

Vole-halla: Effects of Townsend's Vole (*Microtus townsendii*) Herbivory on Newly Establishing Shrubs and Trees in a Restored Wetland on Galiano Island, BC

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Territory Acknowledgment

This project was conducted on the shared, asserted, unceded, and traditional territories of the Hul'qumi'num-speaking First Nations Peoples, including the Penelakut, Hwlitsum, and Tsawwassen First Nations, and those who hold traditional rights, responsibilities, and Indigenous rights and title in and around what is now known as Galiano Island (Galiano Conservancy Association, n.d.). We acknowledge and respect the longstanding relationships that Indigenous Peoples have with these lands and waters and recognize their ongoing stewardship of the ecosystems that continue to shape restoration efforts today. We are grateful for the opportunity to learn from and conduct this work on these lands, and we recognize that ecological restoration is strengthened through respect for Indigenous knowledge, relationships, and stewardship.

Acknowledgments

We would like to thank the Galiano Conservancy Association (GCA) for their support throughout this project. In particular, we thank Adam Huggins for sharing his knowledge of the site, providing guidance throughout our work, and teaching us how to use the GCA plant database and mapping tools that made our field surveys possible. We are especially grateful to Eric Higgs for his continued guidance, encouragement, and thoughtful feedback throughout the field school and the development of this project. We would also like to thank Meghan Hamp for her assistance with the statistical analysis and Alia Johnson for helping us navigate the transition into this project. We are grateful to everyone who contributed along the way and helped make both this project and our field school experience possible.

Summary

Townsend's vole (*Microtus townsendii*) have become well established within the restored wetlands at the Millard Learning Centre on Galiano Island, British Columbia, and have been observed girdling newly planted trees and shrubs. Although Townsend's voles are a native and ecologically important component of wetland ecosystems, their herbivory has raised concerns about the survival of restoration plantings and the success of their long-term establishment. This project focused on the survival of plants following vole damage, differences in herbivory and survival among plant species and the use of aluminum foil stem protection by the Galiano Conservancy Association (GCA).

Two field surveys were completed in July 2026 using the GCA's ArcGIS Field Maps plant database. The first survey revisited plants previously identified as vole damaged and given aluminum foil stem protection, while the second assessed planted trees and shrubs within a selected area of the restoration site that had not received stem protection. In the vole-damaged plant survey, 85.45% of girdled plants survived. In the broad-scale survey, 48 of the 69 plants assessed showed evidence of girdling by vole herbivory, with partial girdling occurring more often than full girdling, and 95.83% of girdled plants survived. Most of the damaged plants assessed were still alive, although some plants that had previously died were not included in the survey. There was no significant difference ($p = 0.0679$) in plant survival between plants that received the aluminum foil treatment and plants that did not, however the foil did appear to prevent further herbivory after the initial girdling. Overall, the findings show the importance of continued monitoring to better understand plant survival following vole damage and help guide future management of restoration plantings.

Introduction and Background

The establishment of native trees and shrubs is an important part of many ecological restoration projects because they provide wildlife habitat, improve biodiversity, stabilize soils, and contribute to long-term ecosystem function. However, the success of restoration plantings depends not only on planting native species but also on ensuring those plants are able to survive and become established. Many factors can influence planting success, including environmental conditions, competition with invasive species, and herbivory by wildlife. Herbivory is often associated with larger mammals such as deer, but smaller mammals can also have significant impacts on restoration plantings. The Townsend's vole (*Microtus townsendii*) is a native rodent found throughout southwestern British Columbia and Vancouver Island, with an overall range limited to the western coast of North America extending from Six Rivers National Forest in northwest California up to Strathcona Provincial Park in British Columbia (Fletcher, 2019). Townsend's voles are found in a wide variety of open habitats, including wetlands, marshes, moist meadows, grasslands, and riparian areas (B.C. Conservation Data Centre, 2024). They construct shallow burrow systems and runways through dense vegetation and are commonly associated with areas that provide abundant ground cover and moist soils (NatureServe Explorer, n.d.).

Townsend's voles are primarily herbivores and granivores. Their diet consists mainly of grasses and other herbaceous plants throughout the year, while seeds, bulbs, tubers, and roots become more important during the late summer and fall (Animal Diversity Web, 2019). They also play several important ecological roles within these ecosystems. Their burrowing helps aerate the soil, they contribute to seed dispersal, and they serve as an important food source for numerous predators, including owls and hawks (Animal Diversity Web, 2019; Stream Team, 2016). Although Townsend's voles contribute positively to ecosystem function, high population densities can create challenges for restoration projects. In addition to feeding on grasses and herbaceous vegetation, voles may feed on the bark, cambium, roots, and stems of young trees and shrubs. This feeding can girdle plants by removing the tissue responsible for transporting water and nutrients, often resulting

in reduced growth or mortality. Previous research in British Columbia documented bark and cambium damage to Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and, less frequently, western white pine (*Pinus monticola*), particularly in younger forest stands where vegetation provided suitable cover for voles (Sullivan & Sullivan, 1987). These findings demonstrate that vole herbivory can have substantial impacts on young woody vegetation and highlight the need for further research into how herbivory may influence the success of ecological restoration plantings.

Restoration sites may unintentionally provide favourable habitat for Townsend's voles. Excluding deer from restoration areas often allows grasses and herbaceous vegetation to grow taller and denser, increasing protection from predators while providing abundant food resources. As vole populations increase, herbivory on newly planted trees and shrubs may also increase, potentially reducing the success of restoration efforts (Mayne Island Conservancy, 2024). Within the restored wetlands at the Millard Learning Centre, staff at the GCA have observed extensive herbivory by Townsend's voles on newly planted native trees and shrubs. In response, the GCA began testing methods to prevent further damage from this herbivory. While these protection methods show promise, questions remain about their effectiveness, the survival of plants that have already experienced vole damage, and whether certain native tree and shrub species are more susceptible to herbivory than others. Considerable time, labour, and resources go into propagating or sourcing native plants and establishing them within a restoration site. Losing a significant number of these plantings to vole herbivory can therefore represent both a setback to restoration efforts and a loss of resources invested throughout the restoration process. Understanding patterns of herbivory and plant mortality is important in guiding future restoration planning to improve survival rates of planted trees and shrubs, increase capacity within the conservancy by preventing significant loss of resources, and increasing the long-term success of native vegetation establishment.

Goals and Objectives

The purpose of this project is to evaluate the impacts of Townsend's vole herbivory on native tree and shrub plantings within the Millard Learning Centre wetland restoration site. Specifically, this project assessed the survival and condition of previously damaged plants, evaluated the effectiveness of existing vole protection methods, and compared patterns of herbivory among different native tree and shrub species. By documenting these patterns, this project aimed to identify species that appeared more resistant or resilient to vole damage and provide recommendations to support future restoration management. The overall goal of this project was to evaluate the effects of Townsend's vole herbivory on native tree and shrub plantings. To achieve this goal, the project addressed the following objectives:

1. Assess the extent and outcomes of Townsend's vole herbivory by documenting the frequency and severity of damage to native tree and shrub plantings and evaluating the survival and condition of previously damaged plants.
2. Compare species-specific responses to Townsend's vole herbivory by assessing damage and subsequent plant survival across different native tree and shrub species.
3. Examine the effectiveness of tin foil stem protection by comparing herbivory damage and plant condition of protected and unprotected plants.
4. Develop recommendations for future management based on observed patterns, plant survival, species responses, and protection effectiveness.

Site Description

This project took place in a 1.06 ha fenced wetland restoration area owned and managed by the GCA within the Chrystal Creek watershed on Galiano Island, British Columbia (Figure 1). The restoration area is enclosed by a perimeter fence that excludes deer, reducing browsing pressure on newly established vegetation (Galiano Conservancy Association, n.d.). Prior to restoration, the Chrystal Creek watershed experienced more than a century of agricultural use, logging, and other land alterations. Wetlands were drained through an extensive network of ditches, native vegetation was cleared, and much of the landscape became dominated by introduced pasture grasses and invasive plant species. These changes altered natural hydrological processes, contributing to erosion, seasonal flooding, and the loss of native wetland habitat (Galiano Conservancy Association, n.d.). Since acquiring the property in 2012, the GCA has worked to restore natural hydrology and re-establish native wetland and forest ecosystems throughout the watershed.



Figure 1. Map of the study area within the Chrystal Creek watershed on Galiano Island, British Columbia. The white outline delineates the 1.06 ha fenced wetland restoration site within which native tree and shrub plantings were assessed for Townsend's vole (*Microtus townsendii*) herbivory

in two field surveys. The yellow smiley face indicates the location of the Millard Learning Centre classroom building. Map retrieved from Galiano Conservancy Association ArcGIS FieldMaps data on July 10, 2026.

The study area (Figure 1) consists of an open wetland restoration site with a mixture of native trees, shrubs, grasses, and other wetland vegetation. The landscape is uneven and characterized by numerous shallow depressions and small ponds that hold standing water during months of the year with higher levels of precipitation. Stands of large Douglas-fir (*Pseudotsuga menziesii*) and Western redcedar (*Thuja plicata*) trees were present around the perimeter of the restoration area, while the interior remained relatively open with recently established vegetation. The exclusion of deer has allowed grasses and other herbaceous vegetation to grow tall and dense throughout much of the restoration area. While this supports the establishment of native vegetation, it also creates favourable habitat for Townsend's voles by providing abundant ground cover from predators and a readily available food source. These conditions make the restoration site well suited for evaluating the effects of vole herbivory on restoration plantings.

Methods

Preliminary Research

We began by conducting preliminary research on the ecology, life history and habitat requirements of Townsend's voles to understand factors that may have driven the observed increase in damage from vole herbivory to young trees and shrubs. We also spoke with Adam Huggins, the Restoration Coordinator for the Galiano Conservancy Association, about observed patterns of vole activity and concerns the Conservancy has about the girdling of newly established plants by the Townsend's vole. We discussed recently trialled vole-prevention methods involving the placement of tin foil (aluminum foil) around the bases of stems of newly establishing plants showing signs of

Townsend's vole herbivory (girdled stem, bite marks) (Adam Huggins, Personal Communications, July 2026).

Field Surveys

Two field surveys were completed in July 2026 using the Galiano Conservancy Association's plant database in ArcGIS Field Maps. Individual restoration plantings were mapped as point features within the database, allowing previously monitored plants to be relocated in the field. Survey information was recorded directly into ArcGIS Field Maps during fieldwork to maintain consistency with the GCA restoration monitoring database. The surveys were designed to assess both the condition of plants previously known to have experienced vole herbivory and the broader occurrence of herbivory among restoration plantings. For a full list of plants surveyed, their scientific names and their Hul'qumi'num names, refer to Appendix A. For a breakdown of attributes noted during individual field assessments, see Table B1 in Appendix B.

The initial survey examined plants that had been previously identified by the GCA with vole damage, focusing on approximately forty native trees and shrubs that had previously been identified by the GCA as exhibiting Townsend's vole herbivory. These plants were revisited to determine whether they had survived following herbivory, or had died. During each assessment, plants were examined for evidence of previous and ongoing vole damage, and the condition of any aluminum foil stem protection was also recorded. Health status of each individual plant was recorded on a five-point scale (Table B2). These observations allowed previously damaged plants to be compared with earlier monitoring records and provided information on plant survival following herbivory.

A second broad-scale survey was conducted within a selected polygon (Figure 2) located near the centre of the fenced restoration area. The selected polygon was chosen for its high density and species diversity of plants that had not been surveyed since 2024, therefore had no previously noted vole damage. Unlike the targeted survey, this assessment included all planted trees and shrubs within the selected polygon that had not yet been surveyed for herbivory damage. This broader

survey provided a more representative assessment of herbivory throughout the restoration site and allowed comparisons among species, damage severity, and the occurrence of herbivory on protected and unprotected plants. For each individual assessment, information on the health status of the individual was recorded on a five-point scale (Table B2), and evidence of vole damage was noted.

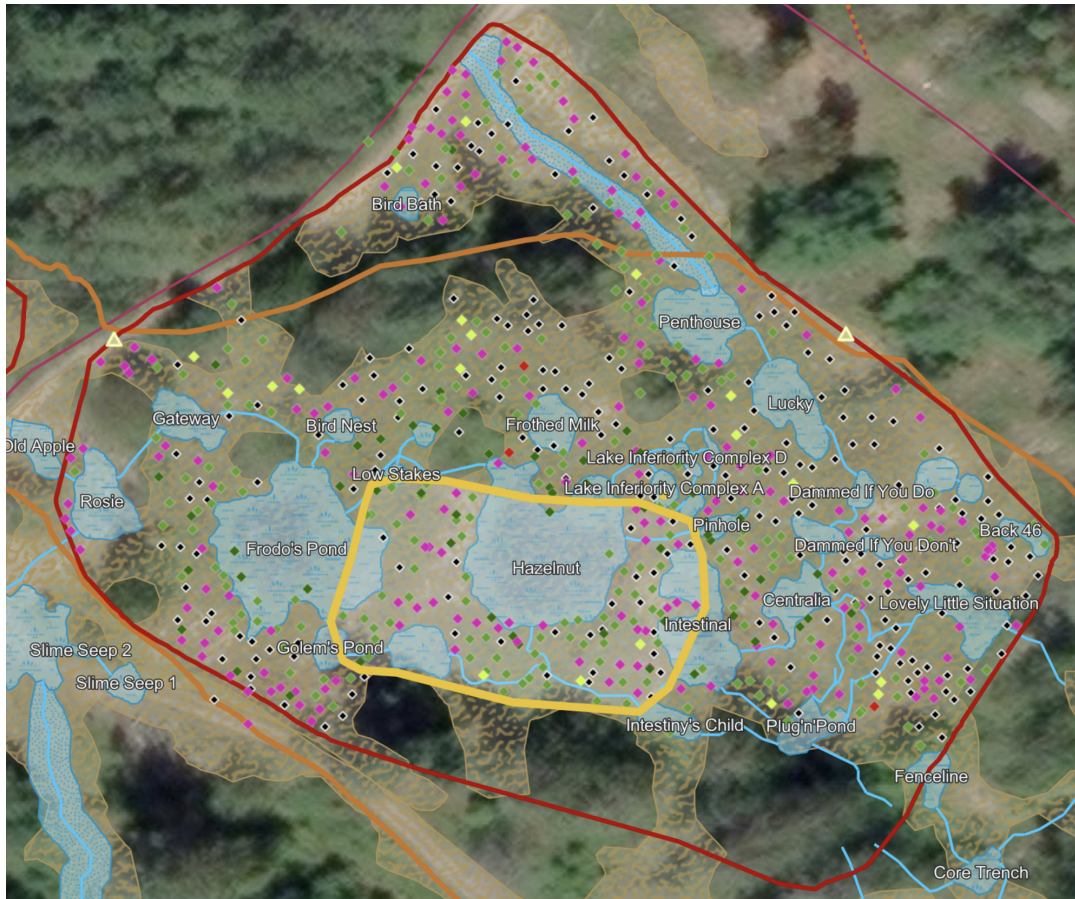


Figure 2. Map of the fenced wetland restoration area at the Millard Learning Centre. The red polygon outlines the 1.06 ha fenced restoration site in which an initial survey of previously identified vole-damaged plant individuals was conducted, while the yellow polygon indicates the selected polygon area of the broad-scale survey of native tree and shrub plantings. Map retrieved from Galiano Conservancy Association ArcGIS FieldMaps data on July 10, 2026.

Data Analysis

To assess the difference in survival rate in plant individuals with the aluminum foil treatment around the base of the stem and individuals without the treatment across both surveys, a two-sample t-test (Welch's t-test) was performed on the mean survival rates of plants with and without the aluminum foil treatment.

Results

A total of 126 native tree and shrub plantings were assessed during two field surveys examining evidence of Townsend's vole herbivory within the fenced wetland restoration area (see species table in Appendix A). The targeted vole-damaged plant survey revisited 55 plants previously identified as vole-damaged ("girdled"), while the broad-scale survey assessed 69 native tree and shrub plantings within a selected area of the restoration site (Figure 2). The results presented below describe the plants assessed during the 2026 field surveys and do not include previously recorded plants that were no longer present or were not revisited at the time of the surveys.

Percentage of survival of plants from both surveys, with and without aluminum foil stem treatment were compared (Figure 3). Of the vole-damaged plants that received the aluminum foil stem treatment ($n = 55$), 85.45% were alive at the time of survey, and 14.55% were dead. Of the plants that did not receive the aluminum foil treatment, 95.83% were alive following vole herbivory, and 4.17% were dead.

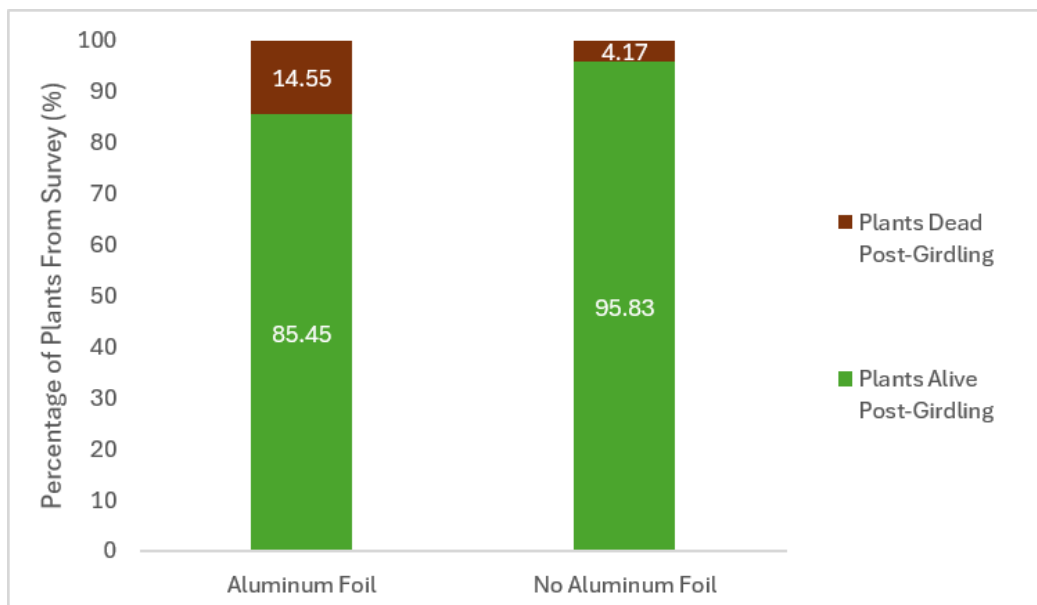


Figure 3. Comparison of survival percentages of plant individuals with observed signs of Townsend's vole herbivory with ($n = 55$) and without ($n = 48$) aluminum foil stem treatment.

Percentage of individuals alive following vole herbivory (“girdling”) is shown in green, and percentage of individuals dead following vole herbivory is shown in brown.

A two-sample t-test was performed to compare percent survival in plants that received the aluminum foil treatment and plants that did not receive the treatment. There was not a significant difference ($p < 0.05$) in percent survival between plants with the aluminum foil treatment ($M = 0.8545$, $SD = 0.3558$) and plants without the aluminum foil treatment ($M = 0.9583$, $SD = 0.2019$); $t(87.5201) = 1.8488$, $p = 0.0679$.

Vole-Damaged Plant Survey Results

A total of fifty-five plants previously identified as vole-damaged ($n = 53$) or identified as potentially at risk of vole damage ($n = 2$) were revisited during the vole-damaged plant survey. A majority of these plants (excluding hardhack shrubs, $n = 2$) had aluminum foil wrapped around the base of the stem. The species composition of plants identified as vole-damaged and revisited in this survey (Table 1) was varied, with red alder being the most abundant at 21 individuals (38.18% of total), followed by red osier dogwood with 6 individuals (10.91%) and Western redcedar with 5 individuals (9.09%). Cascara, Pacific crabapple, Pacific dogwood, and Pacific ninebark were the least abundant with 1 individual (1.82%) each (Table 1). See Figure 4 for a visual representation of percent species composition.

Table 1. Numbers (n) of individuals of each species surveyed in the targeted vole-damaged plant survey and proportion of each species represented in the total population surveyed.

Species	n (Number Surveyed)	Species proportion of total population surveyed (%)
Red Alder (<i>Alnus rubra</i>)	21	38.18
Red Osier Dogwood (<i>Cornus stolonifera sericea</i>)	6	10.91
Western Redcedar (<i>Thuja plicata</i>)	5	9.09
Black Cottonwood (<i>Populus balsamifera trichocarpa</i>)	4	7.27

Black Hawthorn (<i>Crataegus douglasii</i>)	4	7.27
Scoulers Willow (<i>Salix scouleriana</i>)	3	5.45
Bigleaf Maple (<i>Acer macrophyllum</i>)	2	3.64
Hardhack (<i>Spiraea douglasii</i>)	2	3.64
Pacific Willow (<i>Salix lucida</i>)	2	3.64
Red-Flowering Currant (<i>Ribes sanguineum</i>)	2	3.64
Cascara (<i>Rhamnus purshiana</i>)	1	1.82
Pacific Crab Apple (<i>Malus fusca</i>)	1	1.82
Pacific Dogwood (<i>Cornus Nuttallii</i>)	1	1.82
Pacific Ninebark (<i>Physocarpus capitatus</i>)	1	1.82

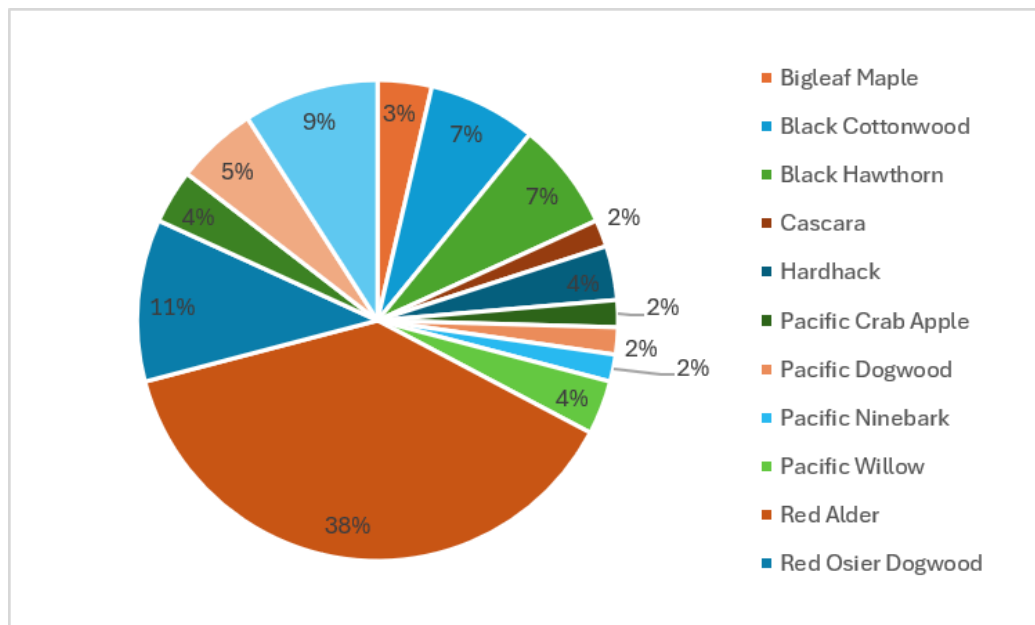


Figure 4. Percent species composition represented in the vole-damaged plant survey (n = 55).

Of the surveyed vole-damaged plants, Pacific willow had the highest percentage of plants found dead post-girdling at 100% mortality, followed by black cottonwood at 75%, Scouler's willow at 33.33%, and Western redcedar at 20% (Figure 5). Bigleaf maple, black hawthorn, cascara, hardhack, Pacific crabapple, Pacific dogwood, Pacific ninebark, red osier dogwood, and red-flowering currant all displayed the highest percent survival at 100% (Figure 5).

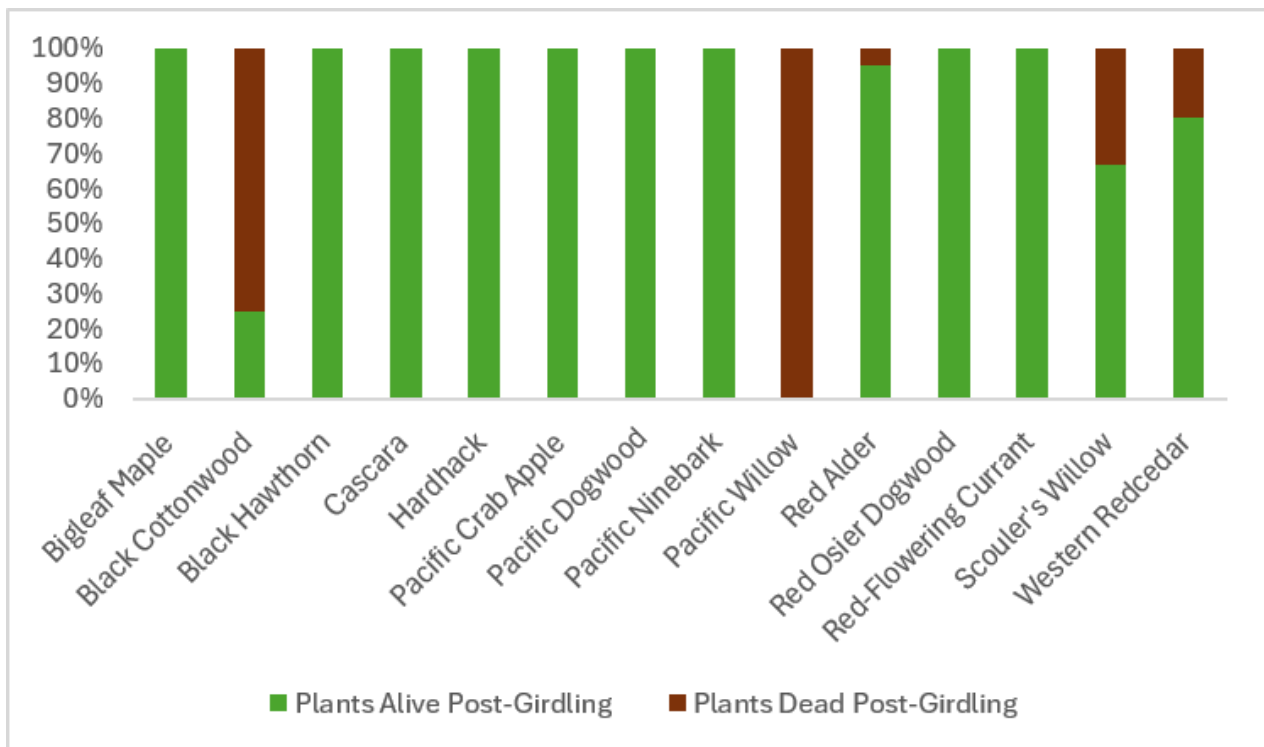


Figure 5. Percentage of plant individuals with observed signs of herbivory (“girdling”) from the vole-damaged plant survey (n = 55) which remained alive after girdling by Townsend’s voles (green) and which were observed to have died after girdling (brown).

Of the species surveyed, hardhack was found to have the highest average health status at 5.00, followed by red-flowering currant at 4.50, and Pacific crab apple, Pacific dogwood, and Pacific ninebark at 4.00 (Figure 6). The species determined to have the lowest recorded average health status was Pacific willow at 0.00, followed by black cottonwood at 0.50 and cascara at 1.00 (Figure 6).

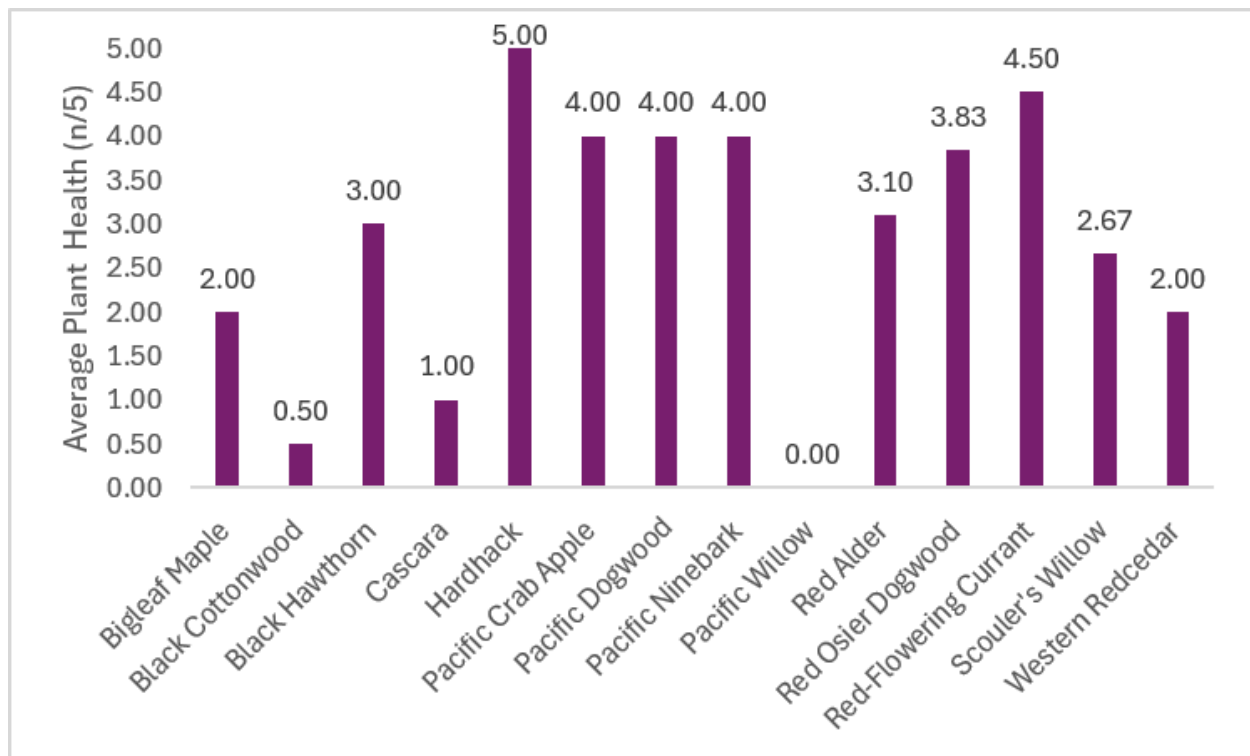


Figure 6. Average health status of plant species surveyed in the vole-damaged plant survey (n = 55). Health status was based on a 5 point scale (see Table B2 in Appendix B) and averaged across all individuals recorded for each plant species.

Out of the total 55 plants assessed, 20 plant individuals were recorded to have insects present under the aluminum foil stem protection (Table 2). Red alder had the highest number of individuals with insect infestations under the foil (7 individuals), followed by red osier dogwood with 4 individuals, and black cottonwood and black hawthorn each with 2 individuals (Table 2).

Table 2. Number of individuals of each species surveyed in the vole-damaged plant survey with observed insects and detritivores present under aluminum foil stem protection.

Species	Number Surveyed	Number of Individuals with Insects Under Foil
Bigleaf Maple	2	1
Black Cottonwood	4	2
Black Hawthorn	4	2
Cascara	1	1
Hardhack	2	0
Pacific Crab Apple	1	1
Pacific Dogwood	1	0

Pacific Ninebark	1	0
Pacific Willow	2	0
Red Alder	21	7
Red Osier Dogwood	6	4
Red-Flowering Currant	2	0
Scouler's Willow	3	1
Western Redcedar	5	1
Total:	55	20

Broad-Scale Plant Survey Results

A total of 69 plant individuals were assessed in the selected target study area of the broad-scale plant survey (Table 3). Of those 69 individuals, 48 were found to be girdled by voles, and 6 individuals were found dead with 2 deaths attributed to Townsend's vole herbivory (Table 3). Of the 14 species observed, 3 did not have any individuals with observed evidence of vole herbivory: cascara, Nootka rose, and Pacific crabapple (Table 3)

Table 3. Number of individuals surveyed, number of individuals girdled, number of individuals dead at the time of survey, and number of those deaths that can be attributed to herbivory, for each species of the total plant individuals surveyed in the broad-scale plant survey (n = 69).

Species	n (Number Surveyed)	Number of Individuals Girdled	Number of Individuals Dead at Time of Survey	Number of Individual Deaths Attributed to Herbivory
Bigleaf Maple (<i>Acer macrophyllum</i>)	1	1	0	0
Black Cottonwood (<i>Populus balsamifera trichocarpa</i>)	4	3	1	1
Black Hawthorn (<i>Crataegus douglasii</i>)	8	6	1	0
Cascara (<i>Rhamnus purshiana</i>)	1	0	0	0
Douglas Maple (<i>Acer glabrum</i>)	4	3	1	0
Hardhack (<i>Spiraea douglasii</i>)	6	6	0	0
Highbush Cranberry (<i>Viburnum edule</i>)	3	3	0	0
Nootka Rose (<i>Rosa nutkana</i>)	3	0	0	0
Pacific Crab Apple (<i>Malus fusca</i>)	1	0	0	0
Pacific Willow (<i>Salix lucida</i>)	2	1	1	0
Red Alder (<i>Alnus rubra</i>)	23	17	2	1
Red Osier Dogwood (<i>Cornus stolonifera sericea</i>)	10	5	0	0
Salmonberry (<i>Rubus spectabilis</i>)	1	1	0	0
Western Redcedar (<i>Thuja plicata</i>)	1	1	0	0

Total:	69	48	6	2
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Of the plant individuals with observed vole damage, 46 were found alive and 2 were dead at the time of survey (Table 3). Of the vole-damaged plants found alive, 93.5% had stems that were partially girdled by voles, and 6.5% had fully girdled stems (Table 4). Of the plants found dead, 0% had partially girdled stems, while 100% had stems that had been fully girdled (Table 4).

Table 4. Percentage of girdled plant individuals alive ($n = 46$) and plant individuals dead ($n = 2$) from the broad-scale plant survey with stems observed to be partially girdled and fully girdled.

Survival Status at time of survey	Percentage with Partially Girdled Stem	Percentage with Fully Girdled Stem
Alive	93.5%	6.5%
Dead	0%	100%

Of the species observed in the broad-scale survey, bigleaf maple, hardhack, highbush cranberry, salmonberry, and Western redcedar had the highest percentage of individuals girdled at 100% (Figure 7; Table 5). Black cottonwood, black hawthorn, and Douglas maple have the next highest percentage with 75% of individuals girdled (Figure 7; Table 5).

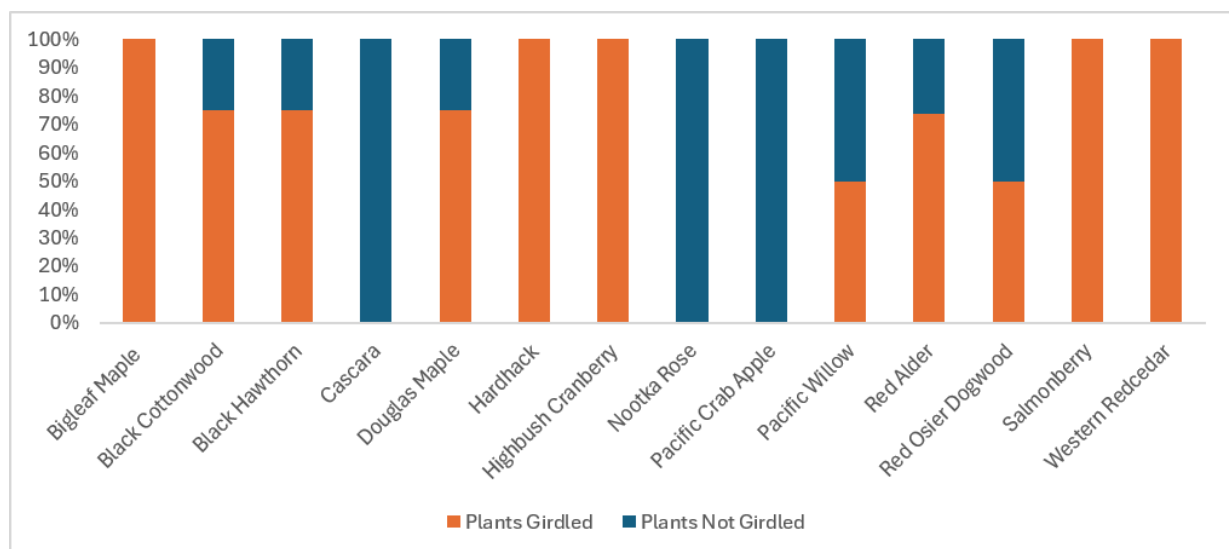


Figure 7. Percentages of plant individuals observed as girdled and not girdled for each species represented in the broad-scale plant survey ($n = 48$). Percentage of plants identified as girdled is shown in orange, and percentage not girdled is shown in blue. For exact proportions, see Table 5.

Table 5. Proportions of plant individuals observed as girdled and not girdled for each species represented in the broad-scale plant survey (n = 48).

Species	Proportion of Plants Girdled	Proportion of Plants Not Girdled
Bigleaf Maple	1	0
Black Cottonwood	0.75	0.25
Black Hawthorn	0.75	0.25
Cascara	0	1
Douglas Maple	0.75	0.25
Hardhack	1	0
Highbush Cranberry	1	0
Nootka Rose	0	1
Pacific Crab Apple	0	1
Pacific Willow	0.5	0.5
Red Alder	0.74	0.26
Red Osier Dogwood	0.5	0.5
Salmonberry	1	0
Western Redcedar	1	0

Of the surveyed plants identified as vole-damaged, black cottonwood displayed the highest percentage of plants found dead post-girdling (66.67%), followed by red alder (5.88%) (Figure 8).

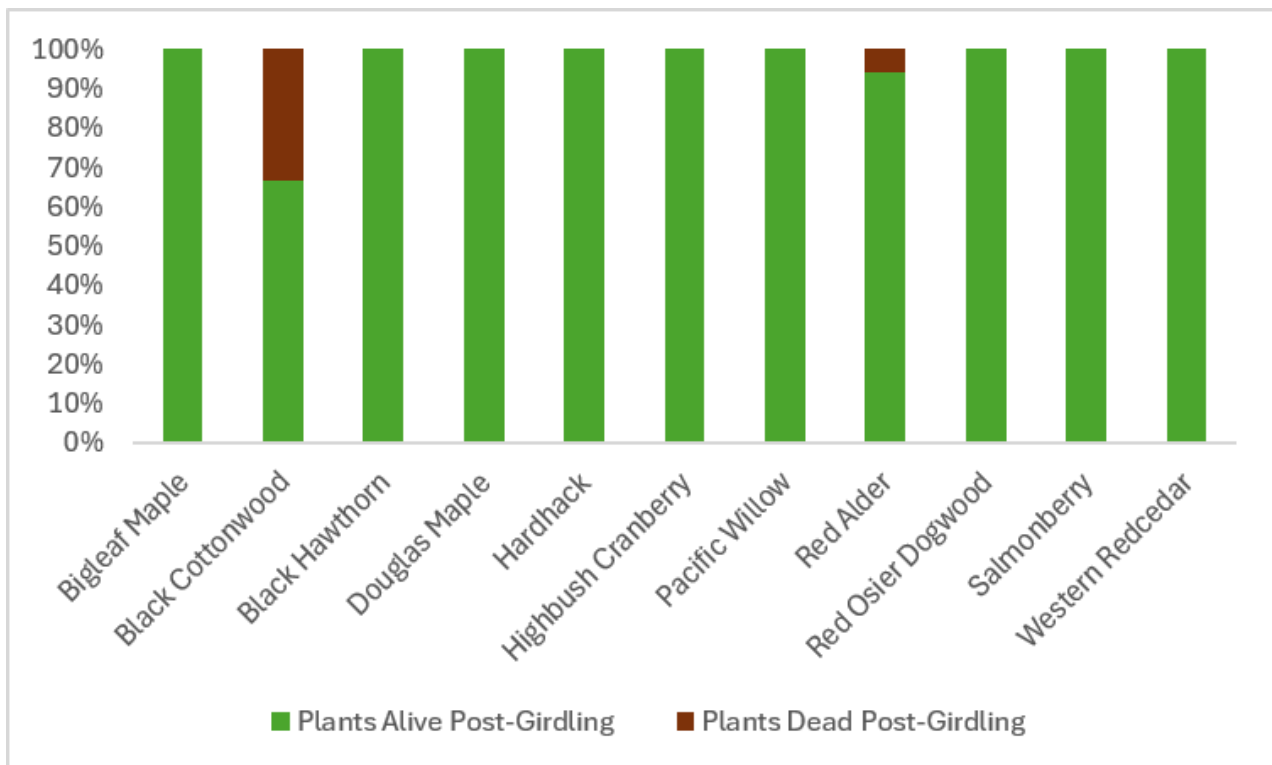


Figure 8. Percentage of plant individuals with observed signs of herbivory (‘girdling’) from the broad-scale plant survey (n = 48) which remained alive after girdling by Townsend’s voles (green) and plants dead after girdling (brown).

Hardhack was found to have the highest average health status of the plants identified as girdled with an average of 5.00, followed by red osier dogwood with 4.50 and Pacific willow with 4.00 (Figure 9). Douglas maple had the lowest average health of 1.00, followed by salmonberry with 2.00 (Figure 9)

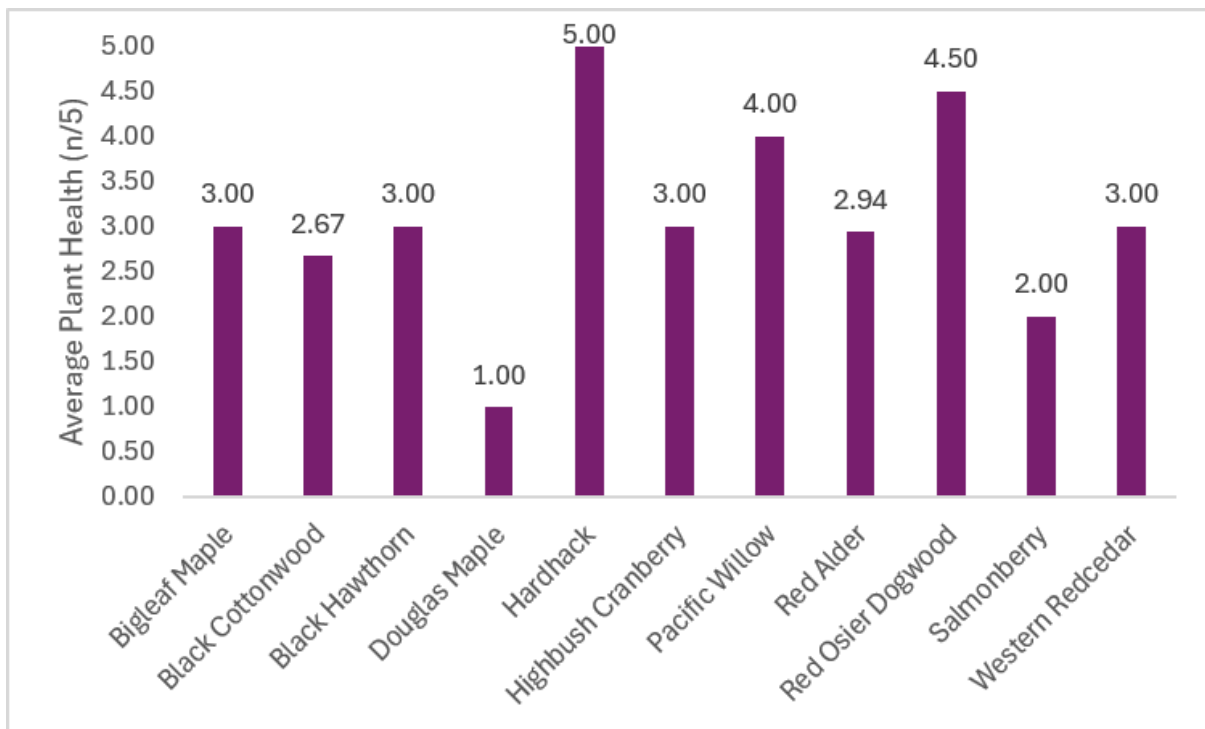


Figure 9. Average plant individual health, recorded for each individual as a value on a 5 point scale (Table B2) and grouped and averaged by species surveyed for plants identified as vole damaged or “girdled” in the broad-scale plant survey (n = 48) within a selected area (Figure 2).

Discussion

The results of statistical testing comparing percent survival of plants from both surveys that received aluminum foil stem protection and unprotected plants found that there is no significant difference between the mean survival rates of plants with and without aluminum foil treatment. We fail to reject the null hypothesis, that there is no difference between the two means. As such, there is not sufficient data from this survey alone to fully conclude that there is a difference in survival rate between plants receiving the aluminum foil stem treatment and plants without it. That being said, the aluminum foil did appear to prevent further vole herbivory following the initial girdling.

Based on the data collected, a majority of the plant mortality across both surveys occurred following a full girdling of the stem rather than a partial one. Here we defined a full girdling as an interruption of the xylem and phloem transport layers that extends all the way around the stem's circumference (Figure 10). A partial girdling would then be defined as an interruption of the stem's transport layer that only extends around part of the stem's circumference, leaving a portion of the xylem and phloem intact (Figure 11).

The species composition represented in the vole-damaged plant survey may be indicative of overall observed trends in species preference for Townsend's voles, as the set of species surveyed was based on previous observations of herbivory damage. In this first survey, red alder was the most surveyed species followed by red osier dogwood and Western redcedar (Figure 4). Red alder in particular makes up a large proportion of the population surveyed, which may provide evidence for species preference but also may be



Figure 10. A fully girdled black cottonwood stem.



Figure 11. A partially girdled Western redcedar stem.

attributed to a larger number of this species being planted in the wetland initially. Some plants previously recorded as vole damaged were not revisited during the 2026 field survey, including plants that were known to have died before the survey. Because these plants are not represented in the current survey data, the fifty-five plants assessed should not be considered a complete representation of all plants that had previously experienced vole herbivory. A complete assessment of survival following previous vole damage would require these earlier records to be included.

In results of the vole-damaged plant survey, young planted shrubs and trees showed interesting variation in response across different species, indicating that certain species may be more capable of survival following herbivory than others, or may display variation in response to effects of the aluminum foil treatment. Black cottonwood, Pacific willow and Scouler's willow trees in particular were found to have high rates of mortality following girdling despite aluminum foil stem treatments (Figure 5). Red alder had a high number of individuals represented in the survey, and a relatively high number of surviving individuals following herbivory, which may indicate not only that it may be a preferred food source but that it may also be a species that is resilient to girdling and able to recover. Some species, while found to have a high percentage of individual survival, show a low average health status, suggesting that girdling may have more immediately fatal effects on some species and more long-term health consequences for others. Bigleaf maple, with 100% individual survival (Figure 5) yet an average health status of only 2.00 out of 5.00 (Figure 6) is an example of this, as well as cascara with 100% survival and 1.00 out of 5.00 average health status. Some species including bigleaf maple and western redcedar exhibited discolouration in upper leaves following herbivory, which may be indicative of an interrupted flow of nutrients up the stem from the girdling of xylem and phloem transport layers in the plant, potentially resulting in long-term effects on the health of the plant.

The prevention measure of aluminum foil wrapped around the base of the stem seems promising in preventing further herbivory damage after initial girdling, however several other



Figure 12. Evidence of vole burrowing exposing the roots of a black hawthorne tree.



Figure 13. Insects, larvae and eggs found beneath aluminum foil stem treatment.

notable side effects of the aluminum foil covering were observed in field surveys. Very few stem-protected plants showed repeated evidence of vole herbivory, aside from a few outliers that displayed bite marks through the foil or signs of burrowing to access plant roots (Figure 12).

Several potentially adverse effects of the aluminum foil treatment were observed throughout the survey and should continue to be monitored throughout following seasons. One of these effects is the presence of insects, detritivores, larvae and eggs underneath the foil (Figure 13). Just under half of the stem protected plants surveyed were recorded to house insects on the stem under the foil layer (Table 2). Red alder and red osier dogwood each had a high proportion of individuals with insects under the foil, with a third of red alder individuals and two thirds of red osier dogwood individuals housing insects. The presence of insects, in particular detritivores, may exert further pressure on the plant by reinforcing or deepening the damage to xylem and phloem transport tissues caused by the initial girdling. Often coinciding with the presence of insects, many of the stems observed displayed discolouration beneath the foil layer, typically appearing a rusty orange colour, as well as apparent rotting or

decomposing of stem tissue (Figure 14). Several plants, namely red alder individuals, displayed discolouration of the stem as well as root-like outgrowths from the portion of the stem that had been covered by the foil (Figure 15), indicating that the absence of light reaching an aboveground portion of the stem may result in abnormal growth patterns. Many of the red alder individuals observed also exhibited an uneven wart-like outgrowth around the base of the stem where they had previously been



Figure 14. A black cottonwood stem displaying discolouration, apparent rotting of stem material, and presence of detritivores.



Figure 15. A red alder stem with discolouration of the stem as well as root-like outgrowths from the area of the stem covered by aluminum foil.

girdled, indicative of regeneration or healing around the initial girdling wound. These observations, alongside further investigation into species-specific responses to herbivory may help guide future plantings in areas that are known to house large Townsend's vole populations.

Townsend's vole herbivory was found to be widespread within the broad-scale survey area, with evidence of girdling recorded on more than two-thirds of the plants surveyed. Most of the observed girdling was partial rather than complete, and many of the girdled plants included in the survey were still alive at the time of assessment. All of the plants in the broad-scale survey that were found dead following herbivory had

fully girdled stems. These results suggest that visible vole damage does not necessarily mean that a plant will die, and that the severity of damage may also be important when considering plant survival.

Lower mortality was recorded in the broad-scale plant survey than the vole-damaged plant survey, with only 2 out of 48 girdled plants found dead. This could be due to a variety of factors, such as slight environmental variation amongst different areas of the site (i.e. the selected study area of the broad-scale plant survey sat at lower elevation than the majority of the rest of the site surveyed in the vole-damaged plant survey, therefore the water table would be higher and plants would receive more moisture), variation in soil nutrient content throughout the site, or difference in species composition sampled. This difference could also be driven by habitat preference of voles, with some areas



Figure 16. Previously girdled red alder stems displaying wart-like, discoloured outgrowths of the stem where vole damage had occurred.

potentially being more suitable than others. Habitat assessment, soil moisture and nutrient content, or vegetation cover surveys could all provide more insight into why survival rates are higher in certain areas.

However, some plants that had already died were not revisited and are therefore not represented in the current data. Because of this, the number of plants recorded as alive should not be considered an overall survival rate following vole herbivory. Being alive at the time of the survey also does not necessarily mean that a plant has fully recovered or will survive over the longer term. Additionally, of the deaths recorded in the broad scale survey, only two can be attributed to herbivory with confidence, and the remaining four either did not show signs of herbivory or had no remaining stem to be examined. Due to this, the data from this survey may not express the actual number of deaths that can be attributed to herbivory. Continued monitoring will help provide a better understanding of how damaged plants respond over time and whether differences in damage severity, species, or protection methods influence their survival.

The amount of vole herbivory observed in both surveys also highlights a potential unintended consequence of deer exclusion within the restoration site. While excluding deer helps protect young plantings from browsing, the tall and dense vegetation within the fenced area also provides suitable cover for Townsend's voles. This creates an interesting management challenge, as protecting plants from one herbivore may increase their exposure to another. Since Townsend's voles are a native part of the ecosystem, the goal does not necessarily need to be preventing all vole herbivory, but rather finding ways for enough native trees and shrubs to successfully establish alongside the vole population.

Conclusion and Recommendations

This study found that Townsend's vole herbivory is an important consideration for the ongoing restoration of the wetland at the Millard Learning Centre. Vole damage was common among the plants surveyed, although many of the damaged plants assessed were still alive and most of the observed girdling was partial. However, because some plants that had already died were not included in the surveys, continued monitoring will be important for better understanding the longer-term effects of vole herbivory on plant survival.

Further research should aim to collect data on a more even distribution of the number of individuals of each species, to prevent biased results from insufficient data on particular species that may be present at lower numbers in the site. Due to the nature and scope of this project, results were based on the plants able to be surveyed in the study area in a short period of time, and a larger control group of overall species composition of the site was unable to be attained. Further studies may benefit from comparison of species variation within surveyed vole-girdled trees with overall species presence in the study site.

Further monitoring studies may seek to compare vole herbivory data from a fenced site like the one surveyed in this study with data from an unfenced site to examine effects of deer exclusion on herbivory patterns. As it has been observed that deer exclusion creates optimal habitat for the Townsend's vole, we may expect vole herbivory damage to be lessened in areas where deer are included.

Findings from this study may be used to inform future wetland planting in areas with high vole populations. Prioritizing species observed to have a better chance of survival following herbivory such as bigleaf maple, black hawthorn, Douglas maple, cascara, hardhack, highbush cranberry, Pacific crabapple, Pacific dogwood, Pacific ninebark, red osier dogwood, red-flowering currant, and salmonberry may lead to higher success of planted individuals and higher overall

resilience in spite of ongoing herbivory. Further research into the specific responses of trees like red alder and black cottonwood may also provide insight on additional species to prioritize in wetland plantings.

Based on our overall findings, we recommend continuing to monitor damaged plantings over time, with particular attention to the severity of girdling, plant health, and differences among species. Further monitoring is also needed to better understand whether aluminum foil provides effective protection from continued herbivory and whether it has any unintended effects on plant health. These findings could help the GCA identify which plantings are most vulnerable to vole damage and where protection or other management efforts would be most useful.

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Appendix A

List of Plant Names Included in Report

The following table lists names of plant species surveyed in this report, including the scientific name (latin binomial), common name, and name in the Hul'qumi'num language.

Hul'qumi'num names from FirstVoices Hul'qumi'num (FirstVoices.Com, 2025) and Nuts'a'maat

Forage Forest signage designed in collaboration by Augie Sylvester, Karen Charlie, Ts'ules, and the Galiano Conservancy Association (GCA).

Scientific Name	Common Name	Hul'qumi'num Name
<i>Acer glabrum</i>	Douglas Maple	ts'alhulhp (maple tree)
<i>Acer macrophyllum</i>	Bigleaf Maple	q'umun'ulhp
<i>Alnus rubra</i>	Red Alder	kwulala'ulhp
<i>Cornus nuttallii</i>	Pacific Dogwood	kwit-xulhp
<i>Cornus stolonifera sericea</i>	Red Osier Dogwood	qw'si'unlhp (Red Osier Dogwood); kwumkwim-mu mutth' or tskwimkwimu-mutth' (Red Osier Dogwood when branches are red)
<i>Crataegus douglasii</i>	Black Hawthorn	metthun'ulp
<i>Malus fusca</i>	Pacific Crabapple	qwa'upulhp
<i>Physocarpus capitatus</i>	Pacific Ninebark	kwunulhp
<i>Populus balsalmifera trichocarpa</i>	Black Cottonwood	tsuw'nulhp
<i>Rhamnus purshiana</i>	Cascara	q'ey'xulhp / qey'hulp
<i>Ribes sanguineum</i>	Red-flowering Currant	sqwuliius (Red-flowering Currant); hwihwukw' (Red-flowering Currant with berries)
<i>Rosa nutkana</i>	Nootka Rose	qel'qulhp
<i>Rubus spectabilis</i>	Salmonberry	lila' / lila-ulhp
<i>Salix lucida</i>	Pacific Willow	~
<i>Salix scouleriana</i>	Scouler's Willow	~
<i>Spiraea douglasii</i>	Hardhack	t'eets'ulhp
<i>Thuja plicata</i>	Western Redcedar	xpey'
<i>Viburnum edule</i>	Highbush Cranberry	mal'sum (cranberry)

Appendix B

Keys to Field Notes Shorthand and Health Status

The following keys list the shorthand letter and number codes with their corresponding meanings as used in field survey notes taken using ArcGIS FieldMaps. Table B1 lists the shorthand letter codes and corresponding meanings that were input into the “Notes” section of FieldMaps observations. Table B2 lists the number indicator (number out of 5) used in the “Status” section of FieldMaps observations to indicate the health/persistence of individual plants.

Table B1. Shorthand letter code used in “Notes” section of FieldMaps observations

Category	Letter Code	Meaning
Damage from herbivory	N	No damage
	G	Girdled (if plant is girdled, will be marked as G and followed by P or F to denote extent of damage)
	P	Stem partially girdled
	F	Stem fully girdled (sometimes also noted as C for Complete)
Stem Protection	TF	Tin foil
Continued herbivory (post original girdling)	BM	Bite marks through tin foil
	AF	Bite marks above tin foil
	BF	Bite marks below tin foil
Overall plant health	H	Healthy
	M	Mid (plant is not healthy but not yet dead)
	D	Dead
Other observations	R	Rotting apparent on stem
	B	Bugs present under tinfoil
	DC	Discolouration on stem
	*	Denotes input of qualitative observations outside of shorthand code

Table B2. Health status indicator (number out of 5) used in “Status” section of FieldMaps observations

Status (number out of 5)	Health Condition of Individual
0	Dead

1	Barely Alive
2	Poor
3	Average
4	Vigorous
5	Vigorous and Mature

Appendix C

Field Observations

The following tables include notes and observations taken in the field in the restored wetland study site using ArcGIS FieldMaps. Observations from the site-wide survey of previously identified vole-damaged plants is listed in Table C1, and data from the broad-scale plant survey of the selected polygon area is listed in Table C2. For a key to the shorthand letter code used in notes from 2026 surveys and the health status number scale see Table B1 and B2 respectively.

Table C1. Field observations from site-wide survey of previously identified vole-damaged plants

OBJECTID	Class	Category	Notes from 2025 Survey	Notes from 2026 Survey	Status	Stem Protection
1348	Pacific Crab Apple (Malus Fusca)	Broadleaf	Vole damage	G, P, TF, H, DC, B	4	foil
1352	Red-Flowering Currant (Ribes Sanguineum)	Shrub	Girdled, tinfoil	G, P, TF, H	4	foil
1369	Red Alder (Alnus Rubra)	Broadleaf	Partially Girdled by voles, tinfoil	G, P, TF, M, B	3	foil
1376	Western Redcedar (Thuja Plicata)	Conifer	Partially Girdled by voles, tinfoil	G, P, BM AF, TF, M	3	foil
1388	Red Alder (Alnus Rubra)	Broadleaf	Likely to die - girdled by voles completely , tinfoil	G, H, TF (not fully covering) *previous assessment said likely to die but looks healthy and lots of new growth	4	
1389	Red Osier Dogwood (Cornus Stolonifera Sericea)	Shrub	Vole damage, tinfoil	G, P, H, TF (not fully wrapped), *couldn't see full base the tarp is covering	4	
1392	Red Osier Dogwood (Cornus Stolonifera Sericea)	Shrub	Partially Girdled by voles, tinfoil	G, TF, B, R, M,	3	
1395	Black Cottonwood (Populus Balsalmifera Trichocarpa)	Broadleaf	Girdled by voles, tinfoil	G, F, D, BM AF,	0	
1396	Red Alder (Alnus Rubra)	Broadleaf	Girdled by voles, tinfoil	G, P, TF, BM, H, DC	4	
1397	Western Redcedar (Thuja Plicata)	Conifer	Girdled by voles, tinfoil	G, P, TF (not fully covering), BM, M, B *voles chewed through tinfoil and chewed upper roots	3	
1398	Red Alder (Alnus Rubra)	Broadleaf	Partially Girdled by voles, tinfoil	G, P, TF, M, DC,	3	foil

OBJECTID	Class	Category	Notes from 2025 Survey	Notes from 2026 Survey	Status	Stem Protection
1405	Red Alder (Alnus Rubra)	Broadleaf	Partially Girdled by voles, tinfoil	G, P BM AF, H, DC	4	
1414	Black Hawthorn (Crataegus Douglasii)	Broadleaf	Partially Girdled by voles, tinfoil	G, P, H, TF	4	foil
1416	Red Alder (Alnus Rubra)	Broadleaf	Girdled by voles, tinfoil	G, P, TF, DC, H	3	
1419	Black Cottonwood (Populus Balsalmifera Trichocarpa)	Broadleaf	Girdled by voles, tinfoil	G, F, D	0	
1420	Red Alder (Alnus Rubra)	Broadleaf	Partially Girdled by voles, tinfoil	G, P, TF, H	4	
1422	Black Hawthorn (Crataegus Douglasii)	Broadleaf	Partially Girdled by voles, tinfoil	G, P, H, TF	3	
1426	Red Osier Dogwood (Cornus Stolonifera Sericea)	Shrub	Girdled by voles, tinfoil	G, F, TF, BM AF, M	3	
1452	Pacific Willow (Salix Lucida)	Broadleaf	Partially Girdled by voles, tinfoil	G, F, D, TF	0	
1462	Red Alder (Alnus Rubra)	Broadleaf	Girdled by voles, tinfoil	G, P, H, TF,	4	foil
1463	Scouler's Willow (Salix Scouleriana)	Broadleaf	Damaged by voles, tinfoil	G, P, H, TF, BM	4	foil
1471	Scouler's Willow (Salix Scouleriana)	Broadleaf	Girdled by voles, tinfoil	G, P, TF, DC, B, H, *little roots growing from discoloured part	4	foil
1475	Red Alder (Alnus Rubra)	Broadleaf	Completely girdled by voles, tinfoil	G, P, DC, B, H, *warty orange outgrowths	4	foil
1477	Red Alder (Alnus Rubra)	Broadleaf	Completely girdled by voles, tinfoil	G, F, TF, M, DC, *tin foil removed in pieces, new tin foil needed * weird warty outgrowth around bottom stem , herbivory on leaves	3	foil
1484	Bigleaf Maple (Acer Macrophyllum)	Broadleaf	Damaged by voles, tinfoil	G, P, TF, M, some discolouration on tops of leaves	2	foil
1487	Red Alder (Alnus Rubra)	Broadleaf	Girdled by voles, tinfoil	G, P, TF, M, DC, B, *weird and warty under tinfoil, roots growing off as if it thinks it's below ground	2	foil
1491	Red Alder (Alnus Rubra)	Broadleaf	No damage, still tinfoil	Still no vole damage, some slight discolouration (DC), and bugs (B) under tinfoil, ends of some leaves dried up/fried	3	foil

OBJECTID	Class	Category	Notes from 2025 Survey	Notes from 2026 Survey	Status	Stem Protection
1508	Western Redcedar (Thuja Plicata)	Conifer	Girdled by voles, tinfoil	G, P, TF, DC, M (very little new growth), stem secreting resin/sap under the foil	3	foil
1525	Red-Flowering Currant (Ribes Sanguineum)	Shrub	Damaged by voles, tinfoil	G, P, H, DC, TF, fruiting	5	foil
1528	Red Alder (Alnus Rubra)	Broadleaf	Damaged by voles, tinfoil	G, P, TF, M , *yellowing leaves	2	foil
1532	Bigleaf Maple (Acer Macrophyllum)	Broadleaf	Damaged by voles, tinfoil	G, P, TF, M, B, *herbivory on leaves, none-little new growth	2	foil
1533	Red Alder (Alnus Rubra)	Broadleaf	Not damaged by voles, still tinfoil	No damage	3	foil
1534	Red Alder (Alnus Rubra)	Broadleaf	Damaged by voles, tinfoil	G, P, TF, DC, H	4	foil
1543	Red Alder (Alnus Rubra)	Broadleaf	Damaged by voles, tinfoil	G, P, M, DC, B, TF	3	foil
1544	Red Alder (Alnus Rubra)	Broadleaf	Completely girdled by voles, tinfoil	G, F, B, D, R, * base of stem has roots growing off	0	foil
1549	Red Alder (Alnus Rubra)	Broadleaf	Damaged by voles, tinfoil	G, P, H, TF	3	foil
1580	Scouler's Willow (Salix Scouleriana)	Broadleaf	Completely girdled by voles, tinfoil	G, F, D, TF	0	
1582	Pacific Ninebark (Physocarpus Capitatus)	Shrub	Damaged by voles, tinfoil	G, P, TF *sort of it only is on one of many stems H	4	
1583	Pacific Dogwood (Cornus Nuttallii)	Broadleaf	Damaged by voles, tinfoil	G, P, TF, H *re. 2024 inspection not a dogwood - pacific willow	4	foil
1584	Red Osier Dogwood (Cornus Stolonifera Sericea)	Shrub	Damaged by voles, tinfoil	G, P, H, TF, BM BF, B, DC	4	foil
1594	Red Alder (Alnus Rubra)	Broadleaf	Damaged by voles, tinfoil	G, P, TF, H, B, DC,	4	foil
1597	Red Alder (Alnus Rubra)	Broadleaf	Damaged by voles, tinfoil	G, P, H, TF, DC,	3	foil
1603	Black Hawthorn (Crataegus Douglasii)	Broadleaf	Completely girdled by voles, tinfoil	G, F, M, B, R, TF	3	foil
1605	Red Osier Dogwood (Cornus Stolonifera Sericea)	Shrub	Damaged by voles, tinfoil	G, P, TF, B, M, AF, *some discolouration on leaves, signs of herbivory	4	foil
1687	Red Alder (Alnus Rubra)	Broadleaf	Damage by voles, tinfoil	G, P, M, TF, DC, *roots growing from base of stem, discolouration and herbivory on upper leaves	2	foil

OBJECTID	Class	Category	Notes from 2025 Survey	Notes from 2026 Survey	Status	Stem Protection
1688	Black Hawthorn (Crataegus Douglasii)	Broadleaf	Damaged by voles, tinfoil	G, P, TF, DC, B, M, *insect eggs on upper leaves and lower stem, detritivores under tin foil, signs of burrowing by roots	2	foil
1692	Western Redcedar (Thuja Plicata)	Conifer	Completely girdled by voles, tinfoil	G, F, D, AF	0	foil
1712	Black Cottonwood (Populus Balsalmifera Trichocarpa)	Broadleaf	Fully girdled by voles - Tinfoil added 2025	G, F, TF, D, B, *ant colony nesting in tin foil— tons of eggs	0	foil
1714	Hardhack (Spiraea Douglasii)	Shrub	Some vole damage	G, P, H, *going to flower, bite marks present but seems unaffected	5	
1720	Hardhack (Spiraea Douglasii)	Shrub	Some vole damage	G, P, H, * looking a little dry up top but still flowering	5	
1723	Cascara (Rhamnus Purshiana)	Broadleaf	Some vole damage - Tinfoil added 2025	G, P, M, B, TF, *nesting ant colony, lots of eggs	1	foil
1724	Black Cottonwood (Populus Balsalmifera Trichocarpa)	Broadleaf	Vole damage - Tinfoil added 2025	G, P, TF, B, R, M, *wood bugs under tf seem to be eating away at the wood, some discolouration and herbivory on upper leaves	2	foil
1765	Red Osier Dogwood (Cornus Stolonifera Sericea)	Shrub	Damaged by voles, tinfoil	G, P, H, B, TF, *some discolouration on leaves, shrub is fruiting, détritivore activity on lower stem (potential damage)	5	foil
1766	Western Redcedar (Thuja Plicata)	Conifer	Completely girdled by voles, tinfoil	G, F, M, TF, *very discoloured/yellowed	1	foil
1773	Pacific Willow (Salix Lucida)	Broadleaf	Damage by voles, tinfoil	G, F, D, TF, R, *tinfoil removed, completely dead	0	foil

Table C2. Field observations from broad-scale plant survey of selected polygon area

OBJECTID	Class	Category	Notes from 2026 Survey	Status
1561	Red Osier Dogwood (Cornus Stolonifera Sericea)	Shrub	H, N	4
1563	Red Osier Dogwood (Cornus Stolonifera Sericea)	Shrub	G, P, H, * signs of burrowing, roots exposed	5
1566	Black Hawthorn (Crataegus Douglasii)	Broadleaf	H, N	4
1567	Red Osier Dogwood (Cornus Stolonifera Sericea)	Shrub	G, P, H	5
1568	Black Cottonwood (Populus Balsalmifera Trichocarpa)	Broadleaf	G, F, D	0

1781	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, M, *potentially girdled, hard to tell	2
1783	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, M, *herbivory on leaves	2
1785	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	N, H	3
1786	Black Cottonwood (<i>Populus Balsalmifera Trichocarpa</i>)	Broadleaf	G, P, H	3
1787	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	G, P, H, *potentially girdled, hard to tell	4
1788	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	N, M, *lots of herbivory on upper leaves	3
1790	Black Cottonwood (<i>Populus Balsalmifera Trichocarpa</i>)	Broadleaf	N, H	4
1791	Pacific Willow (<i>Salix Lucida</i>)	Broadleaf	G, P, H	4
1792	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	G, P, H	5
1793	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	G, P, H	5
1794	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	G, P, H	5
1796	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	N, H	4
1797	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	N, H	5
1798	Nootka Rose (<i>Rosa Nutkana</i>)	Shrub	N, *spreading so hard to tell, no visible damage	4
1799	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, M	3
1800	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	N, H, *no visible damaged but very exposed roots so maybe underneath?	3
1802	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	G, P, M	3
1804	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	G, P, M	3
1806	Pacific Willow (<i>Salix Lucida</i>)	Broadleaf	D, *suspected dead, no plant present	0
1813	Douglas Maple (<i>Acer Glabrum</i>)	Broadleaf	G, P, M, *discolouration on leaves	1
1814	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	N, H	5
1816	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, H	4
1817	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	G, P, H, *potentially girdled, hard to tell	5
1818	Nootka Rose (<i>Rosa Nutkana</i>)	Shrub	N, H	5
1819	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	G, P, H, *potentially girdled? Hard to tell	4
1820	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, M	3
1821	Salmonberry (<i>Rubus Spectabilis</i>)	Shrub	G, P, M	2
1822	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, H, *girdling looks recent	4
1823	Douglas Maple (<i>Acer Glabrum</i>)	Broadleaf	D, suspected dead (no plant present)	0
1826	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	G, P, M	2
1832	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, M	3
1833	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	G, P, H	3

1835	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	G, P, H	5
1837	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, M	3
1838	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, H, *potentially girdled? Hard to tell, healed over	3
1839	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	D, suspected dead (no plant present)	0
1840	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	N, H	4
1841	Douglas Maple (<i>Acer Glabrum</i>)	Broadleaf	G, C, M	1
1842	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	G, P, M	3
1843	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, C, M, *discolouration on leaves, girdling looks new	2
1844	Douglas Maple (<i>Acer Glabrum</i>)	Broadleaf	G, F, M	1
1846	Western Redcedar (<i>Thuja Plicata</i>)	Conifer	G, P, H, *roots super exposed - vole tunnel?	3
1847	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	G, P, H	5
1849	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, H	4
1852	Pacific Crab Apple (<i>Malus Fusca</i>)	Broadleaf	N, M	3
1855	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, H	3
1856	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	G, P, H	5
1857	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	D, suspected dead, can't find	0
1858	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	G, P, H	4
1861	Highbush Cranberry (<i>Viburnum Edule</i>)	Shrub	G, P, M, *discolouration on leaves, girdled part seems healed over	2
1862	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, H	4
1879	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, F, D	0
1881	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	G, P, H	4
1886	Highbush Cranberry (<i>Viburnum Edule</i>)	Shrub	G, P, M	3
1887	Nootka Rose (<i>Rosa Nutkana</i>)	Shrub	N, H	5
1888	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, H, *girdled part seems to have healed over	3
1889	Black Cottonwood (<i>Populus Balsalmifera Trichocarpa</i>)	Broadleaf	G, P, H	5
1890	Highbush Cranberry (<i>Viburnum Edule</i>)	Shrub	G, P, H	4
1891	Bigleaf Maple (<i>Acer Macrophyllum</i>)	Broadleaf	G, P, H	3
1892	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, H	3
1893	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	N, *super tiny	2
1894	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	G, P, H	4
1895	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	N, H	4
1925	Cascara (<i>Rhamnus Purshiana</i>)	Broadleaf	N	3

Appendix D

Data Tables

Included in this appendix are final data sets of field observations exported from ArcGIS FieldMaps and reformatted for data analysis. Data from the site-wide survey of vole-damaged plants is listed in Table D1, and data from the broad-scale survey of the selected polygon area is listed in Table D2. For a key to shorthand code used, see Table B1.

Table D1. Data from site-wide survey of vole-damaged plants

OBJECTID	Class	Status	Girdled?	Fully or Partially?	Tin foiled?	Bite Marks?	Rotting?	Bugs?	Discolouration?
1348	Pacific Crab Apple (<i>Malus Fusca</i>)	4	Yes	P	Yes	No	No	Yes	Yes
1352	Red-Flowering Currant (<i>Ribes Sanguineum</i>)	4	Yes	P	Yes	No	No	No	No
1369	Red Alder (<i>Alnus Rubra</i>)	3	Yes	P	Yes	No	No	Yes	No
1376	Western Redcedar (<i>Thuja Plicata</i>)	3	Yes	P	Yes	Yes	No	No	No
1388	Red Alder (<i>Alnus Rubra</i>)	4	Yes	F	Yes	No	No	No	No
1389	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	4	Yes	P	Yes	No	No	No	No
1392	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	3	Yes	P	Yes	No	Yes	Yes	No
1395	Black Cottonwood (<i>Populus Balsalmifera Trichocarpa</i>)	0	Yes	F	Yes	Yes	No	No	No
1396	Red Alder (<i>Alnus Rubra</i>)	4	Yes	P	Yes	Yes	No	No	Yes
1397	Western Redcedar (<i>Thuja Plicata</i>)	3	Yes	P	Yes	No	No	Yes	No
1398	Red Alder (<i>Alnus Rubra</i>)	3	Yes	P	Yes	No	No	No	Yes
1405	Red Alder (<i>Alnus Rubra</i>)	4	Yes	P	Yes	Yes	No	No	Yes
1414	Black Hawthorn (<i>Crataegus Douglasii</i>)	4	Yes	P	Yes	No	No	No	No
1416	Red Alder (<i>Alnus Rubra</i>)	3	Yes	P	Yes	No	No	No	Yes
1419	Black Cottonwood (<i>Populus Balsalmifera Trichocarpa</i>)	0	Yes	F	Yes	No	No	No	No
1420	Red Alder (<i>Alnus Rubra</i>)	4	Yes	P	Yes	No	No	No	No
1422	Black Hawthorn (<i>Crataegus Douglasii</i>)	3	Yes	P	Yes	No	No	No	No
1426	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	3	Yes	F	Yes	Yes	No	No	No
1452	Pacific Willow (<i>Salix Lucida</i>)	0	Yes	F	Yes	No	No	No	No
1462	Red Alder (<i>Alnus Rubra</i>)	4	Yes	P	Yes	No	No	No	No
1463	Scouler's Willow (<i>Salix Scouleriana</i>)	4	Yes	P	Yes	Yes	No	No	No
1471	Scouler's Willow (<i>Salix Scouleriana</i>)	4	Yes	P	Yes	No	No	Yes	Yes
1475	Red Alder (<i>Alnus Rubra</i>)	4	Yes	P	Yes	No	No	Yes	Yes

1477	Red Alder (Alnus Rubra)	3	Yes	F	Yes	No	No	No	Yes
1484	Bigleaf Maple (Acer Macrophyllum)	2	Yes	P	Yes	No	No	No	No
1487	Red Alder (Alnus Rubra)	2	Yes	P	Yes	No	No	Yes	Yes
1491	Red Alder (Alnus Rubra)	3	No	N	Yes	No	No	Yes	Yes
1508	Western Redcedar (Thuja Plicata)	3	Yes	P	Yes	No	No	No	Yes
1525	Red-Flowering Currant (Ribes Sanguineum)	5	Yes	P	Yes	No	No	No	Yes
1528	Red Alder (Alnus Rubra)	2	Yes	P	Yes	No	No	No	No
1532	Bigleaf Maple (Acer Macrophyllum)	2	Yes	P	Yes	No	No	Yes	No
1533	Red Alder (Alnus Rubra)	3	No	n/a	Yes	No	No	No	No
1534	Red Alder (Alnus Rubra)	4	Yes	P	Yes	No	No	No	Yes
1543	Red Alder (Alnus Rubra)	3	Yes	P	Yes	No	No	Yes	Yes
1544	Red Alder (Alnus Rubra)	0	Yes	F	Yes	No	Yes	Yes	No
1549	Red Alder (Alnus Rubra)	3	Yes	P	Yes	No	No	No	No
1580	Scouler's Willow (Salix Scouleriana)	0	Yes	F	Yes	No	No	No	No
1582	Pacific Ninebark (Physocarpus Capitatus)	4	Yes	P	Yes	No	No	No	No
1583	Pacific Dogwood (Cornus Nuttallii)	4	Yes	P	Yes	No	No	No	No
1584	Red Osier Dogwood (Cornus Stolonifera Sericea)	4	Yes	P	Yes	Yes	No	Yes	Yes
1594	Red Alder (Alnus Rubra)	4	Yes	P	Yes	No	No	Yes	Yes
1597	Red Alder (Alnus Rubra)	3	Yes	P	Yes	No	No	No	Yes
1603	Black Hawthorn (Crataegus Douglasii)	3	Yes	F	Yes	No	Yes	Yes	No
1605	Red Osier Dogwood (Cornus Stolonifera Sericea)	4	Yes	P	Yes	No	No	Yes	No
1687	Red Alder (Alnus Rubra)	2	Yes	P	Yes	No	No	No	Yes
1688	Black Hawthorn (Crataegus Douglasii)	2	Yes	P	Yes	No	No	Yes	Yes
1692	Western Redcedar (Thuja Plicata)	0	Yes	F	Yes	No	No	No	No
1712	Black Cottonwood (Populus Balsalmifera Trichocarpa)	0	Yes	F	Yes	No	No	Yes	No
1714	Hardhack (Spiraea Douglasii)	5	Yes	P	No	No	No	No	No
1720	Hardhack (Spiraea Douglasii)	5	Yes	P	No	No	No	No	No
1723	Cascara (Rhamnus Purshiana)	1	Yes	P	Yes	No	No	Yes	No
1724	Black Cottonwood (Populus Balsalmifera Trichocarpa)	2	Yes	P	Yes	No	Yes	Yes	No
1765	Red Osier Dogwood (Cornus Stolonifera Sericea)	5	Yes	P	Yes	No	No	Yes	No
1766	Western Redcedar (Thuja Plicata)	1	Yes	F	Yes	No	No	No	No
1773	Pacific Willow (Salix Lucida)	0	Yes	F	Yes	No	Yes	No	No

Table D2. Data from broad-scale survey of selected polygon area

OBJECTID	Class	Category	Status	Girdled?	Full/Partial
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1561	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	4	No	n/a
1563	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	5	No	P
1566	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	4	No	n/a
1567	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	5	Yes	P
1568	Black Cottonwood (<i>Populus Balsalmifera Trichocarpa</i>)	Broadleaf	0	Yes	F
1781	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	2	Yes	P
1783	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	2	Yes	P
1785	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	No	n/a
1786	Black Cottonwood (<i>Populus Balsalmifera Trichocarpa</i>)	Broadleaf	3	Yes	P
1787	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	4	Yes	P
1788	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	No	n/a
1790	Black Cottonwood (<i>Populus Balsalmifera Trichocarpa</i>)	Broadleaf	4	No	n/a
1791	Pacific Willow (<i>Salix Lucida</i>)	Broadleaf	4	Yes	P
1792	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	5	Yes	P
1793	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	5	Yes	P
1794	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	5	Yes	P
1796	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	4	No	n/a
1797	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	5	No	n/a
1798	Nootka Rose (<i>Rosa Nutkana</i>)	Shrub	4	No	n/a
1799	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	Yes	P
1800	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	3	No	n/a
1802	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	3	Yes	P
1804	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	3	Yes	P
1806	Pacific Willow (<i>Salix Lucida</i>)	Broadleaf	0	n/a	n/a
1813	Douglas Maple (<i>Acer Glabrum</i>)	Broadleaf	1	Yes	P
1814	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	5	No	n/a
1816	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	4	Yes	P
1817	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	5	Yes	P
1818	Nootka Rose (<i>Rosa Nutkana</i>)	Shrub	5	No	n/a
1819	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	4	Yes	P
1820	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	Yes	P
1821	Salmonberry (<i>Rubus Spectabilis</i>)	Shrub	2	Yes	P
1822	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	4	Yes	P
1823	Douglas Maple (<i>Acer Glabrum</i>)	Broadleaf	0	n/a	n/a
1826	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	2	Yes	P
1832	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	Yes	P
1833	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	3	Yes	P
1835	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	5	Yes	P
1837	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	Yes	P
1838	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	Yes	P
1839	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	0	n/a	n/a
1840	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	4	No	n/a

1841	Douglas Maple (<i>Acer Glabrum</i>)	Broadleaf	1	Yes	F
1842	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	3	Yes	P
1843	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	2	Yes	F
1844	Douglas Maple (<i>Acer Glabrum</i>)	Broadleaf	1	Yes	F
1846	Western Redcedar (<i>Thuja Plicata</i>)	Conifer	3	Yes	P
1847	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	5	Yes	P
1849	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	4	Yes	P
1852	Pacific Crab Apple (<i>Malus Fusca</i>)	Broadleaf	3	No	n/a
1855	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	Yes	P
1856	Hardhack (<i>Spiraea Douglasii</i>)	Shrub	5	Yes	P
1857	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	0	n/a	n/a
1858	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	4	Yes	P
1861	Highbush Cranberry (<i>Viburnum Edule</i>)	Shrub	2	Yes	P
1862	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	4	Yes	P
1879	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	0	Yes	F
1881	Red Osier Dogwood (<i>Cornus Stolonifera Sericea</i>)	Shrub	4	Yes	P
1886	Highbush Cranberry (<i>Viburnum Edule</i>)	Shrub	3	Yes	P
1887	Nootka Rose (<i>Rosa Nutkana</i>)	Shrub	5	No	n/a
1888	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	Yes	P
1889	Black Cottonwood (<i>Populus Balsalmifera Trichocarpa</i>)	Broadleaf	5	Yes	P
1890	Highbush Cranberry (<i>Viburnum Edule</i>)	Shrub	4	Yes	P
1891	Bigleaf Maple (<i>Acer Macrophyllum</i>)	Broadleaf	3	Yes	P
1892	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	3	Yes	P
1893	Black Hawthorn (<i>Crataegus Douglasii</i>)	Broadleaf	2	No	n/a
1894	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	4	Yes	P
1895	Red Alder (<i>Alnus Rubra</i>)	Broadleaf	4	No	n/a
1925	Cascara (<i>Rhamnus Purshiana</i>)	Broadleaf	3	No	n/a

Author Contributions

Maisie:

- Table of contents
- Territory acknowledgement
- Acknowledgements
- Summary
- Introduction and background
- Goals and objectives
- Site Description
- Methods
- References
- Background research
- Map creations and figure captions
- Draft Revisions from feedback
- Discussion (of broad-scale survey results) and Conclusion

Maya:

- Title Page
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- Table of contents
- Summary
- Methods
- Data entry, data sorting and statistical analysis
- Appendix A, B, C, D
- Formatting and editing
- Background research
- Results reporting
- Creation of tables and table captions in results
- Creation of statistical figures and figure captions
- Draft revisions from feedbacks
- Images sourcing and figure captions
- Discussion
- Conclusions and Recommendations
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