in transect 00, which has a 1m measurement of 0.03m, giving a 2:1 ratio of 69.00.

Furthermore, there is a possibility that the shrubs along the boundary line of transects were evaluated in different transect groups between years. A lower precision GPS can give a bigger variance in the calculated coordinates between measurements. Notably, the points between transects 00 and 0A present a similarly shaped distribution of data points, but they reside on different sides of the boundary line (Figure 6). It is possible that the same shrub was measured both years, but its data is used for two different transect analyses. This can lead to a less direct comparison of deer browsing intensity across time.

While a transect-by-transect analysis compares browsing intensity over the whole transect area, it may not be the best for measuring change in specific regions of interest. Since the vertical transects run directly south through the MLC property, it will inherently take measures of oceanspray in various environmental conditions. The survey also contains shrubs that reside in both open restoration sites and enclosed sites. Future analyses could be a more focused comparison instead of being transect-based. For example, it could be targeted to areas of interest, like active restoration sites where over-browsing can prevent the establishment and growth of new plants, as well as specific ecosystems within the MLC property. This could also provide support to a more direct approach to measuring deer population, such as camera traps within an area of interest.

A sample gradient map is provided for the 2021 data points to visualize the level of browsing intensity in the area recently measured (Figure 4). This type of map may provide aid in determining areas of interest for monitoring based on browsing intensity. For example, the southern region of the MLC property shows a horizontal section of high-intensity points.

4.3 Challenges in performing the Transect Sampling Method

- Human capital: The transect protocol requires a high degree of human effort. During the 2021 field work, transect measurements were performed by teams of 3. To maintain the transect's path, one member was often dedicated to holding the south-bound bearing. Therefore, not all members were actively involved with the data collection of oceanspray shrubs.
- Learning curve: Most surveyors in 2021 were non-specialists, and the first transect completed (00-1A) was part of the field-training experience. With the surveyors of different skill levels on the field, they may introduce measurement errors into the dataset through variations in measurement technique and judgement. They may even mis-identify focal species. Smaller oceanspray recruits also risk being missed in the survey due to variation in understorey

vegetation, and the limitations of trying to sample a 50m-wide transect with variable visibility.

- Time cost: The completion of transects was a time-intensive process. With 4 transects being run simultaneously in groups of 3, there was 12 surveyors conducting the transect work during the field course. Each transect took 2 hours to complete. These 4 teams spent 4 hours conducting field work, which led to 8 completed transects. With 33 total transects to be performed on the MLC property, it would take an estimated 12.5 hours for 4 teams to complete the remaining transects. If only a single crew was available, completing the transects could take up to 50 hours.

5.0 RECOMMENDATIONS:

The following recommendations are given since we believe there are alternative methods of surveying the deer population and herbivory pressure on the MLC property. While the transect method can be used to sample the entire property for deer browsing intensity, it is only an indirect method of assessing deer density. In the pursuit of continuing deer research, a more direct method of deer monitoring would be beneficial to generate an estimate of the deer population on the property. An estimate of population size can then be related to observations of browsing pressure. We also suggest potential avenues for deer management worth pursuing on the property. However, the application of management strategies may depend on deer population estimates.

5.1: Camera Traps:

Our project supports the suggestions by Khan and Howse (2020) that camera trap sampling is a valuable next step for determining deer density and distribution. The oceanspray transects conducted are not sufficient on their own to draw information on deer populations on the MLC property. So far, the transect method has informed us that deer density is high and hasn’t changed significantly since 2015. Camera traps provide an opportunity to directly observe deer activity over a continuous period of time and offer more accurate estimates of population size. (Khan and Howse 2020). It would be interesting to see how the estimated population obtained from camera traps compares with the limits suggested by Martin *et al* (2011) for establishing full native plant biodiversity. Expanding camera trap research to the whole island could reveal if behavioural or demographic differences exist between the deer populations on disturbed sites (urban-like) and nonurban sites. This knowledge could inform design methods in restoration practice that reduce selection of urban-adapted native herbivores. This is also an opportunity for the GCA and MLC to contribute to the body of research developing around hyperabundant herbivores in urban areas in the CDF ecosystem (Pons 2020).

5.2: Vegetation monitoring using exclosure & open plot surveys

We agree with Khan and Howse (2020) that regular sampling and comparison of existing exclusion and open plots should continue. Paired plots of equal size, one fenced to exclude deer and the other a control, are surveyed for relative plant abundance, plant density, and species richness over time. (Pendergast 2015). These comparisons can offer information on deer preferences for certain plants and browsing effects on understory composition. The placement of plots in different ecological communities at the MLC offer the potential to make cross site comparisons to assess deer preferences for certain landscapes. However, by excluding native herbivores the exclosure plots are not representative of the complete ecosystem community. Culturally and ecologically significant plant species can be monitored using the plot method *(*Arcese 2014*)*. Species lists for the plot sites were created by Khan and Howse (2020) (Figure 7). The protocol should be standardized to account for seasonal variations in species observations and to minimize observer differences through training and education. Using this method may prove more effective for long-term data gathering compared to transect sampling. Longitudinal data gathered from these plots, if combined with camera trap arrays, may offer insight into deer movements, location, and herbivory preferences.

Another method to consider is to identify certain individuals or groups of oceanspray to monitor over time. Various sites on the MLC property can be chosen to represent different ecological communities with the transect data providing the locations of oceanspray to pick from. These survey events would be be less time consuming and provide a better approximation of impacts compared to transect sampling.

5.3: Hunting

We support continuing the coordinated hunts with the Penelakut First Nation, encouraging the incorporation of traditional knowledge and cultural restoration (Facilitating Traditional food harvesting 2019). We recommend the collection of GPS coordinates for the locations of the deer taken by hunters. This may provide additional information about deer preferences for certain landscapes or deer movements in response to hunting. If hunting is being used to replace natural predation as a deer population control, it may take longer than 2 years to detect any potential effects on population and site biodiversity. This delay in effect is Therefore, we suggest that coordinated hunts with the Penelakut Nation be extended beyond 2022 while the data on browsing pressure and population estimates can be gathered.

6.0 CONCLUSION:

(Distinct opportunity of CCA & MLC for deer population research & MGMT) (Lessons learned on Galiano will serve great for neighboring islands) (Centre of distinct research & findings for ecological restoration) (Centre of active management of ecosystems for long-term research)

Ecological stewardship and restoration in the CDF ecosystem require a strategy for reducing the negative consequences of excessive browsing by abundant herbivores. While considered “hyperabundant” in certain locations, native Black-tailed deer populations have been decreasing throughout their range compared to their 1994 population size. Active population management through lethal means, contraception, or aversion techniques are all being used and studied in different locations in the CDF zone. Understanding the site-specific deer community and its population size is crucial for monitoring the impacts of different management methods. Traditional ecological knowledge and scientific inquiry working together at MLC can inform integrated wildlife management policies that are region-specific, culturally and scientifically sound with the goals of food security, biodiversity, and resilience. Knowledge acquired through research at the MLC may prove useful on the other Gulf Islands where similar excessive herbivory complicates restoration efforts and biodiversity protection.

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8.0 REFERENCES:

2020 Range-wide Status of Black-tailed and Mule Deer. (2020). Mule Deer working group. Western Association of Fish and Wildlife Agencies (pp 9-11). Retrieved from: https://wafwa.org/wp-content/uploads/2020/08/2020_MuleDeer-and-BTD_Status-Update.pdf

Arcese, P., Schuster, R., Campbell, L., Barber, A., Martin, T.G. (2014). Deer density and plant palatability predict shrub cover, richness, diversity and aboriginal food value in a North American archipelago. Retrieved from: https://bright.uvic.ca/d2l/le/content/141438/viewContent/1116925/View

Curran, Deborah. (2013). Collaborative Conservation Planning: A Resource Guide. A Publication of the Galiano Conservancy Association. Retrieved from: https://galianoconservancy.ca/wp-content/uploads/2016/11/Resource_Guide_to_Collaborative_Conservation_Planning_-_Curran_2013.pdf

Facilitating Traditional Food Harvesting. (2019) Galiano Conservancy Association. Retrieved from: https://galianoconservancy.ca/wp-content/uploads/2020/09/Facilitating-Traditional-Food-Harvesting.pdf

Galiano Conservancy Association. (2021). Retrieved July 25, 2021 from: https://galianoconservancy.ca/

Galiano Learning Centre Management Plan (2013). Galiano Conservancy Association. Retrieved from:https://galianoconservancy.ca/wp-content/uploads/2016/11/Galiano_Learning_Centre_Management_Plan_-_February_15th_2013skm.pdf

Khan, P., Howse, M. (2020). Hyperabundant Deer: Making a Case for Monitoring and Management. Retrieved from: https://bright.uvic.ca/d2l/le/content/141438/viewContent/1116939/View

Martin, T., Arcese, P., Scherdeer, M. (2011). Browsing down our natural heritage: Deer impacts on vegetation structure and songbird populations across an island archipelago. https://bright.uvic.ca/d2l/le/content/141438/viewContent/1116908/View

Mule and Black-tailed Deer in British Columbia. (2000) Ecology, Conservation, and Management. BC Ministry of Environment, Lands, and Parks. Retrieved from: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/staying-safe-around-wildlife/muledeer.pdf

Mule Deer Working Group. (2020), Western association of Fish and Wildlife Agencies. Retrieved from:https://wafwa.org/wp-content/uploads/2020/08/2020_MuleDeer-and-BTD_Status-Update.pdf)

Pendergast IV, T. H. IV, Hanlon, S. M., Long, Z. M., Royo, A. A., Carson, W. P. (2016). The legacy of deer overabundance: long-term delays in herbaceous understory recovery. *Canadian Journal of Forest Research. 46(3), 362-369.*

Pons, K., (2020). Population Estimate Survey of Columbian Black-tailed Deer in Esquimalt, BC.: Third annual report of the three-year study from 2017-2019. Township of Esquimalt. Retrieved from:https://www.esquimalt.ca/sites/default/files/docs/public-safety/Final_Deer_Survey_Report_KP.pdf

Wright, C. A., Adams, I. T., Stent, P., & Ford, A. T. (2020). Comparing Survival and Movements of Non-Urban and Urban Translocated Mule Deer. *The Journal of Wildlife Management*, *84*(8), 1457-1472 https://wildlife-onlinelibrary-wiley-com.ezproxy.library.uvic.ca/doi/epdf/10.1002/jwmg.21935

9.0 APPENDIX:

9.1 Figures

Figure 2: MLC Transect Paths

Figure 3: All Oceanspray Data Points from 2015 & 2021

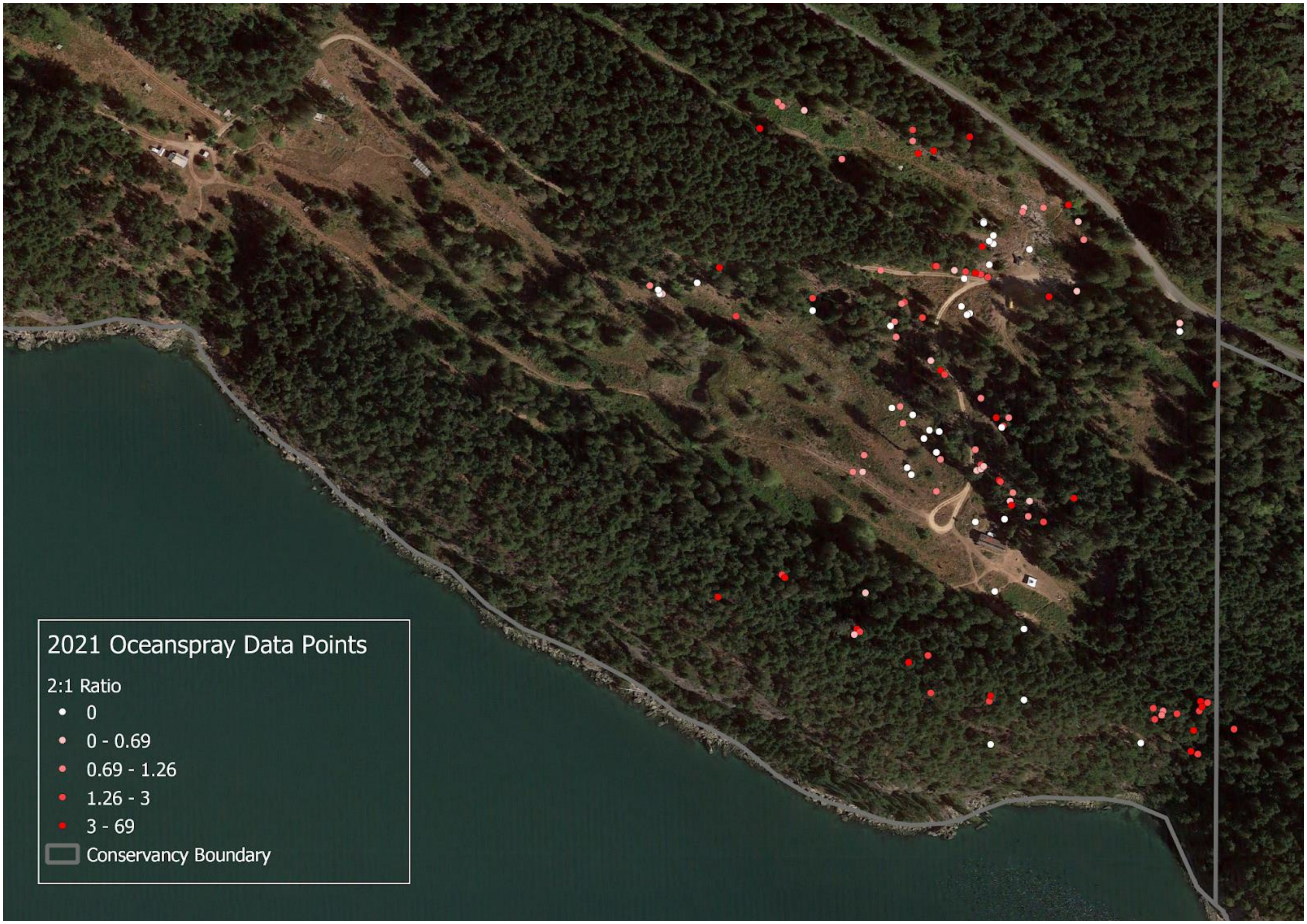


Figure 4: Sample map displaying different levels of browsing intensity within the 2021 survey area.

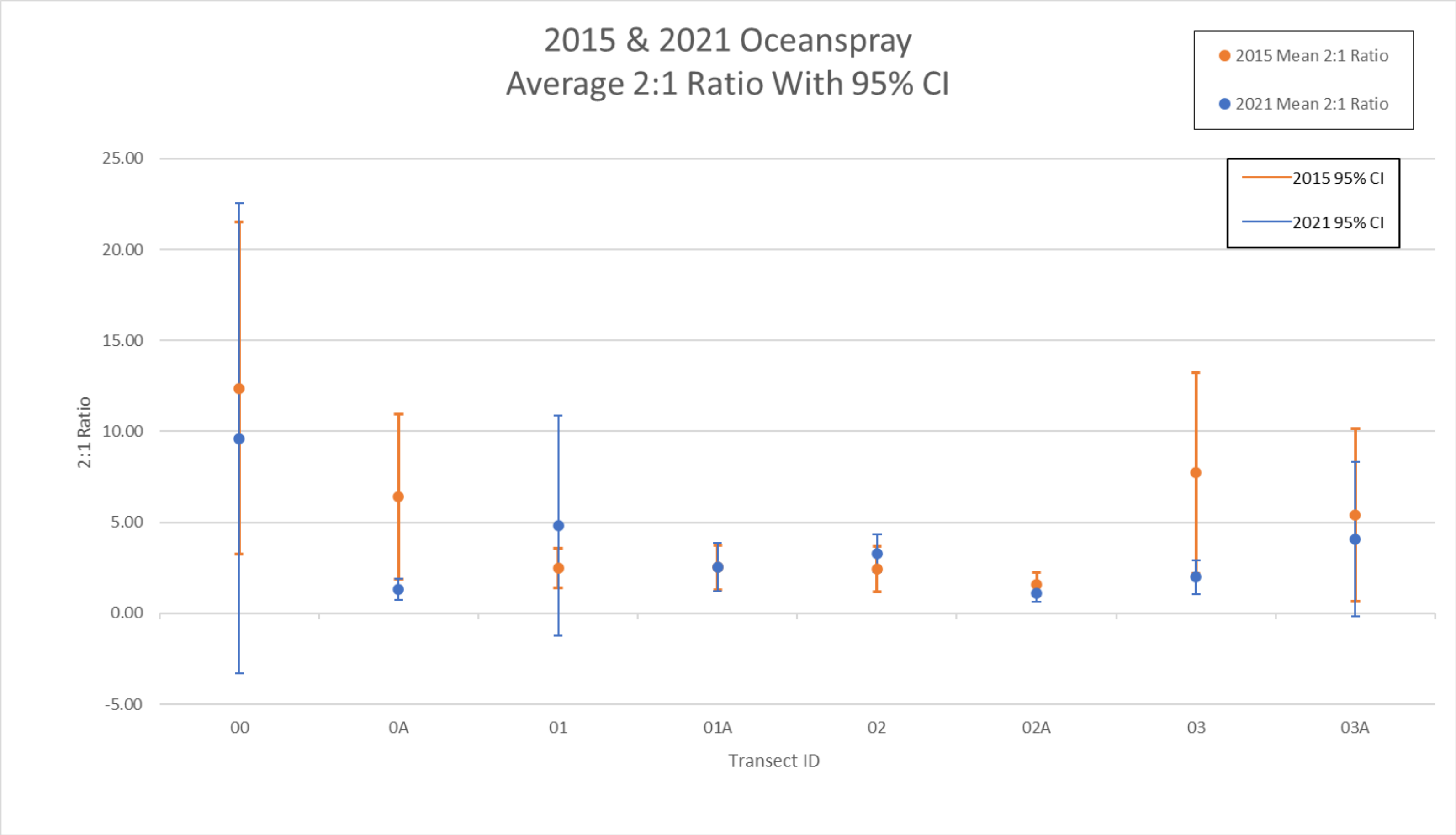


Figure 5: Comparison of mean 2:1 ratio (Note: Points for transect 01A are overlapping)

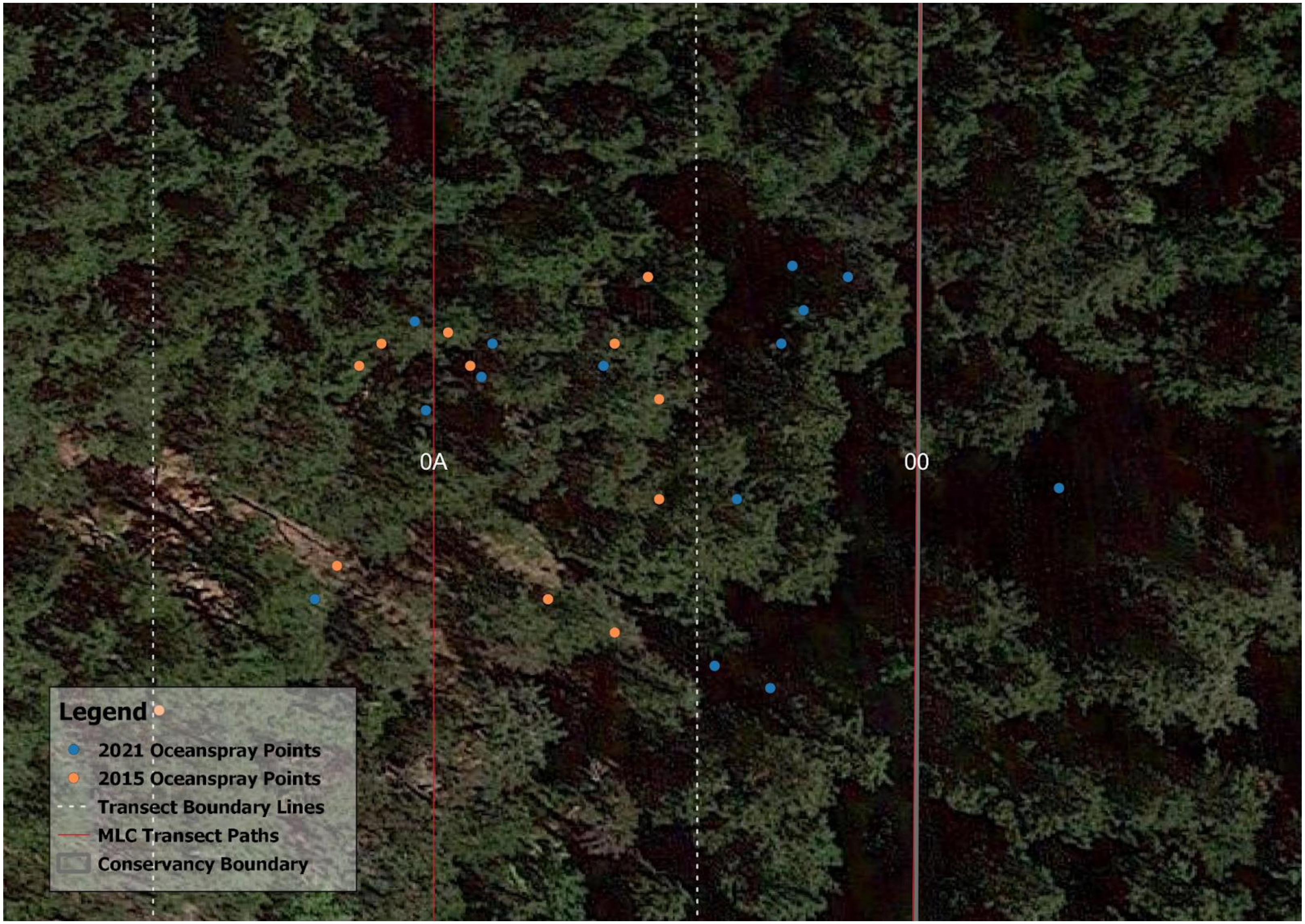


Figure 6: Points along 0A & 00 boundary lines have a similar distribution. There is a possibility that the points represent the same plant over time, but they are categorized under different transects for the data analysis.

Table 2. Percent cover data from the Trimcomalli Bluffs exclosure site, comparing data from 2019/2020 open and exclosure plots.

Trimcomalli Bluffs		**2020 % Cover**		**2019 % Cover**	
		Open	**Exclosure**	**Open**	**Exclosure**
Herbs	*Plantanthera transversa*	1%	0%	0%	0%
	Anisocarpus madioides	0%	3%	0%	0%
	Lysimachia latifolia	0%	15%	0%	0%
	Polystichum munitum	0%	17%	0%	0%
	unk. carrot spp.	0%	0%	1%	1%
	unk. aster spp.	0%	0%	1%	1%
	Trientalis borealis	0%	0%	0%	10%
Shrubs	*Lonicera hispidula*	5%	8%	10%	10%
	Berberis nervosa	10%	15%	12%	15%
	Rosa gymnocarpa	10%	9%	10%	8%
	Gaultheria shallon	20%	10%	15%	6%
	Symphoricarpos albus	0%	2%	0%	1%
	Rubus ursinus	0%	1%	0%	1%
	Berberis aquifolium	0%	0%	0%	1%
Trees	*Arbutus menziesii*	17%	15%	5%	5%
	Pseudotsuga menziesii	25%	20%	50%	43%
	Prunus emarginata	7%	0%	0%	0%
	Thuja plicata	0%	1%	0%	0%
	Salix spp.	0%	0%	6%	0%

Figure 7: Species tables 2-4 by Khan and Howse (2020)

Table 3. Percent cover data from the Millsite exclosure site, comparing data from 2019/2020 open and exclosure plots.

Millsite		2020 % Cover		2019 % Cover	
		Open	Exclosure	Open	Exclosure
Herbs	*Hypochaeris radicata*	5%	5%	0%	0%
	Leucanthemum vulgare	15%	15%	5%	0%
	Lapsana communis	3%	10%	0%	0%
	Cirsium arvense	7%	40%	15%	12%
	Cirsium vulgare	3%	0%	0%	1%
	Ranunculus repens	2%	3%	0%	0%
	Digitalis purpurea/Digitalis spp.	7%	5%	6%	4%
	Vicia sativa	0%	5%	0%	0%
	Nemophila parviflora	0%	3%	0%	0%
	Galium aparine	0%	4%	0%	0%
	Polystichum munitum	0%	0%	0%	4%
	Juncus effusus	0%	0%	15%	12%
	Unk. aster spp.	0%	0%	0%	10%
	Urtica diotica	0%	0%	0%	4%
	Cats tongue	0%	0%	10%	0%
	Trifolium repens	0%	0%	2%	0%
Shrubs	*Rubus spectabilis*	0%	4%	3%	8%
	Symphoricarpos albus	0%	1%	0%	5%
	Polystichum munitum	0%	1%	0%	0%
	Rubus laciniatus	2%	5%	3%	2%
	Rubus vestitus	0%	3%	0%	0%
	Rubus ursinus	1%	8%	2%	8%
	Gaultheria shallon	1%	8%	1%	10%
	Rosa gymnocaropa	1%	0%	0%	0%
	Cystisus scoparius	3%	0%	0%	0%
	Rubus armenicus	0%	0%	0%	1%
	Berberis nervosa	0%	0%	0%	1%
	Cornus stolinifera	0%	0%	0%	3%
Trees	*Abies grandis*	1%	1%	0%	0%
	Alnus rubra	10%	40%	4%	45%
	Thuja plicata	1%	0%	1%	1%
	Acer macrophyllum	0%	5%	0%	3%
	Pseudotsuga menziesii	0%	3%	1%	5%
	Abies amabalis	0%	0%	1%	4%
	Poplus trichocarpa	0%	0%	0%	1%

Figure 7: Continued

Table 4. Percent cover data from the Forage Forest exclosure site, comparing data from 2019/2020 open and exclosure plots.

Forage Forest		**2020 % Cover**		**2019 % Cover**	
		Open	**Exclosure**	**Open**	**Exclosure**
Herbs	*Polystichum munitum*	35%	35%	30%	60%
	Pteridium aquilinum	15%	8%	15%	12%
	Anaphalis margaritacea	1%	2%	0%	0%
	DIgitalis purpurea	2%	1%	0%	0%
	Lonicera hispidula	7%	15%	0%	0%
	Cirsium vulgare	4%	1%	7%	3%
	Achlys triphylla	5%	0%	0%	0%
	Torilis arvensis	1%	0%	0%	0%
	Cirsium arvense	4%	0%	0%	0%
	Hypochaeris radicata	1%	0%	0%	0%
	Trifolium repens	1%	0%	0%	0%
	Mycelis muralis	2%	0%	0%	0%
	Lysimachia latifolia	0%	3%	0%	0%
	Galium aparine	0%	1%	0%	0%
	Clematis ligusticifolia	0%	1%	0%	0%
Shrubs	*Gaultheria shallon*	40%	30%	65%	40%
	Berberis nervosa	20%	0%	3%	0%
	Rubus occidentalis	4%	3%	0%	0%
	Rubus ursinus	0%	20%	20%	35%
	Rubus spectabilis	0%	5%	0%	0%
	Holodiscus discolor	0%	12%	0%	15%
	Prunus emarginata	0%	1%	0%	0%
	Lonicera hispidula	0%	0%	0%	20%
	Rubus leucodermis	0%	0%	0%	5%
Trees	*Thuja plicata*	1%	9%	0%	3%

Figure 7: Continued

9.2: Original 2015 Transect Protocol

Ocean Spray Ratio Sampling Protocol

Ocean Spray, *Holodiscus discolor,* is a common shrub found throughout the Gulf and San Juan archipelago. It is also one of several highly palatable shrubs preferred by Black-tailed deer *Odocoileus hemionus.* Martin et al. (2011) found that the ratio of foliar width at 2:1 m above ground on ocean spray shrubs provide an index of browsing impacts in the Gulf and San Juan Islands; the species becomes umbrella-shaped when browsing limits shoot recruitment. In a follow-up study Arcese et al (2014) further validated the ocean spray ratio (OSR) as a regional indicator of deer density and impact. This protocol is based on a protocol developed for us by Dr. Tara Martin. Tara.Martin@csiro.au

Aim: Determine the browsing pressure experienced by the Galiano Learning Centre.

Sampling:

1. Following North-South transects spaced 50 m apart locate ocean spray individuals or patches. Please strive for a complete audit of all ocean spray plants along your transects within approximately 25 m of your transect line. Please do not sample ocean spray at the bottom of the coast cliff; these will be sampled separately.
2. For each record, characterize the distribution using the numerical value (1-9) in the table below. Please add this code directly to the GPS coordinates, and *precede this with a unique letter code to be provided* (e.g., D3). Record the GPS Northing and Easting coordinates in the data sheet.
3. For every individual or patch (see below for definitions), measure the diameter of the shrub at 1and 2 m above ground level along the stem line (i.e., if the plant is leaning, then measure from the bottom of the stem). These two measurements form the ratio of foliage at 1 versus 2 m in height. Ratios below c 0.3 indicate a strong browsing impact and an umbrella like architecture.
4. For every individual, please also record:
   - Canopy cover O (open), P (partial), F (full)
   - Slope (to the nearest 5 degrees using an compass inclinometer)
   - Aspect (determine azimuth to nearest 1/16 cardinal direction (e.g., NNE).
5. If the sample is a patch, select the northernmost individual in clump for measurement.
6. In cases where shrubs are below 1.5m, measurements of stem density has proven an effective measure of browsing pressure (See Martin et al 2011, Figure 6 pasted below). On each shrub measure the number of stems originating at the base without living foliage ('dead stems'), the number of stems that have been browsed and finally the number of live stems that are between >0 and 0.5 cm in diameter.

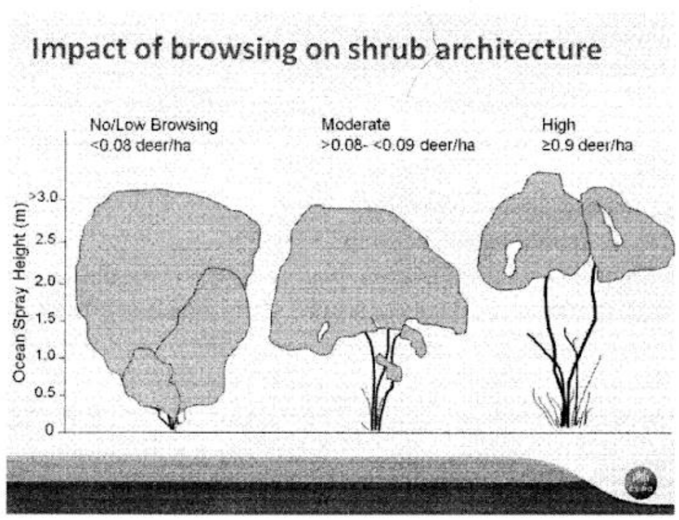
Definitions

Individual. A single plant separated by more than 10 m from its nearest neighbour.

Patch. A group of individuals whose foliage is contiguous or overlaps.

Distribution. This is a 9-class description of spatial arrangement ranging from single individuals to continuous dense patches (see below). "Few" refers for 2-4 individuals; "Several," is more than 5.

Distribution	
Code	**Description**
1	Rare individual, single occurrence
2	A few sporadically occurring individuals
3	A single patch or clump of a species
4	Several sporadically occurring individuals
5	A few patches or clumps of a species
6	Several well-spaced patches or clumps
7	Continuous uniform occurrence of well-spaced individuals
8	Continuous occurrence of a species with a few gaps
9	Continuous dense occurrence of a species



impact of deer browsing (Martin et al 2011)

References

Arcese, P., Schuster, R., Campbell, L., Barber, A., Martin, T.G., 2014. Deer density and plant palatability predict shrub cover, richness, diversity and aboriginal food value in a North American archipelago. Diversity & Distributions 20, 1368–1378.

Martin, T.G., Arcese, P., Scheerder, N., 2011. Browsing down our natural heritage: Deer impacts vegetation structure and songbird assemblages across an island archipelago. Biological Conservation 144, 459-469

Deer Transect Project Report 2015

Daniel Lipp, Martin Faeth, Julia Braun Summer 2015

Overview

The whole oceanspray monitoring is about getting an idea of how dense the deer population at the Learning Center property is. It is also used to show how massive the deer is making an impact on the vegetation.

Material and Methods

The Learning Centre Property was divided into 34 transects each transect with a width of 50 m. Each transect runs from north to south trough the property starting at the east end of the property (just like the human legacy transect project from the UVIC class just with an additional transect between every existing transect). The transects are numbered 0, 0A, 1, 1A...16 and 16A.

Transect Number	Northing	Easting	**Transect Number**	Northing	Easting
00	5419736	465902	**09**	5420191	465005
00A	5419736	465855	**09A**	5420191	464955
01	5419831	465805	**10**	5420191	464906
01A	5419831	465755	**10A**	5420191	464855
02	5419907	465705	**11**	5420192	464805
02A	5419907	465655	**11A**	5420192	464755
03	5419963	465605	**12**	5420194	464706
03A	5419963	465555	**12A**	5420194	464655
04	5420011	465505	**13**	5420194	464605
04A	5420011	465455	**13A**	5420194	464555
05	5420063	465405	**14**	5420195	464505
05A	5420063	465355	**14A**	5420195	464455
06	5420119	465305	**15**	5420192	464409
06A	5420119	465255	**15A**	5420192	464355
07	5420173	465205	**16**	5420197	464305
07A	5420173	465155	**16A**	5420197	464255
08	5420188	465106			
08A	5420188	465055			

Materials: compass, measuring tape, gps unit, worksheet.
Method: start at the north end of the transect and head straight south using a compass. Record every oceanspray within 25 m of the left or right of the transect. Fill out the following categories on the work sheet: Waypoint, Northing, Easting, Canopy (open, closed, partly), Slope, Aspect, Diameter at 1 m, Diameter at 2 m.

The Waypoints describe the plants and are divided into 9 categories:
(1) individual
(2) sporadic individual
(3) patch (touching foliage)
(4) sporadically occurring individual
(5) few patches
(6) several patches
(7) continuous individuals
(8) continuous with gaps
(9) continuous dense
An individual is less than 10 m apart, a patch over 10 m. When measuring a patch or several individuals always measure the most northern plant.

The ratio of the two diameters give us an idea of how big the impact, that the deer is making is, because we know that the deer browsing changes the shape of oceanspray plants from unbrowsed/shrubby to browsed/umbrella-shaped.

Results:

All Oceanspray individuals:
Ratio Average: 4.48 (Ratio: Diameter 2m/Diameter 1m)
Maximum: 57.5
Minimum: 0.00
Median: 2.15

9.3: Deer hunting History in the GCA property:

Date	Hunters	Deer	Location	Notes
12/6/2019	Stephen Sylvester, Janzen Edwards	Buck	Fork in road near office	2 point
12/6/2019	Stephen Sylvester, Janzen Edwards	Buck	Slope above road between parking lot and lower loop	4 point
12/6/2019	Stephen Sylvester, Janzen Edwards	Doe	Fuelwood forest	
12/6/2019	Stephen Sylvester, Janzen Edwards	Doe	Slope above sheep shed	
12/6/2019	Stephen Sylvester, Janzen Edwards	Juvenile	Valley, below pond, above greenhouse	
12/6/2019	Stephen Sylvester, Janzen Edwards	Juvenile	Valley, below pond, above greenhouse	
12/6/2019	Stephen Sylvester, Janzen Edwards	Juvenile	Clearing near water tanks above office	
12/6/2019	Stephen Sylvester, Janzen Edwards	Buck	Clearing above pond, below NFF	2nd year
12/7/2019	Stephen Sylvester, Janzen Edwards	Doe	Clearing above pond, below NFF	
12/7/2019	Stephen Sylvester, Janzen Edwards	Buck	Under the plum tree / orchard area	
1/27/2019	N/A	Juvenile Male	Food Forest	1st year; died from broken neck after trying to escape fenced area
9/26/2020	Stephen Sylvester	Buck	Clearing below NFF	2 point; large animal
9/26/2020	Stephen Sylvester	Buck	Orchard clearing	2 point
9/26/2020	Stephen Sylvester	Doe	south of Greenhouse	
9/27/2020	Stephen Sylvester	Doe	-	

9.4: Compiled Data (available in Excel spreadsheet)

2021 Data Analysis Table

2021 Transect Descriptive Stats					Data points range			
Transect ID	**2:1 Mean**	**2:1 Min**	**2:1 Max**	**2:1 Median**	**Easting max**	**Easting min**	**N Data points**	**Standard Dev.**
0	9.62	1.68	69.00	2.88	465914	465873	10	20.87584883
A	1.31	0.66	2.40	0.81	465875	465856	5	0.666326445
1	4.84	0.29	32.00	0.88	465806	465766	10	9.747836209
1A	2.53	0.29	12.00	1.00	465763	465713	21	3.082734592
2	3.31	0.69	8.40	0.36	465745	465677	19	2.313384086
2A	1.13	0.20	4.63	1.23	465703	465632	15	1.02916703
3	1.99	0.56	4.37	1.57	465611	465543	8	1.342731167
3A	4.08	0.63	10.00	2.84	465573	465494	4	4.316090712
All Transects	3.44	0.20	69.00	1.43	465914	465494	92	7.907366501

2015 Data Analysis Table

2015 Descriptive Stats (2021 Analysis)					Estimated Transect Range			
Transect ID	**2:1 Mean**	**2:1 Min**	**2:1 Max**	**2:1 Median**	**Max**	**Min**	**N Data points**	**Standard Deviation**
00	12.38	3.13	18		465914	465880.98	3	8.07
0A	6.41	1.41	30		465880.98	465832.32	14	8.68
01	2.48	1.41	4.07		465832.32	465781.79	5	1.23
01A	2.52	0.13	8.4		465781.79	465728.99	14	2.35
02	2.44	0.57	10		465728.99	465678.83	14	2.33
02A	1.60	0.26	4.12		465678.83	465630.88	12	1.12
03	7.72	0.64	20		465630.88	465581.49	7	7.43
03A	5.41	0.75	24		465581.49	465533.26	9	7.24
All Equivalent transects	4.24	0.13	30		465914	465533.26	78	5.78

T-Test Table

Transect ID	2015			2021						
	Mean	N	SD	Mean	N	SD	Standard Error	T Stats	P Value	Degrees of Freedom
00	12.38	3.00	8.07	9.62	10.00	20.88	8.080139287	-0.3408427	0.73964302	11.00
0A	6.41	14.00	8.68	1.31	5.00	0.67	2.340072335	-2.176748808	0.04388322	17.00
01	2.48	5.00	1.23	4.84	10.00	9.75	3.131524401	0.752326307	0.46525972	13.00
01A	2.52	14.00	2.35	2.53	21.00	3.08	0.919738656	0.007012409	0.99444717	33.00
02	2.44	14.00	2.33	3.31	19.00	2.31	0.819206214	1.057164068	0.29860569	31.00
02A	1.60	12.00	1.12	1.13	15.00	1.03	0.418504894	-1.129513767	0.26940279	25.00
03	7.72	7.00	7.43	1.99	8.00	1.34	2.848124557	-2.01249576	0.06536004	13.00
03A	5.41	9.00	7.24	4.08	4.00	4.32	3.237780238	-0.412067262	0.68820612	11.00
All Equivalent Transects	4.24	78.00	5.78	3.44	92.00	7.91	1.05	-0.76	0.45	168.00

2021 Transect Record (June 20-28, 2021)

ransect ID	Waypoint ID	Northing	Easting	1m diameter	2m diameter	2:1 ratio	Canopy (open, partial, full [O,P,F])	Slope (nearest 5 degrees)	Aspect	Patch Distribution	Notes	# Dead Shoots	# Browsed Shoots	# Shoots <0.5cm
0	2	5419696	465901	1.9	3.2	1.684	p	20	NEN	1	Leaning over down the slope			
0	7	5419430	465888	1.4	3.94	2.814	p	10	SSS	1				
0	5	5419461	465889	1.46	4.15	2.842	p	10	SSS	2				
0	8	5419448	465914	1.2	3.42	2.850	p	10	SSW	1	Fallen branches with no leaves			
0	4	5419467	465895	1.07	3.06	2.860	p	25	SSS	2	Growing on fallen log			
0	10	5419459	465873	0.8	2.32	2.900	p	0		2				
0	11	5419432	465883	0.79	2.57	3.253	p	25	SSW	1	Rocks covering north side, new shoots appearing			
0	3	5419468	465890	1.25	4.2	3.360	p	30	SSW	2				

0	6	5419464	465891	0.74	3.45	4.662	p	15	SSS	4	Growth started under log			
0	9	5419447	465885	0.03	2.07	69.000	p	15	SSW	1	Very tall, little horizontal spread, 1m measured only stem			
1	112	5419763	465801	2.38	0.68	0.286	p	10	N	2	2 plants clumped			
1	115	5419612	465767	1.54	0.72	0.468	p	90	SW	2	2 plants 7 m apart			
1	111	5419813	465802	1.88	0.89	0.473	p	5	SE	2	3 close together with similar browsing			
1	112	5419800	465806	0.47	0.34	0.723	o	0	SW	1	under 2m, measured at highest point			
1	110	5419823	465777	0.6	0.5	0.833	o	5	S	1				
1	116	5419601	465766	3.34	3.1	0.928	o	35	SW	4	3 plants			
1	117	5419597	465777	1.02	1.97	1.931	p	35	SW	2	leaning over			
1	114	5419759	465781	0.28	1.28	4.571	p	5	NW	2	1 plant outside fence, another inside fence			
1	109	5419825	465795	0.97	5.98	6.165	p	10	SW	5	Part of a patch			
1	118	5419614	465799	0.05	1.6	32.000	F	15	SW	2	1 bigplant, 1 small plant			

2	231	5419496	465680	0.5	4.2	8.400	p	0		2				
2	213	5419874	465724	0.45	3	6.667	p	20	NNE	1	New unbrowsed shoots			
2	217	5419781	465699	0.45	2.9	6.444	p	45	SSE	1				
2	228	5419672	465743	0.25	1.5	6.000	p	40	SSW	3				
2	215	5419862	465687	0.28	1.35	4.821	p	40	S	2	Bushy near the ground			
2	225	5419706	465703	0.75	3.6	4.800	p	85	SSW	3				
2	214	5419864	465698	0.6	2.55	4.250	p	40	S	2	Line of a few oceanspray			
2	226	5419627	465745	0.65	2.4	3.692	p	55	SSW	1				
2	227	5419638	465732	1.67	4.8	2.874	o	60	SSW	2				
2	222	5419744	465690	1.5	3.95	2.633	p	0	NNE	6	Large 10m circular patch of 7+ oceanspray			
2	232	5419474	465696	2	4.1	2.050	p	50	SSE	2	on steep slope			
2	230	5419501	465694	0.9	1.7	1.889	p	20	N	2				

2	218	5419781	465700	1.1	1.75	1.591	p	45	SSE	1	1.8m tall, measured at highest point			
2	220	5419755	465677	3.9	5.7	1.462	o	25	w	8	5 feet tall, seems like popular browsing patch to look out for			
2	224	5419703	465706	2.8	3.8	1.357	p	25	SSW	1				
2	212	5419879	465683	1.5	1.9	1.267	p	8	NNE	1	New shoots appearing			
2	229	5419619	465700	1.1	1.1	1.000	o	0		1	unbrowsed, 1.9m tall			
2	216	5419871	465683	3.65	3.35	0.918	p	0		3	3 individuals			
2	223	5419713	465696	1.75	1.2	0.686	p	30	NNW	6	heavy browsing limiting growth			
2	219	5419772	465720				p	65	SSE	3	Patch of 2 young oceanspray on cliff, less than 1.5m	1	1	4
3	324	5419893	465605	2.4	1.35	0.563	p	15	SE	4				
3	323	5419896	465589	1.1	0.87	0.791	p	5	SE	1				
3	322	5419899	465586	3.02	3.16	1.046	p	5	SE	1				
3	325	5419758	465611	1.72	2.35	1.366	p	20	S	1	2 main stems, not browsed, no dead stems from 0-0.5 cm			

3	327	5419745	465556	1.12	2	1.786	o	5	S	1				
3	328	5419559	465589	0.58	1.57	2.707	f	10	N	1				
3	330	5419543	465543	0.64	2.1	3.281	f	0	N	1				
3	329	5419557	465591	0.52	2.27	4.365	f	10	NE	1				
3	326	5419749	465611	0.9			p	20	S	2				
1A	1A34	5419612	465753	1.7	0.5	0.294	p	60	SW	2				
1A	1A30	5419634	465729	3.2	1.3	0.406	o	85	W	2				
1A	1A31	5419635	465732	1.6	0.7	0.438	o	80	W	2				
1A	1A19	5419778	465713	2.2	1	0.455	p	35	S	2				
1A	1A4	5419823	465763	0.65	0.3	0.462	p	5	SSW	1				
1A	1A29	5419637	465734	4.1	2.6	0.634	o	80	W	2				
1A	1A28	5419649	465728	1.2	1	0.833	p	0		1				

1A	1A24	5419686	465732	1.9	1.6	0.842	p	85	S	1	Steep cliff			
1A	1A3	5419820	465762	0.6	0.6	1.000	o	5	S	1				
1A	1A25	5419672	465752	2	2	1.000	p	60	S	3	Clump of 3 individuals			
1A	1A33	5419618	465755	2	2	1.000	p	60	EW	2				
1A	1A17	5419775	465732	0.5	0.7	1.400	o	35	SW	2				
1A	1A18	5419777	465721	2.8	4.4	1.571	p	35	SSW	2				
1A	1A26	5419666	465748	0.7	2	2.857	p	60	S	1	Umbrella shaped, droopy			
1A	1A32	5419626	465746	0.8	2.4	3.000	p	45	WSW	1				
1A	1A15	5419773	465737	0.9	2.7	3.000	o	20	SSW	1				
1A	1A39	5419468	465738	0.9	2.7	3.000	p	25	NE	2				
1A	1A11	5419795	465733	0.2	0.8	4.000	o	40	S	1				
1A	1A40	5419472	465739	0.6	3.2	5.333	p	25	NE	2				

1A	1A35	5419609	465754	0.4	3.8	9.500	o	60	SW	2				
1A	1A16	5419776	465728	0.1	1.2	12.000	p	25	SSE	2				
1A	1A05	5419813	465734				o	5	N	2		0	0	1
1A	1A06	5419812	465734				p	5	N	2		0	0	6
1A	1A07	5419803	465741				o	15	ESE	2		0	1	4
1A	1A08	5419793	465767				o	5	NNE	1		1	16	4
1A	1A09	5419797	465741				o	15	ESE	2		1	3	4
1A	1A10	5419799	465738				o	5	NE	2		0	2	6
1A	1A12	5419782	465738				f			2	Under solar panels	0	0	4
1A	1A13	5419782	465738				f			2	Under solar panels	0	2	6
1A	1A14	5419782	465738				f			2	Under solar panels	0	2	6
1A	1A21	5419747	465724				o	10	W	2	Inside nursery	0	0	0

1A	1A22	5419746	465722				o	10	W	3	Inside nursery	0	0	0
1A	1A23	5419752	465718				o	10	W	4	Inside nursery	0	0	0
1A	1A27	5419665	465747				f	40	S	3	2 individuals clumped together	0	1	0
1A	1A36	5419599	465749				o	5	SW	1	Caged	0	0	1
1A	1A37	5419597	465728				o	5	SW	1	Caged	0	0	1
1A	1A38	5419547	465742				o	5	S	1		0	6	4
1A	1A41	5419437	465739				p	70	S	1		3	3	0
1A	1A42	5419469	465763				p	10	NE	1		0	1	1
2A	2A31	5419520	465643	0.6	2.78	4.633	p	20	NNW	1	Umbrella shape			
2A	2A29	5419518	465645	0.55	0.9	1.636	p	15	NNW	1	Scraggly, looks dead			
2A	2A25	5419645	465648	2.08	2.55	1.226	o	20	NNW	1	FF			
2A	2A11	5419741	465670	3.5	4	1.143	p	20	ESE	1	Within a salal patch			

2A	2A9	5419778	465660	2.7	3	1.111	o	60	SSW	1				
2A	2A12	5419730	465671	11.9	12.3	1.034	o	20	ESE	9	Forage Forest (F.F.) (Forage Forest is protected from deer)			
2A	2A22	5419642	465703	1.8	1.85	1.028	o	10	SE	1	FF, unbrowsed			
2A	2A8	5419858	465632	3.2	2.6	0.813	o	5	NNE	3		1		
2A	2A15	5419668	465676	1.65	1.3	0.788	o	0		1	F.F.			
2A	2A26	5419633	465640	11.4	8.8	0.772	o	30	NNW	8	FF, long section of 10+ unbrowsed individualas			
2A	2A10	5419754	465675	11.9	9.1	0.765	o	15	SE	9	Uneven ground, difficult terrain			
2A	2A16	5419680	465674	2.55	1.8	0.706	o	0			F.F.			
2A	2A30	5419516	465641	1.32	0.88	0.667	p	15	NNW	1	Mostly dead			
2A	2A27	5419633	465647	1.5	0.6	0.400	o	30	NNW	1	FF, young unbrowsed			
2A	2A28	5419546	465649	4.57	0.92	0.201	p	15	NNW	3	Long, droopy patch of 2			
2A	2A13	5419738	465667	1.46			o	10	ESE	1	Under 2m, every branch browsed, only 1 live branch		All	

2A	2A14	5419674	465683	1			o	0			3 closely spaced (F.F.)			
2A	2A17	5419679	465668	2.85			o	0		1	F.F., below 1.5m			
2A	2A18	5419663	465695	1.9			o	5	SE	1	F.F., flat plant			
2A	2A19	5419662	465702	1.9			o	5	SE	1	F.F., flat plant			
2A	2A20	5419657	465691	1.05			o	5	NE	1	F.F., Juvenile, unbrowsed			
2A	2A21	5419647	465700	1.7			o	10	NE	1	FF, Juvenile unbrowsed			
2A	2A23	5419636	465679	1.85			o	5	ENE	1	FF, Juvenile			
2A	2A24	5419631	465682	0.54			o	10	E	1	FF, Juvenile			
3A	3A48	5419761	465503	3.2	2	0.625	p	35	S	1				
3A	3A45	5419767	465494	2.56	2.9	1.133	p	40	SSE	1				
3A	3A44	5419780	465544	0.55	2.5	4.545	p	60	SSW	1				
3A	3A43	5419880	465573	0.3	3	10.000	p	40	ENE	1				

3A	3A46	5419761	465501				o	40	S	2		0	0	3
3A	3A47	5419764	465500				o	40	S	2		0	0	3
3A	3A49	5419769	465528				p	45	S	1		0	0	1
3A	3A50	5419520	465763				p	25	SSW	1		0	21	0
A	A6	5419455	465857	1.96	4.7	2.398	p	20	S	1	Very umbrella shaped			
A	A3	5419463	465856	2.1	2.84	1.352	p	20	S	3	2 distinct individuals			
A	A5	5419461	465863	3.1	3.85	1.242	p	20	S	1	Long & lateral. Low, unbrowsed live stems			
A	A4	5419458	465862	3.46	3.15	0.910	p	20	S	1	Long, lateral dead stems at 1m height			
A	A1	5419740	465875	3.5	2.3	0.657	f	15	NNE	2	Clump of 4 plants, layers of dead branches give wide bottom and narrow top			
A	A2	5419734	465875				f	15	NNE	2		1	0	0
A	A7	5419438	465847	1.81			o	20	S	1	Top sheared off, on rocky outcrop			

2015 Transect Data Used in 2021 Analysis (Full range of 2015 data available in the complete Excel file)

WAYPOINT	NORTHING	EASTING	CANOPY	SLOPE_IN__	ASPECT	D_1M_IN_M_	D_2M_IN_M	2:1 RATIO	ECO_COMM		2021 Transect ID
D1	5419808	465497	C	90	SSW	1.30	3.00	2.31	Mature Forest - Zonal		3A
D5	5419942	465499	P	20	SSE	1.50	1.30	0.87	Mature Forest - Ridge		3A
D5	5419939	465499	P	60	SSE	1.25	2.90	2.32	Mature Forest - Ridge		3A
D2	5419765	465504	P	40	SSW	1.00	4.00	4.00	Recently Harvested - Zonal		3A
D1	5419988	465504	C	50	NNE	0.30	1.60	5.33	Mature Forest - Zonal		3A
D2	5419775	465504	P	50	WSW	0.60	4.00	6.67	Recently Harvested - Zonal		3A
D2	5419774	465507	O	30	WSW	0.05	1.20	24.00	Recently Harvested - Zonal		3A
D2	5419770	465511	O	70	WSW	2.00	1.50	0.75	Recently Harvested - Zonal		3A
D1	5419781	465544	O	70	S	1.60	3.90	2.44	Mature Forest - Zonal		3A
D2	5419551	465583	C	20	N	0.30	4.80	16.00	Mature Forest - Zonal		3
D1	5419891	465587	O	20	S	2.50	1.60	0.64	Graminoid Zonal		3

D1	5419553	465588	C	20	E	0.40	1.90	4.75	Mature Forest - Zonal		3
D1	5419540	465599	C	30	N	0.40	1.90	4.75	Mature Forest - Zonal		3
D3	5419748	465611	P	35	SSW	1.50	1.73	1.15	Recently Harvested - Zonal		3
D1	5419564	465613	C	30	NNE	0.40	2.70	6.75	Mature Forest - Zonal		3
D1	5419851	465615	O	16	WSW	0.20	4.00	20.00	Coordinates wrong		3
D4	5419515	465640	P	10	NNE	2.60	4.00	1.54	Mature Forest - Zonal		2A
D1	5419557	465644	P	15	N	0.34	1.40	4.12	Coordinates wrong		2A
D4	5419518	465645	P	10	NNE	3.30	2.50	0.76	Mature Forest - Zonal		2A
D4	5419514	465646	P	10	NNE	2.60	2.20	0.85	Mature Forest - Zonal		2A
D4	5419516	465650	P	10	NNE	2.50	2.20	0.88	Mature Forest - Zonal		2A
D4	5419513	465651	P	10	NNE	0.05	0.10	2.00	Mature Forest - Zonal		2A
D4	5419518	465653	P	10	NNE	4.12	4.00	0.97	Mature Forest - Zonal		2A
D1	5419543	465657	P	10	N	2.00	3.05	1.53	Mature Forest - Zonal		2A

D1	5419777	465673	O	45	S	1.90	0.50	0.26	Recently Harvested - Zonal		2A
D5	5419742	465674	O	15	WSW	2.80	3.60	1.29	Graminoid Zonal		2A
D5	5419748	465674	O	25	SW	3.00	4.87	1.62	Graminoid Zonal		2A
D2	5419873	465674	P	30	SSW	0.90	3.05	3.39	Mature Forest - Ridge		2A
D2	5419870	465679	P	30	SSW	1.20	2.50	2.08	Mature Forest - Ridge		2
D2	5419873	465680	C	10	SSW	1.00	2.90	2.90	Mature Forest - Ridge		2
D5	5419732	465680	O	10	SW	0.10	1.00	10.00	Graminoid Zonal		2
D4	5419739	465685	O	30	WSW	2.85	3.50	1.23	Graminoid Zonal		2
D3	5419684	465689	P	50	SSW	1.30	3.50	2.69	Graminoid Zonal		2
D3	5419741	465693	P	15	SW	1.00	1.50	1.50	Graminoid Zonal		2
D3	5419729	465695	P	40	WSW	0.30	0.40	1.33	Graminoid Zonal		2
D2	5419783	465698	P	35	SSE	2.20	2.20	1.00	Mature Forest - Zonal		2
D1	5419862	465699	P	25	SSW	0.60	1.90	3.17	Graminoid Zonal		2

D2	5719782	465702	P	30	S	0.40	1.20	3.00	Coordinates wrong		2
D1	5419642	465706	O	5	W	4.00	3.00	0.75	Graminoid Zonal		2
D2	5419717	465707	P	20	SSW	1.30	2.45	1.88	Graminoid Zonal		2
D2	5419779	465717	P	25	S	2.20	4.50	2.05	Mature Forest - Zonal		2
D2	5419775	465724	P	40	SSW	4.80	2.75	0.57	Industrial Mill Site		2
D1	5419468	465736	P	30	N	0.65	1.72	2.65	Mature Forest - Ridge		1A
D2	5419773	465737	O	30	SSW	1.00	2.20	2.20	Industrial Mill Site		1A
D2	5419773	465739	O	15	SSW	0.30	1.20	4.00	Industrial Mill Site		1A
D3	5419675	465744	C	40	SSE	1.30	0.50	0.38	Graminoid Zonal		1A
D1	5419628	465747	P	50	SSE	2.00	3.05	1.53	Graminoid Zonal		1A
D8	5419669	465748	P	50	SSE	1.50	0.20	0.13	Graminoid Zonal		1A
D8	5419661	465748	P	20	SSE	1.50	2.00	1.33	Graminoid Zonal		1A
D8	5419663	465749	C	30	SSE	1.80	2.00	1.11	Graminoid Zonal		1A

D4	5419611	465755	O	30	SSE	0.40	1.90	4.75	Graminoid Zonal		1A
D4	5419612	465756	C	30	SSE	0.25	0.60	2.40	Graminoid Zonal		1A
D1	5419634	465756	P	0	SSE	0.55	2.88	5.24	Graminoid Zonal		1A
D4	5419617	465761	C	40	SE	2.47	1.78	0.72	Graminoid Zonal		1A
D4	5419620	465766	O	30	SSE	0.25	2.10	8.40	Graminoid Zonal		1A
D3	5419612	465774	O	20	SSE	4.16	1.75	0.42	Graminoid Zonal		1A
D2	5419618	465789	C	35	SSW	0.30	1.22	4.07	Graminoid Zonal		1
D1	5419619	465793	C	35	SSW	0.30	0.75	2.50	Mature Forest - Zonal		1
D2	5419773	465805	O	20	NNE	0.30	0.75	2.50	Industrial Mill Site		1
D4	5419581	465822	C	60	SW	0.55	1.50	2.73	Mature Forest - Zonal		1
D1	5419560	465832	P	38	WSW	1.80	1.10	0.61	Mature Forest - Zonal		1
D1	5419428	465833	P	44	SSW	0.75	3.75	5.00	Old-Growth Forest - Dry		A
D2	5419578	465836	C	40	SSW	0.30	2.70	9.00	Mature Forest - Zonal		A

D2	5419563	465838	P	52	WSW	0.48	1.70	3.54	Mature Forest - Zonal		A
D2	5419441	465849	P	42	SSW	0.05	1.50	30.00	Old-Growth Forest - Dry		A
D4	5419459	465851	P	30	SSE	1.70	2.60	1.53	Old-Growth Forest - Dry		A
D4	5419461	465853	P	5	S	1.00	3.10	3.10	Old-Growth Forest - Dry		A
D4	5419462	465859	C	10	SSE	1.00	4.20	4.20	Mature Forest - Zonal		A
D3	5419459	465861	C	10	S	0.70	1.20	1.71	Mature Forest - Zonal		A
D1	5419438	465868	P	10	SSW	1.30	2.10	1.62	Old-Growth Forest - Seepage		A
D4	5419461	465874	C	25	S	2.55	3.60	1.41	Mature Forest - Zonal		A
D1	5419435	465874	P	44	SSW	1.10	3.10	2.82	Old-Growth Forest - Seepage		A
D5	5419467	465877	P	15	SSW	2.00	3.00	1.50	Mature Forest - Zonal		A
D5	5419447	465878	P	60	SSW	1.20	2.70	2.25	Mature Forest - Zonal		A
D5	5419456	465878	P	36	SSW	0.05	1.10	22.00	Mature Forest - Zonal		A
D1	5419659	465886	P	50	ENE	0.10	1.80	18.00	Graminoid Zonal		0

D1	5419523	465893	C	50	SSW	0.05	0.80	16.00	Mature Forest - Zonal		0
D1	5419686	465898	P	35	NNE	0.80	2.50	3.13	Graminoid Zonal		0