Mixed Grassland/Forest Ecosystem Restoration: Invasive Removal and Trail Rehabilitation in Skyline Park, Kamloops, BC

Photo source: Trevor Ashe

Trevor Ashe

ER390

Date Submitted: Mach 30, 2020

Submitted to Nancy Shackelford

Abstract

Skyline Park is a trail system in the Aberdeen residential area of Kamloops, British Columbia. It exhibits a mosaic of grassland and forest, which is experiencing reduced native vegetation species richness and cover due to infestation of spotted knapweed (*Centaurea maculosa*) and non-native grasses established in the park. The presence of knapwed on disturbed sites left behind from residential development around the park has hindered the establishment of native species in those areas. Skyline Park has approximately 3.2km (320m/Ha) of trails, which are fragmenting the ecosystem. The open grassland forest portion of Skyline Park is experiencing diminished biodiversity and succession towards shade tolerant species and bare ground due to the formation of thickets of interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*). To reverse the adverse effects the ecosystem is experiencing and prevent further loss of biodiversity, a prescription was prepared, and actions were taken for the restoration site. The total trail length was reduced to 2.5km (250m/Ha) by defining the trail system and closing selected trails by tilling the compacted soil with a rake and reseeding with a native grass "Stump mix" of Bluebunch wheatgrass (*Pseudoroegneria spicata*), Annual Ryegrass (*Lolium multiflorum*), Rough fescue (*Festuca scabrella*), Rocky mountain fescue (*Festuca saximontana*) and Sandberg bluegrass (*Poa secunda*). A combination of manual removal by pulling, cutting, bagging and disposal in the land fill of spotted knapweed (*Centaurea maculosa*) and the application of root feeding biological control agent, *Cyphocleonus achates*, was used to reduce the density of spotted knapweed (*Centaurea maculosa*) in Skyline Park. Informational signage will be placed at the entrances to the park to educate park users on how they can prevent the spread of spotted knapweed (*Centaurea maculosa*) and properly remove it. As a trial, plugs of native grass "Stump mix" were planted in a selected area within the manually treated patch to determine if plug planting is beneficial in the reestablishment of native grasses in comparison to natural reestablishment from surrounding area. It is recommended that thickets are treated by thinning and pruning to mimic the natural open grassland forests typical of the bunchgrass biogeoclimatic zone. Recommendations are made for the continued monitoring of biological control survival and population establishment, as well as monitoring and managing the spread and cover of spotted knapweed (*Centaurea maculosa*) for several years after complete removal from Skyline Park.

Table of Contents

Acknowledgements

I would like to thank Kirsten Wourms, Natural Resources Crew Leader, and the City of Kamloops for providing me the opportunity to perform a restoration in Skyline Park, Kamloops, BC.

Richard Hebda and Rick Tucker for their assistance in vegetation identification and Teresa Corboy for assisting me in bird identification in the bird count.

Coleen Hougen, Mike Dedels and the Thompson Nicola Regional District Invasive Plant Management Committee for participating in the Knapweed Knockdown, providing snacks and water for volunteers and hosting the Weed Warrior Challenge.

Jesse Ritcey and the volunteers from the Kamloops Naturalist Club for assisting in the organization and participation of the Knapweed Knockdown events.

Helen Newmarch and the Aberdeen Neighborhood Association for promoting and participating in the Knapweed Knock down events.

Dr. Catherine Tarasoff, P. Ag and Sophie Church, from Agrowest Consulting Scientists for providing me biological controls for the release sites.

The BC Wildfire Service for building trails to better define the trail system.

My wife, Kelsey Ashe and all my friends that participated in the Knapweed Knockdown events and supporting me through this project.

1.0 Introduction

Many parks and grasslands in Kamloops are infested with spotted knapweed (*Centaurea maculosa*) and the City of Kamloops received concerns over the spread of spotted knapweed (*Centaurea maculosa*) within Skyline Park. Skyline Park is primarily used for hiking and dog walking (City of Kamloops, 2019); however prior to residential development in the 1970's, the area was likely used for livestock grazing as that was historically the main land use for the majority of grasslands surrounding Kamloops (Grassland Conservation Council of BC (GCCBC) & Biospherics Environmental Inc.(BEI), 2008).

The Grasslands Conservation Council of British Columbia and Biospherics Environmental Inc. (2008) performed an ecological assessment for the Aberdeen Area Plan for the City of Kamloops to:

- Provide baseline information of the natural features in the Aberdeen Area Plan study area;
- Complete an ecological assessment of the Aberdeen Area Plan study area;
- Prioritize areas into Priority Ecological Zones; and
- Provide the City of Kamloops with guidance and recommendations for conservation measures and future steps.

From the study they defined areas of Aberdeen as:

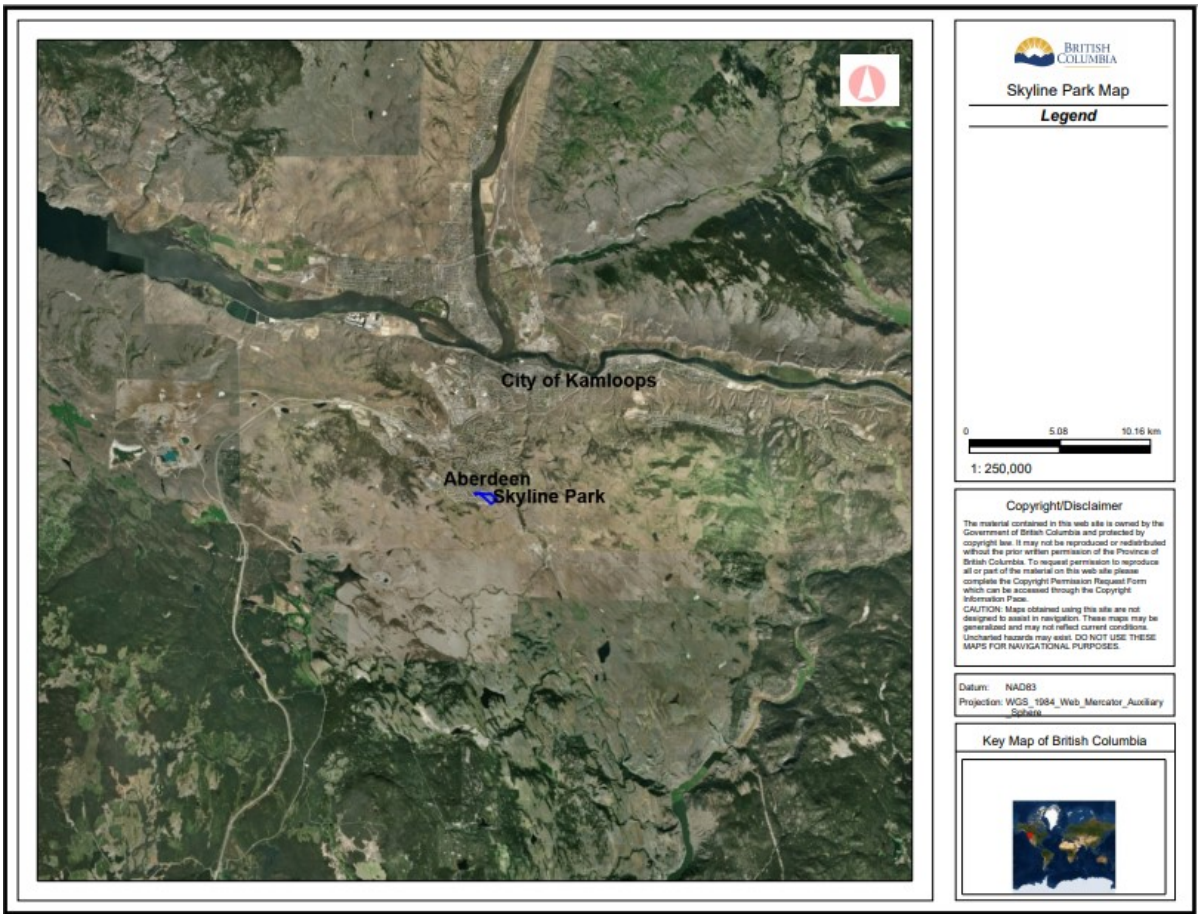
1. Class 1: "Green zones" have no specific ecological concerns and are areas of lower conservation value, which can be considered for development or urban green space (GCCBC & BEI, 2008).
2. Class 2: "Amber zones" are areas of moderate ecosystem value with patches of high priority elements and connective value, which are recommended for sustainable development that does not compromise high priority ecological features (GCCBC & BEI, 2008).
3. Class 3: "Red Zones" are areas with large concentrations of high and moderate ecosystem value, which are recommended to be set aside as conservation areas (GCCBC & BEI, 2008).

Skyline Park is located within the study area of the ecological assessment and was identified as an amber zone with two high priority habitat features (Appendix A) (GCCBC & BEI, 2008). The two high priority features identified during the ecological assessment were a Lewis's Woodpecker (*Melanerpes lewis*) nest and an Aspen Riparian area (GCCBC & BEI, 2008).

1.1 Location and Description

Skyline Park is in the Aberdeen residential area of the City of Kamloops in the Southern Interior Region of British Columbia (Figure 1).

Figure 1: Location of Skyline Park in the Aberdeen residential area of Kamloops, BC (Sourced from: https://maps.gov.bc.ca/ess/hm/imap4m/)



Kamloops local climate is semi-arid with hot, dry summers, mild winters and an average annual precipitation of 217 mm of rain and 75 mm of snow (City of Kamloops, 2016). Skyline Park is in the Nicola very dry warm bunchgrass variant (BG xw1) Biogeoclimatic Ecosystem Classification (BEC) zone in the Thompson Basin ecosection of the Thompson-Okanagan Plateau ecoregion (Figure 2) (Government of British Columbia, n.d.). The environmental characteristics of the Nicola very dry warm bunchgrass variant (BG xw1) BEC zone are summarized from A Guide to Site Identification for the Kamloops Forest Region in Table 1 (Lloyd, Angrove, Hope & Thompson, 1990).

Figure 2: Skyline Park BEC zone map displaying the Nicola very dry warm bunchgrass (BG xw1) and Thompson very dry hot interior Douglas-fir (IDF xh2) variants (Sourced from: https://maps.gov.bc.ca/ess/hm/imap4m/)

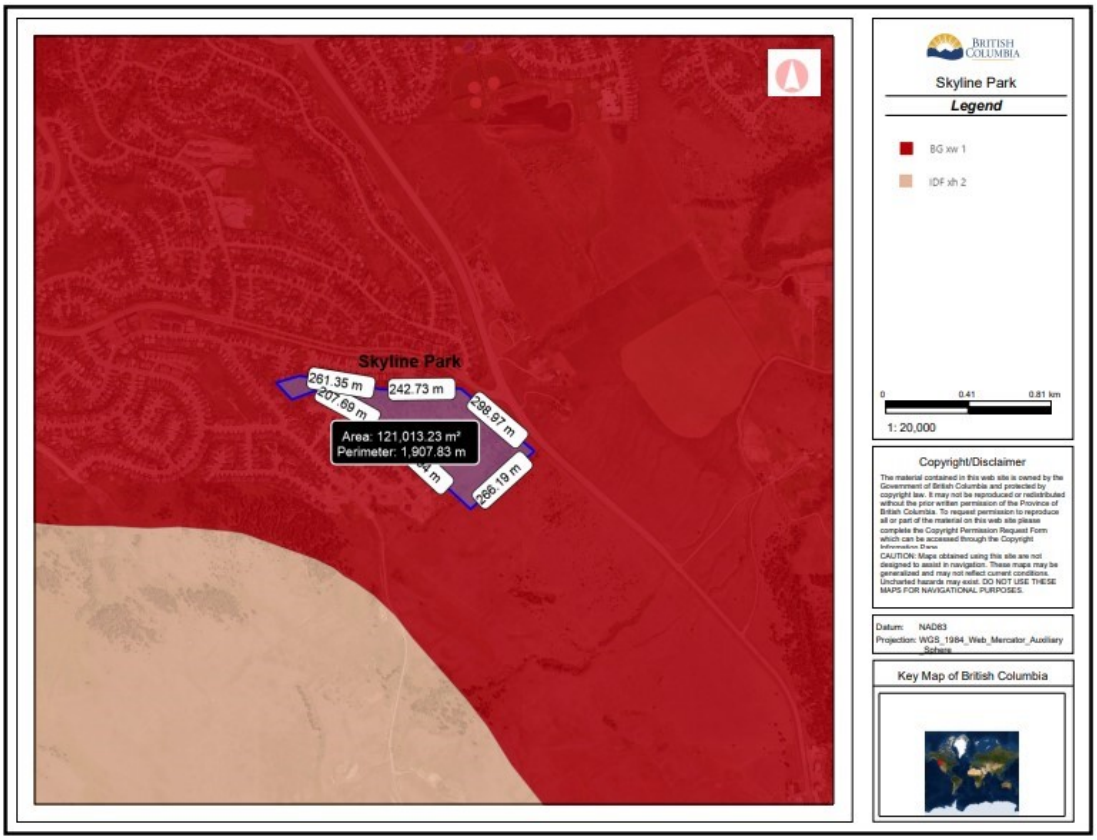


Table 1: Environmental Characteristics of BGxw1 BEC zone of Skyline Park (Lloyd, et al., 1990).

Biogeoclimatic Unit	**BGxw1**
Elevation Range (m)	330-1000
Soil Classification[1]	DB, B
Annual Precipitation (mm)	160-458
Growing Season Precipitation (mm)	79-225
Annual Snowfall (cm)	100 (mean)
Annual Temp. (°C)	4.4-7.6
Growing Season Temp. (°C)	12.9-16.2
Mean Min. Jan. Temp. (°C)	-13.5 - -10.3
Growing Degree Days (>5°C)	1383-1990
Frost-Free Period (days)	79-143

Notes: 1 See Canadian systems of soil classification in Appendix B.

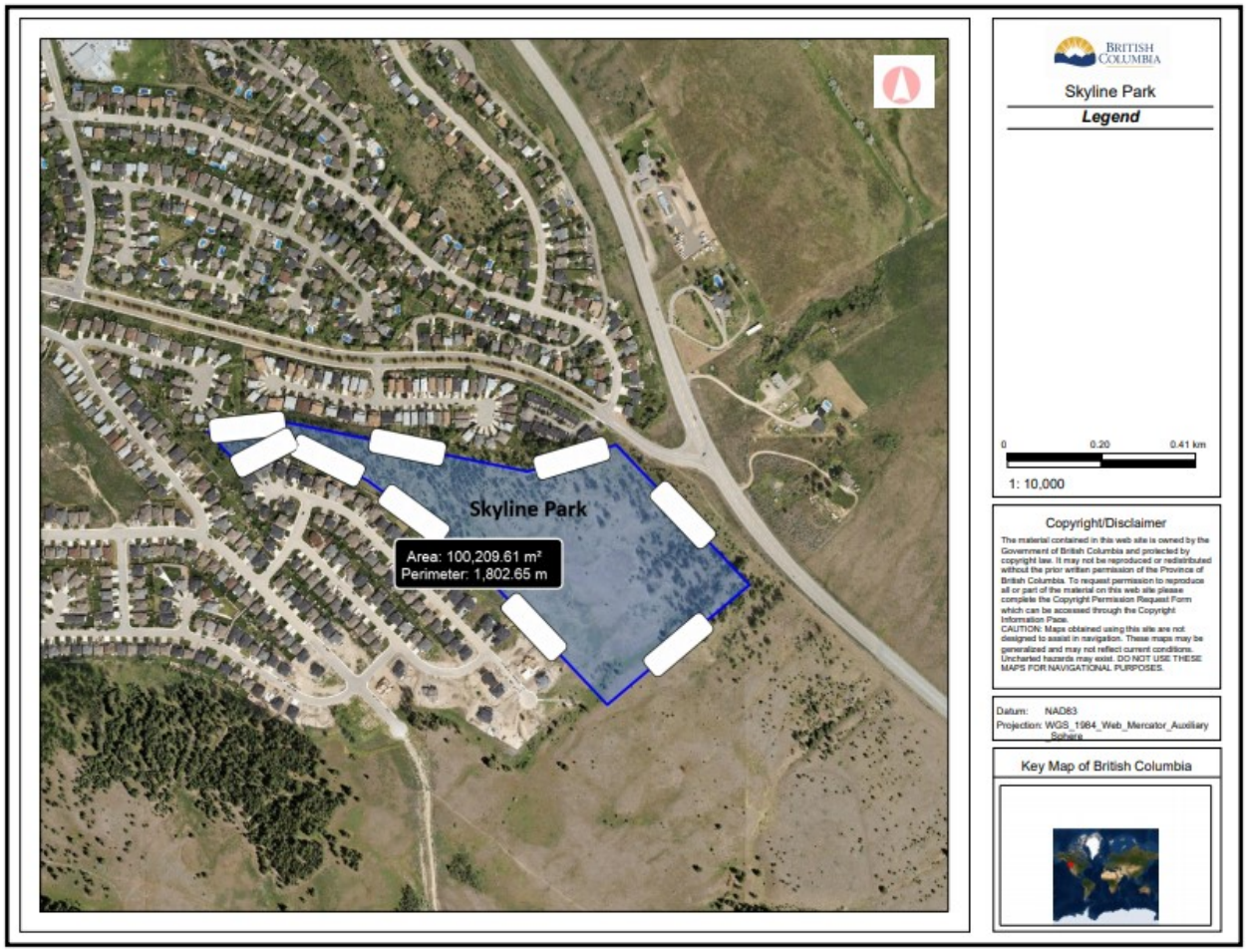
The dominant tree species that occurs in the BGxw1 BEC zone are the ponderosa pine (*Pinus ponderosa*) and interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), with trembling aspen (*Populus tremuloides*) being present in wet sites (Lloyd et al., 1990). The understory of the BGxw1 BEC zone can be dominated

by bluebunch wheatgrass (*Agropyron spicatum*), rough fescue (*Festuca scabrella*), as well as common snowberry (*Symphoricarpos albus*) and Nootka rose (*Rosa nutkana*) in wet sites (Lloyd et al., 1990).

1.2 Project Site Description

The restoration site is an approximately 10-hectare plot of mixed grassland and open forest in Skyline Park, Kamloops, BC, which is outlined in blue in Figure 3.

Figure 3: Skyline Park project site (Sourced from: https://maps.gov.bc.ca/ess/hm/imap4m/)



Skyline Park, like many of the grasslands of Kamloops, consist of a mosaic of grassland and forest with a forest edge of Ponderosa pine (*Pinus* ponderosa) or interior Douglas-fir (*Pseudotsuga menziesii* var. glauca) (GCCBC & BEI, 2008). This mosaic has been altered in Skyline Park through the last century of suppression of the natural fire regime allowing for encroachment of forest on the grassland and the formation of dense thickets of interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) in the open forested areas (

The goal of this project is to engage the Kamloops community in the enhancement of native flora and fauna in Skyline Park by:

- Determining the effects of spotted knapweed (*Centaurea maculosa*) patches on the native grass species, primarily rough fescue (*Fescuta scabrella*) and bluebunch wheatgrass (*Agropyron spicatum*) and perform a restoration to increase native species richness, herbaceous forage for wildlife, and educate park users on spread prevention;
- Determine the total distance of single-track trail present in Skyline Park to define a trail system and restore unnecessary trails to reduce ecosystem fragmentation and soil erosion; and
- Determine the effects of thickets formation on shrub and herb layers of grassland forests and create a restoration plan for tree density reduction.

Figure 4)(GCCBC & BEI, 2008). Skyline Park has many grassland, forested and disturbed areas where spotted knapweed (Centaurea maculosa) has formed dense patches, which is likely outcompeting native species and creating homogenous plant communities at a local scale (

Figure 5 and Figure 6). Skyline Park also has a high density of single-track trails that run parallel to each other to the same location, come from private property into the grassland, or are too steep, which are fragmenting the ecosystem and causing erosion of soils.

The goal of this project is to engage the Kamloops community in the enhancement of native flora and fauna in Skyline Park by:

- Determining the effects of spotted knapweed (*Centaurea maculosa*) patches on the native grass species, primarily rough fescue (*Fescuta scabrella*) and bluebunch wheatgrass (*Agropyron spicatum*) and perform a restoration to increase native species richness, herbaceous forage for wildlife, and educate park users on spread prevention;
- Determine the total distance of single-track trail present in Skyline Park to define a trail system and restore unnecessary trails to reduce ecosystem fragmentation and soil erosion; and
- Determine the effects of thickets formation on shrub and herb layers of grassland forests and create a restoration plan for tree density reduction.

Figure 4: Thicket of interior Douglas-fir (Pseudotsuga menziesii var. *glauca), native grasses, rough fescue (Festuca scabrella) and bluebunch wheatgrass (Agropyron spicatum), spotted knapweed (Centaurea maculosa) and Saskatoon (Amelanchier alnifoilia) in vegetation plot Skyline Park 11 (SLP11)*

Figure 5: Patch of spotted knapweed (Centaurea maculosa) in Skyline biological release site 1 (SLBR1)

*Figure 6: Landscape disturbance of a pile of excess rock and dirt material from residential development, patch of spotted knapweed (Centaurea maculosa), Common rabbit-brush (*Chrysothamnus nauseosus*) and thicket of interior Douglas-fir (Pseudotsuga menziesii* var. *glauca) in vegetation plot SLP12*

1.3 Project Objectives

The objectives of this project are to:

- Map current trail system and determine total trail length and trail density;
- Perform vegetation survey to determine species cover;

- Perform pellet count and bird count to determine wildlife habitat use;
- Prepare and execute a restoration plan for reducing trail density;
- Prepare and execute a restoration plan to educate community on invasive species spread prevention and involve community in invasive species removal;
- Prepare recommendations for reducing tree density in thickets;
- Prepare recommendations for continued monitoring of invasive coverage and treatment effectiveness.

1.4 Literature Search

Spotted knapweed (*Centaurea maculosa*) is a biennial short-lived perennial that is considered regionally noxious under BC *Weed Control Act* and is distributed throughout southern BC and is of major concern in the Thompson, Okanagan, Cariboo, Kootenay, Omineca and Peace River regions (Invasive Species Council of BC (ISCBC), 2020). Spotted knapweed (*Centaurea maculosa*) prefer open areas with well-draining soil, such as grasslands, open forests, along roadsides and in right-of-way's (ISCBC, 2014). Spotted knapweed (*Centaurea maculosa*) produces up to 140,000 seeds per square metre that can remain viable in the soil for over 15 years and are usually dispersed in the immediate vicinity of the parent plant (ISCBC, 2020). Large infestations can increase run off causing soil erosion and impact biodiversity by displacing native vegetation and altering soil chemistry, which prevents growth of other plants (ISCBC, 2014). The displacement of native vegetation by spotted knapweed (*Centaurea maculosa*) can have a detrimental effect on wildlife populations as it reduces the abundance of vegetation that is available for foraging (ISCBC, 2014).

Recommended management techniques include spread prevention, mechanical control, biocontrol and chemical control (ISCBC, 2014). To prevent the spread of spotted knapweed (*Centaurea maculosa*), it is important to keep out (including pets) of patches of spotted knapweed and to remove any plant parts or seed from personal gear, equipment or pets before leaving infested sites (ISCBC, 2014). Mechanical Control involves pulling, cutting or mowing of treatment areas (ISCBC, 2014). If treated prior to flowering stems can be twisted and left on site, however if flowers are present plants must be bagged and removed from the site (ISCBC, 2014). Treatments are most effective when performed prior to seed set and require annual monitoring and retreatment until areas are knapweed-free for several consecutive years (ISCBC, 2014).

Selective spot spraying with various herbicide, including picloram, dicamba, 2,4-D, clopyralid, aminopyralid and glyphosate, is effective in controlling spotted knapweed (*Centaurea maculosa*), (ISCBC,

2014). A study compared the effects of picloram, clopyralid plus 2,4-D and dicamba plus 2,4-D on spotted knapweed (*Centaurea maculosa*) and perennial grass biomass and found that picloram provided the most control of spotted knapweed (*Centaurea maculosa*) and the largest increase in perennial grass biomass (Sheley, Duncan, Halstvedt and Jacobs, 2000). Though these have been found effective, they are not permitted for use in the City of Kamloops under the Pesticide Use Bylaw No. 26-4 (2016).

There are twelve biological control agents that have been released in British Columbia, which attack various parts of spotted knapweed (*Centaurea maculosa*) (ISCBC, 2014) (Table 2). The Thompson-Nicola Regional District has previously released *Larinus minutus, Larinus obtusus and Cyphocleonus achates* as part of their Noxious Weed Control Program (Thompson-Nicola Regional District Invasive Plant Committee, 2009).

Table 2: Spotted knapweed (Centaurea maculosa) biological control agents released in BC (Powell, et al., 1994).

Biological Control Agent	**Type**	**Part of Plant Attacked**
Agapeta zoegana	Moth	Root
Chaetorellia acrolophi	Fly	Seed
Cyphocleonus achates	Beetle (weevil)	Root
Larinus minutus	Beetle (weevil)	Seed
Larinus obtusus	Beetle (weevil)	Seed
Metzneria paucipunctella	Moth	Seed
Pelochrista medullana	Moth	Root
Puccinia jaceae	Stem and leaf rust	Stem and leaf
Sphenoptera jugoslavica	Beetle	Root
Terellia virerns	Fly	Seed
Urophora affinis	Fly	Seed
Urophora quadrifasciata	Fly	Seed

A study was performed on nineteen vegetation monitoring sited in the Southern Interior of British Columbia to determine the effects seed feeder and root feeder biological control agents on diffused knapweed (*Centaurea diffusa* Lam.) and spotted knapweed (*Centaurea maculosa*) (Gayton & Miller, 2012). The study determined that using root feeder in combination with seed feeder biocontrol agents are the primary drivers in the decline of knapweed observed at the monitoring sites (Gayton & Miller, 2012). Knochel and Seastedt (2010) had similar results, observing that the root feeder (*Cyphocleonus achates*) reduced the flower production and aboveground biomass, and the seed feeder (*Larinus minutus*) reduced the seed production of spotted knapweed (*Centaurea maculosa*). Another study found

that *L. minutus* exerted larger negative effects than *C. achates* on spotted knapweeds (*Centaurea maculosa*) physiology and reproductive output, but the use of both should enhance density reduction (Wooley, et al., 2011).

2.0 Methods and Materials

I performed a trail survey to map existing trails and determine the total length of trail and trail density. I performed twelve vegetation surveys to determine the effects of spotted knapweed (*Centaurea maculosa*) on the native flora, primarily rough fescue (*Fescuta scabrella*) and bluebunch wheatgrass (*Agropyron spicatum*) and created a map of spotted knapweed (*Centaurea maculosa*) patch locations. I measured the diameter at breast height and performed a stem count to determine the tree density and cover in the twelve vegetation plots. I performed vegetation surveys in two dense patches of spotted knapweed (*Centaurea maculosa*) selected for release of biological control agents. I also performed a bird count and pellet count to determine the wildlife habitat use in Skyline Park.

2.1 Trail Survey

On April 10, 2019, I walked all the trails of Skyline Park and recorded the trail system using my Trailforks app on my Google Pixel 2XL cell phone (Appendix C). I then used the map created by my Trailforks app to make a more legible map on iMapBC to assess the total trail density (length of trail per hectare) of Skyline Park (Government of British Columbia, n.d.).

2.2 Vegetation Survey

I carried out site inspections on May 22, 27, 28, 29, 30, June 4, 5, 12 and July 8 of 2019 for twelve sites throughout Skyline Park, guided by the procedures outlined in the Field Manual for Describing Terrestrial Ecosystems (B.C. Ministry of Forests and Range & B.C. Ministry of Environment, 2010). The survey sites were randomly selected to represent open forest and grassland typical of the BGxw1 BEC zone and to observe the effects of spotted knapweed, disturbance from development and formation of interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) thickets. The plots were identified as Skyline Park 1 (SLP1)-SLP12.

I began each site inspection by placing a wooden stake in the starting corner of the plot and recording the GPS location and elevation with my Garmin 64s GPS unit using UTM UPS position format and WGS 84 Map Datum. I then used my Suunto MC-2 compass, with my declination set to 16^{o} east, to determine the aspect of the slope (Appendix D). Using the angle determined from the aspect and the perpendicular angle, I used my compass and 30m measuring tape to measure the boundaries of each 20m by 20m plot.

I then took photos, drew a site diagram and determined the slope of my plot using a clinometer. At 5m, 10m and 15m along the perpendicular to aspect boundary I carried out three 20m line intercepts, according to the method outlined by Dr. Antos (as sited in Schaefer, 2018), to assess the percent cover and frequency of the species in the plots, these were labeled as Transect 1,2 and 3 respectively for each plot (Appendix E). Each line intercept was performed by measuring the total distance that each species intercepted the plane (above or below) the measuring tape (transect line). Plant identification was carried out using a combination of the Plants of Southern Interior British Columbia and Inland Northwest (Antos, et al.,1996) and Plants of the Kamloops Area (Ryan M., 2018).

Using my Google Pixel 2 XL cell phone, I created a map recording spotted knapweed (*Centaurea maculosa*) patch locations at the centre of each patch observed throughout Skyline Park.

2.3 Tree Stem Count

Starting in the corner initially marked by GPS of each vegetation survey plot I counted each tree as I moved counterclockwise through the plot. I noted the species and measured the circumference at breast height (CBH) for each tree over 3m. The circumference was divided by π to determine the diameter at breast height (DBH). I counted the total number of trees that were under 3m and noted their species but did not measure the circumference at breast height. Tree species identification was confirmed using Plants of Southern Interior British Columbia and Inland Northwest (Antos, et al., 1996). The estimated canopy cover was determined by standing in the centre of the plot and looking straight up and visually estimating the canopy cover percentage for each plot.

2.4 Biological Release Site Vegetation Survey

I contacted Kirsten Wourms, City of Kamloops Natural Resources crew leader, to enquire about the possibility of performing a biological control release in Skyline Park. Kirsten contacted Dr. Catherine Tarasoff, P. Ag., with Agrowest Consulting Scientists, that was contracted by the City of Kamloops to perform biological releases through out other areas of Kamloops in the summer of 2019. I was informed that the biological control, *Cyphocleonus achates*, would be made available to release at the Skyline Park study area. On August 2, 2019, I randomly selected two dense patches of spotted knapweed (*Centaurea maculosa*) and placed a permanent stake marker in the patch. The two plots were identified as Skyline Biological Release site 1 (SLBR1) and SLBR2. I recorded the GPS location and elevation with my Garmin 64s GPS unit using UTM UPS position format and WGS 84 Map Datum (Appendix F). Using my Suunto MC-2 compass, with my declination set to 16^{o} east, I laid my 1m by 1m PVC quadrat so that one corner was touching the permanent marker and one edge was on the north axis and the other was on the west

axis (Appendix G). I then estimated the cover of all species found in the quadrat. I then flipped the quadrat around the permanent marker and repeated the estimation for the North-East, South-West and South East quadrats.

2.5 Bird Survey

On August 2, 2019 at 6:00 AM, I met with Teresa Corboy, an avid bird watcher that volunteered from the Kamloops Naturalist Club, at Skyline Park to perform a bird survey. We stopped at random locations along the trails and each plot was assigned a plot identification of Skyline Bird Count site 1 (SLBC1) to SLBC7. I recorded the GPS location and elevation with my Garmin 64s GPS unit using UTM UPS position format and WGS 84 Map Datum and the start time for our observations (Appendix H). Point counts were performed by standing still for 5 minutes while listening and watching for birds. We recorded each species and the number of individuals that was observed (seen or heard) in the habitat area, as well as species flying overhead, but not in the habitat area. After 5 minutes I recorded the stop time and we proceeded to the next location and repeated. I also made note of any other wildlife observed during the bird count.

2.6 Pellet Count

On August 2, 2019, while walking through Skyline Park, I randomly selected ten starting points to perform pellet counts and assigned the transect identification of Skyline Pellet Count transect 1 (SLPC1) to SLPC10. At each selected starting point, I would record the GPS location and elevation with my Garmin 64s GPS unit using UTM UPS position format and WGS 84 Map Datum. I would determine and record the slope aspect with my Suunto MC-2 compass, with my declination set to 16^{o} east (Appendix I). I laid out a 30m transect line with my 30m measuring tape along the aspect angle down slope. I laid my 1m by 1m quadrat to the right or left side of the transect line to start, I alternated which side with each transect (Appendix J). I would record the species and number of pellets observed in the quadrat. I would then flip the quadrat down the transect 1m, then flip it to the opposite side of the transect and recorded the species and number of pellets observed in that quadrat. I repeated flipping the quadrat down the entire 30m transect and recorded all observed species and number of pellets. I also made note of any wildlife observed while performing the pellet counts.

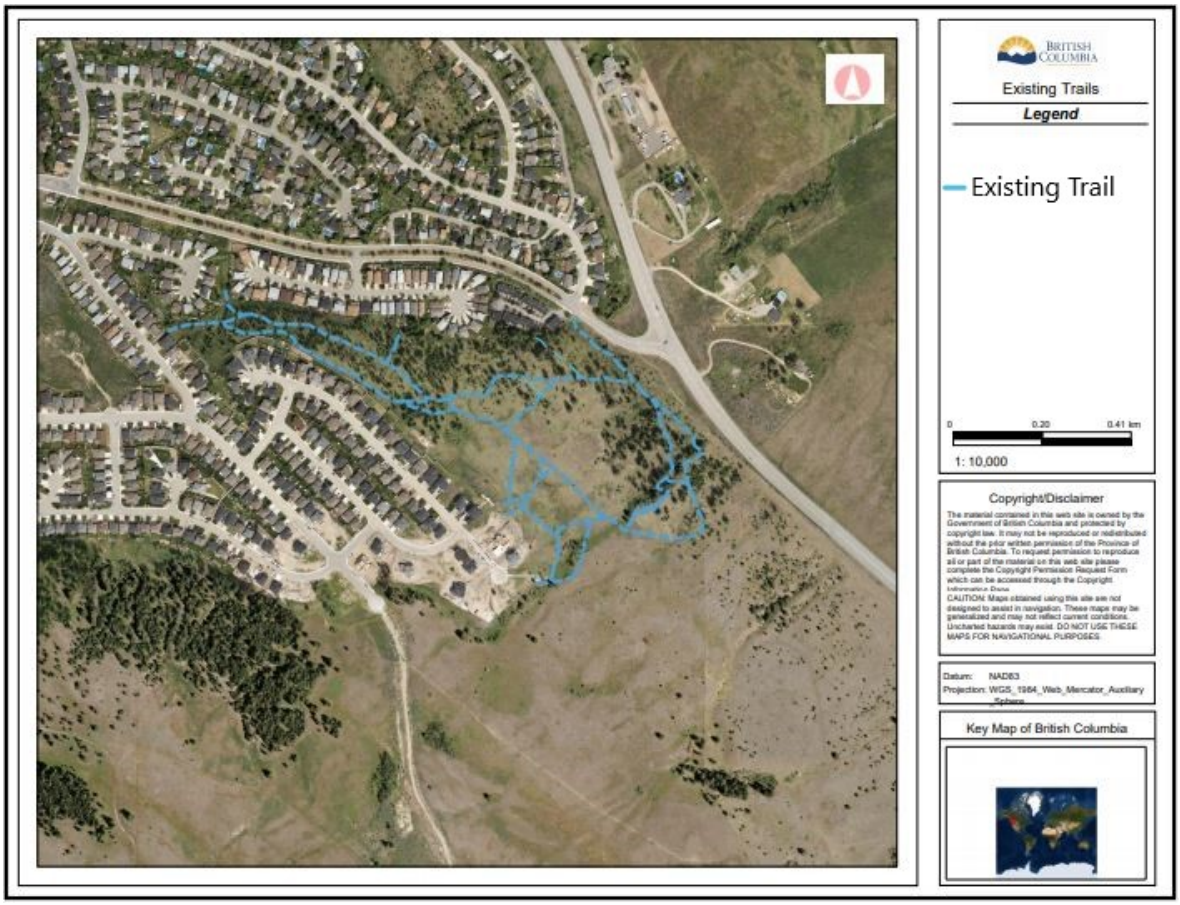
3.0 Results

3.1 Trail Survey

I created a map (Figure 7) and determined that the total trail length in Skyline Park, which measured to be approximately 3.2 kilometers of single-track trail with a trail density of 320 m/Ha of trail. There were

several trails leading from private property to the main trails that were being used as alternatives to the main entrance. There were a couple of trails that were parallel to each other that led to the same place, which were deemed redundant. Skyline Park is on a hillside and one trail leading to a bench was determined to be at too steep with a slope of 39% and was showing signs of erosion. There is an alternate access trail to the bench that is not as well defined but is not as steep and does not show signs of erosion.

Figure 7: Map of 3.2km of trail walked in Skyline Park and mapped using the Trailforks app (Sourced from: https://maps.gov.bc.ca/ess/hm/imap4m/)



3.2 Vegetation Survey

Through the vegetation survey the total distance measured along the three transects for each plot was used to calculate the cover and relative cover for all species observed in each sample plot (Appendix K). For all species observed, the total distance covered in all plots and the number plots a species occurred

out of the twelve plots were used to determine the cover, relative cover, frequency and relative frequency of occurrence for the entire site (Appendix L).

Spotted knapweed (*Centaurea maculosa*) was observed to be present in ten of the twelve sites in various amounts and the results were analyzed to determine its effects on native grasses (Table 3). Sites (SLP1, SLP6, and SLP7) with more cover of native grasses, rough fescue (*Fescuta scabrella*), bluebunch wheatgrass (*Agropyron spicatum*), Sandberg bluegrass (*Poa secunda*) and Junegrass (*Koeleria macrantha*), had less cover of spotted knapweed (*Centaurea maculosa*) and non-native grasses, Kentucky bluegrass (*Poa prantensis*), cheatgrass (*Bromus tectorum*), crested wheatgrass (*Agropyron cristatum*), smooth brome (*Bromus inermis* ssp. *inermis*) and quackgrass (*Agropyron repens*). In comparison, sites SLP3 and SLP5 were observed to have increased cover of spotted knapweed (*Centaurea maculosa*) and non-native grasses and decreased cover of native grasses. These observations demonstrate when dense stands of spotted knapweed (*Centaurea maculosa*) and non-native grasses are established, they can outcompete native species.

Sites (SLP2 and SLP8) were observed to have more tree, interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) and Ponderosa pine (*Pinus ponderosa*), and native grass cover, and had reduced cover of spotted knapweed (*Centaurea maculosa*) and non-native grasses. This observation could be due to the shade intolerance of spotted knapweeds (*Centaurea maculosa*) (ISCBC, 2014). However, forested sites (SLP10 and SLP12) that appeared to be affected by landscape disturbance from the residential development above Skyline Park appear to have increased cover of spotted knapweed (*Centaurea maculosa*) and non-native grasses than in the undisturbed forested sites (SLP2 and SLP8).

Increased cover of bare ground was observed in sites with thickets of interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) (SLP11 and SLP12). Under the very dense thickets in SLP11 and SLP12 there was a reduction in vegetation cover in the shrub and herb layer and an increase of litter from the trees. In addition to the bare ground under the thicket in SLP12, the site was also disturbed by the addition of material (rock and dirt), likely dumped during the development of the residential area above the park, which is not supporting much vegetation growth.

Table 3: Vegetation survey comparison showing relationship between increased spotted knapweed (Centaurea maculosa), and non-native grass species cover and decreased native grass species cover.

Plot ID	Species (*Scientific Name*)	Total Distance (m)	Cover (%)	Relative Cover (%)

SLP1	Rough Fescue (*Fescuta scabrella*)	55.5	92.5	68.9
	Spotted knapweed (*Centaurea maculosa*)	1.5	2.5	1.9
	Bare ground/moss/lichen	3.0	5.0	3.7
SLP2	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	24.2	40.3	22.0
	Rough Fescue (*Fescuta scabrella*)	57.4	95.7	52.3
	Bluebunch wheatgrass (*Agropyron spicatum*)	0.6	1.0	0.5
	Spotted knapweed (*Centaurea maculosa*)	0.4	0.7	0.4
	Bare ground/moss/lichen	3.5	5.8	3.2
SLP3	Kentucky bluegrass (*Poa pratensis*)	60.0	100.0	50.9
	Spotted knapweed (*Centaurea maculosa*)	27.5	45.8	23.3
	Cheatgrass (*Bromus tectorum*)	0.7	1.2	0.6
	Rough Fescue (*Fescuta scabrella*)	0.5	0.8	0.4
	Crested wheatgrass (*Agropyron cristatum*)	0.2	0.3	0.2
	smooth brome (*Bromus inermis* ssp. *inermis*)	0.1	0.2	0.1
SLP4	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	40.1	66.8	24.1
	Rough Fescue (*Fescuta scabrella*)	46.8	78.0	28.2
	Kentucky bluegrass (*Poa pratensis*)	26.8	44.7	16.1
	Bluebunch wheatgrass (*Agropyron spicatum*)	10.7	17.8	6.4
	Bare ground/moss/lichen	35.3	58.8	21.2
SLP5	Kentucky bluegrass (*Poa pratensis*)	53.2	88.7	38.1
	Rough Fescue (*Fescuta scabrella*)	40.8	68.0	29.2
	Spotted knapweed (*Centaurea maculosa*)	30.6	51.0	21.9
	Bluebunch wheatgrass (*Agropyron spicatum*)	1.2	2.0	0.9
SLP6	Rough Fescue (*Fescuta scabrella*)	33.2	55.3	38.1
	Sandberg bluegrass (*Poa secunda*)	8.9	14.8	10.2
	Bluebunch wheatgrass (*Agropyron spicatum*)	8.2	13.7	9.4
	Cheatgrass (*Bromus tectorum*)	2.2	3.7	2.5
	Spotted knapweed (*Centaurea maculosa*)	0.2	0.3	0.2
	Bare ground/moss/lichen	16.2	27.0	18.6
SLP7	Rough Fescue (*Fescuta scabrella*)	56.6	94.3	52.8
	Bluebunch wheatgrass (*Agropyron spicatum*)	6.0	10.0	5.6
	Junegrass (*Koeleria macrantha*)	1.8	3.0	1.7
	Sandberg bluegrass (*Poa secunda*)	0.4	0.7	0.4
	Spotted knapweed (*Centaurea maculosa*)	0.1	0.2	0.1
	Bare ground/moss/lichen	5.4	9.0	5.0
SLP8	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	24.8	41.3	20.5
	Rough Fescue (*Fescuta scabrella*)	33.4	55.7	27.6
	Bluebunch wheatgrass (*Agropyron spicatum*)	24.9	41.5	20.6
	Kentucky bluegrass (*Poa pratensis*)	4.1	6.8	3.4
	Crested wheatgrass (*Agropyron cristatum*)	2.2	3.7	1.8
	Cheatgrass (*Bromus tectorum*)	1.4	2.3	1.2

	Junegrass (*Koeleria macrantha*)	0.6	1.0	0.5
	Spotted knapweed (*Centaurea maculosa*)	0.2	0.3	0.2
	Bare ground/moss/lichen	2.1	3.5	1.7
SLP9	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	18.3	30.5	11.4
	Ponderosa pine (*Pinus ponderosa*)	13.0	21.7	8.1
	Kentucky bluegrass (*Poa pratensis*)	38.0	63.3	23.6
	Rough Fescue (*Fescuta scabrella*)	34.1	56.8	21.2
	Bluebunch wheatgrass (*Agropyron spicatum*)	19.9	33.2	12.4
	Smooth brome (*Bromus inermis* ssp. *inermis*)	2.3	3.8	1.4
	Bare ground/moss/lichen	1.3	2.2	0.8
SLP10	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	21.7	36.2	15.2
	Rough Fescue (*Fescuta scabrella*)	43.8	73.0	30.8
	Bluebunch wheatgrass (*Agropyron spicatum*)	27.1	45.2	19.0
	Kentucky bluegrass (*Poa pratensis*)	11.1	18.5	7.8
	Spotted knapweed (*Centaurea maculosa*)	7.7	12.8	5.4
	Crested wheatgrass (*Agropyron cristatum*)	0.6	1.0	0.4
	Junegrass (*Koeleria macrantha*)	0.5	0.8	0.4
	Bare ground/moss/lichen	2.9	4.8	2.0
SLP11	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	24.8	41.3	24.1
	Rough Fescue (*Fescuta scabrella*)	45.5	75.8	44.1
	Bluebunch wheatgrass (*Agropyron spicatum*)	6.3	10.5	6.1
	Kentucky bluegrass (*Poa pratensis*)	4.0	6.7	3.9
	Spotted knapweed (*Centaurea maculosa*)	2.9	4.8	2.8
	Cheatgrass (*Bromus tectorum*)	0.5	0.8	0.5
	Bare ground/moss/lichen	4.5	7.5	4.4
SLP12	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	17.2	28.7	14.7
	Ponderosa pine (*Pinus ponderosa*)	6.0	10.0	5.1
	Kentucky bluegrass (*Poa pratensis*)	32.8	54.7	28.1
	Spotted knapweed (*Centaurea maculosa*)	15.7	26.2	13.5
	Bluebunch wheatgrass (*Agropyron spicatum*)	12.6	21.0	10.8
	Rough Fescue (*Fescuta scabrella*)	1.9	3.2	1.6
	Cheatgrass (*Bromus tectorum*)	1.4	2.3	1.2
	Quackgrass (*Agropyron repens*)	0.7	1.2	0.6
	Bare ground/moss/lichen	16.3	27.2	14.0

Note: See Appendix M for sample calculations of cover and relative cover.

I mapped the locations of the centre of all patches observed though out the park (Figure 8) with the coordinates in Appendix N. The patches varied in size and density of spotted knapweed (*Centaurea maculosa*), which were not all captured in the vegetation surveys as not all patches were surveyed. The

map demonstrates that the grassland portion of Skyline Park is more infested with spotted knapweed than the forested areas.

During the vegetation surveys, some seed heads of spotted knapweed (*Centaurea maculosa*) were observed to have exit holes consistent with the presence of *Larinus minutus* larvae (Figure 9 and Figure 10). These observations lead me to believe that there is a population of *L. minutus* present in Skyline Park through either a release directly to the site or migration from another release location.

Figure 8: Observed spotted knapweed (Centaurea maculosa) patch locations taken at the centre of each patch in Skyline Park (Sourced from: https://www.google.com/maps).

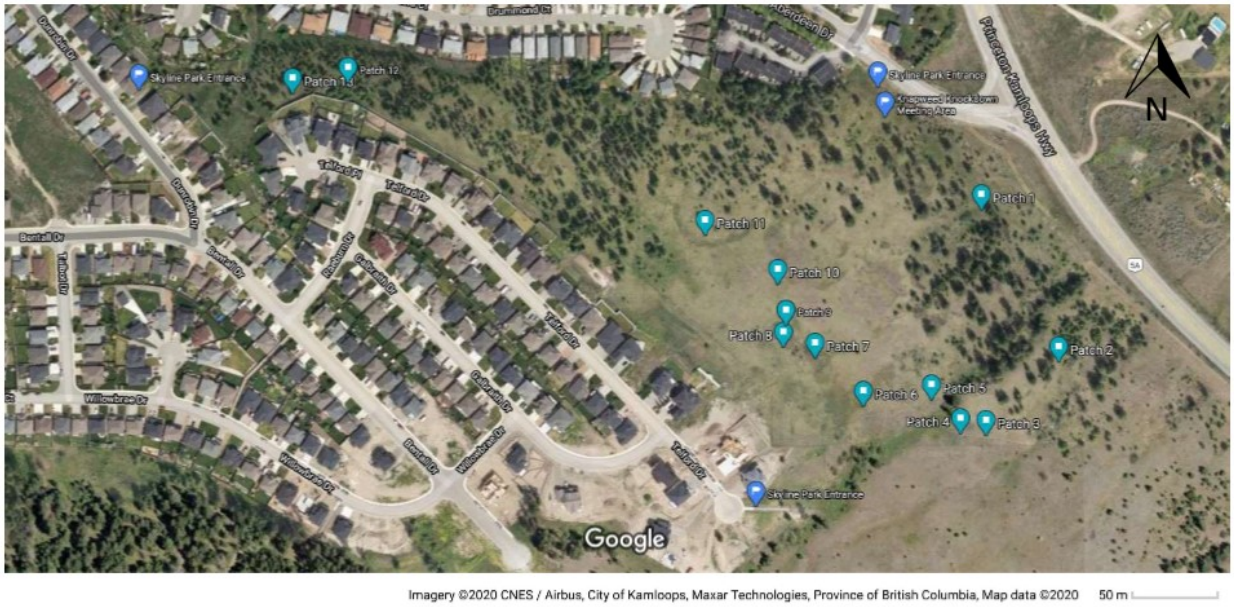


Figure 9: Spotted knapweed (Centaurea maculosa) seed head with exit hole of L. minutus in Skyline Park.

Figure 10: Spotted knapweed (Centaurea maculosa) seed head with exit hole of L. minutus (Powell, Sturko, Wikeem & Harris, 1994).

3.3 Tree Stem Count

The vegetation survey plots containing trees were surveyed to determine the density and cover of the tree species in each plot. The circumference at breast height (CBH) was used to determine the diameter at breast height (DBH), which was used to calculate the basal area coverage and relative coverage (Appendix O, sample calculations Appendix P). The total area of each plot surveyed was 400 m^2. The Coverage Relative Coverage and the Canopy cover for each plot is summarized in Table 4 and the determined tree density is summarized in Table 5.

Table 4: Basal Area, Coverage and Canopy Coverage for all vegetation plots containing trees

Plot ID	Species (*Scientific Name)*	Total Basal Area (m^2)	Coverage (%)	Relative Coverage (%)	Canopy Cover (%)
SLP2	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	0.351	0.088	100	20
SPL4	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	0.651	0.163	100	45
SPL5	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	0.003	0.001	100	5
SPL7	Trembling Aspen (*Populus tremuloides*)	0.012	0.003	100	25
SLP8	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	0.691	0.173	97.09	35
	Ponderosa pine (*Pinus ponderosa*)	0.021	0.005	2.91	
SLP9	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	0.239	0.060	82.6	45
	Ponderosa pine (*Pinus ponderosa*)	0.050	0.013	17.4	
SLP10	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	0.446	0.112	100	45
SLP11	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	0.416	0.104	98.62	50
	Ponderosa pine (*Pinus ponderosa*)	0.006	0.001	1.38	
SLP12	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	0.122	0.030	58.29	50
	Ponderosa pine (*Pinus ponderosa*)	0.087	0.022	41.71	

Table 5: Tree Density and Relative Density for all vegetation plots containing trees.

Plot ID	Species (*Scientific Name)*	Number of trees >3m	Number of Trees <3m	Total # of Trees	Density (Tree/ Hectare)	Relative Density (%)
SLP2	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	5	2	7	175	100
SLP4	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	25	6	31	775	96.9
	Ponderosa pine (*Pinus ponderosa*)	0	1	1	25	3.1
SLP5	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	1	1	2	50	66.7
	Ponderosa pine (*Pinus ponderosa*)	0	1	1	25	33.3
SLP7	Trembling Aspen (*Populus tremuloides*)	5	29	34	850	100
SLP8	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	5	1	6	150	85.7
	Ponderosa pine (*Pinus ponderosa*)	1	0	1	25	14.3
SLP9	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	9	4	13	325	56.5

	Ponderosa pine (*Pinus ponderosa*)	8	2	10	250	43.5
SLP10	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	12	1	13	325	100.0
SLP11	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	16	9	25	625	92.6
	Ponderosa pine (*Pinus ponderosa*)	1	1	2	50	7.4
SLP12	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	27	27	54	1350	88.5
	Ponderosa pine (*Pinus ponderosa*)	4	3	7	175	11.5

By comparing the sites canopy cover and tree density, plots with thickets (SLP11 and SLP12) are observed to have significantly higher tree density than in several of the other open forest plots. Thickets observed in SLP11 and SLP12 had a higher density of trees in a smaller portion of the plot (675 and 1525 trees/hectare, respectively), compared to other plots, which ranged from a density of 75 to 850 trees/hectare. SLP4 has a total density of 800 trees per hectare in comparison to the 675 and 1525 trees per hectare in plots SLP11 and 12, respectively. However, the trees in SLP4 (Figure 11) are more evenly spaced through out the entire site in contrast to concentrated in one part of the plot as observed in SLP11 and SLP12 (Figure 12). SLP11 and SLP12 also had the highest estimated canopy cover with both plots having 50% canopy cover. The forests of the bunchgrass BEC zones are usually open and park like, however these forests can experience ingrowth as is seen in the first SLP11 and SLP12 possibly due to climatic shifts and changes to fire disturbance regime (GCCBC & BEI, 2008). The increased ingrowth of interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) can result in succession from grassland species that would be present in the open forest, to more shade tolerant species, or in the most shaded areas, such as the thickets in plot SLP11 and SLP12, very little to no herbaceous understory (GCCBC & Biospherics Environmental Inc., 2008).

Figure 11: Vegetation plot SLP4 with total 800 trees/hectare.

Figure 12: Vegetation plot SLP11 with total 675 trees/hectare.

3.4 Biological Release Site Vegetation Survey

The two biological release sites were selected for their high cover of spotted knapweed, which is observed in all four quadrats of each of the two sites ranging from 55% to 90% cover by spotted knapweed (*Centaurea maculosa*) (Table 6, Figure 13 and Figure 14). The higher cover of spotted knapweed (*Centaurea maculosa*) demonstrates how it is out competing the native vegetation.

Table 6: Pre-release vegetation survey for biological control release sites.

Plot ID	Quadrat	Species (*Scientific Name*)	Cover (%)
SLBR1	NW	Spotted knapweed (*Centaurea maculosa*)	75
		Rough Fescue (*Fescuta scabrella*)	20
		Yarrow (*Achillea millefolium*)	2
		Silky lupine (*Lupinus sericeus*)	2
		Brown-eyed Susan (*Gaillardia aristata*)	1
	NE	Spotted knapweed (*Centaurea maculosa*)	55
		Rough Fescue (*Fescuta scabrella*)	20
		Bluebunch wheatgrass (*Agropyron spicatum*)	10
		Yarrow (*Achillea millefolium*)	5
		Bare ground/moss/lichen	10
	SE	Spotted knapweed (*Centaurea maculosa*)	80
		Rough Fescue (*Fescuta scabrella*)	10
		Bluebunch wheatgrass (*Agropyron spicatum*)	5
		Old man's whiskers (*Geum triflorum*)	3
		Pasture sage (*Artemisia frigida*)	1
		Large-fruited desert-parsley (*Lomatium macrocarpum*)	1
	SW	Spotted knapweed (*Centaurea maculosa*)	90
		Rough Fescue (*Fescuta scabrella*)	5
		Bluebunch wheatgrass (*Agropyron spicatum*)	5
SLBR2	NW	Spotted knapweed (*Centaurea maculosa*)	90
		Kentucky bluegrass (*Poa pratensis*)	5
		Sticky geranium (*Geranium viscosissimum*)	2
		Parsnip flower buckwheat (*Eriogonum heracleoides*)	2
		Yarrow (*Achillea millefolium*)	1
	NE	Spotted knapweed (*Centaurea maculosa*)	90
		Kentucky bluegrass (*Poa pratensis*)	5
		Parsnip flower buckwheat (*Eriogonum heracleoides*)	2
		Bare ground/moss/lichen	3
	SE	Spotted knapweed (*Centaurea maculosa*)	80
		Rough Fescue (*Fescuta scabrella*)	10
		Bluebunch wheatgrass (*Agropyron spicatum*)	5
		Yarrow (*Achillea millefolium*)	5

		Sticky geranium (*Geranium viscosissimum*)	<1
		Parsnip flower buckwheat (*Eriogonum heracleoides*)	<1
	SW	Spotted knapweed (*Centaurea maculosa*)	85
		Rough Fescue (*Fescuta scabrella*)	10
		Yarrow (*Achillea millefolium*)	<1
		Bare ground/moss/lichen	5

Figure 13: Biological release site SLBR1.

Figure 14: Biological release site SLBR2.

3.5 Bird Survey

Several species were observed in Skyline park during the bird survey (Table 7), including the Lewis's Woodpecker (*Melanerpes lewis*), which is Blue listed as a native species of special concern in British Columbia (B.C. Conservation Data Centre, 2020). A female mule deer (*Odicolius hemionus*) and a Coyote (*Canis latrans*) were also observed at different times during the bird survey in Skyline Park.

Table 7: Summary of bird survey species and total number of birds observed.

Species (*Scientific Name*)	**Number of Birds**
American Goldfinch (*Carduelis tristis*)	1
American Kestrel (*Falco sparverius*)	6
Black-billed Magpie (*Pica hudsonia*)	14
Black-capped Chickadee (*Parus atricapillus*)	3
Dark-eyed Junco (*Junco hyemalis*)	6
House Finch (*Haemorhous mexicanus*)	1
Lewis's Woodpecker (*Melanerpes lewis*)	2

Northern Flicker (*Colaptes auratus*)	2
Red-breasted Nuthatch (*Sitta canadensis*)	1
Western Tanager (*Piranga ludoviciana*)	1
Yellow-rumped Warbler (*Setophaga coronata*)	2

3.6 Pellet Count

The data collected was used to determine the relative density and relative frequency of the species that observed in the pellet count (Table 8). This data and the observed animals during the bird count confirm that Skyline Park provided habitat to several species including mule deer (*Odocoileus* hemionus) and coyote (*Canis latrans*).

Table 8: Density and frequency of pellet occurrence summary

Species (*Scientific Name*)	**Density Per m²**	**Relative Density (%)**	**Frequency**	**Relative Frequency (%)**
Mule Deer (*Odocoileus hemionus*)	0.013	66.7	0.013	66.7
Coyote (*Canis latrans*)	0.007	33.3	0.007	33.3
Total	**0.020**		**0.020**	

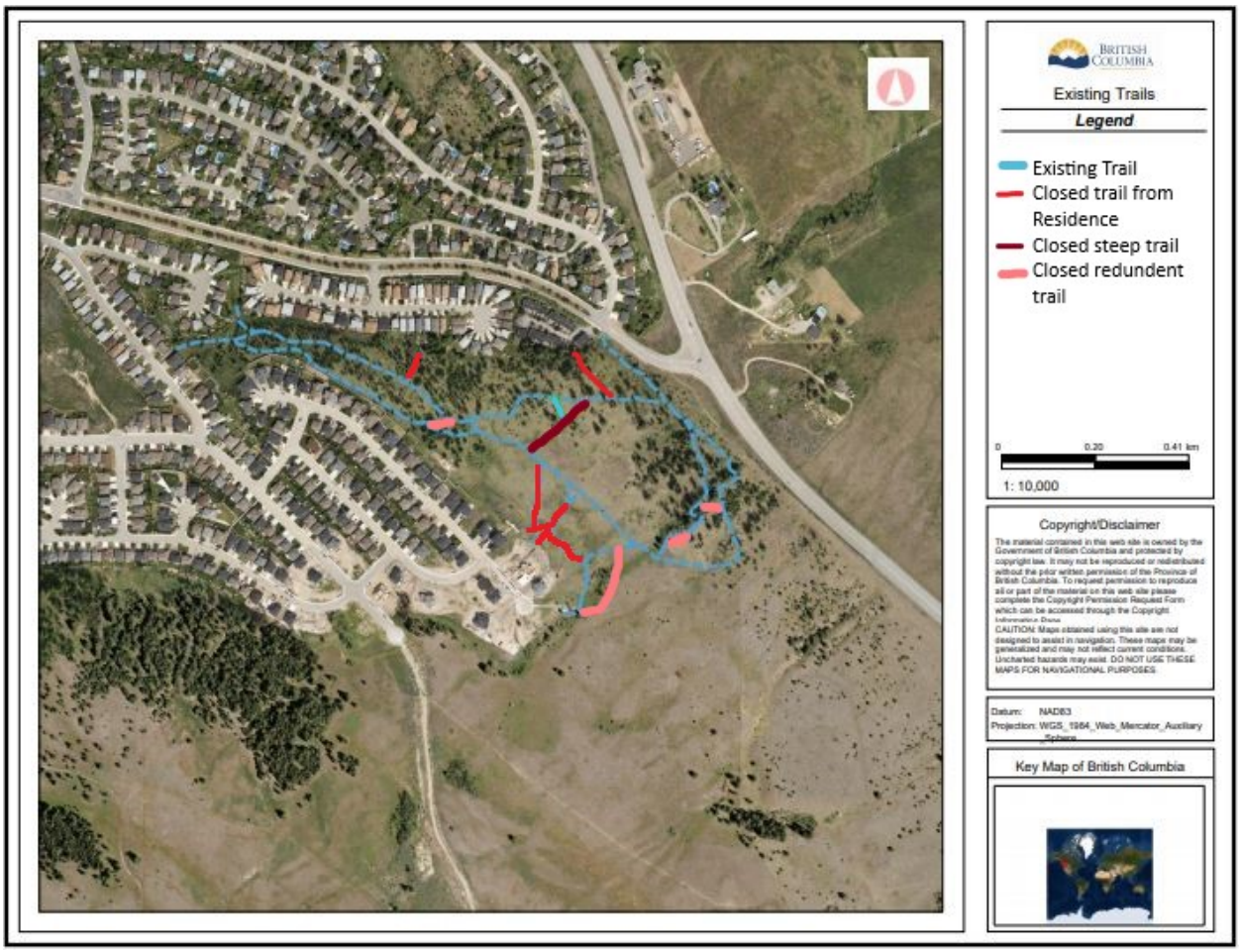
4.0 Actions

I identified several trails for closure in the mapping of the Skyline Park trail system and restored the unnecessary trails to reduce ecosystem fragmentation and soil erosion. I identified several patches of spotted knapweed (*Centaurea maculosa*) in the through the vegetation survey and performed a restoration to increase native species richness, increase herbaceous forage for wildlife, and educate park users on spread prevention To complete the restoration actions, I received support from the City of Kamloops, BC Wildfire Service, the Kamloops Naturalist Club, the Aberdeen Neighborhood Association, Thompson-Nicola Regional District Invasive Plant Management Committee (TNIPMC), and Agrowest Consulting Scientists.

4.1 Trail Selection, Closure and Building

Through mapping of the trail system, I identified that there was 3.2 km of trail running through the ten-hectare Skyline Park (320m/Ha). I identified several trails that were redundant, as they were close together and ran parallel to the same place, came from private property or were on too high of a slope angle, which was leading to soil erosion on the trail. On April 12, 2019, I met with Kirsten Wourms to review the trail map I created on April 10, 2019 and we selected several trails to be closed and restored to reduce the ecosystem fragmentation and soil erosion in Skyline Park (Figure 15).

Figure 15: Skyline Park modified trails map (Sourced from: https://maps.gov.bc.ca/ess/hm/imap4m/)



On April 18, 2019, I met with Kirsten Wourms and crew to build a more defined trail from the entrance at the end of Telford Drive and close several of the existing trails. The entrance trail was made more defined with the use of a rototiller, pickaxes and shovels to disturb the cut the vegetation and form a single-track trail. Trails selected for closure were raked to disturb the compacted soils, and then seeded with a native seed "stump mix" (Table 9), which is one method that the City of Kamloops uses for closing trails. To camouflage closed trails from park users, we raked the grass adjacent to trails and placed the thatch over the trail, as well as moved some coarse woody debris from surrounding area to block trails from use. Some trails were not as well defined as others and were just camouflaged to allow for vegetation regrowth. Closing of the selected trails resulted in a reduction of the total trail length to approximately 2.5 km (250m/Ha) in Skyline Park.

Table 9: Native Seed "Stump mix" used by City of Kamloops for trail restoration.

Common Name (*Scientific Name*)	**Percent of Seed Mix by weight (%)**
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	33
Annual Ryegrass (*Lolium multiflorum*)	20
Rough fescue (*Festuca scabrella*)	19
Rocky mountain fescue (*Festuca saximontana*)	16
Sandberg bluegrass (*Poa secunda*)	9

Kirsten Wourms marked trails that were to be built to be more defined and contacted the BC Wildfire Service for assistance in building the trails, which they have previously done for the City of Kamloops as practice in building fire guards. The BC Wildfire Service built trails throughout the month of May when they had time available. In the spring of 2020, the City of Kamloops will name the trails and the Geographic information Systems (GIS) department will create trail systems maps to be posted at the entrances of Skyline Park.

4.2 Spotted knapweed (*Centaurea maculosa*) Removal

Three methods recommended in the control of spotted knapweed (*Centaurea maculosa*) by the Invasive Species Council of BC (2014) were applied to restore of native species richness, increase herbaceous forage for wildlife in Skyline Park and educate park users on spread prevention. The methods of control applied were prevention, manual removal and biological control application. Revegetation of native grasses was left to occur naturally in treated areas except for a trial patch, which was planted with plugs of the Native seed "Stump Mix" provided by the City of Kamloops.

4.2.1 Prevention by Community Awareness and Education

To educate and encourage further involvement in the community, I will be doing a presentation on this restoration project to the Aberdeen Neighborhood Association, Kamloops Naturalist Club and any interested members of the community on this project on May 11, 2020. Permanent signage will be installed by the City of Kamloops at the entrances of Skyline Park next to the trail map to provide park users with information about spotted knapweed (*Centaurea maculosa*) and its effects on the ecosystem. The sign will encourage park users to help prevent the spread of spotted knapweed (*Centaurea maculosa*) by staying out of patches (including pets), and removing plant seeds and parts from personal clothing, gear and pets before leaving infested sites. The sign will provide information on proper disposal of spotted knapweed (*Centaurea maculosa*) by either twisting and bending the stem to be left onsite prior to flowering or bagging and removing from site to the landfill when flowers are present. This will hopefully encourage community involvement in the removal of spotted knapweed (*Centaurea maculosa*) along trails as individual users or organized groups.

There is currently species information board in the middle of the grasslands at a bench that is weathered and faded. This board had photos and names of different species of vegetation and wildlife that is observed in Skyline Park. The information from the vegetation survey and bird count will be used to update the board and replace current one. This will provide park users with a spot to observe the grasslands and a tool to identify some of the common species in Skyline Park.

4.2.2 Manual Removal of Spotted knapweed (*Centaurea maculosa*)

Manual removal is one method recommended by the Invasive Species Council of BC (2014) and is found to be most effective with the removal of the root system to prevent re-sprouting. If spotted knapweed (*Centaurea maculosa*) has flowered, then the removed plants need to be bagged and removed from site (ISCBC, 2014). I organized two events with the assistance of Jesse Ritcey with the Kamloops Naturalist Club (KNC) and support from Helen Newmach with the Aberdeen Neighborhood Association (ANA) to remove spotted knapweed (*Centaurea maculosa*) from Skyline Park. The KNC entered the TNIPMC "Weed Warrior Challenge," to compete for a $250 honorarium, which they planned to use to support their NatureKids program, offering environmental education to youth. The TNIPMC donated snacks and bottled water for volunteers and the City of Kamloops provided garbage bags and removal.

Twenty volunteers on July 14 and eight volunteers on September 8, 2019, from the KNC and ANA arrived at Skyline Park. I gave a brief presentation on how to identify spotted knapweed (*Centaurea maculosa*) and its effect on the ecosystem. I lead each group of volunteers to a patch of spotted knapweed (*Centaurea maculosa*) where I had performed a vegetation survey (SLP5). As we walked to the patch, we removed any spotted knapweed (*Centaurea maculosa*) that was found within three meters of the trail. Once we reached the patch pulled, cut and bagged spotted knapweed (*Centaurea maculosa*) for two and a half hours on each of the two days (Figure 16). The bags were carried to the meeting area at the park entrance on Aberdeen Drive, where they were weighed for the "Weed Warrior Challenge" by representatives from the TNIPMC, Mike Dedels on July 14 and Coleen Hougen on September 8. Volunteers removed 234 kg (Figure 17) and 114 kg of spotted knapweed on July 14th and September 8th, respectively. I provided volunteers with barbequed hotdogs as a thank you for supporting the project. The bags of spotted knapweed (*Centaurea maculosa*) were removed from site by the City of Kamloops Natural Resources crew and taken to be disposed of at the Mission Flats Landfill, 3095 Mission Flats Rd, Kamloops.

The initial cover of spotted knapweed (*Centaurea maculosa*) measured in the patch during the vegetation survey (SLP5) was 51% (Table 3). After the two invasive pulls I returned to the patch and

estimated the cover of spotted knapweed (*Centaurea maculosa*) to be approximately 5%. The total area of the treated patch was approximately 2,000 m^2, not including any area treated along the path.

Figure 16: Map of removal area in Skyline Park (Sourced from: https://maps.gov.bc.ca/ess/hm/imap4m/)

Figure 17: Knapweed knock down pile of 234 kg of spotted knapweed (Centaurea maculosa).

4.2.3 Biological Release

On August 9, 2019, I met with Sophie Church at Skyline Park to release 100 *Cyphocleonus achates* root feeder beetles at each of biological release sites that I surveyed. *C. achates* attacks spotted knapweed (*Centaurea maculosa*) roots by laying eggs in the root crown (Powell, et al., 1994). The larvae hatch 10-12 days later and then feed on the root as they tunnel through it overwinter (Powell, et al., 1994). The *C. achates* were collected the day before by Dr. Catherine Tarasoff, P. Ag and Sophie Church, from Agrowest Consulting Scientists. The biological release plots (SLBR1 and SLBR2) were chosen because they were dense stands of spotted knapweed (*Centaurea maculosa*), which is required for the release because *C. achates* distributes themselves by walking and does not fly (Powell, et al., 1994) (Figure 18 and Figure 19).

Figure 18: Container of C. achates for released.

Figure 19: C. achates on lid of container.

The release sites will be monitored by Dr. Catherine Tarasoff, P. Ag in the summer of 2020 to determine the survival and population establishment, then every five years to evaluate spotted knapweed (*Centaurea maculosa*) attributes.

During the vegetation survey, larvae exit holes were observed in the seed heads of spotted knapweed (*Centaurea maculosa*) that indicates a population of *L. minutus* is already present in the study area. During the second weed pull on September 8th, 2019, Coleen Hougen found that a population of *C. achates* may already be present as in the study area. We observed larvae tunnelling through a spotted

knapweed (*Centaurea maculosa*) root that was pulled close (approximately 20 m) to the biological release site (SLBR1) (Figure 20).

Figure 20: C. achates larvae observed in root during Knapweed Knock Down on September 8, 2019.

4.2.4 Native Grasses Revegetation

In SLP5, Kentucky bluegrass (*Poa pratensis*) was found to be present with 88.6 cover and 38.14% relative cover to all other species in the plot (Table 3). Three hundred plugs of the City of Kamloops Native Seed "Stump Mix" (Table 9) was grown in their green house over the summer. On October 21, 2019, a City of Kamloops Natural Resources crew member and I planted 300 plugs randomly spaced in a 3m (angle perpendicular to aspect) by 15m (angle of aspect) plot (Appendix S and Appendix T). This was done as a trial to determine if planting plugs of native grass would encourage reestablishment of the native species faster than if left to occur naturally from the existing native vegetation in the area where spotted knapweed (*Centaurea maculosa*) was removed.

5.0 Discussion

I identified that thicket formation is likely causing succession to shade tolerant species and bare ground in what is typically open forest of the BGxw1 BEC zone and have prepared a restoration prescription for the reduction of tree density in thickets for the City of Kamloops to consider. Due to seeds remaining viable in the soil for up to 15 years, monitoring and adaptive management is suggested to continue for several years after all spotted knapweed (*Centaurea maculosa*) has been removed from the study area (ISCBC, 2014).

5.1 Recommended Thinning, Pruning and Revegetating of Thickets

The formation of thickets of Douglas-fir fir (*Pseudotsuga menziesii* var. *glauca*) is partly a result of changes to the fire regimes by fire suppression in this area, which would under normal conditions eliminate the litter around the base of the trees and burn some of the seedlings in the understory resulting in the open parklike forest (GCCBC & Biospherics Environmental Inc., 2008). The BC Forest Practices Board (2015) recognizes that fire is a natural disturbance regime for many ecosystems in British Columbia and that the fire suppression over the last number of years has led to a build up of fuels. Thinning, pruning, and cleaning the debris from forest floors in these areas will reduce the impact of a potential fire in this area, as well as allow for light penetration to the forest floor allowing for succession to the vegetation typical in the open grassland forest of the BGxw1 BEC zone.

I recommend selective removal of interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) to create the spacing observed in other open grassland forested areas while retaining as many of the tallest trees as possible. Thinning should be done to ensure that the crowns do not overlap (approximately 3-6 metre spacing) (BC Forest Practices Board, 2015). Where it will not harm the tree, branches below three metres should be removed from trees to reduce ladder fuels and the risk of crown fire during a wildfire (BC Forest Practices Board, 2015). Trees and limbs should be removed from site to reduce fuels in the park. Thinning of trees in thickets will allow for sunlight penetration to the herb and shrub layers, encouraging succession back to open grassland forest species.

5.2 Recommended Monitoring and Adaptive Management

The biological release sites will be monitored in the spring of 2020 for population establishment and survival of *C. achates* by Dr. Catherine Tarasoff, P. Ag, from Agrowest Consulting Scientists. The attributes of spotted knapweed (*Centaurea maculosa*) will be monitored every five years to determine the effectiveness of the biological control agents released. If the use of the biological control agent is found to be successful in future monitoring, I suggest performing multiple releases of *C. achates* in the large patches through out Skyline Park, as *C. achates* is a beetle that is slow to migrate. The City of Kamloops should confirm that a population of *L. minutus* is present in Skyline Park, as studies have shown that the combination of root feeder and seed feeder biological controls most effective in reducing the physical attributes and seed production of spotted knapweed (*Centaurea maculosa*).

Manual removal is need annually to be an effective method of combating spotted knapweed (*Centaurea maculosa*). Manual removal events organized by the City of Kamloops, volunteer groups, such as the Aberdeen Neighborhood Association and Kamloops Naturalist Club, or individuals could help by clearing

patches of spotted knapweed (*Centaurea maculosa*) or areas on three metres on either side of the trails clear to help prevent further spread of spotted knapweed (*Centaurea maculosa*).

Trail closure should be monitored annually to ensure that closed trails remain closed and are successfully revegetated. If initial trail closure is unsuccessful then further measures should be taken by the City of Kamloops to block trails from use with signs and temporary fencing. If revegetation on trails is not successful through seeding with native grasses "Stump mix," then consideration should be given to planting plugs on closed trails to accelerate revegetation.

5.3 Project Limitations

The manual removal treatment was effective in removing spotted knapweed (*Centaurea maculosa*) along the trail and in the selected area. However, this method limited by the number of volunteers and hours required to fully treat all affected areas of the park. The effectiveness of this treatment is also limited by the required annual treatment until there is no spotted knapweed (*Centaurea maculosa*) present for several years of monitoring (ISCBC, 2014). Treatment of spotted knapweed (*Centaurea maculosa*) in Skyline Park is also limited by the presence of spotted knapweed (*Centaurea maculosa*) on the private properties adjacent to the park. The removal on private property is the responsibility of the property owner and if owners of affected properties are unwilling to remove spotted knapweed (*Centaurea maculosa*) from their property then seeds will likely spread into the park.

6.0 Conclusions

Skyline Park is experiencing a reduction in biodiversity due to large infestations of spotted knapweed (*Centaurea maculosa*). Manual removal of spotted knapweed (*Centaurea maculosa*) as well as application of biological controls were performed to restore of native species richness and increase herbaceous forage for wildlife in Skyline Park. Information on spotted knapweed (*Centaurea maculosa*) spread prevention will be installed to educate park users. Several selected trails were closed and restored to reduce the density of trails fragmenting the grasslands and forested ecosystems. Some areas are experiencing succession towards shade tolerant species or bare ground due to the amount of litter under thickets of interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), and it is recommended that these be thinned and pruned to restore the areas to open forest and reduce the risk of wildfire. The park provides habitat for many species and acts as a corridor for animals to travel through to the open range lands and forests that it is connected to. It is important that the community is involved in the continued restoration of this ecosystem to ensure the recovery of native biodiversity richness and to reduce their impact on the ecosystem while visiting Skyline Park.

Literature Cited

Antos, J., Coupe, R., Douglas, G., Evans, T., Ignace, M., Lloyd, D., Parish, D., Pojar, R., & Roberts, A. (1996). *Plants of southern interior British Columbia and the inland northwest*. Parish, R., Coupe, R. & Lloyd, D. (Ed.). Vancouver, BC: Lone Pine Publishing

B.C. Conservation Data Centre (2020) BC Species and Ecosystems Explorer. B.C. Ministry of Environment Victoria, B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Mar 17, 2020).

B.C. Forest Practices Board (2015). *Fuel management in the wildland urban interface: Update*. Retrieved from: http://www.llbc.leg.bc.ca/public/pubdocs/bcdocs2015/587963/sir43-fuel-management-update.pdf

B.C. Ministry of Forests and Range & B.C. Ministry of Environment (2010) *Field manual for describing terrestrial ecosystems.* Province of British Columbia, Victoria, BC. Retrieved from: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/invasive-species/publications/field_guide_to_the_biological_control_of_weeds_in_british_columbia.pdf

City of Kamloops: *Pesticide Use Control* Bylaw No. 26-4, (2016). Retrieved from: https://kamloops.civicweb.net/document/41930

City of Kamloops (2016). Urban forest management strategy [PDF document]. Retrieved from City of Kamloops website: https://www.kamloops.ca/sites/default/files/docs/our-community/urbanforestmanagementplan.pdf

City of Kamloops (2019) Skyline Park. Retrieved from https://www.kamloops.ca/parks-recreation/parks/skyline-park

Gayton, D., & Miller, V. (2012*).* Impact of biological control on two knapweed species in British Columbia. *Journal of Ecosystems and Management.* 13(3).

Government of British Columbia (n.d.) iMapBC. Retrieved from: https://maps.gov.bc.ca/ess/hm/imap4m/

Grasslands Conservation Council of BC (GCCBC) & Biospherics Environmental Inc. (BEI) (2008). *An ecological assessment for the Aberdeen area plan, Kamloops, B.C.* Retrieved from: https://www.kamloops.ca/sites/default/files/docs/homes-businesses/aberdeenecologicalassessmentfinal.pdf

Invasive Species Council of BC (ISCBC) (2020). Spotted & diffused knapweed. Retrieved from: https://bcinvasives.ca/invasive-species/identify/invasive-plants/spotted-diffuse-knapweed

Invasive Species Council of BC (ISCBC) (2014) *Knapweeds* [PDF document]. Retrieved from: https://bcinvasives.ca/documents/Knapweed_TIPS_Final_08_06_2014.pdf

Knochel, D. G., & Seastedt, T. R. (2010). Reconciling contradictory findings of herbivore impacts on spotted knapweed (centaurea stoebe) growth and reproduction. *Ecological Applications*, 20(7), 1903-1912. doi:10.1890/09-1944.1

Lloyd, D., Angrove, K., Hope, G., & Thompson, C. (1990). *A guide to site identification and interpretation for the Kamloops forest region.* Victoria, B.C.: Ministry of Forests.

Powell, G.W., Sturko, A., Wikeem, B. M., Harris, P., (1994). *Field guide to biological control of weeds in British Columbia.* Victoria, B.C.: Ministry of Forests.

Ryan, M. (2018). *Plants of the Kamloops Area*. Retrieved from: https://www.kamloopstrails.net/news/plants-of-the-kamloops-area/

Schaefer, V. (Ed.), (2018) *Field Study in Ecological Restoration I: Course Readings*. Victoria, BC: University of Victoria

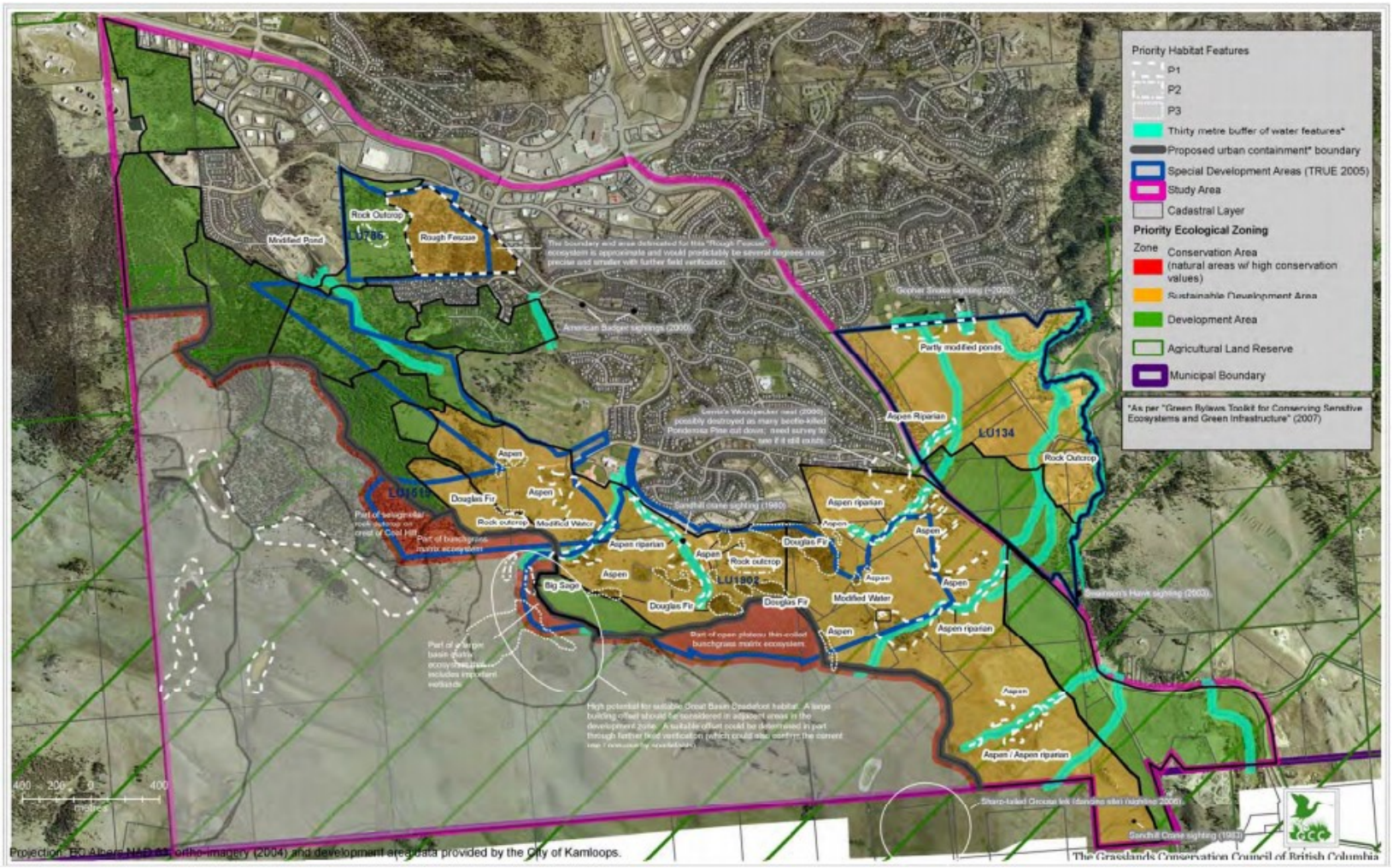
Sheley, R. L., Duncan, C. A., Halstvedt, M. B., & Jacobs, J. S. (2000). Spotted knapweed and grass response to herbicide treatments. *Journal of Range Management*, 53(2), 176-182. doi:10.2458/azu_jrm_v53i2_sheley

Thompson-Nicola Regional District Invasive Plant Committee (2009) [PDF document]. Retrieved from: https://tnrd.civicweb.net/document/11919

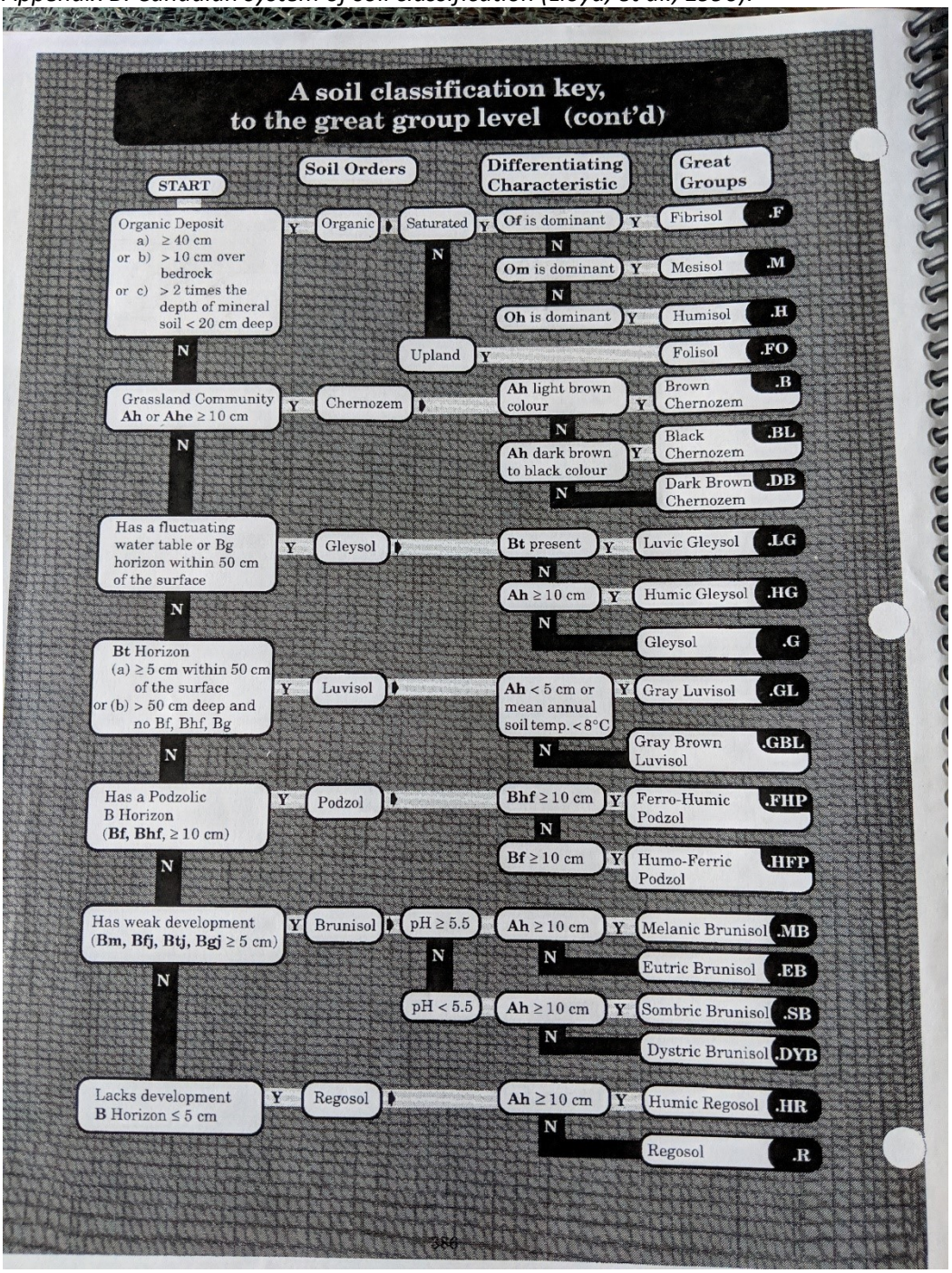
Wooley, S. C., Smith, B., King, C., Seastedt, T. R., & Knochel, D. G. (2011). The lesser of two weevils: Physiological responses of spotted knapweed (centaurea stoebe) to above- and belowground herbivory by larinus minutus and cyphocleonus achates. *Biocontrol Science and Technology*, 21(2), 153-170. doi:10.1080/09583157.2010.534550

Appendix

Appendix A: Map of important habitat features in the Aberdeen Study area in the context of Ecological Zoning and Special Development Areas (GCCBC &BEI, 2008).



Appendix B: Canadian system of soil classification (Lloyd, et al., 1990).

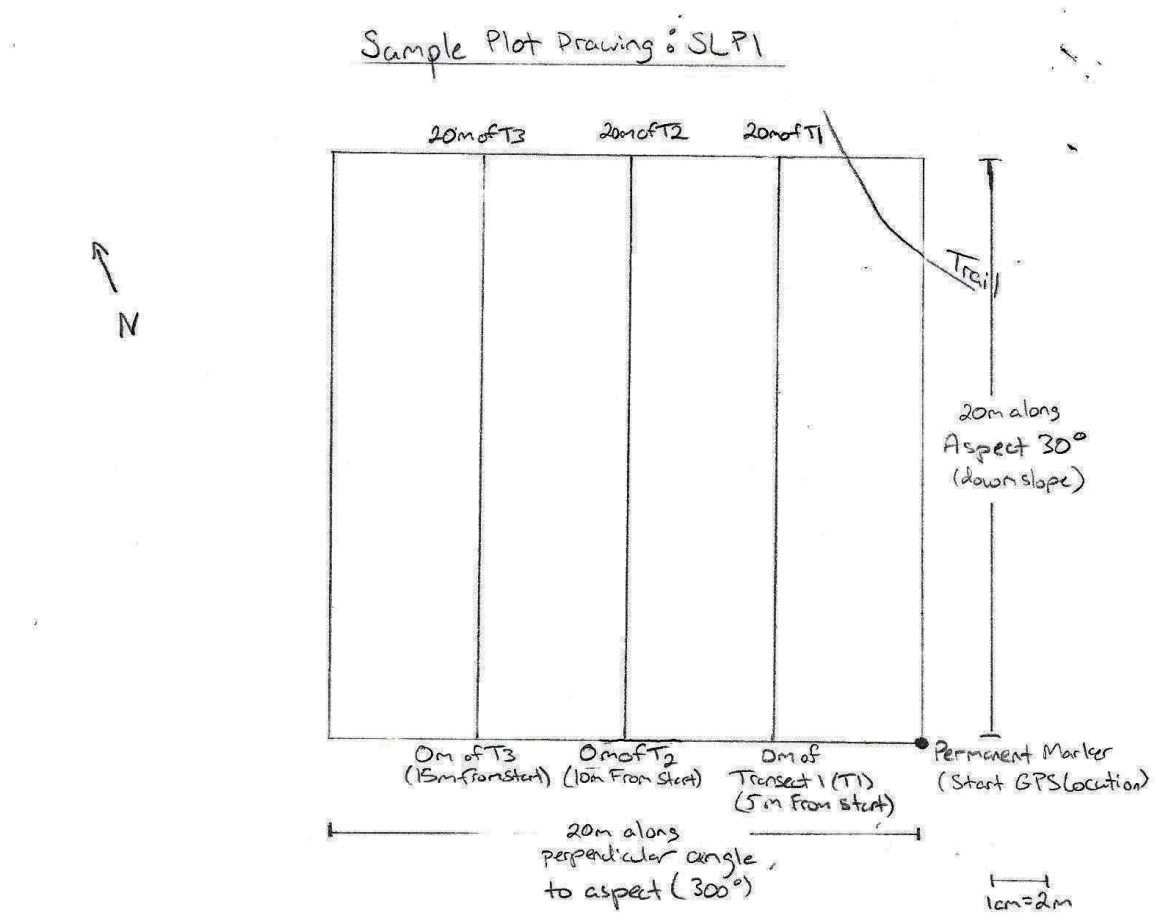


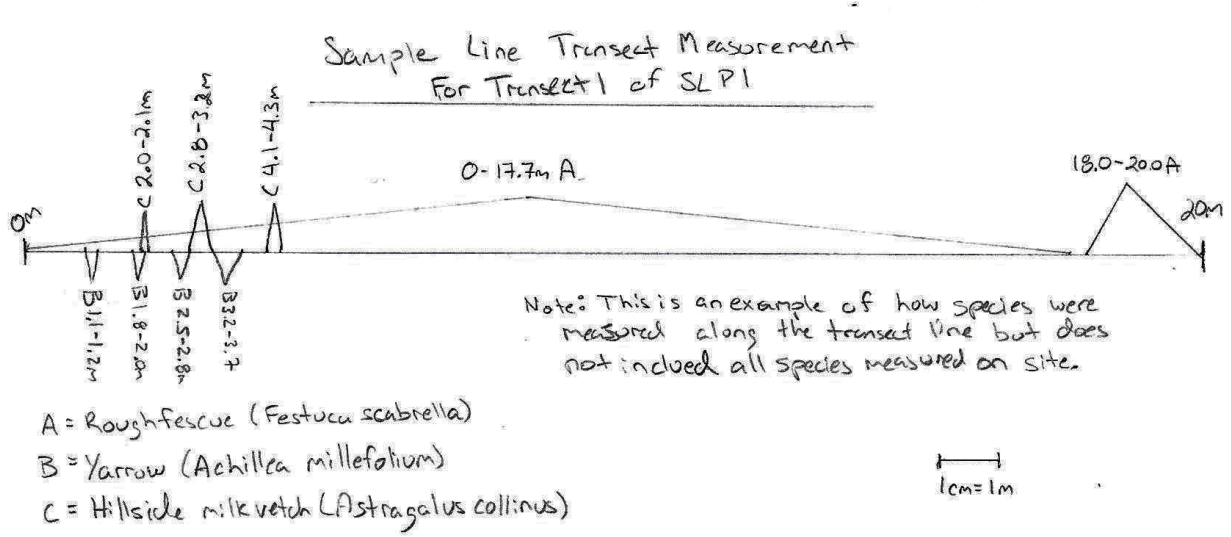
Appendix C: Map of Skyline Park trails created with Trailforks app on Google Pixel 2XL cell phone.

Appendix D: GPS Coordinates and site characteristics for Skyline Park vegetation surveys.

Plot ID	UTM	Easting	Northing	Elevation (m)	Aspect (°)	Slope (%)
SLP1	10U	0687374	5612533	813	30	22
SLP2	10U	0687587	5612544	796	50	25
SLP3	10U	0687464	5612468	804	45	17
SLP4	10U	0687102	5612712	818	32	40
SLP5	10U	0687331	5612617	816	26	12
SLP6	10U	0687469	5612544	805	40	12
SLP7	10U	0687532	5612491	799	45	15
SLP8	10U	0687445	5612678	783	32	30
SLP9	10U	0687211	5612692	789	30	30
SLP10	10U	0687005	5612714	818	0	36
SLP11	10U	0687648	5612502	788	40	21
SLP12	10U	0687040	5612720	823	20	22

Appendix E: Example of vegetation survey plot layout and line transect data collection from SLP1 and Transect 1.

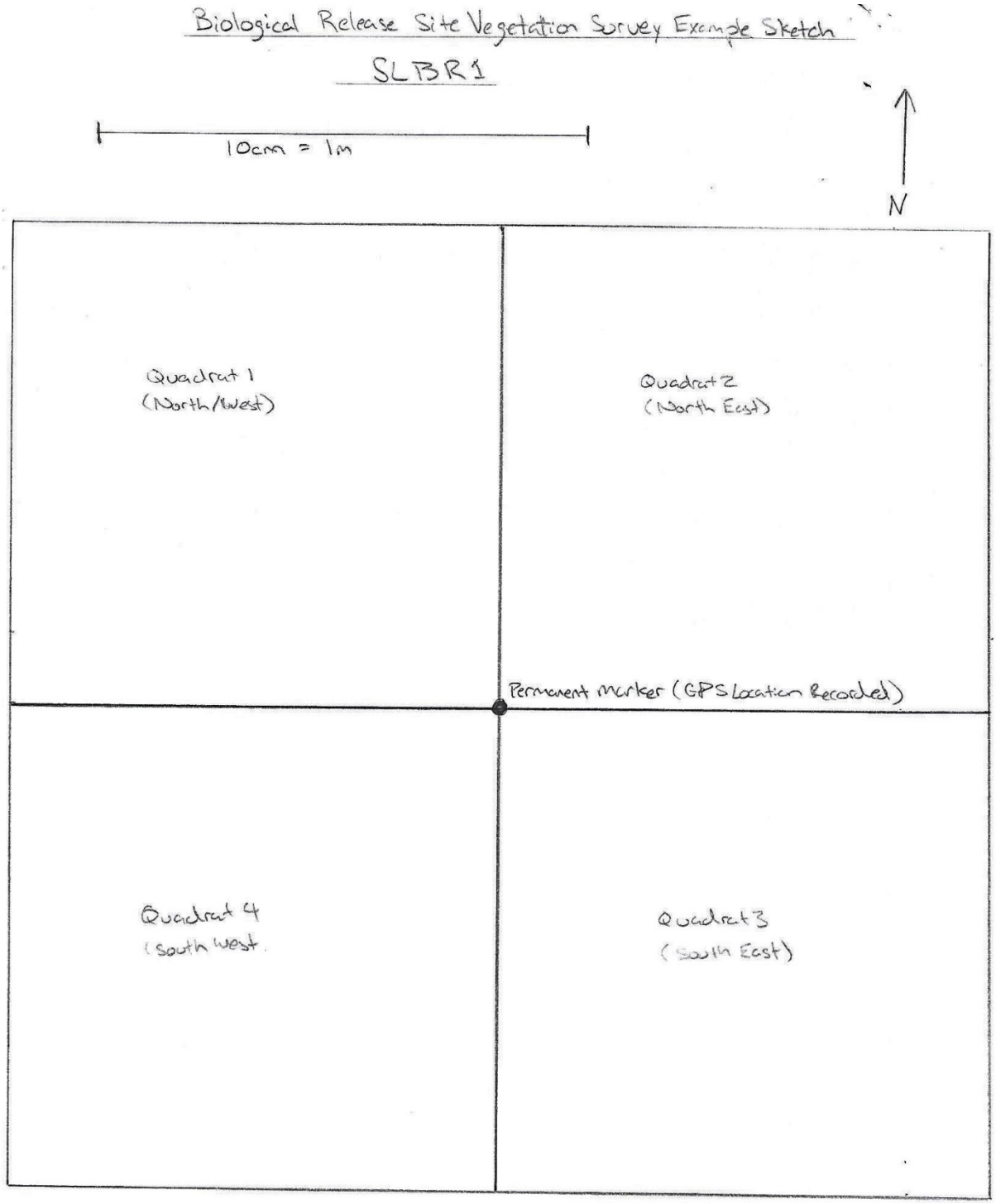




Appendix F: GPS Coordinates and site characteristics of biological release sites.

Plot ID	UTM	Easting	Northing	Elevation (m)	Aspect (°)	Slope (%)
SLBR1	10U	0687333	5612609	814	26	12
SLBR2	10U	0687511	5612469	817	45	17

Appendix G: Biological release site vegetation survey sketch example SLBR1.



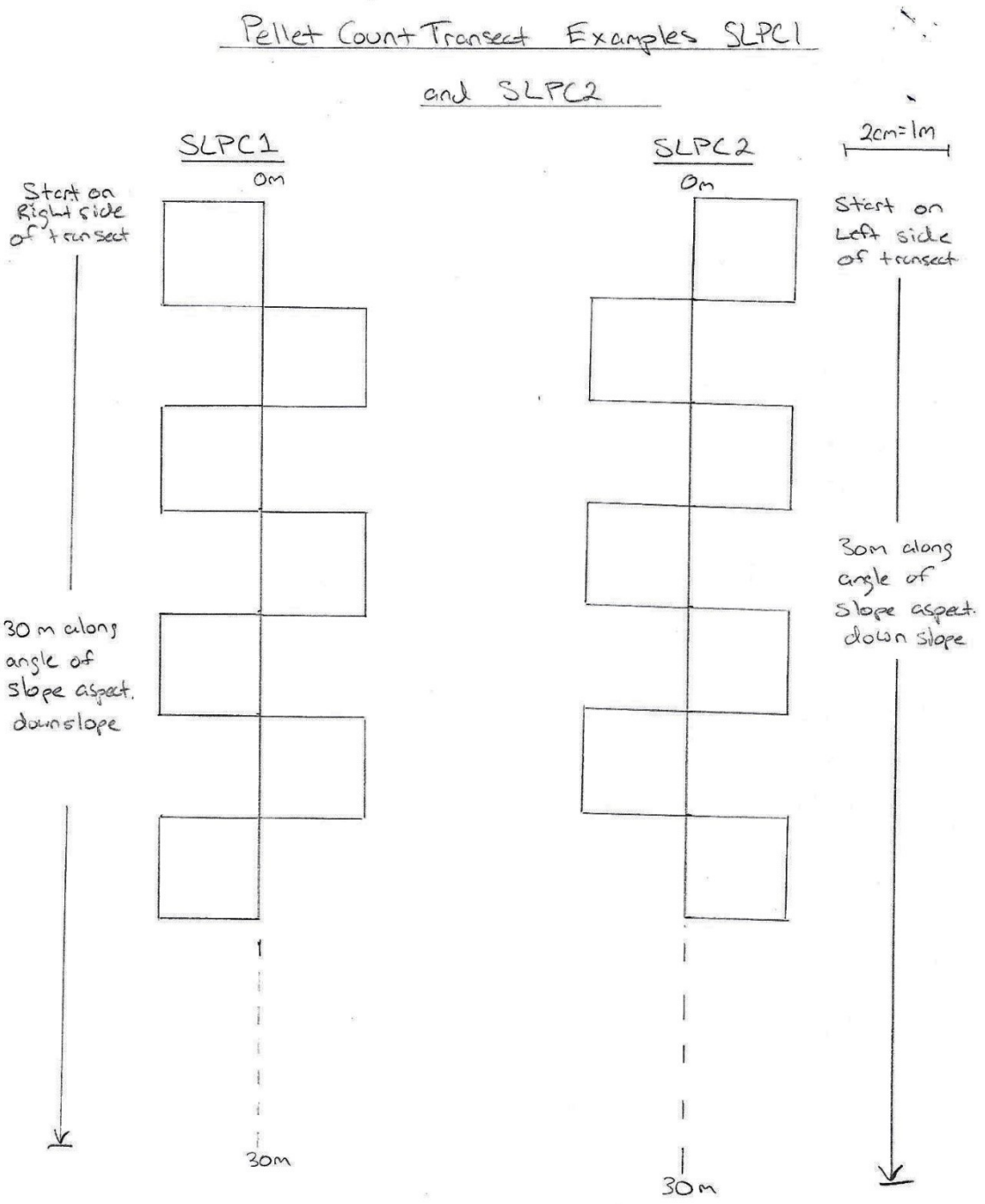
Appendix H: GPS location and start/stop times of bird survey.

Plot ID	UTM	Easting	Northing	Start Time	End Time
SLBC1	10U	0687532	5612703	6:09:00 AM	6:14:00 AM
SLBC2	10U	0687413	5612639	6:19:00 AM	6:25:00 AM
SLBC3	10U	0687450	5612541	6:28:00 AM	6:33:00 AM
SLBC4	10U	0687270	5612623	6:39:00 AM	6:44:00 AM
SLBC5	10U	0687173	5612703	7:00:00 AM	7:05:00 AM
SLBC6	10U	0687250	5612629	7:10:00 AM	7:15:00 AM
SLBC7	10U	0687600	5612609	7:28:00 AM	7:33:00 AM

Appendix I: GPS Location for starting position and characteristics of pellet count transect.

Transect ID	UTM	Easting	Northing	Aspect (°)	Starting side
SLPC1	10U	0687612	5612502	30	Right
SLPC2	10U	0687573	5612524	35	Left
SLPC3	10U	0687479	5612544	26	Right
SLPC4	10U	0687400	5612561	26	Left
SLPC5	10U	0687338	5612617	28	Right
SLPC6	10U	0687240	5612631	30	Left
SLPC7	10U	0687158	5612704	26	Right
SLPC8	10U	0686994	5612725	344	Left
SLPC9	10U	0687297	5612664	13	Right
SLPC10	10U	0687444	5612680	20	Left

Appendix J: Pellet count transect examples SLPC1 (right start) and SLPC2 (left start).



Appendix K: Total distance from the three transect lines and the calculated cover and relative cover for all species observed in each plot of the vegetation survey.

Plot ID	Species (*Scientific Name*)	Total Distance (m)	Cover (%)	Relative Cover (%)
SLP1	Rough Fescue (*Fescuta scabrella*)	55.5	92.50	68.86
	Yarrow (*Achillea millefolium*)	8.5	14.17	10.55
	Hillside milk-vetch (*Astragalus collinus*)	4.3	7.17	5.33
	Round-leaved alumroot (*Heuchera cylindrica*)	2.5	4.17	3.10
	Prickly wild rose (*Rosa acicularis*)	1.8	3.00	2.23
	Spotted knapweed (*Centaurea maculosa*)	1.5	2.50	1.86
	Old man's whiskers (*Geum triflorum*)	1.3	2.17	1.61
	Saskatoon (*Amelanchier alnifoilia*)	0.7	1.17	0.87
	Pussytoes (*Antennaria*)	0.3	0.50	0.37
	Common dandelion (*Taraxacum officinale*)	0.3	0.50	0.37
	Small-flowered blue-eyed Mary (*Collinsia parviflora*)	0.3	0.50	0.37
	long-leaved daisy (*Erigeron corymbosus*)	0.2	0.33	0.25
	Wild strawberry (*Fragaria virginiana*)	0.2	0.33	0.25
	Sticky geranium (*Geranium viscosissimum*)	0.1	0.17	0.12
	Meadow death-camas (*Zigadenus venenosus*)	0.1	0.17	0.12
	Bare ground/moss/lichen	3	5.00	3.72
SLP2	Rough Fescue (*Fescuta scabrella*)	57.4	95.67	52.28
	interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	24.2	40.33	22.04
	Yarrow (*Achillea millefolium*)	5.6	9.33	5.10
	Saskatoon (*Amelanchier alnifoilia*)	3.3	5.50	3.01
	Pussytoes (*Antennaria*)	3.3	5.50	3.01
	Hillside milk-vetch (*Astragalus collinus*)	2.6	4.33	2.37
	Slender hawksbeard (*Crepis atrabarba*)	2.6	4.33	2.37
	Common dandelion (*Taraxacum officinale*)	1.8	3.00	1.64
	Scouler's hawkweed (*Hieracium scouleri*)	1.4	2.33	1.28
	Annual hawksbeard (*Crepis tectorum*)	1.2	2.00	1.09
	Meadow death-camas (*Zigadenus venenosus*)	0.9	1.50	0.82
	Silky lupine (*Lupinus sericeus*)	0.7	1.17	0.64
	Bluebunch wheatgrass (*Agropyron spicatum*)	0.6	1.00	0.55
	Spotted knapweed (*Centaurea maculosa*)	0.4	0.67	0.36
	long-leaved daisy (*Erigeron corymbosus*)	0.2	0.33	0.18
	Round-leaved alumroot (*Heuchera cylindrica*)	0.1	0.17	0.09
	Bare ground/moss/lichen	3.5	5.83	3.19
SLP3	Kentucky bluegrass (*Poa pratensis*)	60	100.00	50.93
	Spotted knapweed (*Centaurea maculosa*)	27.5	45.83	23.34
	Silky lupine (*Lupinus sericeus*)	13.4	22.33	11.38

	Sticky geranium (*Geranium viscosissimum*)	7.4	12.33	6.28
	Rose (*Rosa*)	5.2	8.67	4.41
	Yarrow (*Achillea millefolium*)	1.7	2.83	1.44
	Cheatgrass (*Bromus tectorum*)	0.7	1.17	0.59
	Rough Fescue (*Fescuta scabrella*)	0.5	0.83	0.42
	Round-leaved alumroot (*Heuchera cylindrica*)	0.4	0.67	0.34
	Tarragon (*Artemisia dracunculus*)	0.3	0.50	0.25
	Common dandelion (*Taraxacum officinale*)	0.2	0.33	0.17
	Crested wheatgrass (*Agropyron cristatum*)	0.2	0.33	0.17
	smooth brome (*Bromus inermis* ssp. *inermis*)	0.1	0.17	0.08
	Meadow death-camas (*Zigadenus venenosus*)	0.1	0.17	0.08
	Hillside milk-vetch (*Astragalus collinus*)	0.1	0.17	0.08
SLP4	Rough Fescue (*Fescuta scabrella*)	46.8	78.00	28.16
	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	40.1	66.83	24.13
	Kentucky bluegrass (*Poa pratensis*)	26.8	44.67	16.13
	Bluebunch wheatgrass (*Agropyron spicatum*)	10.7	17.83	6.44
	Common dandelion (*Taraxacum officinale*)	5.3	8.83	3.19
	Yarrow (*Achillea millefolium*)	0.5	0.83	0.30
	Yellow salsify (*Tragopogon dubius*)	0.3	0.50	0.18
	Meadow death-camas (*Zigadenus venenosus*)	0.2	0.33	0.12
	Bare ground/moss/lichen	35.3	58.83	21.24
	Coarse woody debris	0.2	0.33	0.12
SLP5	Kentucky bluegrass (*Poa pratensis*)	53.2	88.67	38.14
	Rough Fescue (*Fescuta scabrella*)	40.8	68.00	29.25
	Spotted knapweed (*Centaurea maculosa*)	30.6	51.00	21.94
	Yarrow (*Achillea millefolium*)	3.3	5.50	2.37
	Round-leaved alumroot (*Heuchera cylindrica*)	2.6	4.33	1.86
	Sticky geranium (*Geranium viscosissimum*)	1.8	3.00	1.29
	Common dandelion (*Taraxacum officinale*)	1.6	2.67	1.15
	Timber milk-vetch (*Astragalus miser*)	1.3	2.17	0.93
	Bluebunch wheatgrass (*Agropyron spicatum*)	1.2	2.00	0.86
	Wild strawberry (*Fragaria virginiana*)	1.1	1.83	0.79
	Big sagebrush (*Artemisia tridentata*)	0.9	1.50	0.65
	Loesel's tumble-mustard (*Sisymbrium loeselii*)	0.5	0.83	0.36
	Pussytoes (*Antennaria*)	0.3	0.50	0.22
	Tall tumble-mustard (*Sisymbrium altissimum*)	0.3	0.50	0.22
SLP6	Rough Fescue (*Fescuta scabrella*)	33.2	55.33	38.07
	Sandberg bluegrass (*Poa secunda*)	8.9	14.83	10.21
	Bluebunch wheatgrass (*Agropyron spicatum*)	8.2	13.67	9.40
	Hillside milk-vetch (*Astragalus collinus*)	6.2	10.33	7.11
	Yarrow (*Achillea millefolium*)	3.9	6.50	4.47

	Small-flowered blue-eyed Mary (*Collinsia parviflora*)	2.5	4.17	2.87
	Large-fruited desert-parsley (*Lomatium macrocarpum*)	2.4	4.00	2.75
	Cheatgrass (*Bromus tectorum*)	2.2	3.67	2.52
	Slender hawksbeard (*Crepis atrabarba*)	0.8	1.33	0.92
	Narrow-leaved desert-parsley (*Lomatium triternatum*)	0.8	1.33	0.92
	Meadow death-camas (*Zigadenus venenosus*)	0.6	1.00	0.69
	Pasture sage (*Artemisia frigida*)	0.4	0.67	0.46
	Pussytoes (*Antennaria*)	0.3	0.50	0.34
	Yellow salsify (*Tragopogon dubius*)	0.2	0.33	0.23
	Spotted knapweed (*Centaurea maculosa*)	0.2	0.33	0.23
	Holboell's rockcress (*Arabis holboellii*)	0.1	0.17	0.11
	Lemonweed (*Lithospermum ruderale*)	0.1	0.17	0.11
	Bare ground/moss/lichen	16.2	27.00	18.58
SLP7	Rough Fescue (*Fescuta scabrella*)	56.6	94.33	52.85
	Yarrow (*Achillea millefolium*)	6.7	11.17	6.26
	Bluebunch wheatgrass (*Agropyron spicatum*)	6	10.00	5.60
	Trembling Aspen (*Populus tremuloides*)	5.7	9.50	5.32
	Pulse milk-vetch (*Astragalus tenellus*)	5.4	9.00	5.04
	Pale comandra (*Comandra umbellata C. pallida*)	5.3	8.83	4.95
	Rose (*Rosa*)	2.2	3.67	2.05
	Timber milk-vetch (*Astragalus miser*)	2.1	3.50	1.96
	Junegrass (*Koeleria macrantha*)	1.8	3.00	1.68
	Small-flowered blue-eyed Mary (*Collinsia parviflora*)	1.5	2.50	1.40
	Silky lupine (*Lupinus sericeus*)	1.4	2.33	1.31
	Yellow salsify (*Tragopogon dubius*)	1.3	2.17	1.21
	Brown-eyed Susan (*Gaillardia aristata*)	1	1.67	0.93
	Pussytoes (*Antennaria*)	1	1.67	0.93
	Tarragon (*Artemisia dracunculus*)	0.9	1.50	0.84
	Round-leaved alumroot (*Heuchera cylindrica*)	0.7	1.17	0.65
	Hillside milk-vetch (*Astragalus collinus*)	0.5	0.83	0.47
	Sandberg bluegrass (*Poa secunda*)	0.4	0.67	0.37
	Large-fruited desert-parsley (*Lomatium macrocarpum*)	0.3	0.50	0.28
	Common dandelion (*Taraxacum officinale*)	0.3	0.50	0.28
	Lemonweed (*Lithospermum ruderale*)	0.3	0.50	0.28
	Meadow death-camas (*Zigadenus venenosus*)	0.1	0.17	0.09
	Slender hawksbeard (*Crepis atrabarba*)	0.1	0.17	0.09
	Spotted knapweed (*Centaurea maculosa*)	0.1	0.17	0.09
	Bare ground/moss/lichen	5.4	9.00	5.04
SLP8	Rough Fescue (*Fescuta scabrella*)	33.4	55.67	27.65
	Bluebunch wheatgrass (*Agropyron spicatum*)	24.9	41.50	20.61
	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	24.8	41.33	20.53

	Kentucky bluegrass (*Poa pratensis*)	4.1	6.83	3.39
	Yarrow (*Achillea millefolium*)	3.8	6.33	3.15
	Timber milk-vetch (*Astragalus miser*)	3.5	5.83	2.90
	Northern bedstraw (*Galium boreale*)	3.4	5.67	2.81
	Yellow salsify (*Tragopogon dubius*)	2.8	4.67	2.32
	Slender hawksbeard (*Crepis atrabarba*)	2.4	4.00	1.99
	Common dandelion (*Taraxacum officinale*)	2.2	3.67	1.82
	Crested wheatgrass (*Agropyron cristatum*)	2.2	3.67	1.82
	Bare ground/moss/lichen	2.1	3.50	1.74
	Saskatoon (*Amelanchier alnifoilia*)	1.5	2.50	1.24
	Cheatgrass (*Bromus tectorum*)	1.4	2.33	1.16
	Pussytoes (*Antennaria*)	1.4	2.33	1.16
	Old man's whiskers (*Geum triflorum*)	1.2	2.00	0.99
	Scouler's hawkweed (*Hieracium scouleri*)	1.2	2.00	0.99
	Coarse woody debris	1	1.67	0.83
	Wild strawberry (*Fragaria virginiana*)	1	1.67	0.83
	Long-leaved daisy (*Erigeron corymbosus*)	0.8	1.33	0.66
	Junegrass (*Koeleria macrantha*)	0.6	1.00	0.50
	Leafy aster (*Aster foliaceus*)	0.3	0.50	0.25
	Loesel's tumble-mustard (*Sisymbrium loeselii*)	0.3	0.50	0.25
	Round-leaved alumroot (*Heuchera cylindrica*)	0.3	0.50	0.25
	Spotted knapweed (*Centaurea maculosa*)	0.2	0.33	0.17
SLP9	Kentucky bluegrass (*Poa pratensis*)	38	63.33	23.60
	Rough Fescue (*Fescuta scabrella*)	34.1	56.83	21.18
	Bluebunch wheatgrass (*Agropyron spicatum*)	19.9	33.17	12.36
	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	18.3	30.50	11.37
	Ponderosa pine (*Pinus ponderosa*)	13	21.67	8.07
	Saskatoon (*Amelanchier alnifoilia*)	12.5	20.83	7.76
	Common snowberry (*Symphoricarpos albus*)	3	5.00	1.86
	Round-leaved alumroot (*Heuchera cylindrica*)	2.5	4.17	1.55
	Yarrow (*Achillea millefolium*)	2.4	4.00	1.49
	Smooth brome (*Bromus inermis* ssp. *inermis*)	2.3	3.83	1.43
	Rose (*Rosa*)	2.1	3.50	1.30
	Small-flowered penstemon (*Penstemon procerus*)	1.9	3.17	1.18
	Timber milk-vetch (*Astragalus miser*)	1.8	3.00	1.12
	Long-leaved daisy (*Erigeron corymbosus*)	1.3	2.17	0.81
	Scouler's hawkweed (*Hieracium scouleri*)	1.2	2.00	0.75
	Showy daisy (*Erigeron speciosus* var. *speciosus*)	1.1	1.83	0.68
	Pussytoes (*Antennaria*)	0.9	1.50	0.56
	Slender hawksbeard (*Crepis atrabarba*)	0.9	1.50	0.56
	Loesel's tumble-mustard (*Sisymbrium loeselii*)	0.6	1.00	0.37

	Menzies's campion (*Silene menziesii*)	0.5	0.83	0.31
	Yellow salsify (*Tragopogon dubius*)	0.3	0.50	0.19
	Common dandelion (*Taraxacum officinale*)	0.3	0.50	0.19
	Small-flowered penstemon (*Penstemon procerus*)	0.3	0.50	0.19
	Flixweed (*Descurainia sophia*)	0.2	0.33	0.12
	Holboell's rockcress (*Arabis holboellii*)	0.1	0.17	0.06
	Sulphur cinquefoil (*Potentilla recta*)	0.1	0.17	0.06
	Northern bedstraw (*Galium boreale*)	0.1	0.17	0.06
	Bare ground/moss/lichen	1.3	2.17	0.81
SLP10	Rough Fescue (*Fescuta scabrella*)	43.8	73.00	30.76
	Bluebunch wheatgrass (*Agropyron spicatum*)	27.1	45.17	19.03
	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	21.7	36.17	15.24
	Kentucky bluegrass (*Poa pratensis*)	11.1	18.50	7.79
	Spotted knapweed (*Centaurea maculosa*)	7.7	12.83	5.41
	Yarrow (*Achillea millefolium*)	5	8.33	3.51
	Pussytoes (*Antennaria*)	3.4	5.67	2.39
	Common dandelion (*Taraxacum officinale*)	2.9	4.83	2.04
	Showy Daisy (*Erigeron speciosus* var. *speciosus*)	2.6	4.33	1.83
	Common rabbit-brush (*Chrysothamnus nauseosus*)	2.4	4.00	1.69
	Old man's whiskers (*Geum triflorum*)	2.1	3.50	1.47
	Yellow salsify (*Tragopogon dubius*)	1.9	3.17	1.33
	Large-fruited desert-parsley (*Lomatium macrocarpum*)	1.8	3.00	1.26
	Long-leaved daisy (*Erigeron corymbosus*)	1.3	2.17	0.91
	Spikelike goldenrod (*Solidago spathulata*)	1	1.67	0.70
	Round-leaved alumroot (*Heuchera cylindrica*)	1	1.67	0.70
	Hillside milk-vetch (*Astragalus collinus*)	1	1.67	0.70
	Crested wheatgrass (*Agropyron cristatum*)	0.6	1.00	0.42
	Junegrass (*Koeleria macrantha*)	0.5	0.83	0.35
	Pasture Sage (*Artemisia frigida*)	0.3	0.50	0.21
	Cut-leaved daisy (*Erigeron compositus* var. *glabratus*)	0.2	0.33	0.14
	Thompson's paintbrush (*Castilleja thompsonii*)	0.1	0.17	0.07
	Bare ground/moss/lichen	2.9	4.83	2.04
SLP11	Rough Fescue (*Fescuta scabrella*)	45.5	75.83	44.13
	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	24.8	41.33	24.05
	Bluebunch wheatgrass (*Agropyron spicatum*)	6.3	10.50	6.11
	Kentucky bluegrass (*Poa pratensis*)	4	6.67	3.88
	Yarrow (*Achillea millefolium*)	3.4	5.67	3.30
	Spotted knapweed (*Centaurea maculosa*)	2.9	4.83	2.81
	Saskatoon (*Amelanchier alnifoilia*)	2.4	4.00	2.33
	Ponderosa pine (*Pinus ponderosa*)	2.1	3.50	2.04
	Pussytoes (*Antennaria*)	1.8	3.00	1.75

	Round-leaved alumroot (*Heuchera cylindrica*)	1.5	2.50	1.45
	Spikelike goldenrod (*Solidago spathulate*)	0.7	1.17	0.68
	Long-leaved daisy (*Erigeron corymbosus*)	0.6	1.00	0.58
	Cheatgrass (*Bromus tectorum*)	0.5	0.83	0.48
	Black medic (*Medicago lupulina*)	0.2	0.33	0.19
	Scouler's hawkweed (*Hieracium scouleri*)	0.2	0.33	0.19
	Parsnip-flowered buckwheat (*Eriogonum heracleoides*)	0.2	0.33	0.19
	Common dandelion (*Taraxacum officinale*)	0.2	0.33	0.19
	Old man's whiskers (*Geum triflorum*)	0.1	0.17	0.10
	Timber milk-vetch (*Astragalus miser*)	0.1	0.17	0.10
	Bare ground/moss/lichen	4.5	7.50	4.36
	Coarse Woody Debris	1.1	1.83	1.07
SLP12	Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	17.2	28.67	14.74
	Kentucky bluegrass (*Poa pratensis*)	32.8	54.67	28.11
	Spotted knapweed (*Centaurea maculosa*)	15.7	26.17	13.45
	Bluebunch wheatgrass (*Agropyron spicatum*)	12.6	21.00	10.80
	Ponderosa pine (*Pinus ponderosa*)	6	10.00	5.14
	Common snowberry (*Symphoricarpos albus*)	3.9	6.50	3.34
	Saskatoon (*Amelanchier alnifoilia*)	2.2	3.67	1.89
	Rough Fescue (*Fescuta scabrella*)	1.9	3.17	1.63
	Cheatgrass (*Bromus tectorum*)	1.4	2.33	1.20
	Alfalfa (*Medicago sativa*)	1.1	1.83	0.94
	Western mountain-ash (*Sorbus scopulina*)	1	1.67	0.86
	Common rabbit-brush (*Chrysothamnus nauseosus*)	0.8	1.33	0.69
	Showy daisy (*Erigeron speciosus* var. *speciosus*)	0.8	1.33	0.69
	Common dandelion (*Taraxacum officinale*)	0.7	1.17	0.60
	Quackgrass (*Agropyron repens*)	0.7	1.17	0.60
	Round-leaved alumroot (*Heuchera cylindrica*)	0.4	0.67	0.34
	Long-leaved daisy (*Erigeron corymbosus*)	0.4	0.67	0.34
	Pasture sage (*Artemisia frigida*)	0.3	0.50	0.26
	Yellow salsify (*Tragopogon dubius*)	0.2	0.33	0.17
	Night-flowering catchfly (*Silene noctiflora*)	0.2	0.33	0.17
	Yarrow (*Achillea millefolium*)	0.1	0.17	0.09
	Bare ground/moss/lichen	16.3	27.17	13.97

Note: See Appendix M for sample calculations of Cover and Relative Cover

Appendix L: Summary of all species observed in all plots of the vegetation surveys of Skyline Park, the observed total distance, and number of plot occurrences, and calculated cover, relative cover, frequency and relative frequency.

Species (*Scientific Name)*	**Total Distance (m)**	**Cover (%)**	**Relative Cover (%)**	**Number of occurrences**	**Frequency (%)**	**Relative Frequency (%)**
Rough Fescue (*Fescuta scabrella*)	449.5	62.4	31.0	12	100.0	5.1
Kentucky bluegrass (*Poa pratensis*)	230	31.9	15.8	8	66.7	3.4
interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*)	171.1	23.8	11.8	7	58.3	3.0
Bluebunch wheatgrass (*Agropyron spicatum*)	117.5	16.3	8.09	10	83.3	4.3
Spotted knapweed (*Centaurea maculosa*)	86.8	12.1	5.98	10	83.3	4.3
Yarrow (*Achillea millefolium*)	44.9	6.24	3.09	12	100.0	5.1
Saskatoon (*Amelanchier alnifoilia*)	22.6	3.14	1.56	6	50.0	2.6
Ponderosa pine (*Pinus ponderosa*)	21.1	2.93	1.45	3	25.0	1.3
Common dandelion (*Taraxacum officinale*)	15.8	2.19	1.09	11	91.7	4.7
Silky lupine (*Lupinus sericeus*)	15.5	2.15	1.07	3	25.0	1.3
Hillside milk-vetch (*Astragalus collinus*)	14.7	2.04	1.01	6	50.0	2.6
Pussytoes (*Antennaria*)	12.7	1.76	0.87	9	75.0	3.8
Round-leaved alumroot (*Heuchera cylindrica*)	12	1.67	0.83	10	83.3	4.3
Rose (*Rosa*)	9.5	1.32	0.65	3	25.0	1.3
Sandberg bluegrass (*Poa secunda*)	9.3	1.29	0.64	2	16.7	0.9
Sticky geranium (*Geranium viscosissimum*)	9.3	1.29	0.64	3	25.0	1.3
Timber milk-vetch (*Astragalus miser*)	8.8	1.22	0.61	5	41.7	2.1
Yellow salsify (*Tragopogon dubius*)	7	0.97	0.48	7	58.3	3.0
Common snowberry (*Symphoricarpos albus*)	6.9	0.96	0.48	2	16.7	0.9
Slender hawksbeard (*Crepis atrabarba*)	6.8	0.94	0.47	5	41.7	2.1
Cheatgrass (*Bromus tectorum*)	6.2	0.86	0.43	5	41.7	2.1
Trembling Aspen (*Populus tremuloides*)	5.7	0.79	0.39	1	8.3	0.4
Pulse milk-vetch (*Astragalus tenellus*)	5.4	0.75	0.37	1	8.3	0.4
Pale comandra (*Comandra umbellata C. pallida*)	5.3	0.74	0.36	1	8.3	0.4
long-leaved daisy (*Erigeron corymbosus*)	4.8	0.67	0.33	7	58.3	3.0
Old man's whiskers (*Geum triflorum*)	4.7	0.65	0.32	4	33.3	1.7
Large-fruited desert-parsley (*Lomatium macrocarpum*)	4.5	0.63	0.31	3	25.0	1.3
Showy daisy (*Erigeron speciosus* var. *speciosus*)	4.5	0.63	0.31	3	25.0	1.3
Small-flowered blue-eyed Mary (*Collinsia parviflora*)	4.3	0.60	0.30	3	25.0	1.3
Scouler's hawkweed (*Hieracium scouleri*)	4	0.56	0.28	4	33.3	1.7
Northern bedstraw (*Galium boreale*)	3.5	0.49	0.24	2	16.7	0.9

Common rabbit-brush (*Chrysothamnus nauseosus*)	3.2	0.44	0.22	2	16.7	0.9
Crested wheatgrass (*Agropyron cristatum*)	3	0.42	0.21	3	25.0	1.3
Junegrass (*Koeleria macrantha*)	2.9	0.40	0.20	3	25.0	1.3
Smooth brome (*Bromus inermis* ssp. *inermis*)	2.4	0.33	0.17	2	16.7	0.9
Wild strawberry (*Fragaria virginiana*)	2.3	0.32	0.16	3	25.0	1.3
Small-flowered penstemon (*Penstemon procerus*)	2.2	0.31	0.15	2	16.7	0.9
Meadow death-camas (*Zigadenus venenosus*)	2.0	0.28	0.14	6	50.0	2.6
Prickly wild rose (*Rosa acicularis*)	1.8	0.25	0.12	1	8.3	0.4
Spikelike goldenrod (*Solidago spathulata*)	1.7	0.24	0.12	2	16.7	0.9
Loesel's tumble-mustard (*Sisymbrium loeselii*)	1.4	0.19	0.10	3	25.0	1.3
Annual hawksbeard (*Crepis tectorum*)	1.2	0.17	0.08	1	8.3	0.4
Tarragon (*Artemisia dracunculus*)	1.2	0.17	0.08	2	16.7	0.9
Alfalfa (*Medicago sativa*)	1.1	0.15	0.08	1	8.3	0.4
Pasture sage (*Artemisia frigida*)	1	0.14	0.07	3	25.0	1.3
Western mountain-ash (*Sorbus scopulina*)	1	0.14	0.07	1	8.3	0.4
Brown-eyed Susan (*Gaillardia aristata*)	1	0.14	0.07	1	8.3	0.4
Big sagebrush (*Artemisia tridentata*)	0.9	0.13	0.06	1	8.3	0.4
Narrow-leaved desert-parsley (*Lomatium triternatum*)	0.8	0.11	0.06	1	8.3	0.4
Quackgrass (*Agropyron repens*)	0.7	0.10	0.05	1	8.3	0.4
Menzies's campion (*Silene menziesii*)	0.5	0.07	0.03	1	8.3	0.4
Lemonweed (*Lithospermum ruderale*)	0.4	0.06	0.03	2	16.7	0.9
Leafy aster (*Aster foliaceus*)	0.3	0.04	0.02	1	8.3	0.4
Tall tumble-mustard (*Sisymbrium altissimum*)	0.3	0.04	0.02	1	8.3	0.4
Black medic (*Medicago lupulina*)	0.2	0.03	0.01	1	8.3	0.4
Cut-leaved daisy (*Erigeron compositus* var. *glabratus*)	0.2	0.03	0.01	1	8.3	0.4
Flixweed (*Descurainia sophia*)	0.2	0.03	0.01	1	8.3	0.4
Holboell's rockcress (*Arabis holboellii*)	0.2	0.03	0.01	2	16.7	0.9
Night-flowering catchfly (*Silene noctiflora*)	0.2	0.03	0.01	1	8.3	0.4
Parsnip-flowered buckwheat (*Eriogonum heracleoides*)	0.2	0.03	0.01	1	8.3	0.4
Sulphur cinquefoil (*Potentilla recta*)	0.1	0.01	0.01	1	8.3	0.4
Thompson's paintbrush (*Castilleja thompsonii*)	0.1	0.01	0.01	1	8.3	0.4
Bare ground/moss/lichen	90.5	12.6	6.23	10	83.3	4.3
Coarse woody debris	2.3	0.32	0.16	3	25.0	1.3
Total	**1452.2**				**1950.0**	

Note: See Appendix M for sample calculations of Cover, Relative Cover, Frequency and Relative Frequency.

Appendix M: Sample calculations for Cover, Relative Cover, Frequency and Relative Frequency

Cover = total intercept length, species A/total transect length x 100

Example: Rough fescue

Cover = 449.5m/720m x 100 = 62.4%

Relative Cover = Total intercept length, species A/total intercept length, all species x 100

Example: Rough fescue

Relative Cover = 449.5m/1452.2m x 100 = 31.0%

Frequency = intervals in which species occurs/total number of transect intervals x 100

Example: Rough fescue

Frequency = 12/12 x 100 = 100%

Relative frequency = frequency value, species A/ total frequency Value, all species x 100

Example: Rough fescue

Relative frequency = 100/1950.0 x 100 = 5.1%

Appendix N: Spotted knapweed (Centaurea maculosa) patch coordinates.

Patch ID	**Coordinates**
Patch 1	50°38'07.6"N 120°20'50.5"W
Patch 2	50°38'03.5"N 120°20'47.2"W
Patch 3	50°38'01.5"N 120°20'50.3"W
Patch 4	50°38'01.5"N 120°20'51.4"W
Patch 5	50°38'02.4"N 120°20'52.6"W
Patch 6	50°38'02.3"N 120°20'55.5"W
Patch 7	50°38'03.6"N 120°20'57.5"W
Patch 8	50°38'03.9"N 120°20'58.9"W
Patch 9	50°38'04.5"N 120°20'58.8"W
Patch 10	50°38'05.6"N 120°20'59.1"W
Patch 11	50°38'06.9"N 120°21'02.2"W
Patch 12	50°38'11.0"N 120°21'17.4"W
Patch 13	50°38'10.7"N 120°21'19.7"W

Appendix O: Data and Calculations for determination of basal area.

Plot ID	Interior Douglas-fir				Ponderosa Pine				Trembling Aspen			
	CBH (cm)	DBH (cm)	Radius (m)	Basal Area (m^2)	CBH (cm)	DBH (cm)	Radius (m)	Basal Area (m^2)	CBH (cm)	DBH (cm)	Radius (m)	Basal Area (m^2)
SLP2	13	4.14	0.02	0.001								
	117	37.24	0.19	0.109								
	121	38.52	0.19	0.117								
	104	33.10	0.17	0.086								
	68	21.65	0.11	0.037								
	11	3.50	0.02	0.001								
Total				**0.351**								
SLP4	61	19.42	0.10	0.030								
	76	24.19	0.12	0.046								
	57	18.14	0.09	0.026								
	47	14.96	0.07	0.018								
	51	16.23	0.08	0.021								
	45	14.32	0.07	0.016								
	47	14.96	0.07	0.018								
	62	19.74	0.10	0.031								
	64	20.37	0.10	0.033								
	37	11.78	0.06	0.011								
	49	15.60	0.08	0.019								
	62	19.74	0.10	0.031								
	41	13.05	0.07	0.013								
	52	16.55	0.08	0.022								
	65	20.69	0.10	0.034								
	48	15.28	0.08	0.018								
	57	18.14	0.09	0.026								
	73	23.24	0.12	0.042								
	59	18.78	0.09	0.028								
	62	19.74	0.10	0.031								
	71	22.60	0.11	0.040								
	40	12.73	0.06	0.013								
	49	15.60	0.08	0.019								
	68	21.65	0.11	0.037								
	63	20.05	0.10	0.032								
Total				**0.651**								
SLP5	20	6.37	0.03	0.003								
Total				0.003								
SLP7									20	6.37	0.03	0.003
									18	5.73	0.03	0.003

									13	4.14	0.02	0.001
									16	5.09	0.03	0.002
									20	6.37	0.03	0.003
Total												**0.012**
SLP8	157	49.97	0.25	0.196	51	16.23	0.08	0.021				
	104	33.10	0.17	0.086								
	125	39.79	0.20	0.124								
	126	40.11	0.20	0.126								
	141	44.88	0.22	0.158								
Total				**0.691**				**0.021**				
SLP9	14	4.46	0.02	0.002	19	6.05	0.03	0.003				
	93	29.60	0.15	0.069	42	13.37	0.07	0.014				
	86	27.37	0.14	0.059	14	4.46	0.02	0.002				
	39	12.41	0.06	0.012	32	10.19	0.05	0.008				
	12	3.82	0.02	0.001	24	7.64	0.04	0.005				
	66	21.01	0.11	0.035	33	10.50	0.05	0.009				
	39	12.41	0.06	0.012	31	9.87	0.05	0.008				
	50	15.92	0.08	0.020	19	6.05	0.03	0.003				
	61	19.42	0.10	0.030								
Total				**0.239**				**0.050**				
SPL10	79	25.15	0.13	0.050								
	77	24.51	0.12	0.047								
	62	19.74	0.10	0.031								
	72	22.92	0.11	0.041								
	70	22.28	0.11	0.039								
	83	26.42	0.13	0.055								
	67	21.33	0.11	0.036								
	57	18.14	0.09	0.026								
	73	23.24	0.12	0.042								
	53	16.87	0.08	0.022								
	22	7.00	0.04	0.004								
	82	26.10	0.13	0.054								
Total				**0.446**								
SLP11	90	28.65	0.14	0.064	27	8.59	0.04	0.006				
	90	28.65	0.14	0.064								
	70	22.28	0.11	0.039								
	114	36.29	0.18	0.103								
	91	28.97	0.14	0.066								
	21	6.68	0.03	0.004								
	17	5.41	0.03	0.002								
	12	3.82	0.02	0.001								

	8	2.55	0.01	0.001								
	69	21.96	0.11	0.038								
	34	10.82	0.05	0.009								
	24	7.64	0.04	0.005								
	23	7.32	0.04	0.004								
	28	8.91	0.04	0.006								
	28	8.91	0.04	0.006								
	18	5.73	0.03	0.003								
Total				**0.416**				**0.006**				
SLP12	16	5.09	0.03	0.002	20	6.37	0.03	0.003				
	19	6.05	0.03	0.003	21	6.68	0.03	0.004				
	9	2.86	0.01	0.001	86	27.37	0.14	0.059				
	33	10.50	0.05	0.009	52	16.55	0.08	0.022				
	14	4.46	0.02	0.002								
	27	8.59	0.04	0.006								
	12	3.82	0.02	0.001								
	16	5.09	0.03	0.002								
	41	13.05	0.07	0.013								
	11	3.50	0.02	0.001								
	13	4.14	0.02	0.001								
	29	9.23	0.05	0.007								
	16	5.09	0.03	0.002								
	13	4.14	0.02	0.001								
	18	5.73	0.03	0.003								
	31	9.87	0.05	0.008								
	25	7.96	0.04	0.005								
	13	4.14	0.02	0.001								
	41	13.05	0.07	0.013								
	34	10.82	0.05	0.009								
	13	4.14	0.02	0.001								
	13	4.14	0.02	0.001								
	16	5.09	0.03	0.002								
	44	14.01	0.07	0.015								
	26	8.28	0.04	0.005								
	26	8.28	0.04	0.005								
	12	3.82	0.02	0.001								
Total				**0.122**				**0.087**				

Appendix P: Sample Calculation for Basal Area, Coverage, Relative Coverage, Density and Relative Density

DBH = CBH/π

Example: SLP2 Douglas-fir 13 cm CBH

DBH = 13cm/π = 4.14 cm

Radius (m) = DBH(cm)*0.5/100(cm/m)

Example: SLP2 Douglas-fir 13 cm CBH

Radius = 4.14cm*0.5/100cm/m = 0.02m

Basal Area (m^2) = π(Radius (m))^2

Example: SLP2 Douglas-fir 13 cm CBH

Basal Area = π(0.02m)^2 = 0.001 m^2

Coverage (%) = (Total Basal Area, of species/ total area of plot) * 100

Example: SLP2 Douglas-fir

Coverage (%) = (0.351m^2/400m^2) * 100 = 0.088%

Relative Coverage (%) = (Coverage (%), of species/Total Coverage (%) of all species in plot) * 100

Example: SLP8 Douglas-fir

Relative Coverage = (0.173%/0.178%) * 100 = 97.09%

Density (Tree/Hectare) = (Total # of Trees in plot/ total area of plot (m^2)) * 10000m^2/Hectare

Example: SLP8 Douglas-fir

Density = (6/400m^2) * 10000 = 150 trees/hectare

Relative Density (%) = (Density of species/total density of all species in plot) * 100

Example: SLP8 Douglas-fir

Relative Density = (150 tree/hectare/175 trees/hectare) * 100 = 85.7

Appendix Q: Observed bird species and number of birds at each location.

Plot ID	Species (*Scientific Name*)	Number of Birds
SLBC1	American Kestrel (*Falco sparverius*)	2
	Northern Flicker (*Colaptes auratus*)	1
	Black-capped Chickadee (*Parus atricapillus*)	1
	House Finch (*Haemorhous mexicanus*)	1
SLBC2	Black-billed Magpie (*Pica hudsonia*)	3
	Dark-eyed Junco (*Junco hyemalis*)	6
SLBC3	American Kestrel (*Falco sparverius*)	3
	Northern Flicker (*Colaptes auratus*)	1
	Black-billed Magpie (*Pica hudsonia*)	1
	Red-breasted Nuthatch (*Sitta canadensis*)	1
SLBC4	Black-billed Magpie (*Pica hudsonia*)	4
	Lewis' Woodpecker (*Melanerpes lewis*)	1
	Western Tanager (*Piranga ludoviciana*)	1
SLBC5	Black-capped Chickadee (*Parus atricapillus*)	1
	Black-billed Magpie (*Pica hudsonia*)	1
	Yellow-rumped Warbler (*Setophaga coronata*)	1
	American Goldfinch (*Carduelis tristis*)	1
SLBC6	Black-billed Magpie (*Pica hudsonia*)	5
	Lewis' Woodpecker (*Melanerpes lewis*)	1
SLBC7	American Kestrel (*Falco sparverius*)	1
	Black-capped Chickadee (*Parus atricapillus*)	1
	Yellow-rumped Warbler (*Setophaga coronata*)	1

Appendix R: Pellet count summary for each transect.

Transect ID	Area (m^2)	Mule Deer (*Odocoileus hemionus*)		Coyote (*Canis latrans*)		# of Types Detected	Total Per Quadrat
		Pellet Count	# of plots present	Pellet Count	# of plots present		
SLPC1	30	0	0	0	0	0	0.00
SLPC2	30	2	2	0	0	1	0.07
SLPC3	30	0	0	0	0	0	0.00
SLPC4	30	0	0	1	1	1	0.03
SLPC5	30	0	0	0	0	0	0.00
SLPC6	30	0	0	0	0	0	0.00
SLPC7	30	0	0	1	1	2	0.03
SLPC8	30	0	0	0	0	0	0.00
SLPC9	30	2	2	0	0	1	0.07
SLPC10	30	0	0	0	0	0	0.00
Total	**300**	**4**	**4**	**2**	**2**		

Appendix S:GPS location and site characteristics of plug planting plot.

Plot ID	UTM	Easting	Northing	Elevation (m)	Aspect (°)	Slope (%)	Angle Perpendicular to Aspect (3m)
SLPP	10U	0687315	5612628	797	15	12	285

Appendix T: Plug planting plot layout, 300 plugs planted randomly throughout plot.