Bridge River Project Water Use Plan

Carpenter Reservoir Riparian Vegetation Monitoring

Implementation Year 1

Reference: BRGMON-2

Study Period: 2013

Splitrock Environmental
PO BOX 798
Lillooet BC
V0K 1V0

Prepared by:
Splitrock Environmental
Odin Scholz B.Sc.

Pascale Gibeau M.Sc., R.P. Bio

September 5, 2014

Executive Summary

The Bridge Seton Water Use Plan (WUP) Consultative Committee recognized the value of maintaining high quality riparian habitats surrounding Carpenter Lake Reservoir. That includes the importance of riparian habitat for ecological structure and function, wildlife habitat, littoral zone productivity, and aesthetic characteristics. Therefore, the protection and enhancement of high quality riparian ecosystems around Carpenter Reservoir were key environmental objectives of the Bridge River WUP, and a motivation for the design of alternatives to the reservoir water operations. The Bridge Seton Water Use Planning project (BRGMON-2) was implemented to document the riparian vegetation communities in the Carpenter reservoir. The objectives of the BRGMON-2 monitoring program are to document the response of the riparian vegetation to chosen alternative operating water regimes in Carpenter Reservoir, as well as associated re-vegetation efforts. The program will use before/after aerial photography, ground surveys, and vegetation transects to assess changes in spatial extent, species composition, and productivity of vegetation over a period of 10 years. This report details the activities of the first year of the BRGMON-02 project.

The study area of BRGMON-2 encompasses the riparian and drawdown zones of the Carpenter Reservoir, from the inflow of the Middle Bridge River (near the town of Goldbridge) in the West, to Terzaghi Dam in the East. Carpenter Reservoir currently operates storage and drawdown of water between elevations of 606.55 m and 651.08 m, covering an approximate area of 50 square kilometers. The current operating levels include a 3m vertical buffer zone that was implemented in 1993, which makes the target elevation 648m and the maximum possible elevation of inundation at 651.08m.

The aerial photography was flown on June 6th, 2013, with the water levels at 635.05 m. The resulting imagery was received in early September for post-field work use. With the 2005 orthophotography, polygon stratification and orthophoto mapping was conducted at a scale of 1:5000. Vegetation zones were classified by terrain class (mudflats, alluvial fans, beaches, and colluvium), formed through hydrological and geomorphological processes. These broad terrain classes were further separated by elevation and slope. The elevations used for the classification were specified based on six days of field ground truthing and sampling.

Field work occurred between May 26th and July 10th, 2013. Random points were generated to locate sampling transects within the stratified locations. Each transect consisted of four 1m by 1m quadrats. Within each quadrat, site data were collected, including sample date, transect number, terrain class, substrate cover, soil texture, coarse fragment type, drainage, growing season water source, wildlife sign, and wildlife species. The vegetation found in the quadrat was identified to species, when possible.

Vegetation characteristics were extensively described based on observations from aerial photography interpretation, ground-truthing, field work, and statistical analyses. The statistical analyses performed were very similar to those done for the similar vegetation monitoring program in Downton reservoir (BRGMON-5).

There were approximately 117 species of vegetation observed during the BRGMON-2 study in 2013, across eight terrain classes and four elevation bands. The mudflats in the west end of the reservoir had the most consistent vegetation cover. Vegetation cover, composition, diversity, and biomass increased with increasing elevation. The low mudflats and steep colluvium tended to be the least vegetated terrain classes. The buffer mudflats at the west end of the reservoir were the most diverse and heavily vegetated terrain classes. The transition zones where vegetation is most likely to be changing under a different water regime are in the mid mudflats, the upper mudflats, and in the buffer zones of the steep beach and alluvial fans. Exotic weedy species were common throughout the study area, and particularly in the steep terrain classes.

It might be challenging to directly attribute any observed shifts in vegetation to management of the reservoir water levels given the numerous confounding variables (e.g. climate, naturally dynamic nature of the reservoir, etc.), the limited statistical power, and the lack of a replicated reservoir where the water regime could be manipulated in isolation of any other variables. However, the sampling design should allow assessing whether or not any changes in vegetation occurred over the 10 years of the study, and how likely those changes can be attributed to the implementation of the N2-2P alternative. The use of techniques such as partial regression analysis and variance partitioning might also increase our understanding of the respective influences of the new water regime, and any other spatial or temporal confounding variables. Also, an analysis and spatial mapping of terrain/elevation and vegetation types from historical aerial photography (if available) would be useful to contextualize the 2013 aerial imagery and increase the power of the statistical tests to detect significant differences in vegetation characteristics over time.

Table of Contents

Table of Figures

Bridge Seton Water Use Plan
Monitoring Program BRGMON-2

Carpenter Reservoir Riparian Vegetation Monitoring

1.0 Introduction

The Bridge Seton Water Use Plan (WUP) Consultative Committee recognized the value of maintaining high quality riparian habitats surrounding Carpenter Lake Reservoir (BC Hydro and Compass Resource Management 2003). That includes the importance of riparian habitat for ecological structure and function, wildlife habitat, littoral zone productivity, and aesthetic characteristics (Decamps et al. 2009). Therefore, the protection and enhancement of high quality riparian ecosystems around Carpenter Reservoir were key environmental objectives of the Bridge River WUP, and a motivation for the design of alternatives to the reservoir water operations.

The Bridge Seton Water Use Planning project (BRGMON-2) was implemented to document the riparian vegetation communities in the Carpenter reservoir. The study has two main components. The first one aims to assess the changes in riparian vegetation in the reservoir over a 10-year period following the implementation of the N2-2P water management operation (BC Hydro 2011). According to the Comptroller "*Carpenter Lake reservoir will be regulated between its licensed minimum and maximum levels of 606.55 and 651.08 m…. To manage the reservoir for generation, fish habitat, and to minimize spills from Terzaghi Dam into Bridge River, BC Hydro will make reasonable efforts to target a maximum elevation of 648.00 m (buffer zone) for the end of snowmelt season in mid-August. Extended reservoir excursions above 648.0 m are expected as a result of meeting other constraints with higher priorities. If operations are expected to exceed 648.00 m for 8 weeks or more, BC Hydro will inform the Comptroller of Water Rights, provincial and federal fisheries agencies and the St'at'imc.*" (BC Hydro, 2011).

The second component addresses the re-vegetation initiatives that are included in the BRGWORKS-1 Water Use Plan project. The BRGWORKS program is to begin in the spring of 2014. The data gathered in 2013 will provide a baseline describing the existing vegetation conditions in and around the region targeted for re-vegetation in the BRGWORKS-1 program. As well, an ongoing objective of BRGMON-2 is the monitoring of the BRGWORKS-1 re-vegetation effort throughout their implementation years. The goal is for BRGMON-2 to design and implement monitoring of the riparian vegetation, and to give feedback information as an adaptive management approach during the five-year implementation of the re-vegetation project.

This report details the activities of the first year of the BRGMON-2 project.

1.1 Study Area

Carpenter Reservoir is a reservoir of approximately 50km long, located in south-western British Columbia (Figure 1). The Carpenter Reservoir is fed by the Middle Bridge River and three other significant water sources (the Hurley River, Gun Creek and Tyaughton Creek). It empties into the Lower Bridge River via Terzaghi dam, which is currently operating at an annual average discharge of 6 cms. The bulk of the water running out of Carpenter Reservoir flows via diversion tunnels through Mission Mountain. This water is used to generate hydroelectric power at the Bridge Generating Station near T sal'alh where it is enters Seton Lake.

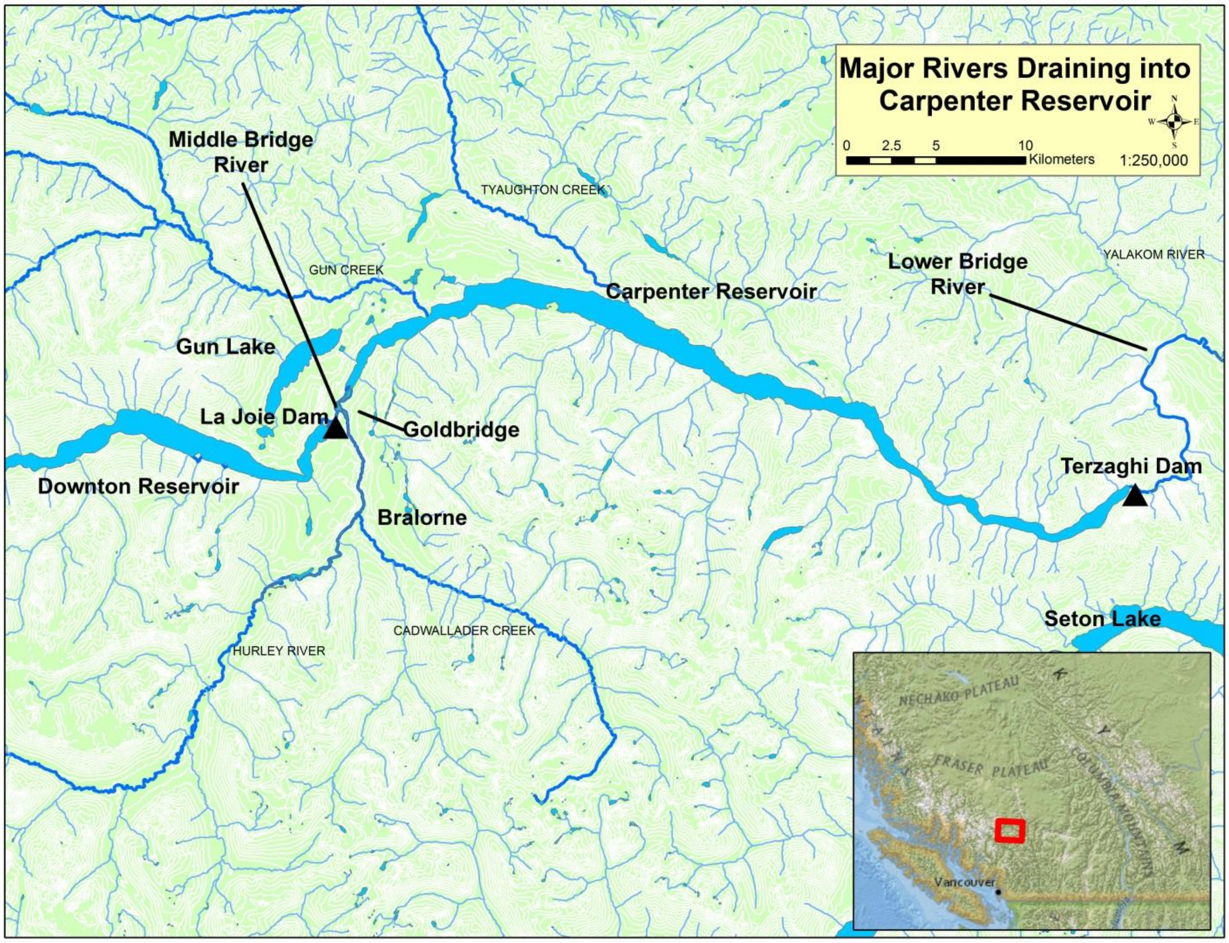


Figure 1. Map of the Carpenter Reservoir, South-West of British Columbia, Canada.

The study area of BRGMON-2 encompasses the riparian and drawdown zones of the Carpenter Reservoir, from the inflow of the Middle Bridge River (near the town of Goldbridge) in the West, to Terzaghi Dam in the East. Prior to the construction of the Terzaghi Dam in 1948, the area now under the waters of the Carpenter Reservoir was a complex river valley where "the river flows sinuously within a mile-wide flood plain of oxbow lakes, marshes and cut-offs" (A. Wood, 1949). Carpenter Reservoir currently operates storage and drawdown of water between elevations of 606.55 m and 651.08 m, covering an approximate area of 50 square kilometers. The current operating levels include a 3 m vertical buffer zone that was implemented in 1993, which attempts to manage water below the 648m elevation, with possible incursions at the maximum elevation of inundation of 651.08m.

Carpenter Reservoir is managed between the 606.55 and 651.08m with target maximum levels at 648masl (BC Hydro, 2011). The majority of the reservoir inundated for over 50% of the growing season is below the 642m elevation occurring east of the Gun Creek Fan, broadly referred to as lower mud flats. The lower mud flat areas annually are sparsely vegetated by a mix of native and exotic annual species. The mud flats west of the Gun Creek fan towards Goldbridge green up during late spring through summer with herbaceous cover dominated by horsetails in the eastern most end grading to tall shrubs and finally a mix of deciduous and coniferous trees in the west at the town of Goldbridge where the buffer zone elevation grades into the Middle Bridge River flood plain. Dead stands of tall shrubs, likely willows (*Salix* sp.*),* punctuate the mud flats between the Gun Creek Fan and Goldbridge a testament to past advances in the shrub communities from the higher western elevations towards the east with a subsequent mortality likely from high water years. Similar examples of advancement and retreat in the woody vegetation encroachment into the reservoir and subsequent die back can be seen throughout the surrounding upper drawdown zone areas.

The upland zone vegetation surrounding the reservoir is influenced by the characteristics of the Interior Douglas Fir Dry Cold (IDFdc) biogeoclimatic zone with south facing open forests on the north side slopes of the reservoir with occurrences of Ponderosa pine (*Pinus ponderosa*), the south shore, cooler, north facing slopes are covered with more dense forests of Douglas-fir with frequent occurrences of Engelmann spruce (*Picea engelmannii*) and western red cedar (*Thuja plicata*). The drawdown zone between the flat reservoir basin and the upland forests varies with elevation, slope, terrain and substrate with annual herbs and grasses lower down and more perennial grasses and herbs higher up with encroachment of shrubs and trees through the buffer zone.

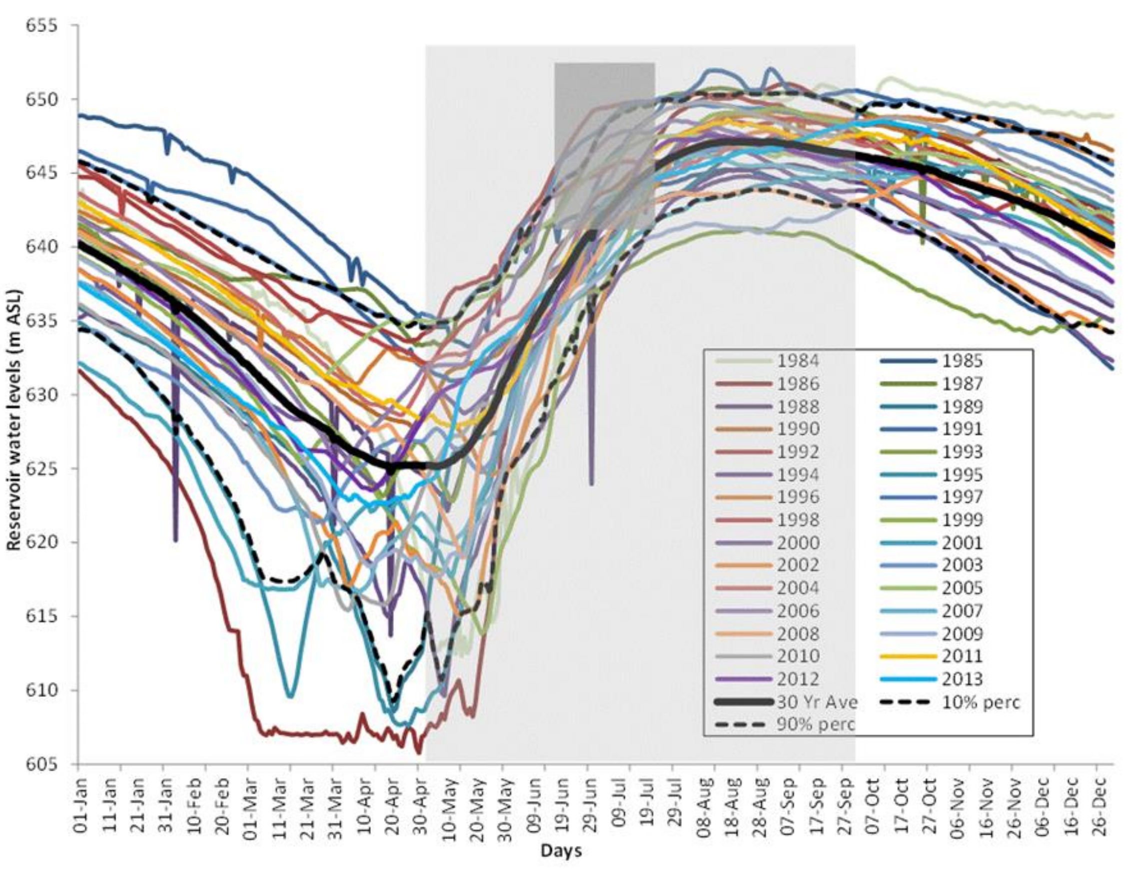


Figure 2 **Variation in water levels in Carpenter Reservoir over the year, from 1985 to 2012 Grey box represents the monitoring period.**

1.2 Goals and hypotheses

The objectives of the BRGMON-2 monitoring program are to document the response of the riparian vegetation to chosen alternative operating water regimes in Carpenter Reservoir, as well as associated re-vegetation efforts. The program will use before/after aerial photography, ground surveys, and vegetation transects to assess changes in spatial extent, species composition, and productivity of vegetation twice over a period of 10 years.

Specifically, the management questions for BRGMON-2 are:

1) Will implementation of the chosen operating alternative have negative, neutral or positive impacts on the quality and quantity (species composition, biological productivity, spatial area) of the riparian area surrounding Carpenter Reservoir?
2) Does the implementation of a short term (5 yr.) intensive reservoir re-vegetation program result in benefits that were equal to or greater than that which were expected from implementation of the O3-2 operating alternative?

To address the management questions, the following primary hypotheses were stated:

H_1: Implementation of the chosen alternative will not result in a reduction of riparian habitats in the area surrounding Carpenter Reservoir.

H_{1A}: There is no significant change in the spatial extent of the vegetated area in the drawdown zone of Carpenter Reservoir.

H_{1B}: There is no significant change in the species composition of the plant community in the vegetated area of the drawdown zone of Carpenter Reservoir.

H_{1C}: There is no significant change in the relative productivity of the plant community in the vegetated area of the drawdown zone of Carpenter Reservoir.

A second primary hypothesis was based on the assumption that, following implementation of the N2-2P operating alternative, short term (<56days) incursions of reservoir levels into the buffer zone (reservoir levels above 648m) would not significantly influence the quality or spatial extent of drawdown zone vegetation.

H_2: Incursions of less than 56 days into the reservoir buffer do not significantly impact the riparian community.

A third primary hypothesis is associated with the reservoir re-vegetation program BRGWORKS-1. The null hypotheses to be addressed through the monitoring of the BRGWORKS-1 Project are:

H_3: Implementation of extensive riparian planting for 5 years will provide the basis for continued natural re-colonization of the drawdown zone between the Gun Creek Fan and the Tyaughton Lake Road Junction.

H_{3A}: Natural re-colonization is significantly greater at treated versus control locations.

H_{3B}: There is no significant difference in the species composition of naturally re-colonizing species in planted versus control areas.

This report focuses is focused on establishing the foundations for answering management question 1, component 1 of the BRGMON-2 program.

2.0 Methods

2.1 Air photo interpretation

In order to provide a baseline at a landscape level for the entire Carpenter Reservoir, the drawdown zone and several hundred meters of the surrounding upland forests were identified as the capture zone for the aerial photography in 2013. BC Hydro's photogrammetry department was directed to produce the aerial photography, orthophotography and digital elevation data for BRGMON-2. The area covered was from the 653m contour, and down. Data was provided in two different formats: 1) Esri Shape files, and 2) MicroStation dgn files.

The aerial photography was flown on June 6th, 2013, when the water level was at 635.05 m (according to BC Hydro Power Records). The resulting photo imagery and draft preliminary orthophotos were received in early September for post-field work use. The final product high resolution orthophotos were received in Feb 2014. Historical orthophotography flown in 2005 was obtained from St'at'imc Government Services to assist for field work planning, to carry out preliminary aerial orthophoto interpretation, and to map the vegetation polygons in the study area.

With the 2005 orthophotography, polygon stratification and orthophoto mapping was conducted at a scale of 1:5000 for the drawdown zone of Carpenter Reservoir. GIS terrain mapping was carried out delineating broad terrain classes to produce a shapefile layer in Arc Map 10 for spatial area calculations. Vegetation zones were classified first by terrain class, and established based on landforms resulting from hydrological and geomorphological processes. Terrain was classified as mudflats, alluvial fans, beaches, and colluvium. These broad terrain classes were further separated by elevation and slope (using 2005 digital elevation data provided by BC Hydro). The elevations utilized for vegetation zone classification were further specified based on six days of field ground truthing and sampling. Field trials indicated five elevation bands may be suited to describe the observed vegetation in the drawdown zone of the Carpenter Reservoir (Table 1).

Table 1. Elevation band stratification for Carpenter Reservoir drawdown zone based on general field observations of vegetation communities *Note buffer zones are within the drawdown zone.*

Elevation Zone	Low Elevation (m)	High Elevation (m)	General Vegetation Characteristics
Upper Buffer	649.5	651	Shrub, sapling, grass
Lower Buffer	648	649.5	Grass herb, shrub
Upper Drawdown	646	648	Sedges, horsetails, annuals, grasses
Mid Drawdown	642	646	Horsetail, sedge, annuals
Low Drawdown	low pool	642	Barrens, sparse annuals

2.2 Field Methods

Geospatial Modeling environment and ArcMap 10 were used to generate random points within stratified sampling locations (Beyer, H.L. 2012). Field maps with random point locations were generated, and points were located in the field using a SXBlue2 GNSS GPS for sub meter accuracy. The suitability of the randomly generated sampling locations was assessed in the field. In some cases, points were eliminated due to physical constraints, such as a random placement landing too close to a polygon edge, a lack of accessibility to a site, or areas being already inundated by the reservoir. In cases of inadequate sampling locations, a secondary or tertiary point was used.

Transects were set up using two different methods, all transects were 40 m long. Beginning at the 40 m mark, all transect quadrats were placed 10 m apart, and were 1X1min size,. Quadrat locations alternated right and left along either side of the transect. To ensure enough replication for statistical analysis, the goal was to establish five permanent transects per terrain class, with four 1X1 m quadrats surveyed per transect, for a total of 20 quadrats per transect type.

Transect establishment methods in low gradient areas differed from high gradient areas in order to reduce the effect of the shoreline curvature in high gradient areas. Low gradient class (mudflats) transects were set by marking a point of origin (by installing 12 inch spike nails with two inch washers into the ground), and randomly choosing an azimuth, for transect direction.

High gradient class (sloped beaches, alluvial fans, and colluvium), transects were sampled along four secondary elevation bands (Figure 3). At each primary transect, a permanent pin was established to run a transect line perpendicular to the water line, and parallel to the direction of slope on the fan. Secondary transects were oriented along elevations 644 m (Mid), 647 m (Upper), 648.5 m (Lower Buffer), and 650.5 m (Upper Buffer). The secondary transects were established at the predetermined elevations along primary transects, and run perpendicularly (utilizing the primary transect as the center of the secondary transects to reduce the effect of the shoreline curvature on the elevation of the secondary transects). In areas where the reservoir water was in line with the primary transect, the water levels were used as the reference, and the points of origin of the secondary transects were located using a clinometer and measuring tapes. They were also referenced using the reservoir levels in the previous day (as posted by BC Hydro Power records) as a benchmark for establishing elevations in the field. On the other hand, for the upper buffer zone, estimates of the top of the buffer zone were identified in the field, and from this elevation of 651m, the transect was established.

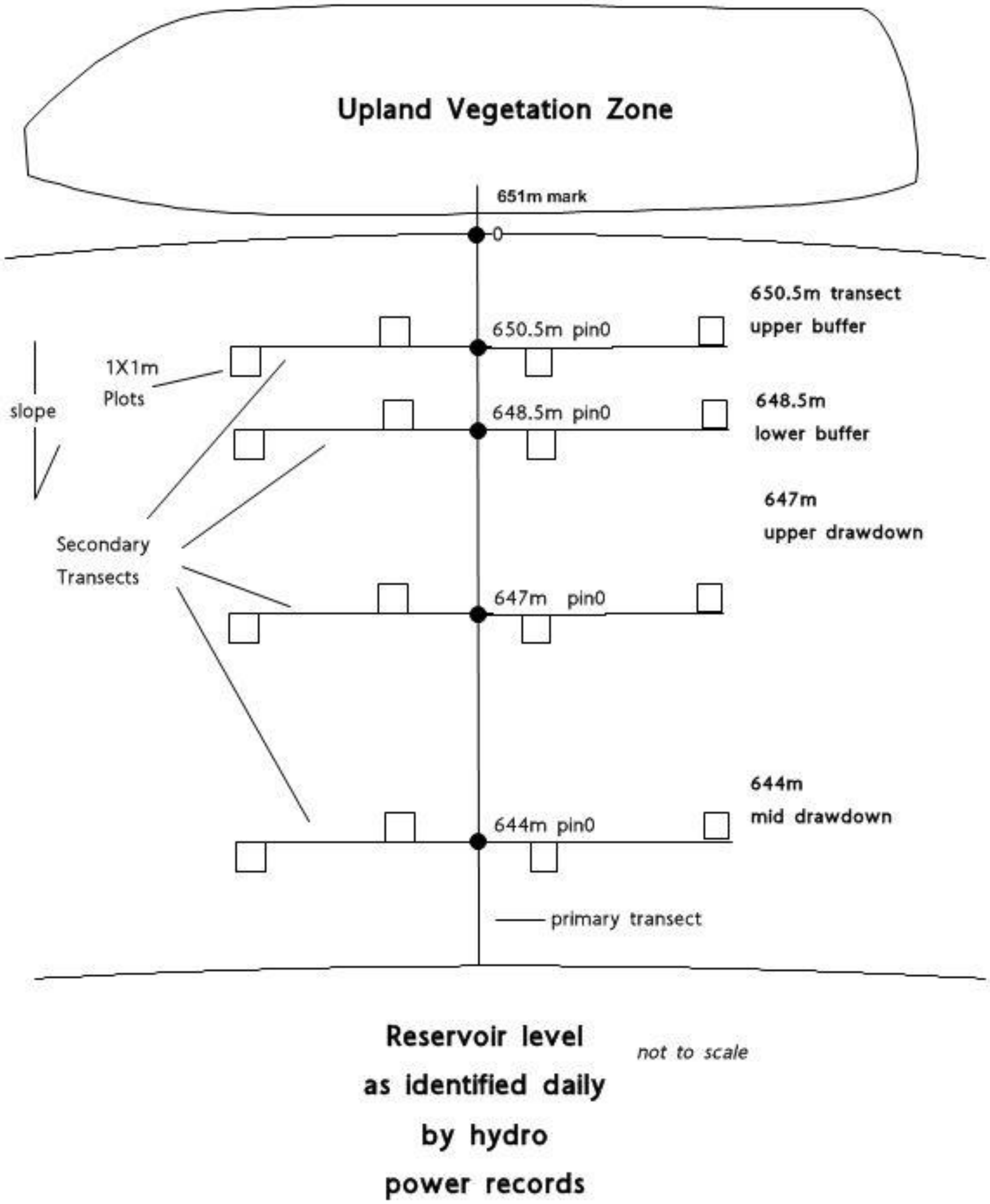


Figure 3. sketch Sketch of transect set up methods for high gradient on sloping fringe drawdown zone terrain class areases.

From their center point, the secondary transects were stretched for 15 m in opposite directions, perpendicularly to the primary line. Quadrat placement alternated above and below the transects in a further attempt to confine sampling within a narrow elevation band. Permanent pins were installed at the center point of each secondary transect, and one main pin was set at the full pool mark along the initial primary transect.

Most of the north shore of Carpenter Reservoir was accessible by vehicle from Highway 40. The south shore of the reservoir was accessible from the town of Goldbridge, in the west end, for a distance of 15.5km along Truax forest service road. The limited road access on the south side of Carpenter reservoir limited the sampling sites, and forced a higher amount of sampling on the north side. Chest waders were needed to access some of the mud flat areas.

Within each quadrat, site data were collected, which included date, transect number, terrain class, substrate cover, soil texture, coarse fragment type, drainage, growing season water source, wildlife sign, and wildlife species. The vegetation found in the quadrat was identified to species, when possible (in some cases, only identification to genius was possible). Data recorded for each species of vegetation included percent cover, distribution, density, vigor, utilization, and generative and vegetative phenology. Data codes were based on the codes found in Field Manual for Describing Terrestrial Ecosystems 2nd edition LMH-25, (BC Ministry of Forests and Range and BC Environment, 2010). Data were entered digitally in the field using FLINT S series F4 hand held devices running EZytag CE software. Hand written back-up copies of the data were also collected. Collected data were uploaded and converted to GIS shapefile data using EZytag Viewer software. Layers were checked for completeness and quality in Arc Map 10, and in Microsoft Excel. Data were edited as needed in the office, and cross referenced with hand written data. Samples of species were collected, and a herbarium was compiled to verify identification. The Illustrated flora of BC, XID digital software, and E-Flora BC were all used to guide identification of unknown species.

2.3 Photo monitoring and biomass productivity

Permanent photo monitoring was established to assess change at each transect, and to provide an inference technique for comparing biomass productivity at each transect. Photo inference for assessing biomass has been used in the past with examples from range management including visual obstruction methods (Vermeire and Gillan 2001). Two photo monitoring points were established for each transect to provide a visual record of change. A one meter tall by 0.10 m wide photo board was set 10m away from the camera, and directly along the transect. The camera was set up on a tripod right over the pin, and one meter high. Two photos were taken with a Canon Power Shot D20 camera 5.0-2.5mm- 1:3.9-4.8 lens. Photo frames were centered on the top to the meter board; a photo was captured at the widest zoom, and a close-up shot was taken.

For the mudflats transects, the camera was set up at each end of the transect line. On the alluvial fans, the camera was set up over the secondary transect center point, and this location was used to capture the two photos in 180° opposite directions. In each case the meter board was placed 10 m away from the camera. Photos were also taken of each 1X1m quadrat with camera held from above to capture the whole plot frame.

Figure 4. Example of biomass assessment using photo, 40 per cent cover.

Photo point images were analyzed to produce two values: biomass and vertical percent cover of vegetation on the meter board. A height value for vegetation was estimated from each photo point image based on the meter board, and these values were averaged for each transect. The amount of vegetation obscuring the meter board was estimated for each photo, and a percent cover value for vertical growth of vegetation was estimated (out of 100 percent as in (Figure 4). This per cent cover value, along with average height and average percent cover from 1mX1m plots, was utilized as a representation of vegetation growth health.

2.4 Statistical analyses

Statistical analyses were very similar to those performed for the similar vegetation monitoring program in Downton reservoir (BRGMON-5, Scholz and Gibeau 2014). The main points are summarized below.

2.4.1 General description of vegetation

Data from the four quadrats sampled per transects were averaged to avoid pseudoreplication (Hurlbert 1984). Four community descriptors (total cover, richness, diversity and evenness of vegetation) were used to describe the vegetation in the Carpenter Reservoir. Total cover was computed by adding up the cover of all species and taxa in each transect, including unknowns and vegetation from all layers. Only taxa identified to species (thus excluding taxa identified to genera or unknowns) were used to compute species richness, diversity and evenness. One exception was made for species of genera *Salix*; given the difficulty of identifying individuals to species at the early stage of the vegetation when it was sampled, all *Salix* were grouped under a common taxum.

Species richness was the total number of species sampled in transects, while diversity was computed with Shannon's index, and corresponds to a measure of species composition that combines both the number of species and their relative abundance (Legendre and Legendre 2012):

$H = -\Sigma\ (pi \log pi)$, where pi is the relative proportion of species i in the transect.

Diversity increases along with the number of species recorded in transects, based on their relative abundance. Evenness (Pielou 1966) was computed to determine how the species were distributed within each transect, e.g. if one or a few species were dominating the plots, or if all the species recorded were distributed fairly equally in the transects. It corresponds to:

$J=H/Hmax= (-\Sigma\ (pi \log pi))/ \log q$, where q is the species richness, and H the diversity.

If the species are evenly distributed in the transect, J will tend towards a value of 1, and if one or a few species are dominating the vegetation, the value of J will tend towards 0 (Legendre and Legendre 2012). The combination of diversity and evenness measures gives an indication about the degree of interspecific competition; if the two indices show high values, transects are diverse and with species evenly distributed (low interspecific competition). Conversely, if diversity is high but evenness is low, it suggests that one or a few species are dominating the transects, and therefore that interspecific competition is high (Legendre and Legendre 1998, 2012).

Trends were described among terrain classes, elevation bands, and between the north and south shore of Carpenter Reservoir using boxplots. Boxplots display the variation, dispersion and skewness of groups of data without making any assumptions about their underlying statistical distributions (Massart et al. 2005). The median is represented by a horizontal line in the box, that is drawn to show the interquartile range (25 per cent to 75 per cent of the ranked data, Sokal and Rohlf 1995). Data with low dispersion (i.e. mostly found around the median) will be indicated by a small box, while data widely dispersed will be shown by a long box. The largest and smallest observations will be represented by whiskers drawn from the top and bottom of the box, respectively, within 1.5 interquartile range of its extremities. Outliers are shown by open circles. In this case, the boxes represent the variation in total cover, richness, diversity, and evenness observed among transects for any combination of terrain classes, elevation bands, and locations assessed.

Differences in cover, richness, diversity, and evenness were statistically tested with unbalanced two-ways analysis of variance (ANOVA), tested with 9999 permutations. Figures and ANOVAs were performed in the R language (version 3.0.2).

2.4.2 Classification of vegetation communities

The same clustering analyses as in BRGMON-5 were performed, and for the same reasons. Details are given in Scholz and Gibeau (2014), and are very similar to those performed for other long-term monitoring programs in reservoirs of British Columbia (e.g. Hawkes et al. 2007).

2.4.3 Reservoir water levels

Reservoir water levels were summarized in a series of figures and tables to show their variation across elevation bands and years. Average daily water levels were provided by BC Hydro for each year.

Duration, timing, and depth of inundation were graphically assessed, and are discussed. The vegetation growing season was considered to span from May 1 until September 30, and elevations sampled ranged from 630 to above 650m.

Duration of inundation was calculated as the proportion of the growing season for which each given elevation band was above the current reservoir water levels. It was computed as a ratio between the number of days that the elevation band was above water levels and the total number of days in the growing season (n=153). Timing corresponded to the date on each year at which a given elevation band was first inundated. Depth of inundation was also dependent on the elevation band, and was computed as the average of all the water that covered a given elevation band in the Carpenter Reservoir.

3.0 Results

3.1 Air photo interpretation

Aerial photography for Carpenter Reservoir was flown on June 6, 2013. As a result, 245 digital stereo images were produced, and later converted into 12 orthophoto, 1m pixel image files, and ultimately 74 high resolution 15cm pixel photos.

Based on the 2005 and 2013 orthoimages, the mapping of the landscape polygons was carried out from an elevation of approximately 652 m, down to water level. A total of 177 polygons were initially isolated, utilizing the 2005 imagery; this number increased to 241 polygons over an area of 1521.75 ha when the 2013 orthophotos were used (Table 2).

Table 2. Number, proportion and areas covered by the polygons of the different terrain classes in the Carpenter Reservoir in 2013.

Terrain Classes	Area (ha)	Proportion (%)	Number of polygons
Alluvial Fan	230.28	15.13	13
Buffer Mudflat	15.43	1.01	7
High Fluvial Bar	7.56	0.5	20
Industrial	5.59	0.37	3
Low Fluvial Bar	73.02	4.8	61
Low Mudflat	327.35	21.51	10
Mid Mudflat	162.7	10.69	16
Shallow Beach	6.53	0.43	3
Steep Alluvial Fan	132.7	8.72	14
Steep Beach	152.9	10.05	26
Steep Bluff	4.78	0.31	1
Steep Colluvium	372.6	24.48	62
Upper Mudflat	30.31	1.99	5
Total	1521.75	100	241

3.2 Description of polygon types

The distribution and characteristics of the various types of polygons (combinations of terrain classes, slopes and elevations), as assessed from the aerial photography and field work, are described in detail below.

3.2.1 Mudflats

Mudflats dominate much of the drawdown zone in the Carpenter Reservoir, testament to the flat river valley that predated the reservoir. The mudflats west of the Gun Creek Fan are an approximately 208 ha delta-like area, where the Middle Bridge River flows into Carpenter Reservoir (Figure 5 and Figure 6).

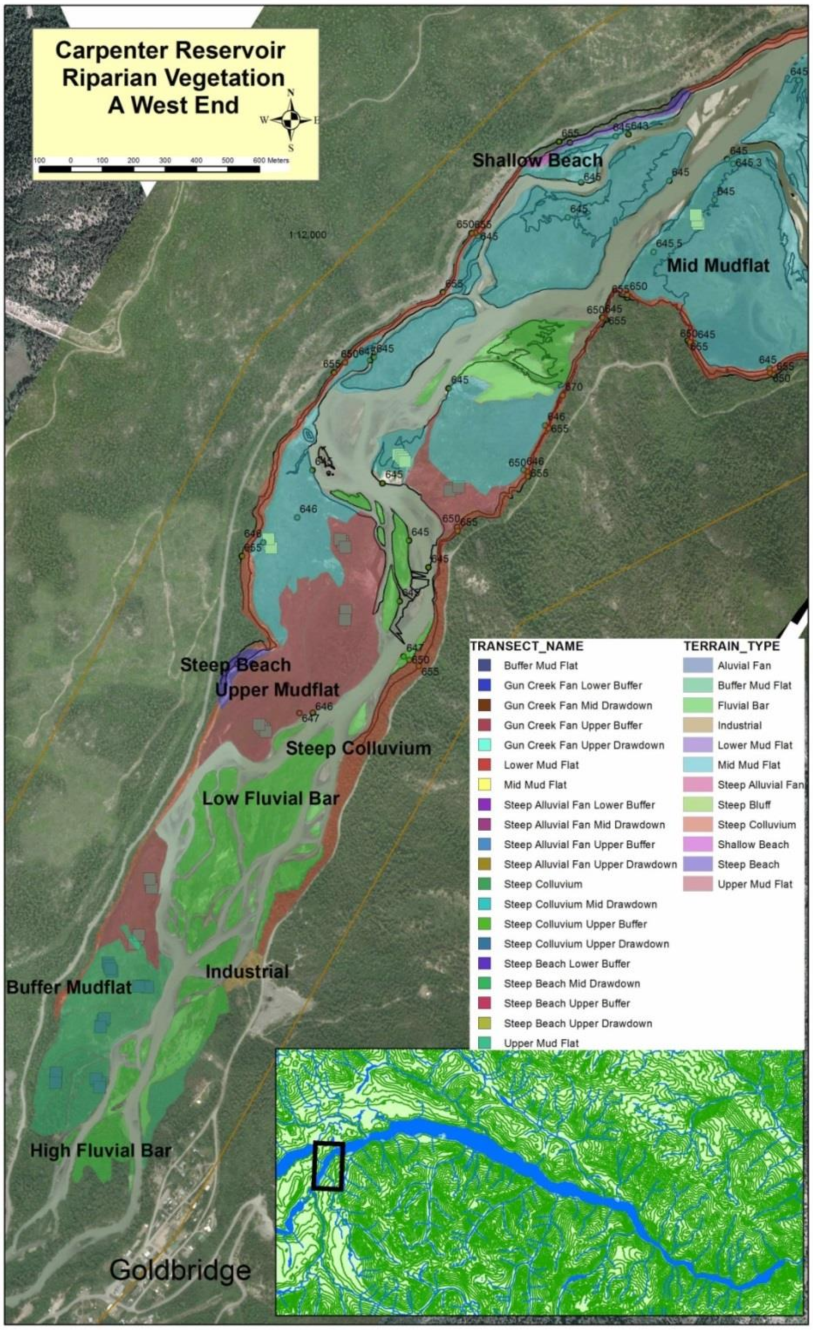


Figure 5. Distribution of the terrain classes and associated transects in the western-most end of the Carpenter Reservoir in 2013 (Part 1).

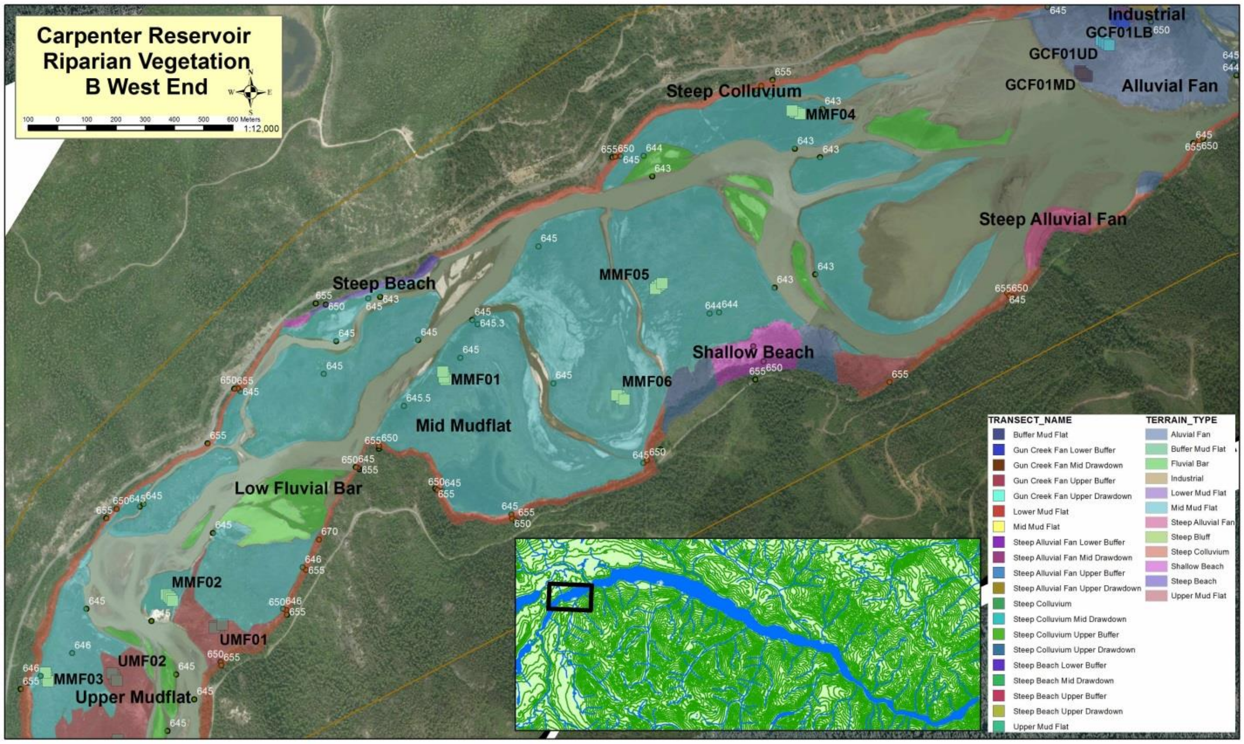


Figure 6. **Distribution of the terrain classes and polygons in the western-most end of the Carpenter Reservoir in 2013 (Part 2).**

Gun Creek and its associated fan geographically separate the visibly vegetated mudflats to the west, from the barren lower mudflats to the east (Figure 7). The lower mudflats are mostly east of the Gun Creek fan, and consist of an area covering 327 ha below the 642m elevation line. At a small scale, it is evident that the lower mudflats are predominantly exposed mineral soils. The mudflats to the west of Gun Creek are notably more densely vegetated.

The mudflats are mainly flat to undulating, and occasionally cut with channels from the Bridge River. Soils were found to be principally silty, grading to fine sands where the Middle Bridge River floods and deposits. There were few, if any, coarse fragments, and the drainage was imperfect to moderate, overall. Generally speaking, vegetation communities ranged from weedy annuals in the east, to horsetails (*Equisetum sp.*) and sedges (*Carex sp.)* in the central areas, to shrubs (*Salix sp*) and tree species (*Populus and Alnus sp.*) in the west.

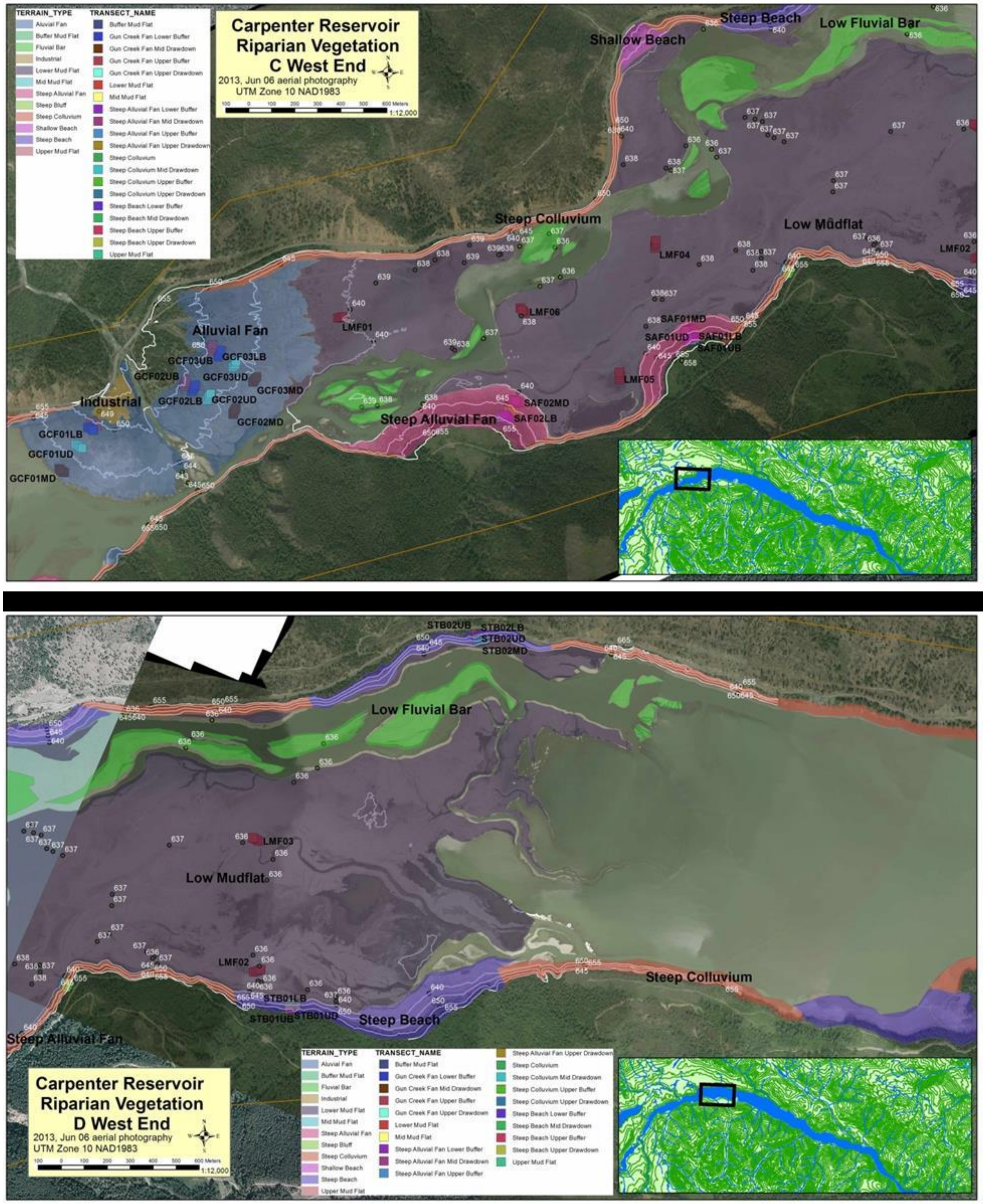


Figure 7. **Distribution of the terrain classes and polygons in the western-most end of the Carpenter Reservoir in 2013 (Part 3). Gun Creek comes into the reservoir on the left of the top map.**

3.2.1.1 Lower Mudflats

As mentioned, the lower mudflats (LMF; Figure 8) formed an extensive area to the east of Gun Creek Fan, stretching over four km to the west on the date of the aerial imagery capture when the reservoir water levels were at 635 m. The LMF covered approximately 327 ha, or 21 per cent of the total polygons mapped. Of the ten polygons that made up the LMF area, the bulk of the area (77%) laid on a contiguous 254 ha polygon on the south side of the channel of the Bridge River (Figure 7). Five of the permanent transects fell into that large south side polygon, and this area is the focal region for the BRGWORKS-1 re-vegetation project. The data gathered from the LMF transects will be used as part of a baseline for species composition, cover and distribution before any re-vegetation efforts are made via the BRGWORKS program. The second largest area of the LMF was the region below Gun Creek Fan where a 35 ha area stretched from the base of the fan to the Bridge River.

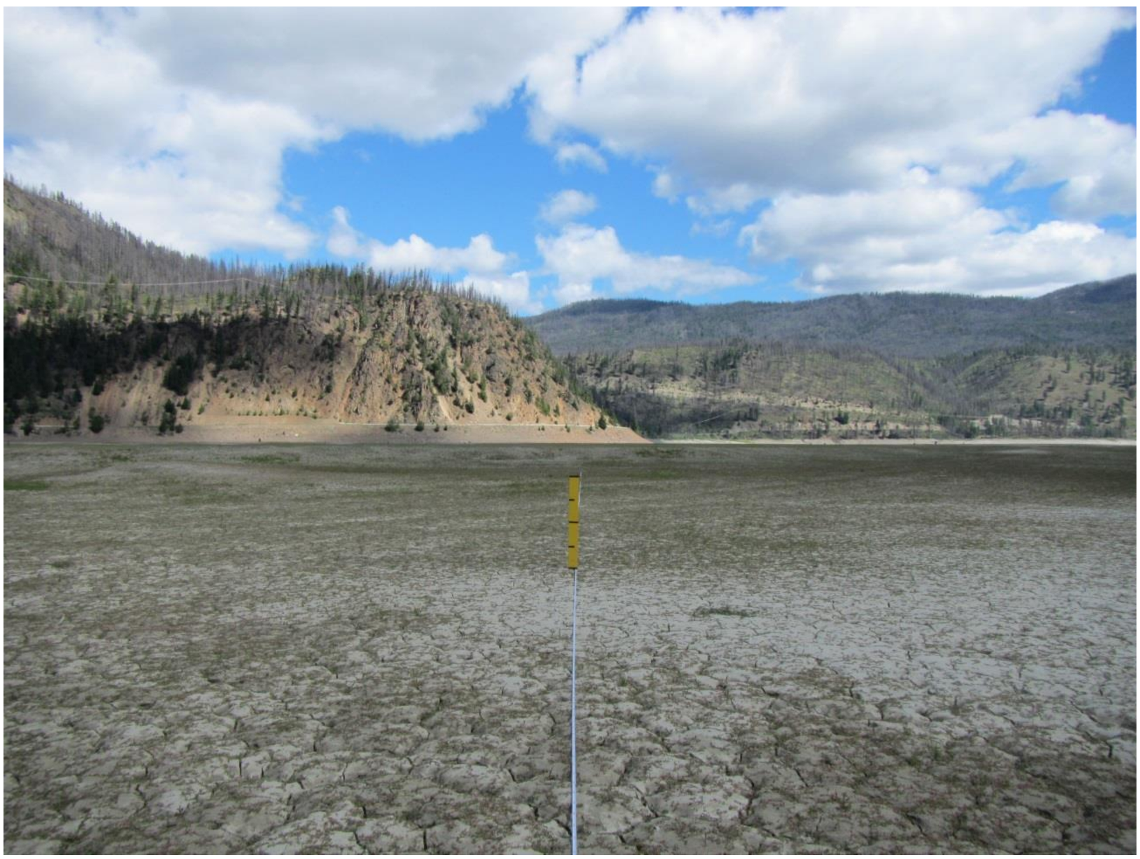


Figure 8. View of a LMF transect (LMF 05), looking north east. June 12, 2013

The LMF are areas of lacustrine deposits. The substrates of the LMF transects were 100% mineral soil, and the soil textures were consistently silts. The micro topography was flat with the occasional channel carved through the landscape from the flow of the Bridge River. At the sub meter scale, the terrain was undulating, and varied from smooth, slightly cracked surface, to dry cracked surface and macro dimple features at lower elevations (around 636 m, Figure 9). It was noted that cracks in the soil were often sites of vegetation growth.

Figure 9. Examples of the range of soil microtopography June 10, 2013.

Mule deer (*Odocoileus hemionus)* tracks were observed in one transect (LMF02, Figure 10). There were little other conclusive signs of wildlife presence on the lower mudflats; it was sometimes difficult to distinguish if the observed micro indentations and erosion features in the substrate were the result of fluvial processes, wind/wave erosion, or weathered wildlife tracks. There were also excavation holes, measuring sometimes a meter wide or more, and it was debatable if these features were of zoological or geomorphological origins. Speculated zoological origins included goose, deer, and/or bear activity. The only other animal sign was on the north side of the Bridge River channel (in LMF01), where a lone horse visited the survey crew. It should also be noted that the LMF area adjacent to the Gun Creek Fan was prone to disturbance from vehicle traffic.

Figure 10. Possible weathered wildlife tracks along transect LMF02. June11, 2013

At least 16 species of vegetation were identified throughout the LMF area. On average, there were 7.5 species per transect, with a low of four species in LMF03 and a high of 12 species in LMF05. Vegetation was very sparse, in general averaging 8 per cent cover (range between .02 in LMF03 up to near 19 per cent in LMF05). The predominant species was fowlers knotweed (*Polygonum fowlerii*), averaging five per cent per transect and occurring in all six transects. Lamb’s quarters (*Chenopodium album*) was also found in all six transects, bird’s eye pearlwort

(Sagina procumbens) and pineapple weed (*Matricaria discoides*) were found in five transects and lady's thumb (*Persicaria maculosa*) in four. Perennial native species that occurred in the low mudflats included horsetails (*Equisetum pratense* and *Equisetum palustre*) and Lakeshore sedge (*Carex lenticularis*), that appeared twice with very little cover at an elevation of approximately 638 m. The transect LMF05 had a relatively higher vegetation cover and a greater number of species than the other transects. Occasional *Carex lenticularis* was also observed on the lower mudflats as well as some dead tussocks from mature *lenticularis* that had since perished.

3.2.1.2 Mid Mudflats

The mid mudflats (MMF) were identified as the smooth or flat flood plains just west of the Gun Creek Fan, where elevation ranged between 642 m and 646 m (Figure 11). The MMF terrain class covered 162.7 ha, or 10.7 per cent, of the spatially mapped drawdown zone, and was comprised of 16 polygons (Table 2). Over half of the MMF polygons were on the south shore of the Middle Bridge River.

Figure 11. Looking south west out across the MMF terrain June 17, 2013 .

The MMF polygons were characterized by lacustrine silt deposits. Most of the growing season water for vegetation growth was from precipitation. The only exception was MMF 06, that lies in a collecting area where ground water was at the surface for a portion of the growing season. The substrate cover was organic matter and mineral soil. One exception was again MMF06, which more closely resembled LMF polygons in terms of species occurrence, and substrate cover (with 100 per cent mineral soil).

A total of 30 species of vegetation were observed in the MMF transects. The average number of species per transect was 12.5, with a range between 8 species and a high of 17 species. The average vegetation cover was 63 per cent over all transects, with a low of 36.5 per cent and a high of 85.25 per cent. MMF vegetation was dominated by horsetails (*Equisetum sp*.), which averaged almost 20 per cent cover and occurred in all transects except one (Figure 12). Swamp horsetail (*Equisetum palustre*) occurred an average of 9 per cent cover across all transects except one, and Lakeshore sedge (*Carex lenticularis*) was observed at four transects. Bluejoint grass (*Calamagrostis canadensis*) was present in relatively high cover and fowl bluegrass (*Poa palustre*) was recorded in three transects. The western most MMF transect had the agronomic grass Timothy (*Phleum pratense*) and clover species (*Trifolium sp.).* There were also notable occurrences of curled dock (*Rumex crispus*) that appeared to be selected for under grazing pressure. A herd of horses was observed ranging in this area.

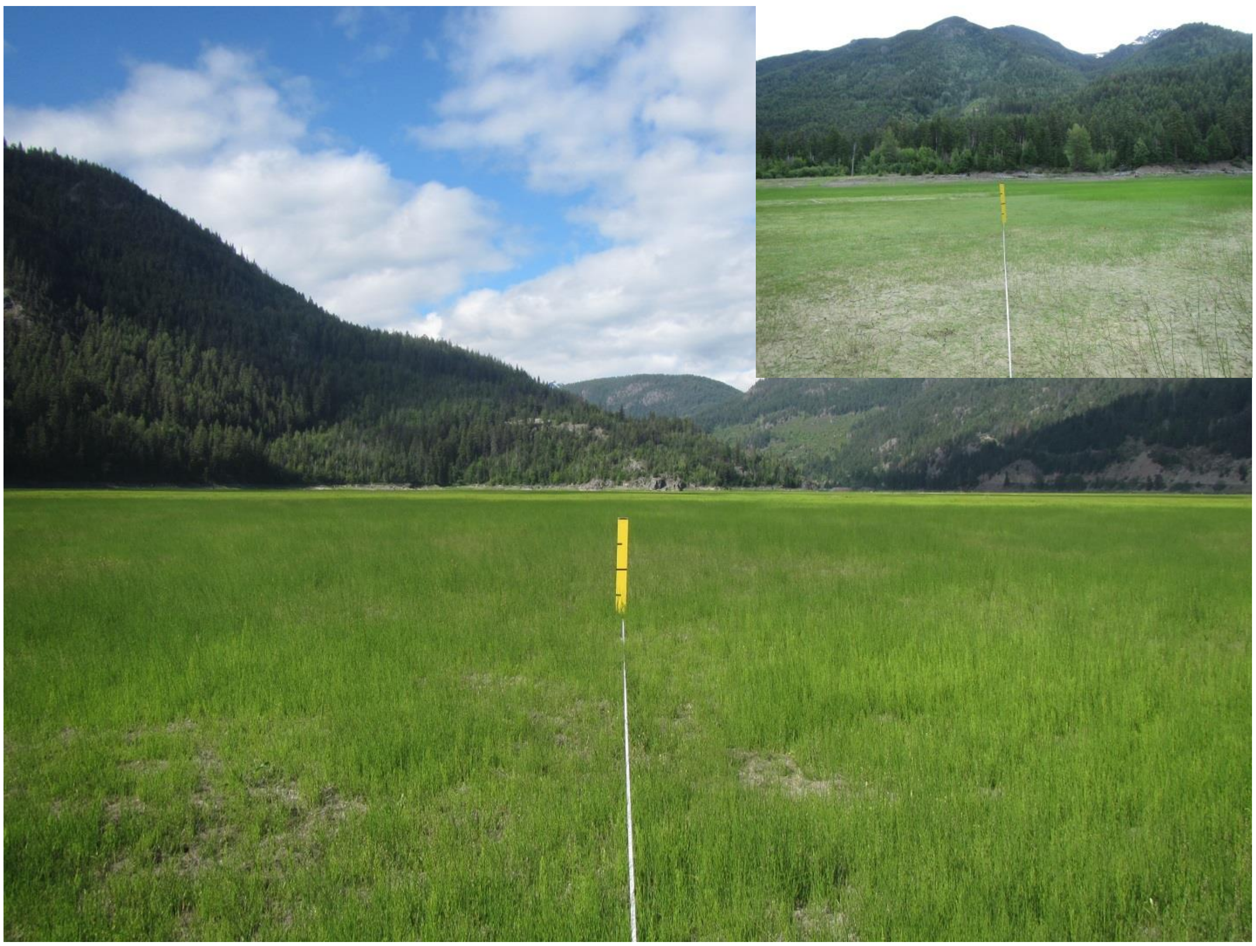


Figure 12. A horsetail dominated transect (MMF05), looking East inset MMF06 June 18, 2013.

Aside from the horses, the most common wildlife sign in the MMF terrain was from Canada goose (*Branta Canadensis*); browse, feces and tracks were recorded, as well as large flocks (30+ birds) of geese seen on several occasions. Mule deer (*Odocoileus hemionus*) tracks were noted along one MMF transect.

3.2.1.3 Upper Mudflats

The Upper Mudflat (UMF) terrain class (Figure 13) covered 30.3 ha, or about two per cent of the stratified area, and was comprised of five polygons (Table 2). The bulk of the UMF area was on the north side of the Middle Bridge River, with only one 3.5 ha polygon on the south side of the river. That polygon was also the furthest UMF polygon to the east (Figure 6).

UMF transects were smooth to undulating terrain of lacustrine silt deposits. The substrate cover was predominantly organics, with an average plot cover of 88 per cent, while the remaining was mineral soil. Precipitation was the predominant water source during the growing season, although deeper rooted plants could be tapping into the ground water.

Figure 13. Vegetation in one UMF transect, with curly dock, white clover, and agronomic grasses, in area grazed by horses June 19, 2013

A total of 31 species of vegetation were recorded in the UMF polygon transects (Figure 14). The average number of species per transect was 14, with a tight range between 13 and 15 per transect. The average vegetation cover for the UMF transects was 75 per cent, with a low of 35 and a high of 120 per cent. The UMF was characterized by frequent occurrences of Poaceae species. Three grass species were recorded in all six transects, with red top (*Agrostis gigantea*) providing the most cover (on average 19 per cent), followed by fowl bluegrass (*Poa palustris*), and foxtail barley (*Hordeum jubatum*). Bluejoint grass (*Calamagrostis canadensis*) was found in five transects, and the exotic species quack grass (*Elytrigia repens*) was found in four transects. Four Carex species were identified in the UMF transects, namely *Carex lenticularis, aquatilus, phaeocephala,* and *utriculata,* and two rushes (*Juncus effusus* and *Juncus balticus*).

All of the UMF transects on the north side showed presence and use by horses. The horses were the same herd as the one observed in MMF 03. Horse browse, tracks and feces were evident. Moose (*Alces alces*) feces were also recorded along one transect, as well as mule deer (*Odocoileus hemionus*) browse was noted. Canada goose (*Branta canadensis*) droppings were recorded on the south side transect only.

Figure 14. Examples of vegetation in UMF quadrats.

3.2.1.4 Buffer Mudflats

The buffer mudflat (BMF) area was formed and shaped by fluvial action from the historic Bridge River, current flows of the Middle Bridge River, and inundation from the Carpenter Reservoir. The BMF area covers approximately 15.4 ha, just over 1 per cent of the mapped terrain. The BMF area was in two patches, with one small area on the south side of the river just behind the town of Goldbridge, and one larger area on the north side of the river (Figure 5). The north side area was divided into six contiguous polygons, indicating some degree of heterogeneity in the BMF terrain and vegetation structure. The south side polygon was not sampled due to project time constraints. The topography of the eastern most transect (BMF01) was similar to the UMF polygons, and was influenced by lacustrine deposition from inundation and flooding, with a smooth to undulating topography and loamy soils. The western most BMF transects were predominantly formed from the fluvial actions of the Middle Bridge River. The topography was channeled, with fluvial sands and sandy loam soils. The substrate of the BMF was predominantly organics, with an average cover of organics matter of 86 per cent. The remainder of the substrate cover was a mix of occasional wood, and mineral soil.

The vegetation structure was complex, with multi-layered canopies of deciduous trees and shrubs, shrubs, and understory herb layers totaling on average over 100 per cent cover (Figure 15). 37 species of vegetation were recorded in the Buffer Mud Flat transects. On average, 16 species were found along the transect, with a fairly consistent range between 15 and 18 species. The average cover in the BMF transects was 120 per cent, with a range from 96.5 per cent to 160 per cent.

Figure 15. Example of vegetation in a BMF transect.June 20, 2013.

There was a dominant and relatively continuous canopy layer of tall shrubs (Figure 16), made up mainly of mountain alder (*Alnus incana;* 37 per cent cover on average) and Pacific willow (*Salix lucida ssp. Lasiandra;* 29 per cent cover on average). Other willow species made up an additional 6 per cent cover, over all. Alder was found in four of the five transects, and Pacific willow in three. Cottonwood (*Populus balsamifera*) was observed occasionally throughout the area, although it did not show in quadrat samples. The understory was comprised of a mix of herbs and shrubs, with an exotic species, giant burdock (*Arctium lappa*), occurring in four of the five transects with an average cover of 13 per cent. In one transect (BMF 05), burdock made up the majority of the understory cover, equaling 60 per cent of the total vegetation cover. Other species in the understory of the BMF transects included red raspberry (*Rubus idaeus*), Red Osier dogwood (*Cornus stolonifera*), black twinberry (*Lonicera involucrata*), Bluejoint grass (*Calamagrostis canadensis*), fowl bluegrass (*Poa palustris*), Common horsetail (*Equisetum arvense*), and swamp horsetail (*Equisetum palustris*). Less common herb species found in the understory were Indian paint brush (*Castilleja miniata*), slender bog orchid (*Platanthera stricta*) and pink wintergreen (*Pyrola asarifolia*); less common shrubs were prickly rose (*Rosa acicularis*), soapberry (*Sheperdia canadensis*), snowberry (*Symphoricarpus alba*), thimbleberry (*Rubus parviflorus*), and Saskatoon berry (*Amelanchier alnifolia*).

Figure 16. Multi-storied vegetation in BMF polygons June 24, 2013.

The BMF transects had a relatively high amount of wildlife signs compared to the other mudflat classes. Horse and mule deer tracks were recorded, as well as moose browse or feces, beaver (*Castor canadensis*) browse or chew, and rabbit (*Lepus americanus*) browse. Many song birds were heard in the BMF stands, but identification was beyond the scope of this study. While sampling at one transect (BMF 04), a record of a COSEWIC endangered and provincially red listed species, the Western screech owl (*Megascops kennicottii ssp macfarlanei),* was made by the crew.

3.2.2 Gun Creek Fan

The Gun Creek Fan (GCF) is the largest alluvial fan on the Carpenter Reservoir, created by one of the largest rivers flowing into the reservoir. There are multiple jurisdictions and land uses on the fan. A ministry of transportation gravel yard exists on the North West side of the fan, and a BC Hydro recreation campground on the East side. The drawdown zone on the East side of the fan is also the site of the historical town of Minto, and foundations and debris remain. The town site is highlighted for those interested in visiting it through a sign along the road.

The terrain of Gun Creek fan covers approximately 60 ha, making it over a quarter of the total area of alluvial fans in Carpenter Reservoir (Figure 17). The fan is unique in the reservoir by its size and gradual slope of about 1.5 per cent. The uniqueness of the fan, and the fact that the fan is a target area for re-vegetation in the BRGWORKS-1 project, required treating the fan as a separate terrain class. Due to time constraints, a total of three primary transects, with four secondary transects each, were established across the Gun Creek Fan. One transect was located on the West side of the fan and two on the east (Figure 17).

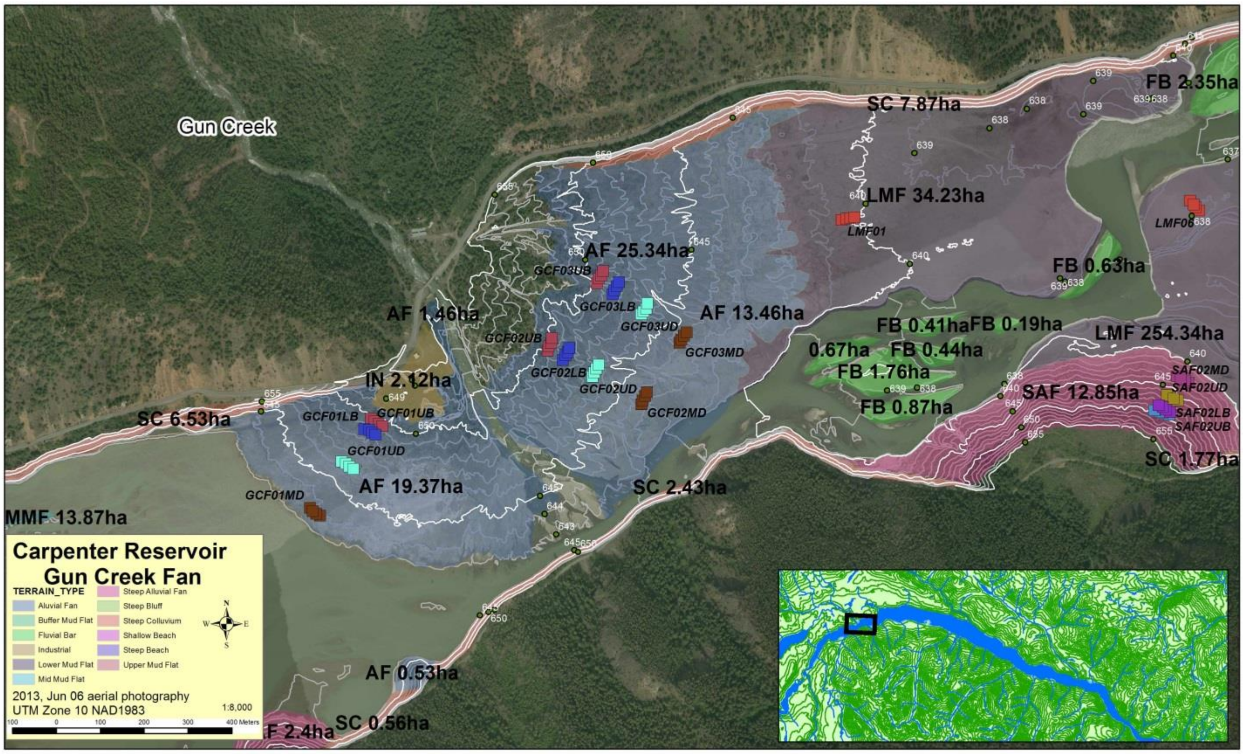


Figure 17. **Distribution of the terrain classes and polygons in the Gun Creek Fan of the Carpenter Reservoir in 2013.**

3.2.2.1 Gun Creek Fan, mid elevation

The mid elevation transects in the Gun Creek Fan (GCFmd) were targeting the 644m elevation band. The topography on the fan varied from smooth to channeled (Figure 18). The channeling observed across parts of the fan was from historical flooding of Gun Creek. One transect on the west side of the fan (GCFmd 01) had a significant component of rounded rock as substrate cover, and sandier soils, as testaments of the influence of the Middle Bridge River on this side of the fan. The transects on the east side of the creek were predominantly covered by sandy, well-draining mineral soils. They also had more silts as a result of accumulated sediment deposition from reservoir inundation. The silty soils were less well draining.

Figure 18. Example of the smooth to channeled topography in the mid elevation zone of the Gun Creek Fan. July 04, 2013.

The overall cover of vegetation was relatively low across the GCFmd transects, averaging 17 per cent with a low of 3.92 per cent and a high of 36 per cent. 14 species of vegetation were recorded from the transects. The average frequency of species per transect was 7.5, and ranged between 6 and 10 species. Most species were very rare, with the exception of bird's-eye pearlwort (*Sagina procumbens*), which was found to as high as 30 per cent in one transect. Another notable occurrence, at this relatively low elevation, was the native grass foxtail barley (*Hordeum jubatum*).

Horse and deer tracks were recorded on the transects on the east side of the creek. Deer tracks were also observed on the west side of the creek. Truck tire tracks were recorded on the west side, in the areas where vehicles have access (Figure 19).

Figure 19. Truck tire tracks observed on the west side of Gun Creek. July 04, 2013.

3.2.2.2 Gun Creek Fan, upper elevation

Microtopography in the transects at upper elevation of Gun Creek fan (GCFud) varied from smooth, to undulating and ribbed. Ribbing was the result of wave action, which had a notable influence at this elevation. The soils were much coarser than at lower elevations, with rock totaling, on average, over 35 per cent cover of the quadrats, followed by mineral soils. The rocks were river cobbles and boulders, and increased in coverage from the west to the east side of the fan (Figure 20). Soils were sandy and drainage varied from well to rapid in the western side of the fan.

Figure 20. Shift in substrate from sand to river cobbles, from west to east in the upper elevation transects of the Gun Creek Fan, in Carpenter Reservoir, in July 09, 2013.

Vegetation cover on the GCFud transects was very low on average with 5.5 per cent cover (range: 0.5 per cent to 11 per cent). The species with the greatest amount of cover was quack grass

(*Elytrigia repens*), a rhizomatious, exotic, perennial species. The second most abundant species was Canada bluegrass (*Poa compressa*). Several other perennial grass species had trace occurrence in the upper drawdown of the Gun Creek fan, including foxtail barley (*Hordeum jubatum*), and fowl bluegrass (*Poa palustrus*).

The same wildlife species as in the mid drawdown transects were observed in the upper drawdown. Vehicle disturbance was also noted on the west side.

3.2.2.3 Gun Creek Fan, lower buffer

The transects in the lower buffer zone of the Gun Creek fan (GCF LB) had smooth to ribbed micro-topography, due to wave action from the reservoir. Substrate cover was mixed, with 53 per cent rock, and 47 per cent mineral soil. As with the upper elevation transects, there were more rounded fluvial cobbles and gravels in the east site of the fan, compared to the sandier substrates of the west side (Figure 21 and Figure 22). This is again an indication that the west side of the fan is a deposition area for the Middle Bridge River, while the east side is more influenced by the historical floods of Gun Creek.

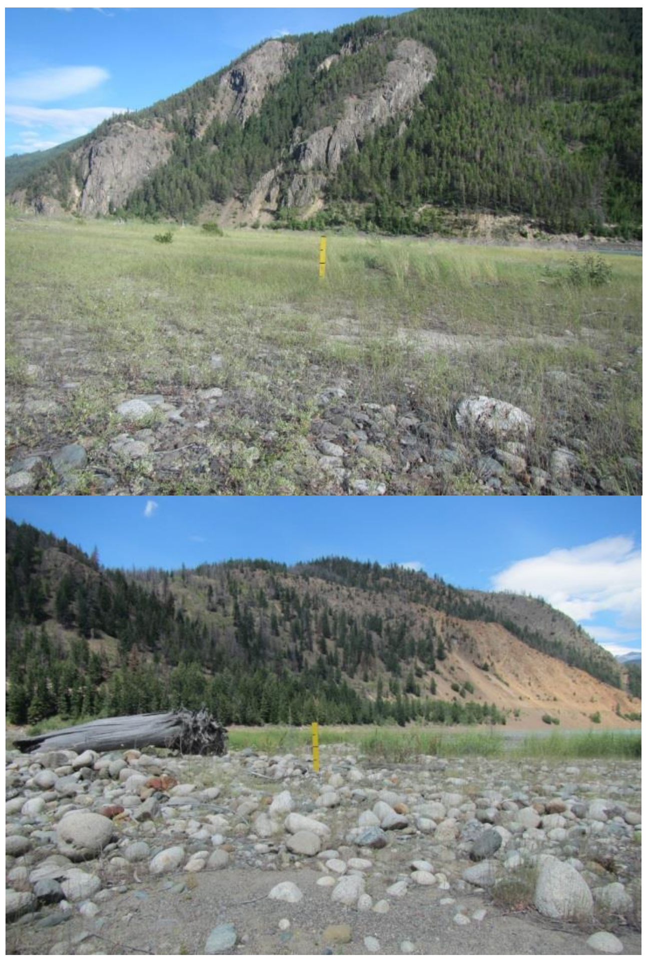


Figure 21. Transition from the sandier substrate in the West side of the fan, to cobbles/gravels in the East side of the fan. July 09, 2013.

Figure 22. Examples of quadrats with substrate transitioning from sandy, to gravel and rocks.

Seventeen species of vegetation were recorded in the Lower buffer zone of Gun Creek Fan. On average, the number of species recorded per transect was 8 (ranging from seven to 11 species). Overall, vegetation coverage was sparse (14.5 per cent on average, ranging from 5 to 21.5 per cent). The two most common species were Canada bluegrass (*Poa compressa*) and silvery cinquefoil (*Potentilla argentea).* Two perennial shrub species were recorded in trace amounts: prickly rose (*Rosa asicularis*), and red-osier dogwood (*Cornus stolonifera*). Yarrow (*Achillea millifolium*), curled dock (*Rumex crispus*), dandelion (*Taraxacum officinale*), small flowered evening star (*Mentzelia albicaulis*), and two noxious weeds were also recorded in trace amounts (spotted knapweed, *Centaurea biebersteinii,* and common toadflax, *Linaria vulgaris*). Other weeds include great mullein (*Verbascum Thapsus*), alfalfa (*Medicago sativa,* and quack grass (*Elytrigia repens*).

Mule deer tracks were recorded on the east side transects. Two mule deer were observed in the field browsing on *Populus balsamifera* leaves on the edge of the Upper buffer zone. Vehicle tracks were also observed on the west side.

3.2.2.4 Gun Creek Fan, upper buffer

Although the target for sampling the upper buffer zone in Gun Creek (GCF UB) was at an elevation of 650.5 m, it appears from a review of the current digital data and the transect quadrat locations, that the elevation sampled was closer to 649.5m. The micro-topography for the GFC UB transects was generally smooth, with wave action influence. The substrate in the west side of the fan was covered in driftwood and organics (Figure 23), while the eastern most transects were rocks and mineral soils. The west side of the Gun Creek Fan was a zone of collection and deposition, where the Middle Bridge River flows run into the fan. On the east side of the fan, there were channeled undulations from historic flooding of Gun Creek, with associated deposits of fluvial gravels, cobbles and boulders (Figure 24).

Vegetation cover in the upper buffer of the Gun Creek Fan varied from 6.5 per cent in the west, to a maximum of 38 per cent in the cooler east side. Twenty-one species were recorded in the transects. The greatest amount of cover was from black cottonwood (*Populous balsamifera*), and two other tree species were recorded with trace occurrences: Ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*). The most common herbaceous species was Canada bluegrass (*Poa compressa*). Most of the species recorded in the upper buffer were perennials and included perennial shrubs red-osier dogwood, prickly rose, and choke cherry (*Prunus virginiana*), although occurrences were very sparse. Weedy species included provincial noxious weed diffuse knapweed, and other nuisance weeds including quack grass, and mullein

(*Verbascum thapsus*). The native, parasitic, and rhizomatious species pale commandra (*Comandra umbellate*) was recorded from one transect.

Figure 23. Example of substrate covered with driftwood and organic deposits on the west side of the fan. July 09, 2013.

Figure 24. Channeled undulations from historic flooding of Gun Creek, with associated deposits of fluvial gravels, cobbles and boulders, on the east side of the fan. July 09, 2013.

3.2.3 Steep Alluvial Fans

Steep alluvial fans (SAF) were the fans formed by small creeks with steep drainages (slopes greater than 10 per cent). SAF covered 132.7 ha, for 8.7 per cent of the total mapped area. There were fourteen polygons identified, and four (the largest) were sampled with five transects (Figure 25 and Figure 26). Two fans were located on the south shore of the reservoir, and two on the north side.

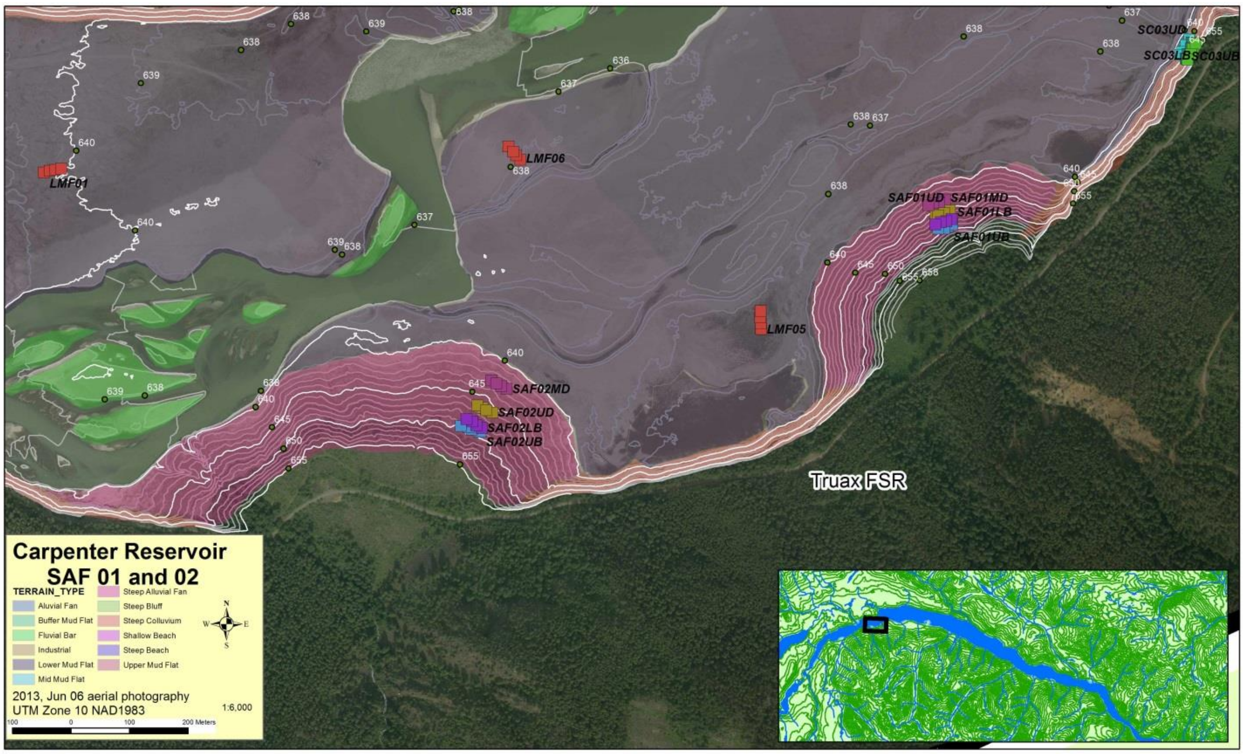


Figure 25. Distribution of the terrain classes and polygons on the south shores of the central areas in the Carpenter Reservoir in 2013.

The fan at Jones Creek was the largest of the SAF (Figure 26). There was a recreation area on its west side, and a gravel pit for the Ministry of Highways on the east side. Each side of the Jones Creek Fan was sampled with one primary and four secondary transects.

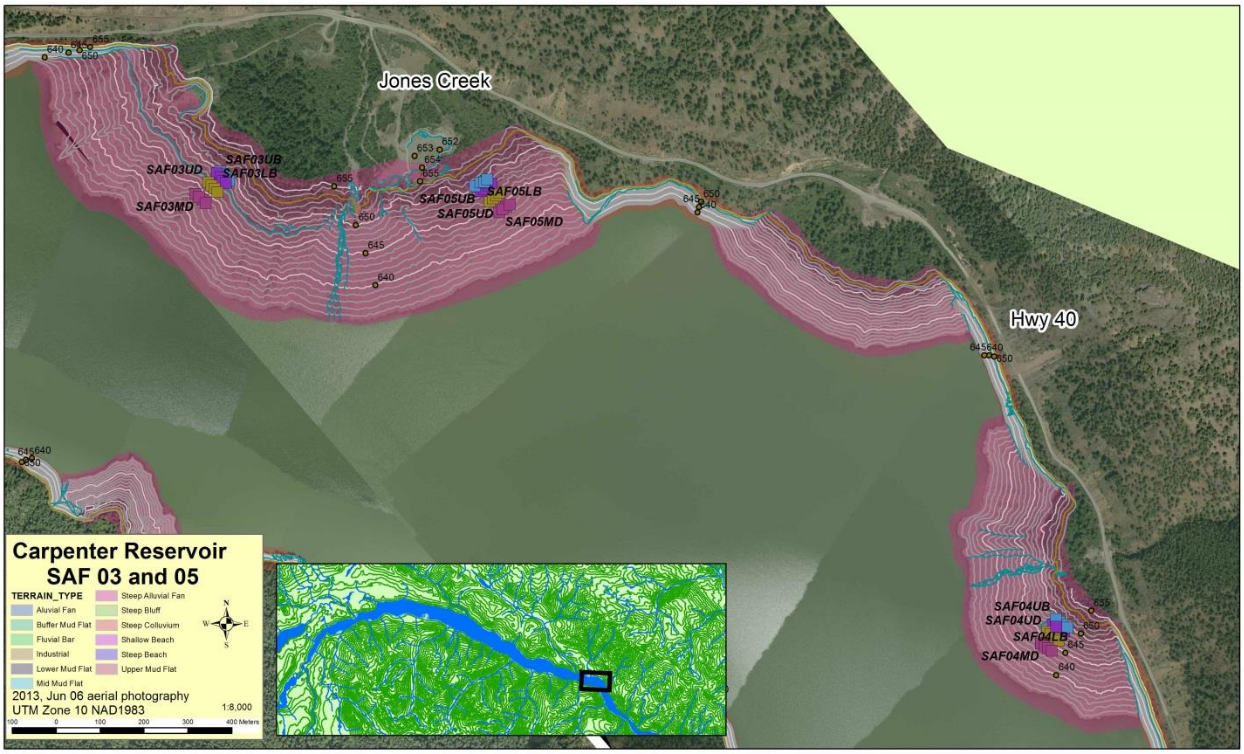


Figure 26. Distribution of the terrain classes and polygons on the north shores of the central areas in the Carpenter Reservoir in 2013.

3.2.3.1 Steep Alluvial Fans, middle elevation

The lowest elevation sampled on the steep alluvial fans was the middle elevation band (SAFmd), targeting the 644 m mark. The microtopography varied from smooth to ribbed and undulating, following interactions with wave action from the reservoir, and historical fluvial erosion and deposition. The substrate was almost entirely made up of rocks. Rocks were largely sub-angular gravels, making soils very coarse (Figure 27, Figure 28). Soil textures varied from sands to loam, and drainage ranged from rapid to very rapid.

Figure 27. Examples of the coarse soils with rocky substrate. The furthest right image shows one of the denser samples, where the cover of exotic black medic (*Medicago lupulina*) was relatively high.

Figure 28. View of the rocky substrate of one mid elevation steep alluvial fan, in Carpenter Reservoir in 2013.July 05, 2013.

The SAFmd transects were typically sparsely vegetated, and their average cover was 12 per cent (with a range between 2.1 and 20.5 per cent; Figure 29). Eighteen species of vegetation were recorded, mostly weedy annuals. The only perennial species was common horsetail (*Equisetum arvense*). The most common weed species was annual black medic (*Medicago lupulina*), with an average cover of 7.5 per cent. The most common native species was narrow-leaved collomia (*Collomia linearis*). Other frequent species were tall willowherb (*Epilobium brachycarpum),* Fowler's knotweed (*Polygonum fowlerii*), pineapple weed (*Matricaria discoidea*), Lamb's quarters, Lady's thumb (*Persicaria maculosa*), worm seed mustard (*Erysimum cheiranthoides*), and white sweet clover (*Melilotus alba*).

Wildlife signs were limited to mule deer tracks and Canada goose feces on some of the transects.

Figure 29. Sparsely vegetated transects in a steep alluvial fan of Carpenter Reservoir June 26, 2013.

3.2.3.2 Steep Alluvial Fans, upper elevation

The steep alluvial fans at the upper elevation (SAFud) had micro-topography characteristically smooth to ribbed, with wave action being a key force shaping the land (Figure 31). There was evidence of past industrial use at one of the sites (SAF05), with rock obviously placed in the past. That transect was also situated below an active gravel pit. Substrate cover in the SAFud transects was largely composed of coarse sub-angular gravels, with sandy textured soils (Figure 30). The soils were rapidly draining.

Figure 30. Examples of soils at the upper elevation in steep alluvial fans.

Figure 31. View of an upper elevation steep alluvial fan, in the Carpenter Reservoir June 25, 2013.

Vegetation cover in the SAFud transects was relatively sparse, with average cover from 13 to 21 per cent (Figure 32). Species forms were fairly evenly split between perennials and biennial/annuals. Most species were found in trace amounts, with the exception of black medic, white sweet clover (*Melilotus alba*), Foxtail barley (*Hordeum jubatum*), and biennial cinquefoil (*Potentilla biennis*). Grasses found included fowl bluegrass, Canada bluegrass and quack grass.

The only wildlife observed along the SAFud transects were arthropods.

Figure 32. Sparsely vegetated transect at the upper elevation in a steep alluvial fan of Carpenter Reservoir July 5, 2013.

3.2.3.3 Steep Alluvial Fans, lower buffer

The micro-topography of the lower buffer steep alluvial fans (SAFlb) was smooth to ribbed and once again influenced by the shaping action of the waves. The substrate varied from rock (on average, over 50 per cent), followed by organic matter (30 per cent), driftwood (10 per cent), and mineral soil (5 per cent; Figure 33). Soils were sandy and coarse, with a high sub angular coarse fragment content that made them well drained.

Figure 33. Example of vegetation and substrate in the lower buffer zone of steep alluvial fans.

Vegetation cover in the SAFIb transects averaged over 50 per cent cover, and reached a high of 87 per cent cover. Twenty-nine species were found, and over 65 per cent of the vegetation was composed of perennials. The only species that occurred in all transects was the cinquefoil (*Potentilla biennis*). The most common species was the robust annual plant white sweet clover (*Melilotus alba*, Figure 34). The perennial grass Canada bluegrass (*Poa compressa*) and Foxtail barley were also noted, as were slender wheat-grass (*Elymus trachycaulus*), the native upland species blue wildrye (*Elymus glaucus*), and black cottonwood (*Populus balsamifera*). Trace occurrences of Douglas-fir (*Pseudotsuga menziesii*), red raspberry (*Rubus ideaus*), and prickly rose (*Rosa acicularis*) were made. One exotic species of concern was spotted knapweed (*Centaurea biebersteinii*).

Mule deer tracks were observed in the Jones Creek Fan, and horse tracks were observed on the south side of the reservoir.

Figure 34. View of a transect in the lower buffer zone of a steep alluvial fan (SAFIb 05) in Carpenter Reservoir in 2013. Note the white sweet clover in the center of photo is well over the 1m board height. July 08, 2013.

3.2.3.4 Steep Alluvial Fans, upper buffer

The terrain microtopography in the upper buffer zone of the steep alluvial fans (SAFub) was generally smooth, with wave action being the key geomorphic force. The only exception was one transect (SAF04) where more recent fluvial gravels and sands had been deposited from the creek. Substrate cover was primarily organics and wood (on average, 47 and 33.5 per cent, respectively, Figure 35). Several transects had high percentage of rock cover, and moderate amounts of mineral soil cover. Coarse fragments were sub angular in shape, and soils were loamy sands to sandy loams, which made the soils well drained.

Figure 35. Example of quadrats sampled in the upper zone of steep alluvial fans in Carpenter Reservoir, in 2013.

A total of twenty-five species of vascular plants were recorded at the SAFub transects. Eighteen of the species found were perennials and eight, either annual or biennial. Black cottonwood was the dominant canopy cover in three of the transects that were at the edge of a riparian cottonwood stand (Figure 36). White sweet clover (*Melilotus alba*) was the most frequently recorded species. On transect (SAFub 03) was part of a recreation area, and had a high percent cover of burdock (*Arctium lappa*, Figure 37). Common horsetail was frequently found in the SAFub, as were several grass species (e.g. the Canada bluegrass, Kentucky bluegrass, and the exotic quack grass). The provincial noxious weed Canada thistle (*Cirsium arvense*) was also observed, as well as trace occurrences of Douglas-fir.

Mule deer and horse feces and browse were noted in two transects.

Figure 36. **Stand of cottonwood in the upper buffer zone of steep alluvial fans, looking West through the edge of the forest. July 05, 2013.**

Figure 37. **View of transect SAFub 03 looking West. Note the large patch of burdock. July 08, 2013.**

3.2.4 Steep Beach

The steep beach (STB) terrain class covered 152 ha over 26 polygons, for 10 per cent of the mapped drawdown zone of Carpenter Reservoir (Figure 38, Figure 39, Figure 40). The STB polygons were distributed across the entire Carpenter Reservoir, on both the north and south shores. They had terrain sloping between 15 and 30 per cent, and they spanned all elevation bands. The randomly chosen sampling locations yielded one transect (STB01) on the south shore of the reservoir, and four transects distributed across the north shore. The predominant shape of the micro-topography for the steep beaches was ribbed, and wave action was the driving geomorphological force. Soils were generally coarse and well drained, and covered in rock or mineral soil in the mid and upper elevation bands. One transect (STB03) was anomalous in substrate cover, with high cover of organic matter and vegetation (mostly attributable to white sweet clover), as a result of the landscape and location. It is at the eastern end of the reservoir where the reservoir narrows, and floating organics back up from outflow end of the reservoir at Terzaghi dam (Figure 39). The beach was functioning like a corner pocket where floating materials drifted and collected.

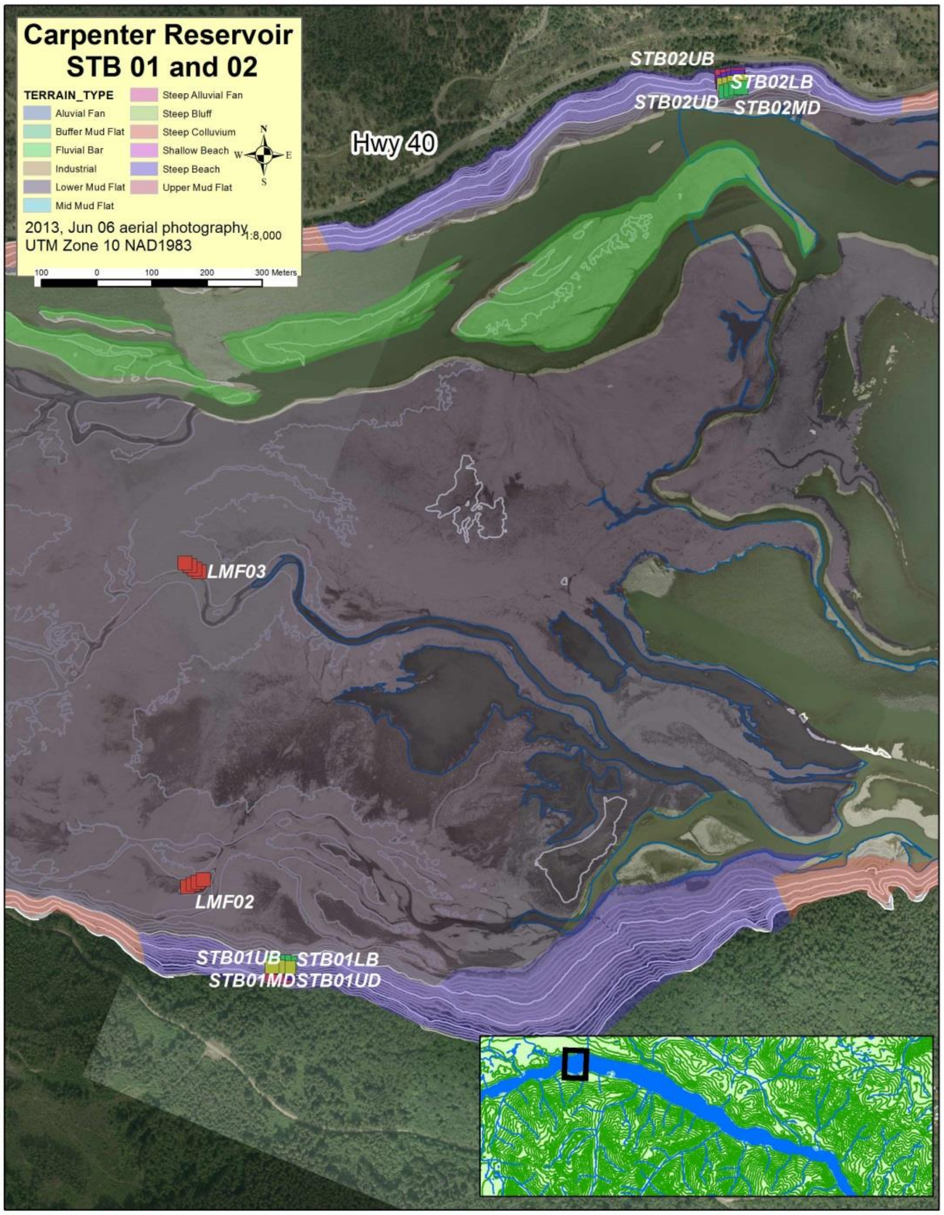


Figure 38. **Distribution of the western-most polygons of steep beaches (STB01 and 02), in the Carpenter Reservoir in 2013**

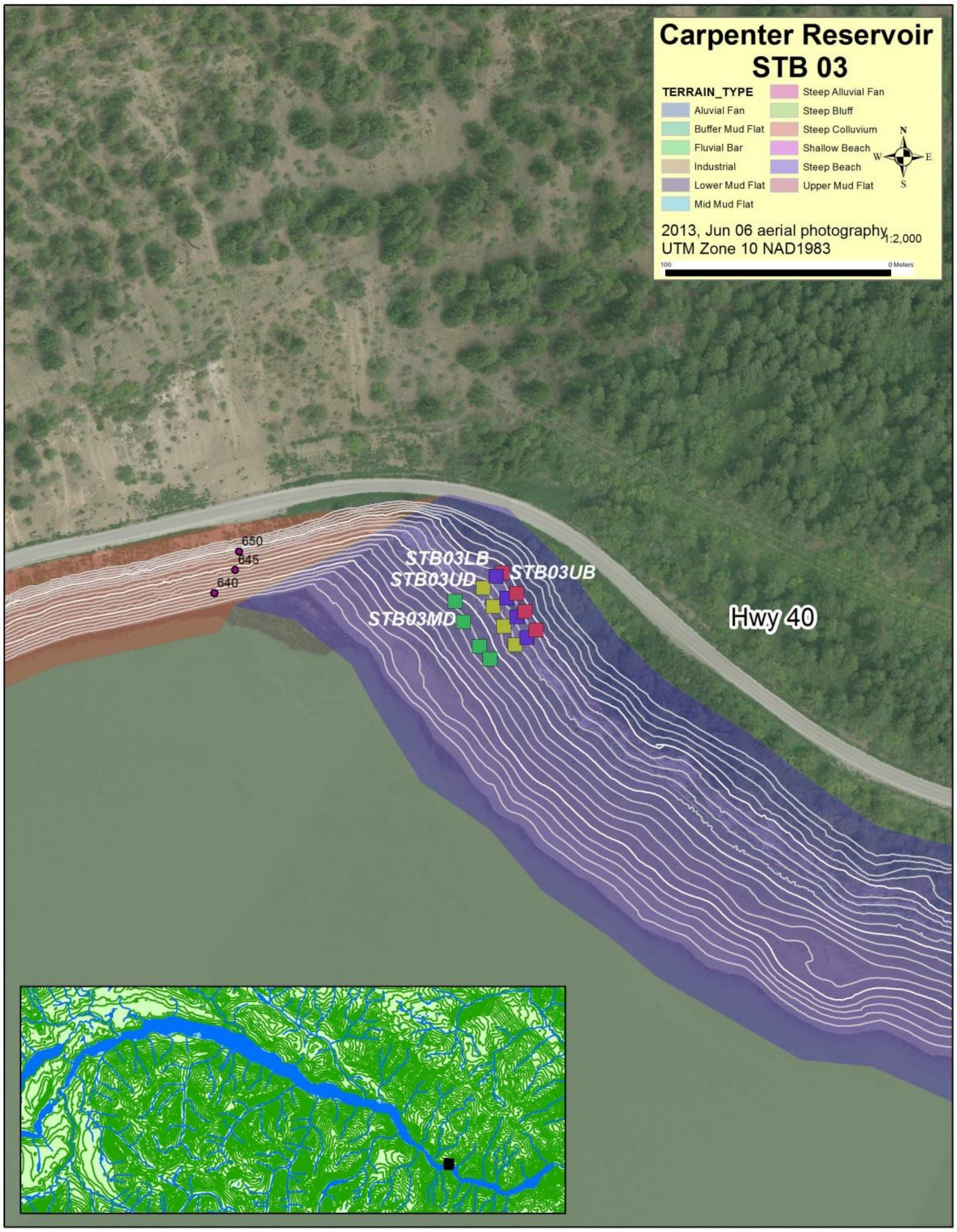


Figure 39. **Location of the eastern-most steep beach transect (STB 03), in the Carpenter Reservoir in 2013. Note that the dark spot in the corner of the beach is a collection of floating organic matter.**

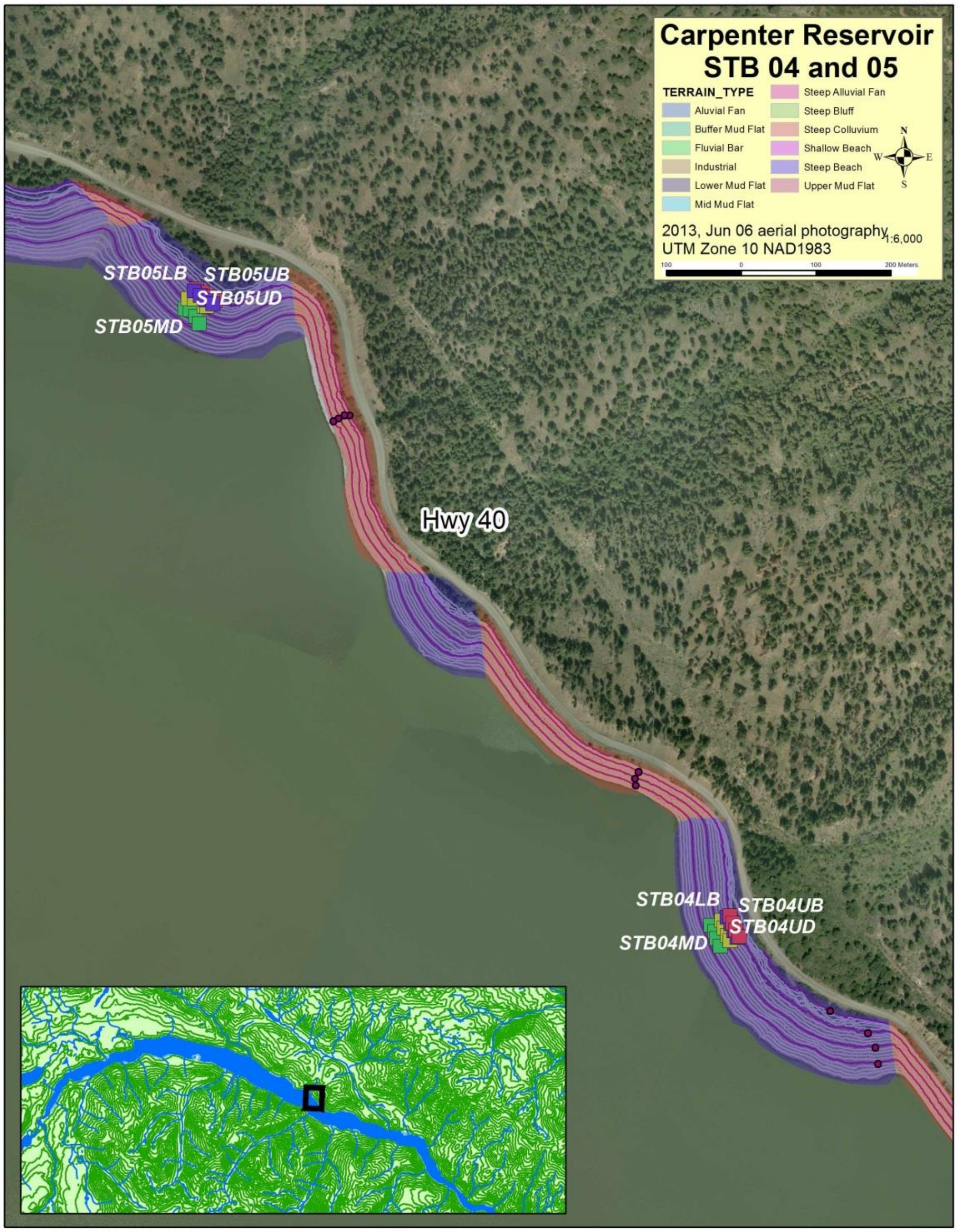


Figure 40. **Location of the central steep beach transects (STB 04 and 05), in the Carpenter Reservoir in 2013.**

3.2.4.1 Steep Beach, middle elevation

The microtopography of the steep beach at middle elevation (STBmd) was ribbed or stepped, and shaped by wave action. Substrate cover was on average mostly rock (65 per cent) and mineral soil (30.5 per cent), with the exception of the STBmd03 transect where there was high cover of fine organic debris (Figure 41). Soils in the STBmd transects were sandy with sub angular coarse fragments, and rapid drainage.

Figure 41. Differences in substrate covers, with the heavily vegetated STB03 transect on the left, and more typical STB transects on the right, with sandy and gravely substrate. Note the mule deer tracks in the further right image.

Twenty-three species of vegetation were observed in the STBmd transects. Most of these were weedy annuals occurring in low to trace amounts (Figure 42), except for the STB03 transect that had 99 per cent of vegetation cover. The high cover in STB03 is attributable to the extensive cover by the native annual species meadow bird's foot trefoil (*Lotus denticularis*), averaging 86 per cent cover (Figure 43). The exotic weedy annual white sweet clover was the most frequently observed species, but was absent from the heavily vegetated SAFmd03.

The only observed sign of wildlife was the mule deer tracks observed in one transect.

Figure 42. **View of a typical steep beach transect at mid elevation, facing north east in the Carpenter Reservoir in June 25, 2013.**

Figure 43. **View of the heavily vegetated mid elevation STB03 transect. Note the high cover of meadow birds foot trefoil (*Lotus denticularis). June 28, 2013.***

3.2.4.2 Steep Beach, upper elevation

The steep beach transects in the upper elevation band (STBud) had ribbed microtopography resulting from the wave action of the reservoir. The substrate cover was mostly rock (78 per cent), and mineral soil 18 (per cent). As for the middle elevation, the STB03ud transect was the exception with a cover of organic matter. Coarse fragments were mostly sub-angular, except for one transect (STB02) where the rocks were rounded. Soils were sandy and rapid to very rapidly drained (Figure 44).

Figure 44. Examples of sparse vegetation over rocky, wave washed substrates, in STBud quadrats.

Thirty-six species of vegetation were identified in the STBud transects. The transects were generally sparsely vegetated (Figure 45), with the exception again of the STBud03 transect that had a high of 73 per cent in vegetation cover. Over half of the species were exotic weedy species (usually annuals). The species with the most cover overall was *Lotus denticularis,* but it occurred only in STBud03. The second highest vegetation cover came from white sweet clover (*Melilotus alba*), followed by black medic. Seedling and saplings of Douglas-fir and Black cottonwood saplings were recorded in two transects.

Wildlife signs included black bear (*Ursus americanus*) feces, and mule deer tracks.

Figure 45. Typical view of a steep beach at upper elevation, in the Carpenter Reservoir on June 27, 2013.

3.2.4.3 Steep Beach, lower buffer

The lower buffer transects in the steep beach terrain class (STBlb) had ribbed to smooth microtopography, with wave action being the principal active geomorphologic agent. Substrate cover varied from rock, on average, the most prevalent cover (over 50 per cent), to mineral soil (21 per cent), wood (15 percent), organics (13 per cent), and occasional small patches of bedrock (Figure 46). Soils were sandy, and ranged from loamy sands to sandy loams, with high coarse fragment contents of angular to rounded rock. Soils were well to very rapidly drained.

Figure 46. Examples of substrate covers in quadrats of steep beaches in the lower buffer zone of Carpenter Reservoir in 2013.

A total of 39 species of vegetation were recorded in the STBlb transects. Richness ranged from 8 species to a high of 21 species (in STBlb 03, again densely vegetated, Figure 47). The most cover on average was from *Melilotus alba* at 13 per cent, followed by *Medicago lupulina*. Other species included upland shrub species snowbrush (*Ceanothus velutinus*), tall Oregon grape (*Mahonia aquifolium*), spreading dogbane (*Apocynum andro saemifolium*), Douglas-fir (Pseudotsuga menziesii), black cottonwood, burdock, white cockle, bull thistle (*Cirsium vulgare*), common toadflax (*Linaria vulgare*), Cheat grass, and great mullein (*Verbascum thapsus*). In some areas, upland vegetation was noticed encroaching on the steep beach sections in the lower buffer zone (Figure 48).

Mule deer tracks, cow prints, and ants were the wildlife signs observed.

Figure 47. Densely vegetated transect in the lower buffer zone of the steep beach transect STB03. Note the presence of the driftwood. June 28, 2013.

Figure 48. Example of vegetation in the lower buffer zone of a steep beach polygon. Note the encroachment of the beach by upland shrub and tree species. June 27, 2013.

3.2.4.4 Steep beach, upper buffer

The transects in the upper buffer of the steep beaches (STBub) were characteristically smooth in micro-topography, with some ribbed patterns from wave action. Driftwood was the predominant substrate type, with cover over 30 per cent, on average. Organics, rock, and mineral soil were the other substrates recorded (all with about 20 per cent cover, on average). Content in coarser fragment was high, with shapes varying from rounded, to mixed and angular (Figure 49). Soil textures were sandy loams and loamy sands, with some finer soils observed in STB03ub.

Figure 49. Examples of substrate in the upper buffer zone of steep beaches. Note the dead Douglas fir sapling in the right picture.

Transects in the upper buffer zone were generally quite diverse and vegetated (Figure 50), and at least 44 species of vegetation were observed throughout the STBub transects. The majority of species (66 per cent) were perennials. The richness per transect varied between 10 and 25 species, and the average per cent cover in vegetation was 33 (ranging from 6.7 to 52 per cent). The species providing the greatest amount of cover was black cottonwood at 7 per cent, although it was recorded in only 40 per cent of the transects. Upland species snowberry (*Symphorocarpus alba*), prickly rose (*Rosa acicularis*), Saskatoon berry (*Amelancier alnifolia*), Ponderosa pine, mountain alder (*Alnus incana*) and paper birch (*Betula papyrifera*) were noted. Alive and dead saplings of Douglas-fir (*Pseudotsuga menziesii*) were also recorded (Figure 51). Herbaceous species included *Equisetum arvense, Lotus denticularis,* and alfalfa (*Medicago sativa*). The most frequently observed species was the weedy biennial great mullein which occurred in all the transects on the north shore of the reservoir.

Mule deer signs were observed in 80 per cent of the transects, with browse, tracks, and feces. Black bear tracks, cow hoof prints, and moose (*Alces alces*) tracks were also noted.

Figure 50. Typical view of the vegetation in the upper buffer of steep beaches in Carpenter Reservoir, June 27, 2013.

Figure 51. Example of upland vegetation advancing in the upper buffer, including Douglas fir dieback. June 25, 2013.

3.2.5 Steep Colluvium

The steep colluvium (SC) terrain covered over 25 per cent (372 ha) of the mapped areas in the drawdown zone of the Carpenter Reservoir in 2013. Due to time constraints, three primary transects (with 12 secondary transects) were established in the SC terrain (Figure 52). Two transects were established on the north shore of the reservoir, and one on the south shore.

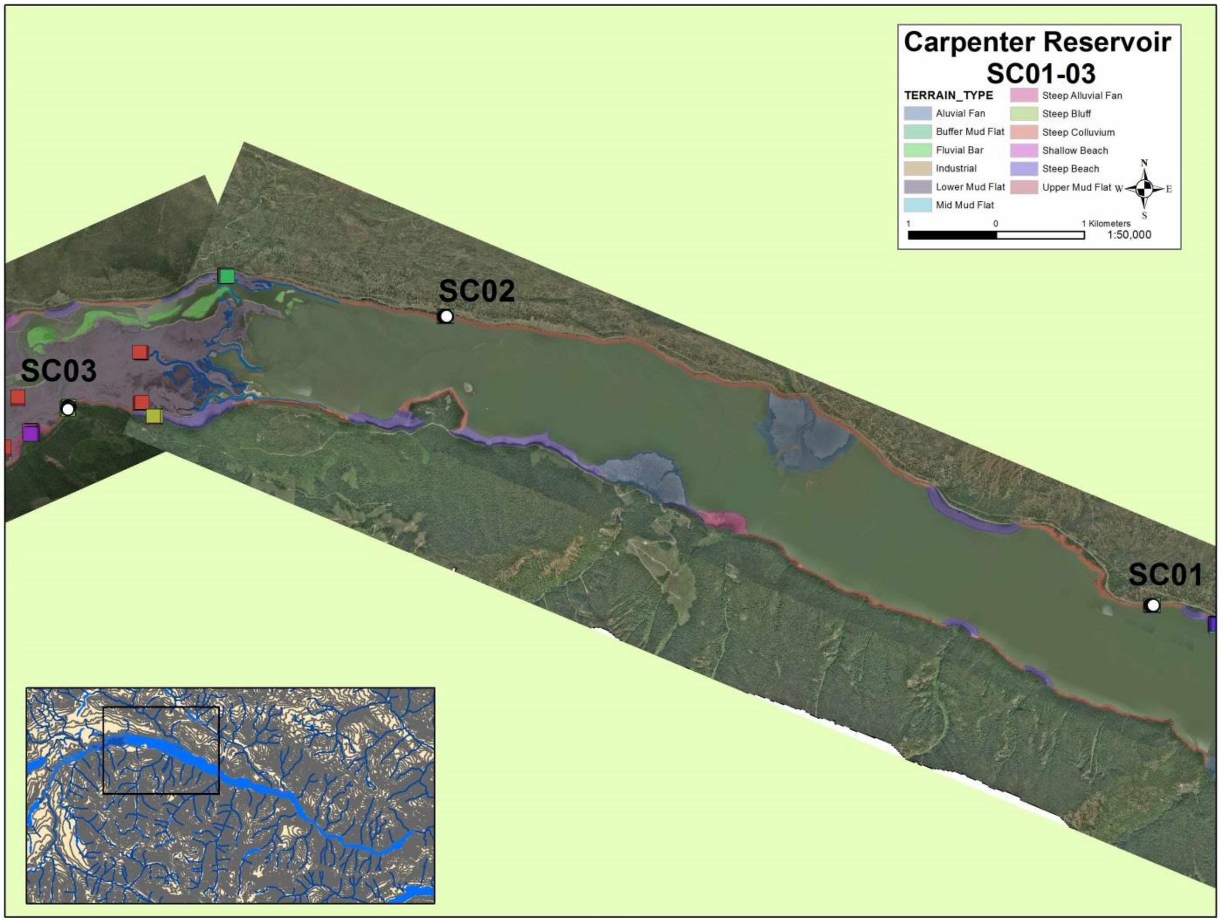


Figure 52. **Location of the transects sampled in the steep colluvium terrain of the Carpenter Reservoir in 2013.**

3.2.5.1 Steep Colluvium, middle elevation

The micro-topography in the middle elevation of the steep colluvium (SCmd) was ribbed, due to the shaping action of waves from the reservoir. The substrate cover consisted of 82 per cent of rock, and 18 per cent of mineral soil (Figure 53). Coarse fragments were mixed to angular, soils were sandy, and drainage was rapid to very rapid.

Figure 53. Typical view of a steep colluvium at middle elevation, in the Carpenter Reservoir in 2013. Note the steepness of the slope, the size of the substrate, and the limited vegetation. July 10, 2013.

The average per cent of vegetation cover for the SCmd transects was very low (1.8 per cent, Figure 54). Eight species of vegetation were recorded with trace amounts; seven annuals and one perennial alfalfa (*Medicago sativa*). Other species included lamb's quarters (*Chenopodium album*), alfalfa, white sweet clover, lady's thumb (*Persicaria maculosa*), narrow leaved collomia (*Collomia linearis*), and Fowler's knotweed (*Polygonum fowleri*).

Deer tracks were observed in one transect.

Figure 54. Sparse vegetation in a middle elevation steep colluvium. July 10, 2013.

3.2.5.2 Steep Colluvium, upper elevation

The transects located at the upper elevation in the steep colluvium (SCud) were shaped from ribbed to smooth, with predominant influence from wave actions. Substrate cover was predominantly rocky (79 per cent), followed by mineral soil (18 per cent), and wood (3 per cent, Figure 55). Soils were sands with some silt, and drained well to rapidly.

Vegetation cover in the SCud transects was meager and averaged just over 1 per cent (Figure 56). Two species were identified: black medic, and white sweet clover.

Mule deer tracks were observed in one transect.

Figure 55. View of a transect in the upper elevation of the steep colluvium, in the Carpenter Reservoir in July 10, 2013.

Figure 56. Sparse vegetation in a transect located at upper elevation in steep colluvium. July 10, 2013.

3.2.5.3 Steep Colluvium, lower buffer

The lower buffer transects in the steep colluvium (SClb) had smooth to ribbed microtopography. The substrate cover was primarily rock (70 per cent), and mineral soil (22 per cent). There were occasional patches of organics, some bedrock outcrop, and some wood. Soils were loamy sands or silt loams, well to rapidly draining, and coarse fragments were angular or rounded Figure 57).

The vegetation cover in the SClb transects was, on average, 9 per cent. Eleven species were recorded, with an average richness of five species per transect. Lamb's quarters (*Chenopodium album*), alfalfa (*Medicago sativa*), white sweet clover (*Melilotus alba*), Lady's thumb (*Persecaria maculosa*), narrow leaved collomia, and Fowler's knotweed were recorded (Figure 58).

Mule deer tracks were observed in one transect.

Figure 57. View of a transect located in the lower buffer of steep colluvium in the Carpenter Reservoir in July 10, 2013.

Figure 58. Typical vegetation in a lower buffer transect of steep colluvium terrain, in the Carpenter Reservoir in July 10, 2013.

3.2.5.4 Steep Colluvium, upper buffer

The micro-topography of the transects located in the upper buffer of steep colluvium (SCub) was smooth. Substrates were primarily mineral soils (60 per cent), followed by coarse fragments or rocks (23 per cent), wood (14 per cent), and minor occurrences of organic matter and bedrock (Figure 59). Coarse fragments were angular or rounded. Soil texture was sandy and silty.

Figure 59. Substrate and vegetation in a transect in the upper buffer zone of steep colluvium. July 10, 2013.

Vegetation was generally very sparse, with cover averaging 9 per cent, and ranging from 1 to 21 per cent (Figure 60). A total of 12 species of vegetation were recorded in the SCub transects; they were all rare occurrences since none occurred in more than one transect. Half of the species recorded were native perennial species, including upland perennial species spreading dogbane (*Apocynum adrosaemifolium*), Douglas-fir (*Pseudotsuga menziesii*), and soapberry (*Sheperdia canadensis*). Black cottonwood and mountain alder were also present, as well as the exotic species Russian thistle (*Salsola kali*), and Jerusalem oak (*Dysphania botrys*).

Mule deer tracks were observed in one transect.

Figure 60. Example of sparse vegetation cover in the upper buffer zone in steep colluvium, in Carpenter Reservoir July 10, 2013.

3.3 Statistical Analysis

Table 3 shows the number of transects sampled in each terrain class and elevations, in 2013 in the drawdown zone of Carpenter Reservoir. Due to the high number of terrain types found around Carpenter Reservoir, some terrain types were not sampled due to their low elevation, and budgetary limitations. Industrially altered zones were eliminated, as were shallow beaches, bedrock and fluvial bars found at the west end of the reservoir. Eleven alluvial fan polygons were identified throughout Carpenter Reservoir, of which four were eliminated due to the absence of road access. A low lying fan at Marshall Creek, that was entirely lying below 642 m, was also removed from the sampling.

Due to the extensive drawdown zone area of Carpenter Reservoir and the complexity of terrain types budgetary constraint did not allow for Upland vegetation sampling.

Table 3. Summary of the transects sampled in each terrain class and elevation in Carpenter Reservoir in 2013.

CODE	TERRAIN TYPE	SLOPE TEXTURE TYPES	ELEVATION ZONE	# transects at each Sampling Elevation					total # transects	total # 1X1m plots
				642m	MD 644m	UD 647m	LB 648.5m	UB 650.5m		
SC	Steep Colluvium	Slope greater than 30%	642-651		3	3	3	3	12	48
STB	Steep Beach	Slope 15% to 30%	642-651		5	5	5	5	20	80
SAF	Steep Alluvial Fan	Slopes greater than 10 %	642-651		5	5	5	5	20	80
GCF	Gun Creek Fan	Slopes less than 10%	642-651		3	3	3	3	12	48
SB	Shallow Beach	Slopes less than 15%	642-651		0	0	0	0	0	0
IN	Industrial	Varied,modified terrain			0	0	0	0	0	0
BR	Bedrock	Varied bedrock and veneers of decomposing bedrock			0	0	0	0	0	0
BMF	Buffer Mudflat	Flat generally silty	648-651		0	0	5		5	20
UMF	Upper Mudflat	Flat generaly silty	646-648			6			6	24
MMF	Mid Mudflat	Flat generaly silty	>642≤646		6				6	24
LMF	Low Mudflat	Flat generaly silty	≤642m	6					6	24
			Totals						87	348

3.3.1 General description of vegetation

At least 117 species of vegetation were sampled (some taxa identified to genus only could be comprised of more than 1 species, e.g. moss); most of these species were rare occurrences (77% of species occurred in less than 10% of the transects, Table 4). Conversely, white clover (MELIALB) and black medick (MEDILUP), two exotic species, were the most frequent species with presence recorded in 49% and 42% of the transects, respectively, followed by Fowler's knotweed (POLYFOW) at 40%.

Table 4. **List of species sampled in the Carpenter reservoir in 2013, in order of frequency of occurrence in transects (n=86 transects), and per cent of occurrence. Only species with frequency (n)>5 are shown.**

Code	Species	Scientific Name	Frequency (n)	Frequency (%)
MELIALB	White sweet clover	*Melilotus alba*	42	49
MEDILUP	Black medick	*Medicago lupulina*	36	42
Polyfow	Fowler's knotweed	*Polygonum fowleri*	34	40
CHENAlb	Lamb's quarters	*Chenopodium album*	31	36
COLLIN	Narrow-leafed Collomia	*Collomia linearis*	26	30
MATRDIS	pineapple weed	*Matricaria discoidea*	25	29
RUMECRI	Curly dock	*Rumex crispus*	24	28
TRIFOLI	Clover species	*Trifolium sp.*	23	27
POA PAL	Fowl bluegrass	*Poa palustris*	22	26
TARAOFF			22	26
PERSMAC	Lady's thumb	*Persicaria maculosa*	21	24
ELYTREP	Quack grass	*Elytrigia repens*	20	23
HORDJUB	Foxtail barley	*Hordeum jubatum*	20	23
POA COM	Canada bluegrass	*Poa compressa*	20	23
POTEBIE	Biennial cinquefoil	*Potentilla biennis*	20	23
EQUIARV	Common horsetail	*Equisetum hyemale*	17	20
Sargipro	Birdseye pearlwort	*Sagina procumbens*	17	20
SILELAT	White cockle	*Silene latifolia*	16	19
ERYSINC	Worm seed mustard	*Erysimum inconspicuum*	15	17
EQUIPAL	Swamp horsetail	*Equisetum palustre*	14	16
PLAGSCO	Scouler's popcornflower	*Plagiobothrys scouleri*	14	16
POTEARG	Silvery cinquefoil	*Potentilla argentea*	14	16
ARCTLAP	Great burdock	*Arctium lappa*	13	15
POPUBAL	Black cottonwood	*Populus balsamifera ssp. trichocarpa*	13	15
ELYMTRA	Slender wheat-grass	*Elymus trachycaulus*	12	14
POA PRAT	Kentucky bluegrass	*Poa pratensis*	12	14
VEROPER	Pursulane speedwell	*Veronica peregrine*	12	14
BROMTEC	Cheat grass	*Bromus tectorum*	11	13
CALACAN	Bluejoint grass	*Calamagrostis canadensis*	11	13
MOSS			11	13
PSEUMEN	Douglas-fir	*Pseudotsuga menziesii*	11	13

Code	Species	Scientific Name	Frequency (n)	Frequency (%)
TRIFPRA	Red clover	*Trifolium pratense*	11	13
VERBTHA	Great mullein	*Verbascum thapsus*	11	13
ACHIMIL	Yarrow	*Achillea millifolium*	10	12
AGROGIG	Redtop	*Agrostis gigantea*	10	12
MEDISAT	Alfalfa	*Medicago sativa*	10	12
CARELEN	Lakeshore sedge	*Carex lenticularis*	9	10
EPILOBI SP	Willowherb species	*Epilobium sp.*	9	10
RORIPAL	Marsh yellow cress	*Rorippa palustris*	9	10
ERYSCHE	Worm seed mustard	*Erysimum cheiranthoides*	8	9
ALNUINC	Mountain alder	*Alnus incana*	7	8
EPILBRA	Tall willowherb	*Epilobium brachycarpum*	7	8
POLYCON	Black bindweed	*Polygonum convolvulus*	7	8
ROSAACI	Prickly rose	*Rosa acicularis*	7	8
RUBUIDA	Red raspeberry	*Rubus idaeus*	7	8
CIRSEDU	Eible thistle	*Cirsium arvense*	6	7
CORNSTO	Red-osier dogwood	*Cornus stolonifera*	6	7
SYMPALB	Snowberry	*Symphoricarpos albus*	6	7

3.3.1.1 Variation in vegetation cover

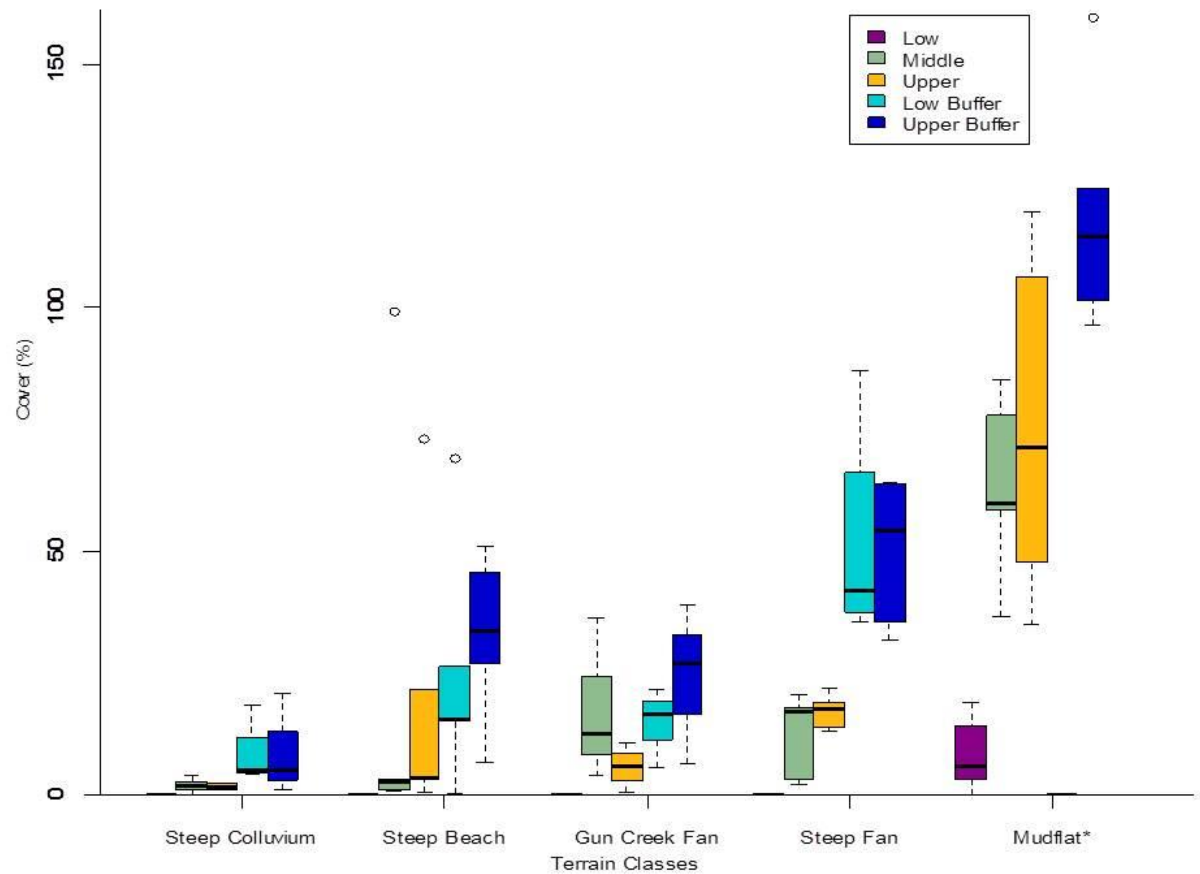


Figure 61. **Variation in vegetation cover (%) in the different terrain classes and elevation bands in 2013. Terrain classes are ordered from lower to higher average cover. * the lower and upper buffer zone in the mudflats was sampled together.**

Cover of vegetation was low in the steep colluvium, steep beaches, and at the Gun Creek fan, while it was highest at mid, upper and in the buffer zone of the mudflats (Figure 61). Cover of vegetation was also maximal in the low and upper buffer zone of the steep fans. Differences in average cover were statistically significant among terrain classes (excluding mudflats, $F=4.7$, $p=0.006$; including mudflats, $F=2.1$, $p=0.0001$), but not among elevation bands ($p> 0.05$). Mudflats were treated separately since they were not sampled in the lower buffer zone; they showed a statistically significant difference in cover among elevation bands ($F=8.5$, $p=0.0001$).

Cover was generally higher in the mudflats on the north shore of the reservoir compared to those on the south shore of the reservoir, while the opposite was true for the steep fans, and, to a lesser degree, for the steep beaches (Figure 62a). Differences in average cover were found to be significant among terrain classes (F=29.1, p= 0.0001), but not between the North and the South shores of the reservoir (p> 0.05).

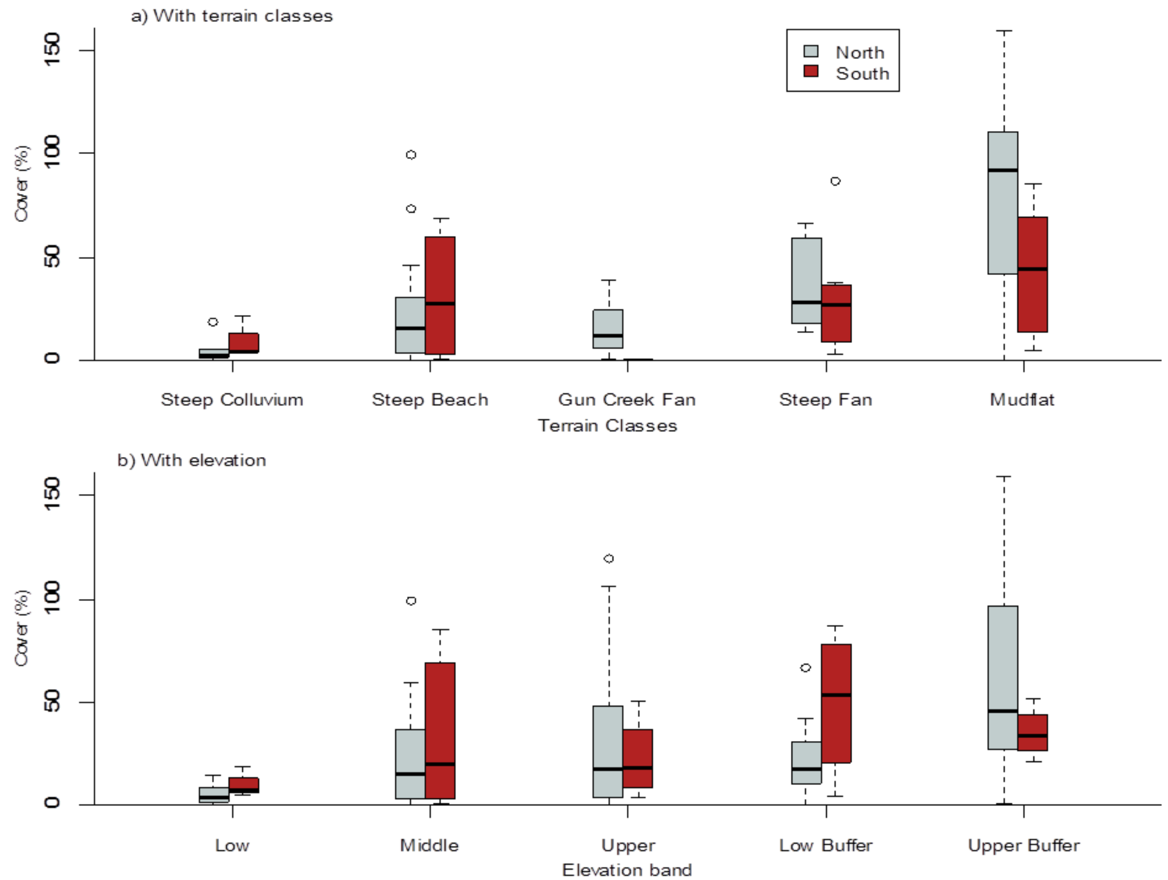


Figure 62. **Variation in vegetation cover (%) from the north to the south of the Carpenter reservoir, and a) the different terrain classes, b) the various elevation bands.**

Cover of vegetation at the various elevation bands does not appear to vary much between the north and the south shores of the reservoir (Figure 62b), which was supported by non-significant results in the ANOVA (p> 0.05). Differences in average cover among elevation bands were significant (F=4.03, p=0.01).

3.3.1.2 Variation in species richness

The richness of species was markedly lower in the steep colluvium, compared to the other terrain classes, for all elevations; it varied between 5 and 25 species in the other terrain classes (Figure 63). Richness was generally higher in the low and upper buffer zones for steep beaches, while it was maximal at upper elevations in the Gun Creek fan, and generally increased with elevation in the mudflats.

Differences in average species richness were found to be statistically significant among terrain classes (excluding mudflats, $F=12.8$, $p=0.0001$; including mudflats, $F=12.3$, $p=0.0001$), but not among elevation bands ($p> 0.05$). Differences in richness among elevation bands in the mudflats only were however significant ($F=4.9$, $p=0.002$).

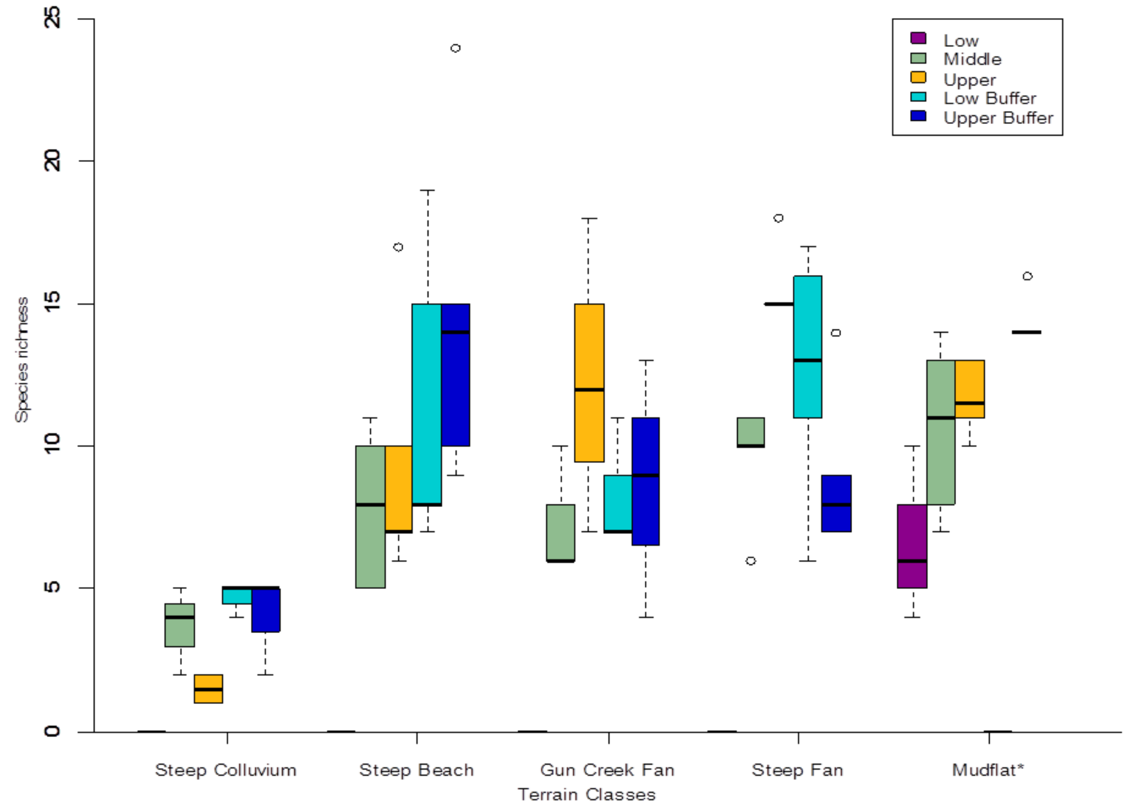


Figure 63. Variation in species richness in the different terrain classes and elevation bands in 2013. Terrain classes are ordered from lower to higher average cover. * the lower and upper buffer zone in the mudflats was sampled together.

Species richness was slightly lower in the mudflats on the south shore of the reservoir than on the north shore, but differences between the two shores were not great for the other terrain classes (Figure 64a). Accordingly, differences in average richness were found to be significant among terrain classes (F=8.5, p= 0.0001), but not between the North and the South shores of the reservoir (p> 0.05). No clear differences between the two shores emerged according to elevation bands either (Figure 64b), which was also reflected by the ANOVA results that did not yield significant differences among elevation bands and the north and south shores (p> 0.05).

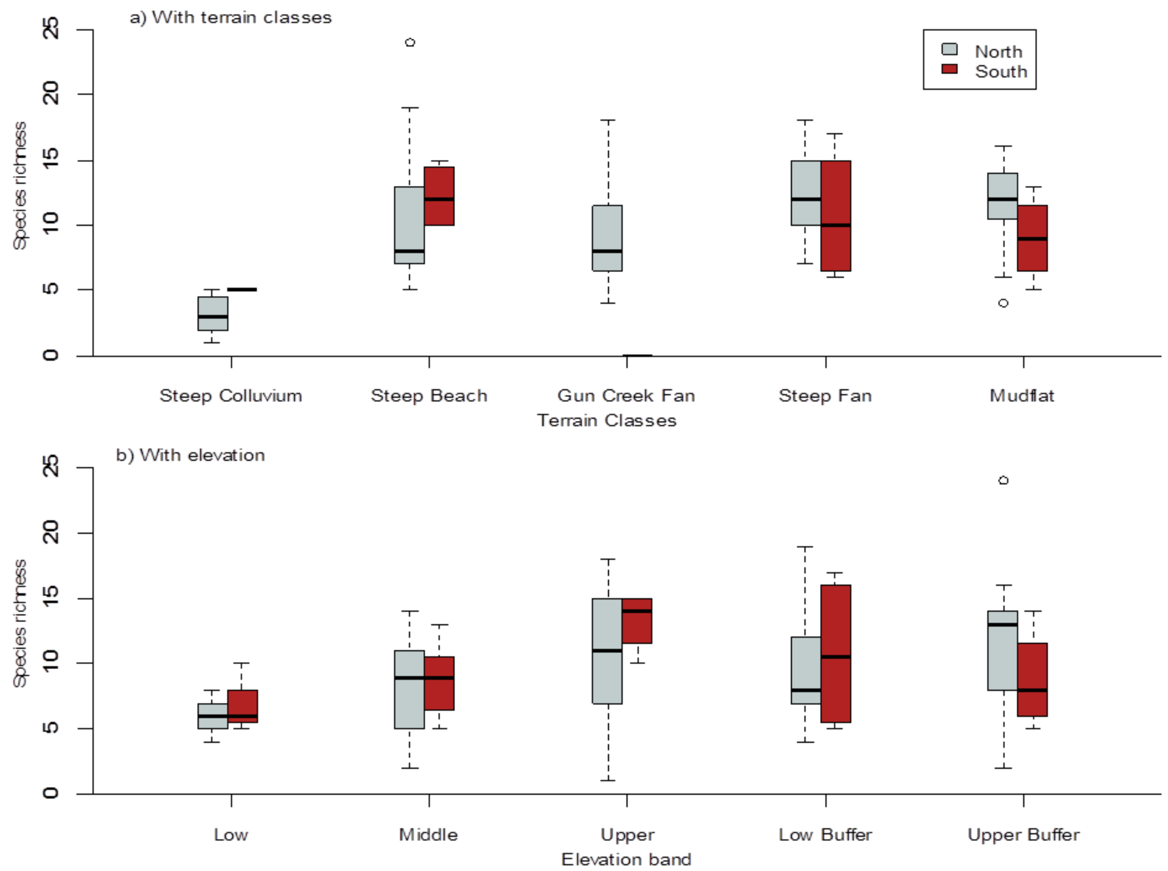


Figure 64. **Variation in species richness from the north to the south of the Carpenter reservoir, and a) the different terrain classes, b) the various elevation bands.**

3.3.1.3 Variation in vegetation diversity

Diversity of vegetation was generally highest in the upper buffer zone of the steep beaches, while it was lower in the low buffer zone at Gun Creek (Figure 65). The same tendencies were not seen in the steep fans or the mudflats, where diversity was either very variable in the upper buffer zone (steep fans) or was comparable to that found at mid and upper elevations (mudflats).

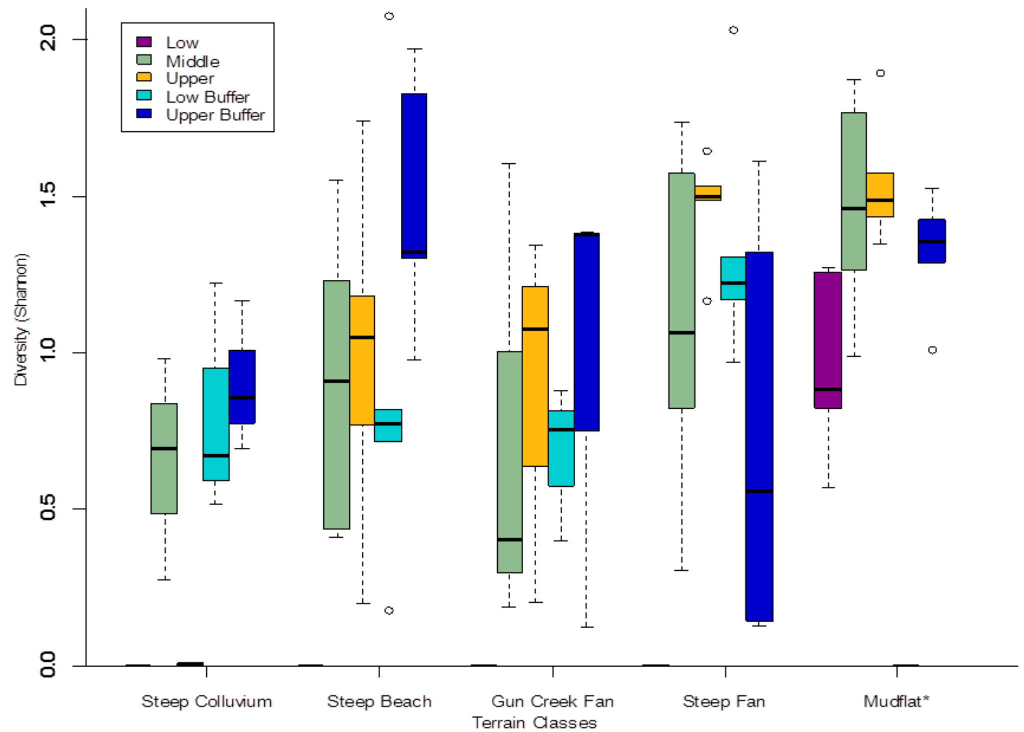


Figure 65. **Variation in diversity of vegetation (Shannon) in the different terrain classes and elevation bands in 2013. Terrain classes are ordered from lower to higher average cover. * the lower and upper buffer zone in the mudflats was sampled together.**

Differences in average diversity were statistically significant among terrain classes (excluding mudflats, $F=3.5$, $p=0.025$; including mudflats, $F=12.6$, $p=0.0001$), but not among elevation bands ($p> 0.05$).

Diversity of vegetation was higher on the south shore of the reservoir compared to the north shore for steep beaches, while the opposite was true for the mudflats (Figure 66a). Average diversity was significantly different among terrain classes ($F=4.7$, $p= 0.006$), but not between the North and the South shores of the reservoir ($p> 0.05$).

Diversity was lower on the south shore at low elevation, but it was slightly higher at middle and upper elevations on the south shore (Figure 66b). These differences were not found to be statistically significant (p> 0.05).

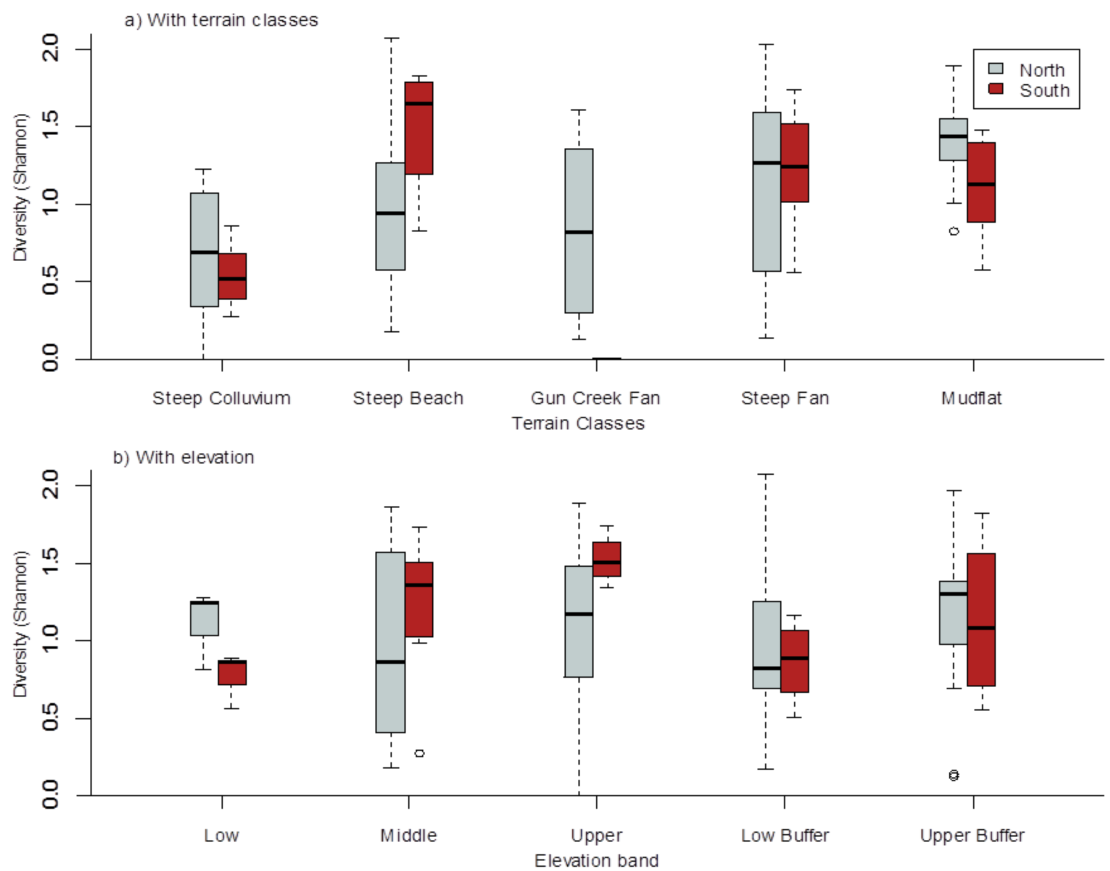


Figure 66. **Variation in diversity of vegetation from the north to the south of the Carpenter reservoir, and a) the different terrain classes, b) the various elevation bands.**

3.3.1.4 Variation in evenness of vegetation

The evenness of vegetation varied greatly among terrain classes and elevation bands; it was near to 0 for the steep colluvium at upper elevation, since those transects were dominated by one or two species, and maximal in some middle elevation and upper buffer zone transects in the steep colluvium (Figure 67). Evenness was minimal in the low buffer for steep beaches, and similar across elevation bands in the Gun Creek fan and mudflats. It was highly variable for the steep fans in the upper buffer zones.

Differences in average evenness were not statistically significant among terrain classes, and elevation bands (p> 0.05).

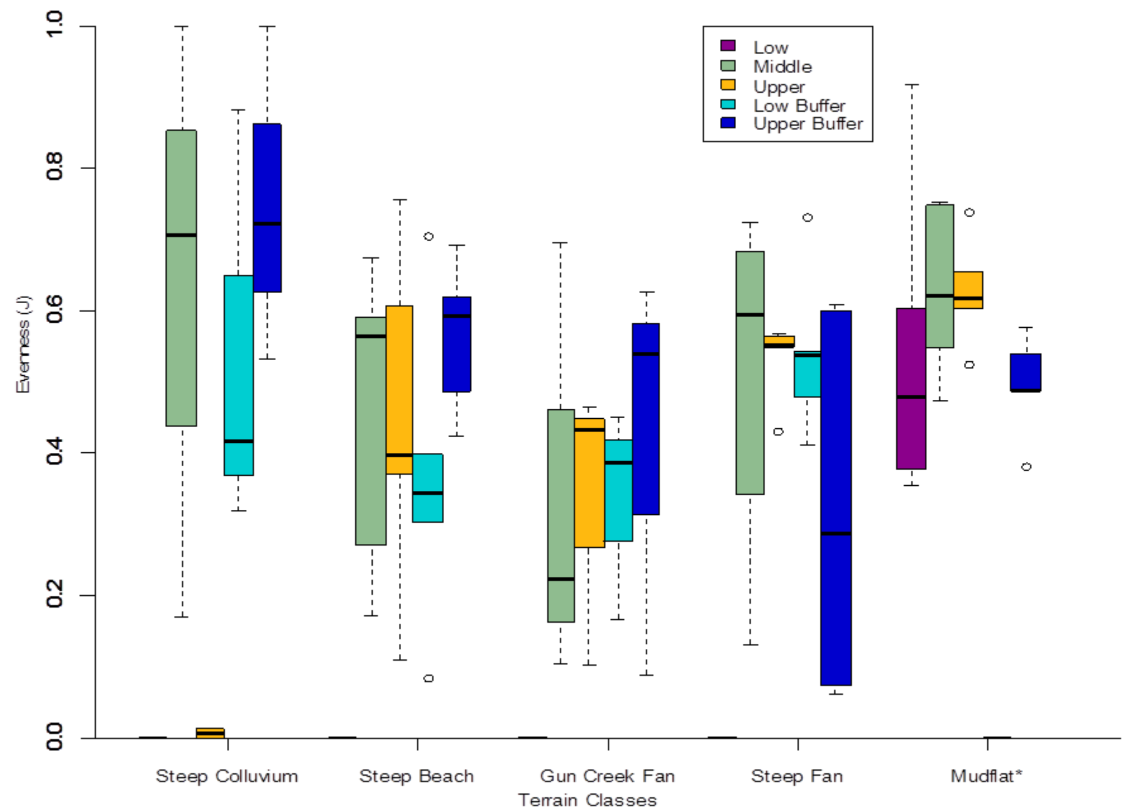


Figure 67. **Variation in evenness of vegetation in the different terrain classes and elevation bands in 2013. Terrain classes are ordered from lower to higher average cover. * the lower and upper buffer zone in the mudflats was sampled together.**

Evenness was slightly higher in steep beaches on the south shore compared to those on the north shore, while again, the opposite was true for mudflats (Figure 68a). Evenness was lower on the south shore compared to the north shore, at low elevation, but slightly higher in the south shore at upper elevations (Figure 68b). The differences in evenness were non-significant among terrain classes, elevation bands, and between the North and the South shores of the reservoir (p> 0.05).

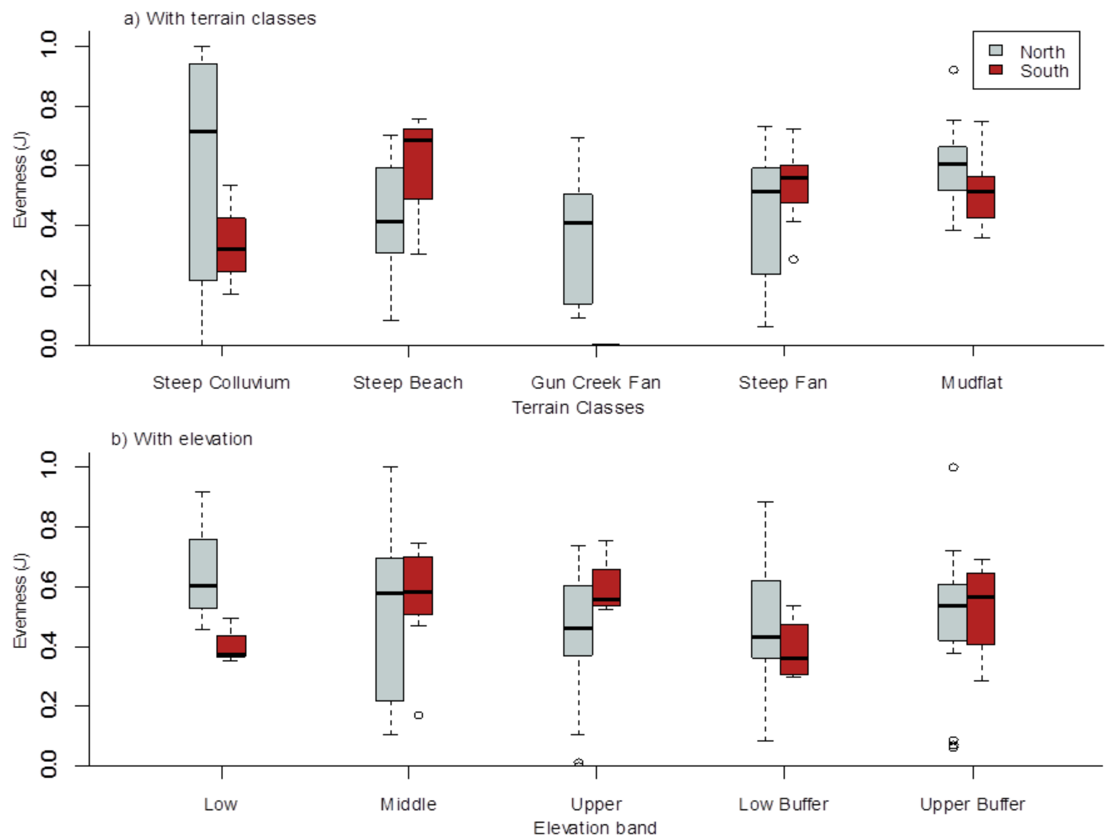


Figure 68. **Variation in evenness of vegetation from the north to the south of the Carpenter reservoir, and a) the different terrain classes, b) the various elevation bands.**

3.3.2 Classification of vegetation communities

3.3.2.1 Species association with Kendall W coefficient of concordance

A total of 55 species and taxa of vegetation were included in the Kendall W concordance analysis (those that were present in at least five transects).

The overall test of concordance was significant (W=0.043 p=0.0001), suggesting that at least some species among those 55 included were significantly found together. The K-means analyses suggested that species were partitioned along two main groups. Each group further had significant associations of species (Group 1: W = 0.16, p=0.0001; Group 2: W = 0.11, p=0.0001). Twelve species were significantly associated to each other in Group 1, and thirteen species were significantly associated in Group 2; each group was more closely associated to a set of transects, elevations and locations (Table 5). For example, species in Group 1were present at all elevations, while Group 2 was made of 50 per cent of exotic species.

Table 5. Characteristics of the groups of species formed by K-Means and the Kendall W analysis of concordance.

Group	Concordant species ($p < 0.05$)	Transects	Elevation and terrain classes	Location
1	AGROGIG, CARDOLI, CARELEN, EQUIARV, EQUIPAL, EQUISETUM, ERYSINC, MATRDIS, PLAGSCO, POLYFOW, RORIPAL, VEROPER	BMF01-02, GCF01MD, GCF02MD-UD, GCF02MD-UD, LMF01-06, MMF01-06, SAF01MD-UD-UB, SAF02MD-UD, SAF03MD-UD, SAF04MD, SAF05MD, SCO3MD, STB01MD, STB03MD, STB05MD, UMF01-06	Spans all elevations, but has several middle elevation transects (Steep beaches and colluvium); otherwise, mostly mudflats, steep fans, and some mid and upper elevation transects in Gun Creek	Mostly found in west and central regions; associated with 2/3 of all the southern transects
2	ACHIMIL, ARCTLAP, BROMTEC, CIRSEDU, CIRSIUM, ELYTREP, POTEBIE, ROSAACI, RUBUIDA, SILELAT, TARAOFF, VERBTHA	BMF03-05, GCF01LB-UD-UB, GCF02LB-UB, GCF03-LB-UB, SAF01LB, SAF02LB-UB, SAF03LB-UB, SAF04LB-UB-UD, SAF05LB-UB-UD, SCO1LB-MD-UB-UD, SCO2LB-MD-UB-UD, SCO3LB-UB, STB01LB-UB-UD, STB02LB-MD-UB-UD, STB03LB-UB-UD, STB04LB-MD-UB-UD, STB05LB-UB-UD	Mostly transects in Gun Creek in the low and upper buffer zones, and steep beaches/collovium/fans	Mostly found in central and east regions, dominance of north shore transects (2/3)

Results of the analysis were superposed on a PCA diagram to show the relationships among the significant species in each group (Figure 69). The low and mid elevation mudflats transects (LMF and MMF, respectively) had a high cover of group 1 species such as AGROGIG, RORIPAL, EQUIARV, CARELEN, EQUISETUM, CARDOLI, and VEROPER, while the steep fans and steep beaches generally appear to have high cover of ERYSINC, and MATRDIS at mid and upper elevations. Two low elevation steep beaches transects (STB01LB and STB03LB) appear to be driving most of the variation in CIRSEDU, ELYTREP, SYMPALB, VERBTHA, and ROSAACI.

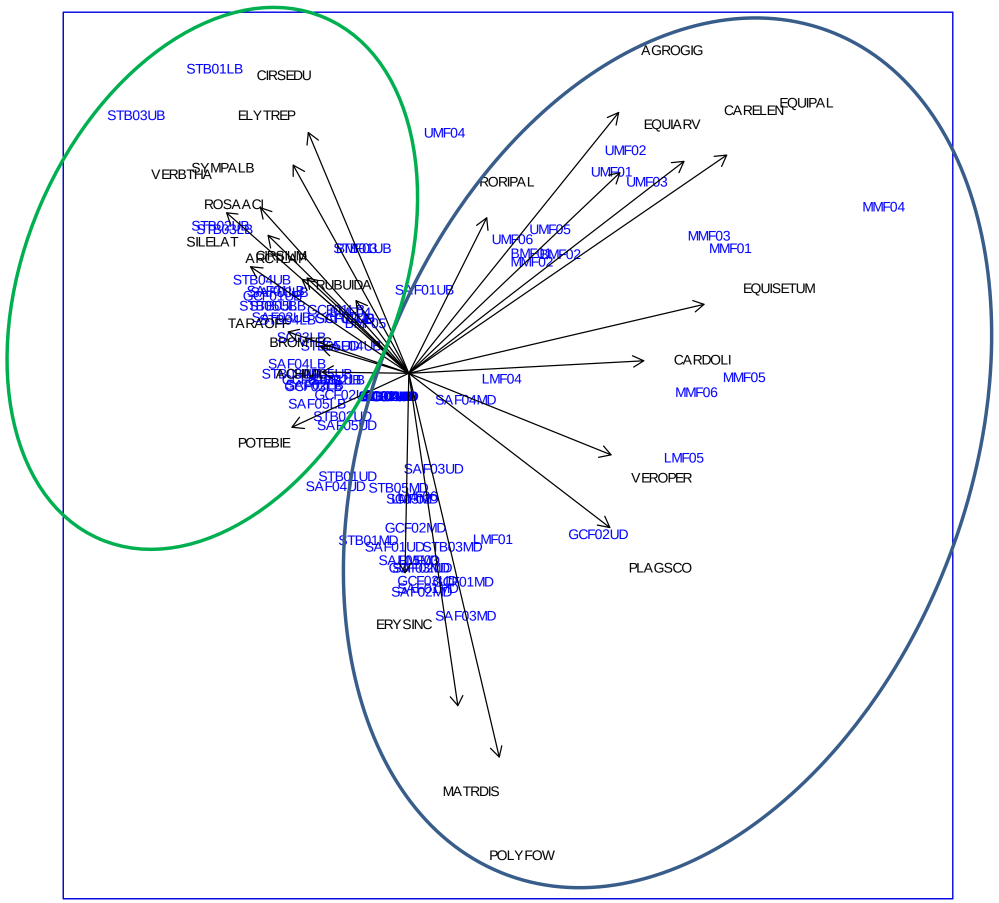


Figure 69. PCA diagram showing relationships between the 25 concordant species over the 86 transects sampled in the Carpenter Reservoir in 2013. Axis 1 explains 11% of the variation in species cover, and axis 2, 9%. Vectors in black represent concordant species while the text in blue shows the transects. The blue ellipse encompasses the species belonging to group 1 as defined by the Kendall W analysis, and the green ellipse surrounds species that belong to group 2. Species acronyms can be found in ,Appendix 2.

3.3.2.2 Clustering based on species composition

The second step in the classification of vegetation communities was to perform clustering based on the species composition at each transect. As part of the baseline characterization of the riparian vegetation communities determining how vegetation communities cluster by transects we can repeat survey in 10 years at the programs end to see if the same characteristic assemblages represent the same transects, This may give us an indication of either how static or dynamic the system is as we track change over time. Cluster analysis is somewhat similar to the Kendall concordance analysis, except that it groups transects instead of species. The same 55 species used in the Kendall analysis (those sampled in at least three transects) were included to assess the similarity of transects. The results of the clustering analysis with similarities computed on species composition and WPGMA, PCA, and PCoA suggest the presence of nine groups of transects (Figure 70, Figure 71,

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
ACERGLA	Douglas maple	*Acer glabrum*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ACHIMIL	yarrow	*Achillea millifolium*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.03	0.00	0.00	0.08	0.05	0.00	0.00	0.00
AGROGIG	redtop	Agrostis gigantea	perennial	exotic	0.00	1.52	19.25	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ALNUINC	mountain alder	*Alnus incana*	perennial	native	0.00	0.00	0.00	37.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
AMELALN	Saskatoon berry	*Amelanchier alnifolia*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AMSINKsp	amsinkia species	amsinkia sp.	annual	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
APOCAND	spreading dogbane	*Apocynum androsaemifolium*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.50
ARABHOL	Holboell's rock cress	*Arabis holboellii*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
ARCTLAP	great burdock	*Arctium lappa*	biennial	exotic	0.00	0.00	0.00	12.90	0.00	0.00	0.00	0.00	0.00	0.15	0.10	0.25	0.00	0.00	0.10	5.50	0.00	0.00	0.00
BETUPAP	paper birch	*Betula papyrifera*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BROMCIL	fringed brome	*Bromus ciliatus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BROMTEC	cheat grass	Bromus tectorum	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.15	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
CALACAN	bluejoint grass	*Calamagrostis canadensis*	perennial	native	0.00	6.35	0.02	5.70	0.00	0.16	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CARDOLI	little western bitter-cress	*Cardamine oligosperma*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREAQU	water sedge	*Carex aquatilis*	perennial	native	0.00	0.33	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CARELEN	Lakeshore sedge	*Carex lenticularis*	perennial	native	0.00	3.35	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREPHA	Dunhead sedge	*Carex phaeocephala*	perennial	native	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREROS	Ross' sedge	*Carex rossii*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREUTR	beaked sedge	Carex utriculata	perennial	native	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CASTMIN	Indian paint brush	*Castilleja miniata*	perennial	native	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEANVEL	snowbrush	Ceanothus velutinus	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CENTBIE	spotted knapweed	Centaurea biebersteinii	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
CENTDIF	diffuse knapweed	Centaurea diffuse	biennial	exotic	0.00	0.00	0.00		0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHENALB	lamb's quarters	*Chenopodium album*	annual	exotic	0.48	0.02	0.00	0.00	0.59	0.09	0.00	0.00	0.23	0.20	0.00	0.00	0.23	0.10	0.00	0.00	0.00	0.00	0.00
CIRSARV	Canada thistle	Cirsium arvense	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.15	0.00	0.00	0.00
CIRSEDU	Eible thistle	Cirsium arvense	biennial	native	0.00	0.00	0.08	0.00	0.00		0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIRSVUL	bull thistle	Cirsium vulgare	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COLLLIN	narrow-leafed Collomia	*Collomia linearis*	annual	native	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	2.50	0.48	0.00	0.00	1.00	0.03	0.08	0.15	0.00	0.00	0.00
COMMUMB	commandra, pale	*Comandra umbellata*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CONYCAN	horseweed	*Conyza canadensis*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
CORNSTO	red-osier dogwood	*Cornus stolonifera*	perennial	native	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
CORYAUR	golden corydalis	*Corydalis aurea*	biennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CREPATR	Slender hawksbeard	Crepis atribarba originalis	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
DESCSOP	flixweed	*Descurainia sophia*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DYSPBOT	Jerusalem oak	*Dysphania botrys*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.17
ELYMGLA	blue wildrye	*Elymus glaucus*	perennial	native	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
ELYMTRA	slender wheat-grass	*Elymus trachycaulus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.25	0.00	0.00	0.53	0.25	0.00	0.00	0.75
ELYTREP	quack grass	*Elytrigia repens*	perennial	exotic	0.00	0.00	2.63	0.00	0.00	3.41	0.08	0.09	0.00	0.20	1.58	0.70	0.00	0.03	2.25	1.68	0.00	0.00	0.00
EPILBRA	tall willowherb	*Epilobium brachycarpum*	annual	native	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00
EPILCIL	purple-leafed willowherb	*Epilobium ciliatum*	perennial	native	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EPILOBIsp	willowherb species	Epilobium sp.			0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00
EQUIARV	common horsetail	*Equisetum arvense*	perennial	native	0.00	19.79	1.71	3.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.03	0.00	0.00	3.03	0.00	0.00	0.00
EQUIHYE	scouring rush	*Equisetum hyemale*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUILAE	smooth scouring rush	*Equisetum laevigatum*	perennial	native	0.00	0.17	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUIPAL	swamp horsetail	*Equisetum palustre*	perennial	native	0.13	9.35	3.25	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUIPRA	meadow horsetail	Equisetum pratense	perennial	native	0.29	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUIVAR	northern scouring rush	*Equisetum variegatum*	perennial	native	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
ERYSCHE	worm seed mustard	*Erysimum cheiranthoides*	biennial	native	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
ERYSINC	worm seed mustard	*Erysimum inconspicuum*	biennial	native	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
FILAARV	field filago	*Filago arvensis*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FRAGVIR	wild strawberry	*Fragaria virginiana*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GALITRI	bedstraw, Sweet scented	*Galium triflorum*	perennial	native	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HERALAN	cow parsnip	*Heracleum lanatum*	perennial	native	0.00	0.00	0.00	2.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HIERGRA	hawkweed, slender	*Hieracium gracile*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
HORDJUB	Foxtail barley	Hordeum jubatum	perennial	native	0.00	0.00	3.29	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.20	0.35	0.00	0.00	0.00
JUNCBAL	Baltic Rush	*Juncus balticus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JUNCEFF	common rush	*Juncus effusus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LACTMUR	wall lettuce	*Lactuca muralis*	biennial	exotic	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LACTSER	Prickly lettuce	Lactuca serriola	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LEPIDEN	Prairie pepper grass	*Lepidium densiflorum*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LINAVUL	common toadflax	*Linaria vulgaris*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.03	0.00	0.00	0.25	0.00	0.00	0.00	0.00
LONIINV	black twinberry	*Lonicera involucrata*	perennial	native	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LOTUDEN	meadow birds-foot trefoil	*Lotus denticulatus*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.20	10.80	0.25	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAHOAQU	tall Oregon grape	Mahonia aquifolium	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan					Steep Beach					Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
MATRDIS	pineapple weed	*Matricaria discoidea*	annual	exotic	0.00	0.15	0.08	0.00	0.05	0.09	0.00	0.00	0.00	0.03	0.00	0.00	0.46	0.25	0.00	0.00	0.00	0.00	0.00
MEDILUP	black medick	*Medicago lupulina*	annual	exotic	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.03	0.38	1.30	0.70	7.40	1.93	0.70	0.08	0.00	0.00	0.00
MEDISAT	alfalfa	*Medicago sativa*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.80	0.00	1.25	0.42
MELIALB	white sweet clover	*Melilotus alba*	annual	exotic	0.00	0.00	1.42	0.40	0.00	0.00	0.00	0.00	0.95	3.61	13.10	0.38	0.25	2.58	#####	0.00	1.38	5.21	0.17
MENTALB	small flowered evening star	*Mentzelia albicaulis*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00
MENTARV	mint	*Mentha arvensis*	perennial	native	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MOSS					0.40	0.00	0.02	0.00	0.00	0.00	0.00	3.75	0.00	0.00	0.25	0.35	0.00	0.00	0.00	0.60	0.00	0.00	0.00
OSMOPUR	purple sweet-cicely	Osmorhiza purpurea	perennial	native	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERSAMP	water smartweed	*Persicaria amphibia*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERSMAC	lady's thumb	*Persicaria maculosa*	annual	exotic	0.48	2.40	0.00	0.00	0.08	0.00	0.00	0.00	0.18	0.08	0.00	0.00	0.63	0.03	0.00	0.00	0.17	0.00	0.00
PHACHAS	silverleaf phacelia	Phacelia hastata	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PHLEPRA	common Timothy	Phleum pratense	perennial	exotic	0.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PICEENC	Engelman spruce hybrid	*Picea engelmannii*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PINUPON	Ponderosa pine	*Pinus ponderosa*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PLAGSCO	Scouler's popcornflower	*Plagiobothrys scouleri*	annual	native	0.00	3.13	0.00	0.00	0.25	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.00	0.00	0.00
PLANMAJ	common plantain	*Plantago major*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
PLATSTR	slender bog orchid	Platanthera stricta	perennial	native	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POA COM	Canada bluegrass	Poa compressa	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.79	7.17	2.83	0.00	0.03	0.90	0.00	0.00	0.20	7.55	2.53	0.00	0.00	0.00
POA PAL	fowl bluegrass	*Poa palustris*	perennial	native	0.00	0.96	5.23	2.17	0.00	0.00	0.00	0.00	0.00	0.03	0.50	0.20	0.00	0.00	0.00	0.06	0.00	0.00	0.00
POAPRAT	Kentucky bluegrass	*Poa pratensis*	perennial	exotic	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.03	0.10	0.00	0.08	2.52	1.75	0.00	0.00	0.00
POA sp.					0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POLEPUL	Jacob's ladder	Polemonium pulcherrimum	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
POLYCON	black bindweed	*Polygonum convolvulus*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.67	0.00
POLYFOW	Fowler's knotweed	*Polygonum fowleri*	annual	native	5.00	0.54	0.02	0.00	0.55	0.01	0.00	0.00	0.10	0.10	0.00	0.00	0.38	0.68	0.00	0.00	0.00	0.00	0.00
POPUBAL	black cottonwood	*Populus balsamifera ssp. trichocarpa*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.66	0.00	0.45	0.95	7.10	0.00	0.00	3.40	29.20	0.00	1.17	0.50
POTEARG	silvery cinquefoil	*Potentilla argentea*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	6.92	0.92	0.00	0.03	0.00	0.00	0.00	0.00	4.20	1.45	0.00	0.00	0.00
POTEBIE	biennial cinquefoil	*Potentilla biennis*	annual/biennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.08	0.08	0.00	1.35	1.35	0.18	0.00	0.00	0.00
POTENsp					0.00	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRUNVIR	choke cherry	*Prunus virginiana*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PSEUMEN	Douglas-fir	Pseudotsuga menziesii	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	2.65	0.00	0.00	0.20	0.03	0.00	0.00	1.25
PSEUSPI	bluebunch wheatgrass	Pseudoroegneria spicata	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PYROASC	pink wintergreen	*Pyrola asarifolia*	perennial	native	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
RORIPAL	marsh yellow cress	*Rorippa palustris*	a/b/slp*	native	0.13	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ROSAACI	prickly rose	*Rosa acicularis*	perennial	native	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.92	0.00	0.00	0.00	1.40	0.00	0.00	0.40	0.00	0.00	0.00	0.00
RUBUIDA	red raspberry	*Rubus idaeus*	perennial	native	0.00	0.00	0.00	5.80	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
RUBULEU	blackcap raspberry	Rubus leucodermis	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RUBUPAR	thimbleberry	*Rubus parviflorus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RUMECRI	curly dock	*Rumex crispus*	perennial	exotic	0.00	0.31	8.31	0.00	0.00	0.00	0.42	0.00	0.00	0.10	0.23	0.00	0.00	0.50	0.45	0.55	0.00	0.00	0.00
SAGIPRO	birdseye pearlwort	*Sagina procumbens*	perennial	unkn	1.02	0.21	0.00	0.00	15.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SALIBEB	Bebb's willow	*Salix bebbiana*	perennial	native	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SALILUC	Pacific willow	*Salix lucida ssp. Lasiandra*	perennial	native	0.00	0.00	3.67	28.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SALIXSP	willow species	*salix species*	perennial	native	0.00	0.00	3.92	6.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
SALSKAL	Russian thistle	Salsola kali	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.04
SHEPCAN	soap berry	*Sheperdia canadensis*	perennial	native	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
SILELAT	white cockle	*Silene latifolia*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.33	0.85	0.00	0.00	0.08	0.00	0.00	0.00	0.00
SISYALT	tall tumbleweed	*Sisymbrium altissimum*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
SOLISPA	spikelike goldenrod	*Solidago spathulatum*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STELMED	common chickweed	*Stellaria media*	perennial	exotic	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STIPOCC	sitiff needle grass	Stipa occidentalis	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
SYMPALB	snowberry	*Symphoricarpos albus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	3.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TARAOFF	dandelion	*Taraxacum officinale*	perennial	exotic	0.00	0.00	0.69	0.35	0.00	0.00	0.00	0.08	0.00	0.00	0.10	0.30	0.00	0.09	0.20	0.08	0.00	0.00	0.00
THALARV	field pennycress	*Thlaspi arvense*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRAGDUB	yellow salsify	*Tragopogon dubius*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRIFOLI	clover species	Trifolium sp.	perennial	exotic	0.00	0.63	18.04	0.35	0.00	0.00	0.00	0.42	0.03	0.65	1.40	1.10	0.00	0.13	3.23	1.00	0.00	0.00	0.00
TRIFPRA	red clover	*Trifolium pratense*	biennial	exotic	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.03	0.05	0.25	0.00	0.00	0.00	1.18	0.25	0.00	0.00	0.00
TRIFREP	white clover	*Trifolium repens*	perennial	exotic	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00
unknown					0.00	5.17	0.00	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.13	0.00	0.00	0.00	0.00	0.00
VERBTHA	great mullein	*Verbascum thapsus*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.78	0.00	0.00	1.33	0.00	0.00	0.00	0.00
VEROPER	pursulane speedwell	*Veronica peregrina*	annual	exotic	0.04	0.75	0.13	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
VIOLLAN	Alaska violet	*Viola langsdorfii*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total				8.0	63.0	75.2	119.3	17.5	5.7	14.6	24.1	21.4	20.4	25.3	32.8	12.0	9.1	53.1	49.9	1.9	9.1	9.0

Appendix 3).

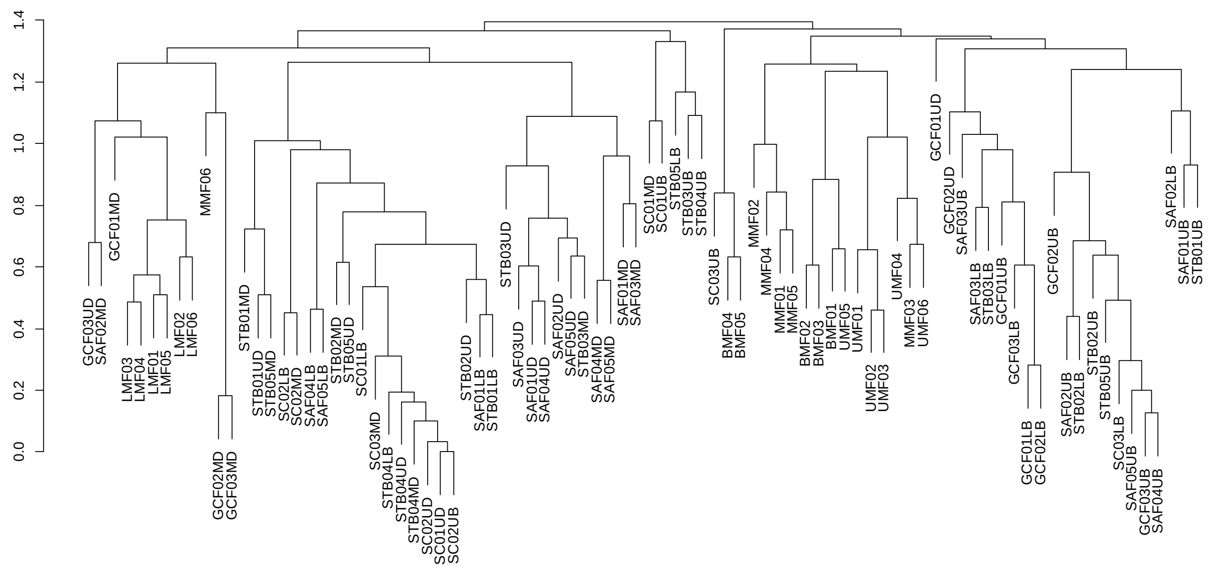


Figure 70. **Dendrogram showing groups of transects formed by WPGMA hierarchical clustering applied after computing similarities among transects with a Hellinger-Euclidian distance coefficient, and based on species covers.**

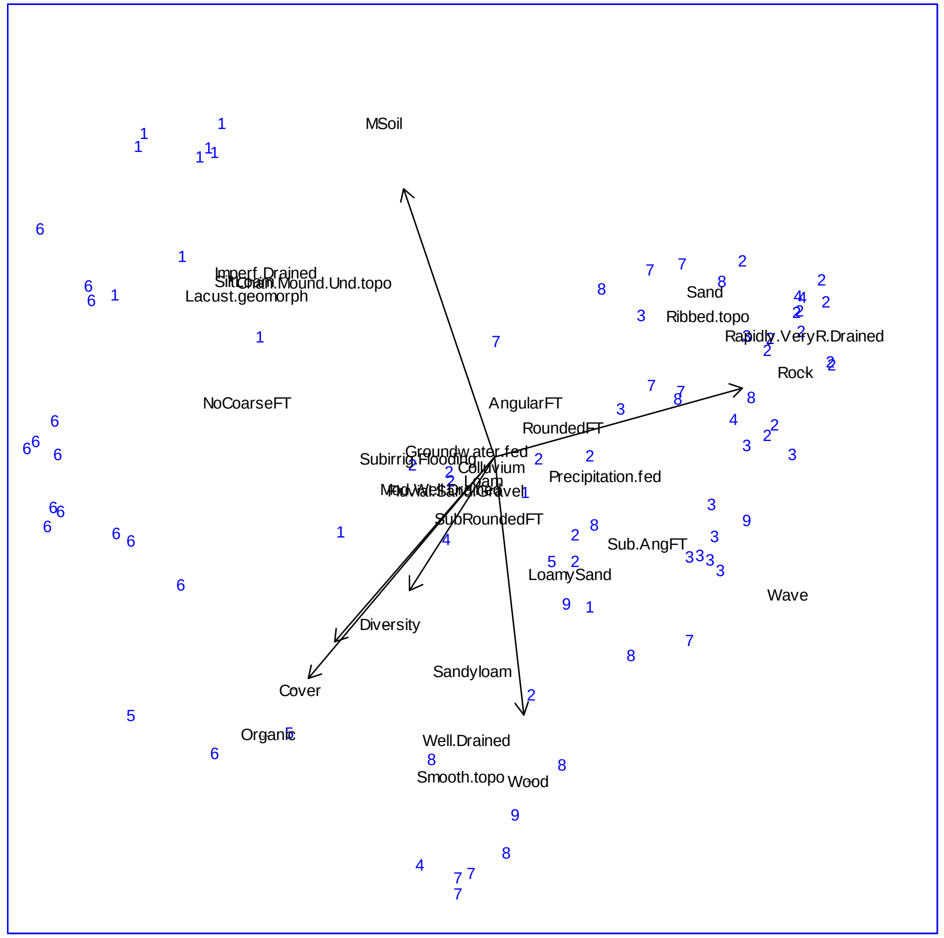


Figure 71. **PCA diagram showing variation in environmental variables among transects sampled in the Carpenter Reservoir in 2013. Axis 1 explains 29% of the variation in species cover, and axis 2, 14%. Numbers refer to groups of transects as formed by the clustering analysis based on species composition (Hellinger-Euclidian distance coefficient and WPGMA; see Table 6 for the names of transects per group).**

Six of these groups appear well defined (Table 6). Group 1 corresponds to all the low elevation mud flats, with a few mid elevations transects in Gun Creek; they were transects with high content in mineral soil, imperfectly drained, channelled/undulating topography, and lacustrine geomorphology. Transects in Group 2 corresponded to steep beaches, fans and colluvium, that were rapidly or very rapidly draining and rocky. Group 3 transects was mostly made off steep alluvial fans in the (mostly) north shores of the reservoir in the middle and upper elevations. All the middle, upper and buffer mud flat transects clustered together to form Group 6; they had high covers of organic matter and vegetation, and high diversity (consistent with what was observed on Figure 61 and Figure 65). The upper elevation, and low and upper buffer transects in the Gun Creek fan (Group 7) had a smooth topography, high concentration of woody debris, and were well drained. Finally, the transects in Group 8 clustered very tightly, and corresponded to transects at low and upper buffer elevation from several terrain classes. They were mostly well drained transects with sandy loam substrate, and a high concentration of woody debris. Fewer transects clustered to form Groups 4, 5 and 9, and their characteristics are less clearly defined, generally being a mix of characteristics from the other groups. Groups 4 and 9 were made of steep beaches and steep alluvial fans, while transects in Group 5 were buffer transects with distinct species composition.

Table 6. Characteristics of each group of transects based on species composition, issued from the hierarchical clustering analysis (Hellinger-Euclidian distance, WPGMA, PCA, and PCoA).

Group	Transects	Environmental characteristics	Elevation	Terrain classes and location
1	GCF01MD, GCF02MD, GCF03MD-UD, LMF01-06, MMF06, SAF02MD	high content in mineral soil, imperfectly drained, channelled, undulating topography, lacustrine geomorphology	Low and mid	all low mudflats
2	STB01UD;LB, STB02MD-UD, STB04MD-LB, STB05MD-UD, SCO1UD-LB, SCO2LB-UB, SCO3MD, SAF01LB, SAF04LB, SAF05LB	Rapidly/very rapidly draining, lots of rocks	Mid, upper, and buffer	steep beaches, colluvium and fans
3	STB03MD-UD, SAF01MD-UD, SAF02UD, SAF03MD-UD, SAF04MD-UD,SAF05MD-UD	Sub-angular fragment types, high content of rocks, affected by wave action	Mid, upper	Steep alluvial fans, mostly North
4	SCO1MD;UB, STB05LB, STB03UB, STB04UB			
5	SCO3UB, BMF04-05			
6	MMF01-05, BMF01-03, UMF01-06	high cover of organic matter and vegetation, high diversity	Mid, upper and buffer	Mud flats
7	GCF01UD-UB, GCF02UD-LB, GCF03LB, SAF03LB-UB, STB03LB	smooth topography, high concentration of woody debris, well drained	Upper, and low and upper buffer	Gun Creek fan
8	GCF02UB, GCF03UB, SAF02UB, SAF04UB, SAF05UB, STB02LB-UB, STB05UB, SCO3LB	sandy loam, well drained, smooth topography, high concentration of woody debris	Low and upper buffer	Gun Creek fan, steep alluvial fan, steep beaches, steep colluvium
9	SAF02LB, SAF01UB, STB01UB	loamy sand, sandy loam, wave impacted	Low and upper buffer	steep alluvial fans, and one steep beach

These nine different groups of transects supported different vegetation communities (Table 7). Transects in Group 1 were dominated by Polgonum fowleriiPOLYFOW , while transects in Group 2 were dominated by Melilotus alba (MELIALB) and transects in Group 8 were dominated by Populus balsamifera POPUBAL (Figure 72). These three species broadly represent the low, mid/upper, and buffer elevations, consistent with the characteristics of the transects where they were most frequent (Table 6). Group 3 showed a similar species composition as Group 1, and Groups 2 and 4 were dominated by exotic species. The mudflats in Group 6 were dominated by Equisetum arvense (EQUIARV), Poa palustris (POA PAL), Equisetum palustris (EQUIPAL), and Agrostis gigantea (AGROGIG), and Poa compressa (POA COM), Rumex crispus (RUMECRI), Potentilla arguta (POTEARG), and Taraxacum officinale (TARAOFF) dominated the Gun Creek fan transects of Group 7 . The transects in the buffer elevation that were part of Group 8 were dominated by woody species such as P. balsamifera , and Pseudotsuga menziesii (PSEUMEN). Finally, the sandy and wave impacted transects in Group 9 were dominated by Achillea millefolium (ACHIMIL), Trifolium sp. , Poa pratensis (POA PRA), and Mentzelia albicaulus (MENTALB).

Table 7. Vegetation communities associated with each groups of transects

Group	Dominant species
1	POLYFOW, CHENALB, SAGIPRO, MATRDIS, PERSMAC
2	MELIALB, MEDILUP, CHENALB, SILELAT
3	POLYFOW, COLLLIN, MEDILUP, CHENALB, MATRDIS
4	BROMTEC, ARCTLAP, MEDILUP, SILELAT, VERBTHA
5	ALNUINC
6	EQUIARV, POA PAL, EQUIPAL, AGROGIG
7	POA COM, RUMECRI, POTEARG, TARAOFF
8	POPUBAL, MEDILUP, PSEUMEN
9	ACHIMIL, TRIFOLIUM, POA PRA, MENTALB

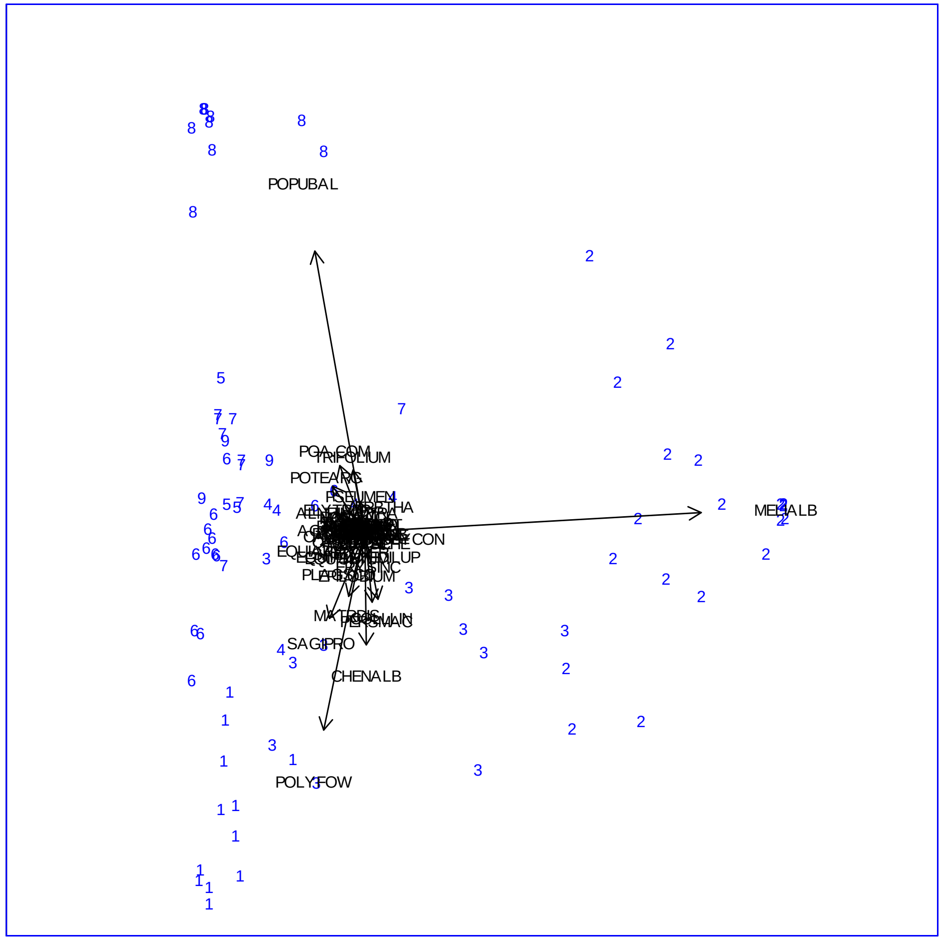


Figure 72. **PCA diagram showing variation in species composition among transects sampled in the Carpenter Reservoir in 2013. Axis 1 explains 16% of the variation in species cover, and axis 2, 11%. Numbers in blue refer to groups of transects as formed by the clustering analysis based on species composition (Hellinger-Euclidian distance coefficient and WPGMA; see Table 6 for the names of transects per group). Black vectors correspond to species.**

3.3.2.3 Clustering based on environmental variables

A similar exercise as performed in Section 3.3.2.2 was repeated, but using environmental variables instead of species composition to group transects. The 30 environmental variables were combined to compute the similarity of transects based on their environmental characteristics. This time, the results of the similarities computed on environmental variables with WPGMA, PCA, and PCoA suggest the presence of five main groups of transects (Figure 73, Figure 74,

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
ACERGLA	Douglas maple	*Acer glabrum*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ACHIMIL	yarrow	*Achillea millifolium*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.03	0.00	0.00	0.08	0.05	0.00	0.00	0.00
AGROGIG	redtop	Agrostis gigantea	perennial	exotic	0.00	1.52	19.25	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ALNUINC	mountain alder	*Alnus incana*	perennial	native	0.00	0.00	0.00	37.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
AMELALN	Saskatoon berry	*Amelanchier alnifolia*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AMSINKsp	amsinkia species	amsinkia sp.	annual	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
APOCAND	spreading dogbane	*Apocynum androsaemifolium*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.50
ARABHOL	Holboell's rock cress	*Arabis holboellii*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
ARCTLAP	great burdock	*Arctium lappa*	biennial	exotic	0.00	0.00	0.00	12.90	0.00	0.00	0.00	0.00	0.00	0.15	0.10	0.25	0.00	0.00	0.10	5.50	0.00	0.00	0.00
BETUPAP	paper birch	*Betula papyrifera*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BROMCIL	fringed brome	*Bromus ciliatus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BROMTEC	cheat grass	Bromus tectorum	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.15	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CALACAN	bluejoint grass	*Calamagrostis canadensis*	perennial	native	0.00	6.35	0.02	5.70	0.00	0.16	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CARDOLI	little western bitter-cress	*Cardamine oligosperma*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREAQU	water sedge	*Carex aquatilis*	perennial	native	0.00	0.33	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach				Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
CARELEN	Lakeshore sedge	*Carex lenticularis*	perennial	native	0.00	3.35	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREPHA	Dunhead sedge	*Carex phaeocephala*	perennial	native	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREROS	Ross' sedge	*Carex rossii*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREUTR	beaked sedge	Carex utriculata	perennial	native	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CASTMIN	Indian paint brush	*Castilleja miniata*	perennial	native	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEANVEL	snowbrush	Ceanothus velutinus	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CENTBIE	spotted knapweed	Centaurea biebersteinii	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
CENTDIF	diffuse knapweed	Centaurea diffuse	biennial	exotic	0.00	0.00	0.00		0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHENALB	lamb's quarters	*Chenopodium album*	annual	exotic	0.48	0.02	0.00	0.00	0.59	0.09	0.00	0.00	0.23	0.20	0.00	0.00	0.23	0.10	0.00	0.00	0.00	0.00	0.00
CIRSARV	Canada thistle	Cirsium arvense	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.15	0.00	0.00	0.00
CIRSEDU	Eible thistle	Cirsium arvense	biennial	native	0.00	0.00	0.08	0.00	0.00		0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIRSVUL	bull thistle	Cirsium vulgare	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COLLLIN	narrow-leafed Collomia	*Collomia linearis*	annual	native	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	2.50	0.48	0.00	0.00	1.00	0.03	0.08	0.15	0.00	0.00	0.00
COMMUMB	commandra, pale	*Comandra umbellata*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CONYCAN	horseweed	*Conyza canadensis*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CORNSTO	red-osier dogwood	*Cornus stolonifera*	perennial	native	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
CORYAUR	golden corydalis	*Corydalis aurea*	biennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
CREPATR	Slender hawksbeard	Crepis atribarba originalis	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
DESCSOP	flixweed	*Descurainia sophia*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DYSPBOT	Jerusalem oak	*Dysphania botrys*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.17
ELYMGLA	blue wildrye	*Elymus glaucus*	perennial	native	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
ELYMTRA	slender wheat-grass	*Elymus trachycaulus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.25	0.00	0.00	0.53	0.25	0.00	0.00	0.75
ELYTREP	quack grass	*Elytrigia repens*	perennial	exotic	0.00	0.00	2.63	0.00	0.00	3.41	0.08	0.09	0.00	0.20	1.58	0.70	0.00	0.03	2.25	1.68	0.00	0.00	0.00
EPILBRA	tall willowherb	*Epilobium brachycarpum*	annual	native	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00
EPILCIL	purple-leafed willowherb	*Epilobium ciliatum*	perennial	native	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EPILOBIsp	willowherb species	Epilobium sp.			0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00
EQUIARV	common horsetail	*Equisetum arvense*	perennial	native	0.00	19.79	1.71	3.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.03	0.00	0.00	3.03	0.00	0.00	0.00
EQUIHYE	scouring rush	*Equisetum hyemale*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUILAE	smooth scouring rush	*Equisetum laevigatum*	perennial	native	0.00	0.17	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUIPAL	swamp horsetail	*Equisetum palustre*	perennial	native	0.13	9.35	3.25	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUIPRA	meadow horsetail	Equisetum pratense	perennial	native	0.29	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUIVAR	northern scouring rush	*Equisetum variegatum*	perennial	native	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ERYSCHE	worm seed mustard	*Erysimum cheiranthoides*	biennial	native	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
ERYSINC	worm seed mustard	*Erysimum inconspicuum*	biennial	native	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
FILAARV	field filago	*Filago arvensis*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FRAGVIR	wild strawberry	*Fragaria virginiana*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GALITRI	bedstraw, Sweet scented	*Galium triflorum*	perennial	native	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HERALAN	cow parsnip	*Heracleum lanatum*	perennial	native	0.00	0.00	0.00	2.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HIERGRA	hawkweed, slender	*Hieracium gracile*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
HORDJUB	Foxtail barley	Hordeum jubatum	perennial	native	0.00	0.00	3.29	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.20	0.35	0.00	0.00	0.00
JUNCBAL	Baltic Rush	*Juncus balticus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JUNCEFF	common rush	*Juncus effusus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LACTMUR	wall lettuce	*Lactuca muralis*	biennial	exotic	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LACTSER	Prickly lettuce	Lactuca serriola	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LEPIDEN	Prairie pepper grass	*Lepidium densiflorum*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LINAVUL	common toadflax	*Linaria vulgaris*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.03	0.00	0.00	0.25	0.00	0.00	0.00	0.00
LONIINV	black twinberry	*Lonicera involucrata*	perennial	native	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LOTUDEN	meadow birds-foot trefoil	*Lotus denticulatus*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.20	10.80	0.25	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAHOAQU	tall Oregon grape	Mahonia aquifolium	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATRDIS	pineapple weed	*Matricaria discoidea*	annual	exotic	0.00	0.15	0.08	0.00	0.05	0.09	0.00	0.00	0.00	0.03	0.00	0.00	0.46	0.25	0.00	0.00	0.00	0.00	0.00
MEDILUP	black medick	*Medicago lupulina*	annual	exotic	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.03	0.38	1.30	0.70	7.40	1.93	0.70	0.08	0.00	0.00	0.00
MEDISAT	alfalfa	*Medicago sativa*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.80	0.00	1.25	0.42

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
MELIALB	white sweet clover	*Melilotus alba*	annual	exotic	0.00	0.00	1.42	0.40	0.00	0.00	0.00	0.00	0.95	3.61	13.10	0.38	0.25	2.58	#####	0.00	1.38	5.21	0.17
MENTALB	small flowered evening star	*Mentzelia albicaulis*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00
MENTARV	mint	*Mentha arvensis*	perennial	native	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MOSS					0.40	0.00	0.02	0.00	0.00	0.00	0.00	3.75	0.00	0.00	0.25	0.35	0.00	0.00	0.00	0.60	0.00	0.00	0.00
OSMOPUR	purple sweet-cicely	Osmorhiza purpurea	perennial	native	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERSAMP	water smartweed	*Persicaria amphibia*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERSMAC	lady's thumb	*Persicaria maculosa*	annual	exotic	0.48	2.40	0.00	0.00	0.08	0.00	0.00	0.00	0.18	0.08	0.00	0.00	0.63	0.03	0.00	0.00	0.17	0.00	0.00
PHACHAS	silverleaf phacelia	Phacelia hastata	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PHLEPRA	common Timothy	Phleum pratense	perennial	exotic	0.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PICEENC	Engelman spruce hybrid	*Picea engelmannii*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PINUPON	Ponderosa pine	*Pinus ponderosa*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PLAGSCO	Scouler's popcornflower	*Plagiobothrys scouleri*	annual	native	0.00	3.13	0.00	0.00	0.25	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.00	0.00	0.00
PLANMAJ	common plantain	*Plantago major*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PLATSTR	slender bog orchid	Platanthera stricta	perennial	native	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POA COM	Canada bluegrass	Poa compressa	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.79	7.17	2.83	0.00	0.03	0.90	0.00	0.00	0.20	7.55	2.53	0.00	0.00	0.00
POA PAL	fowl bluegrass	*Poa palustris*	perennial	native	0.00	0.96	5.23	2.17	0.00	0.00	0.00	0.00	0.00	0.03	0.50	0.20	0.00	0.00	0.00	0.06	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach				Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
POAPRAT	Kentucky bluegrass	*Poa pratensis*	perennial	exotic	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.03	0.10	0.00	0.08	2.52	1.75	0.00	0.00	0.00
POA sp.					0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POLEPUL	Jacob's ladder	Polemonium pulcherrimum	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
POLYCON	black bindweed	*Polygonum convolvulus*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.67	0.00
POLYFOW	Fowler's knotweed	*Polygonum fowleri*	annual	native	5.00	0.54	0.02	0.00	0.55	0.01	0.00	0.00	0.10	0.10	0.00	0.00	0.38	0.68	0.00	0.00	0.00	0.00	0.00
POPUBAL	black cottonwood	*Populus balsamifera ssp. trichocarpa*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.66	0.00	0.45	0.95	7.10	0.00	0.00	3.40	29.20	0.00	1.17	0.50
POTEARG	silvery cinquefoil	*Potentilla argentea*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	6.92	0.92	0.00	0.03	0.00	0.00	0.00	0.00	4.20	1.45	0.00	0.00	0.00
POTEBIE	biennial cinquefoil	*Potentilla biennis*	annual/biennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.08	0.08	0.00	1.35	1.35	0.18	0.00	0.00	0.00
POTENsp					0.00	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRUNVIR	choke cherry	*Prunus virginiana*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PSEUMEN	Douglas-fir	Pseudotsuga menziesii	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	2.65	0.00	0.00	0.20	0.03	0.00	0.00	1.25
PSEUSPI	bluebunch wheatgrass	Pseudoroegneria spicata	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PYROASC	pink wintergreen	*Pyrola asarifolia*	perennial	native	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RORIPAL	marsh yellow cress	*Rorippa palustris*	a/b/slp*	native	0.13	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ROSAACI	prickly rose	*Rosa acicularis*	perennial	native	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.92	0.00	0.00	0.00	1.40	0.00	0.00	0.40	0.00	0.00	0.00	0.00
RUBUIDA	red raspberry	*Rubus idaeus*	perennial	native	0.00	0.00	0.00	5.80	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
RUBULEU	blackcap raspberry	Rubus leucodermis	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
RUBUPAR	thimbleberry	*Rubus parviflorus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RUMECRI	curly dock	*Rumex crispus*	perennial	exotic	0.00	0.31	8.31	0.00	0.00	0.00	0.42	0.00	0.00	0.10	0.23	0.00	0.00	0.50	0.45	0.55	0.00	0.00	0.00
SAGIPRO	birdseye pearlwort	*Sagina procumbens*	perennial	unkn	1.02	0.21	0.00	0.00	15.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SALIBEB	Bebb's willow	*Salix bebbiana*	perennial	native	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SALILUC	Pacific willow	*Salix lucida ssp. Lasiandra*	perennial	native	0.00	0.00	3.67	28.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SALIXSP	willow species	*salix species*	perennial	native	0.00	0.00	3.92	6.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
SALSKAL	Russian thistle	Salsola kali	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.04
SHEPCAN	soap berry	*Sheperdia canadensis*	perennial	native	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
SILELAT	white cockle	*Silene latifolia*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.33	0.85	0.00	0.00	0.08	0.00	0.00	0.00	0.00
SISYALT	tall tumbleweed	*Sisymbrium altissimum*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
SOLISPA	spikelike goldenrod	*Solidago spathulatum*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STELMED	common chickweed	*Stellaria media*	perennial	exotic	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STIPOCC	sitiff needle grass	Stipa occidentalis	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SYMPALB	snowberry	*Symphoricarpos albus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	3.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TARAOFF	dandelion	*Taraxacum officinale*	perennial	exotic	0.00	0.00	0.69	0.35	0.00	0.00	0.00	0.08	0.00	0.00	0.10	0.30	0.00	0.09	0.20	0.08	0.00	0.00	0.00
THALARV	field pennycress	*Thlaspi arvense*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRAGDUB	yellow salsify	*Tragopogon dubius*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
TRIFOLI	clover species	Trifolium sp.	perennial	exotic	0.00	0.63	18.04	0.35	0.00	0.00	0.00	0.42	0.03	0.65	1.40	1.10	0.00	0.13	3.23	1.00	0.00	0.00	0.00
TRIFPRA	red clover	*Trifolium pratense*	biennial	exotic	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.03	0.05	0.25	0.00	0.00	0.00	1.18	0.25	0.00	0.00	0.00
TRIFREP	white clover	*Trifolium repens*	perennial	exotic	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00
unknown					0.00	5.17	0.00	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.13	0.00	0.00	0.00	0.00	0.00
VERBTHA	great mullein	*Verbascum thapsus*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.78	0.00	0.00	1.33	0.00	0.00	0.00	0.00
VEROPER	pursulane speedwell	*Veronica peregrina*	annual	exotic	0.04	0.75	0.13	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
VIOLLAN	Alaska violet	*Viola langsdorfii*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total				8.0	63.0	75.2	119.3	17.5	5.7	14.6	24.1	21.4	20.4	25.3	32.8	12.0	9.1	53.1	49.9	1.9	9.1	9.0

Appendix 3). Table 8 summarizes the characteristics of each group based on their environmental variables.

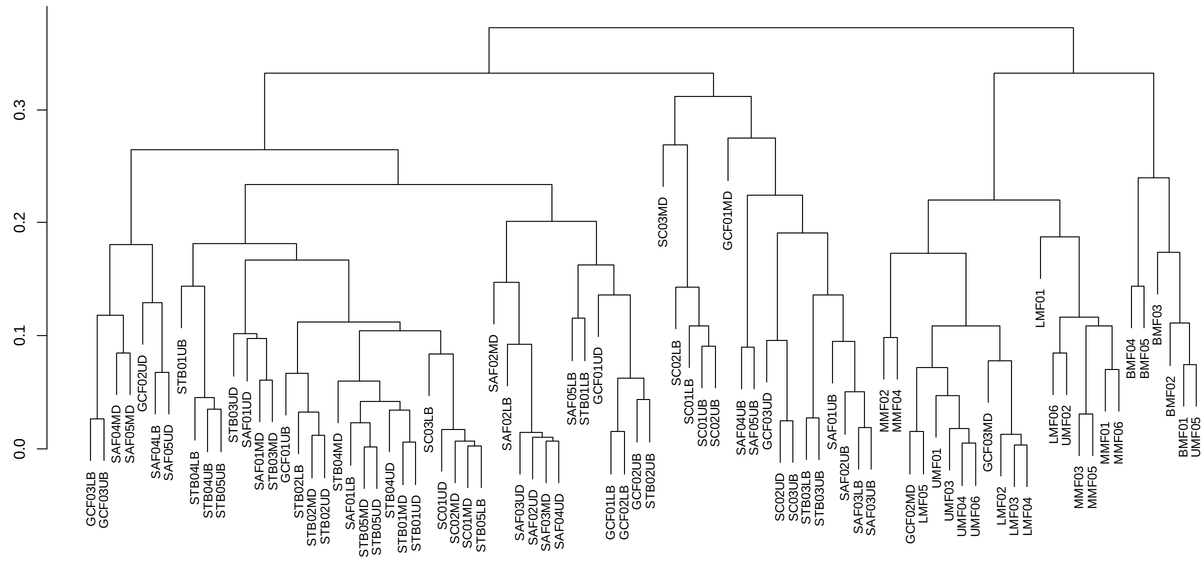


Figure 73. **Dendrogram showing groups of transects formed by WPGMA hierarchical clustering applied after computing similarities among transects with a Gower distance coefficient, and based on environmental variables.**

Transects in Group 1 were dominated by mineral soil, and were mostly part of the Gun Creek fan or steep alluvial fans, on the north shore (Table 8). Transects in Group 2 were all rapidly draining, rocky steep beaches, colluvium or fans, while transects in Group 3 were wave impacted, with loamy sandy substrate. The transects in Group 4 were mostly in the low and upper buffer elevation. Finally, the transects in Group 5 were all mudflats from all elevations. The transects in Group 5 corresponded in large parts to the transects of the Groups 1 and 6 as based on the species composition, while the environmental Group 2 corresponded largely to the transects in Group 2 based on species composition.

Table 8. **Summary of the characteristics of each group of transects formed based on their environmental characteristics, as well as the top five most abundant species in each group (frequency of occurrence, and total cover).**

Group	Transects	Environmental characteristics	Elevation	Terrain classes and location
1	GCF03LB-UB, SAF04MD;LB, SAF05MD-UD, GCF02UD	Mineral soil		Gun Creek and steep alluvial fans, in the North
2	STB01MD-UB, STB02UD;LB, STB03MD;UD, STB04LB-UB, STB05LB-UB, GCF01UB, SAF01MD;LB, SCO01MD-UD, SCO02MD, SCO03LB,	rapidly drained, sandy, ribbed topo, high cover of rocks	Mid, upper and buffer	Steep beaches, colluvium and alluvial fans
3	SAF02UD;LB, SAF03MD-UD, SAF04UD, SAF05LB, STB01LB, STB02UB, GCF01UD;LB, GCF02LB-UB	wave impacted, sub-angular fragment types, loamy sand		Steep beaches and alluvial fans
4	SCO01LB-UB, SCO02UD-UB, SCO03MD;UB, GCF01MD, SAF01UB, SAF02UB, SAF03LB-UB, SAF04UB, SAF05UB, GCF03UD, STB03LB-UB,	well drained, smooth topo, high cover of wood	Mostly low and upper buffer	
5	MMF01-06, GCF02MD, GCF03MD, LMF01-06, UMF01-06, BMF01-05	high cover of organic matter, high cover and diversity of vegetation, no coarse fragment types, lacustrine, imperfectly drained, channelled/mounded/undulating topography	All elevations	Mudflats

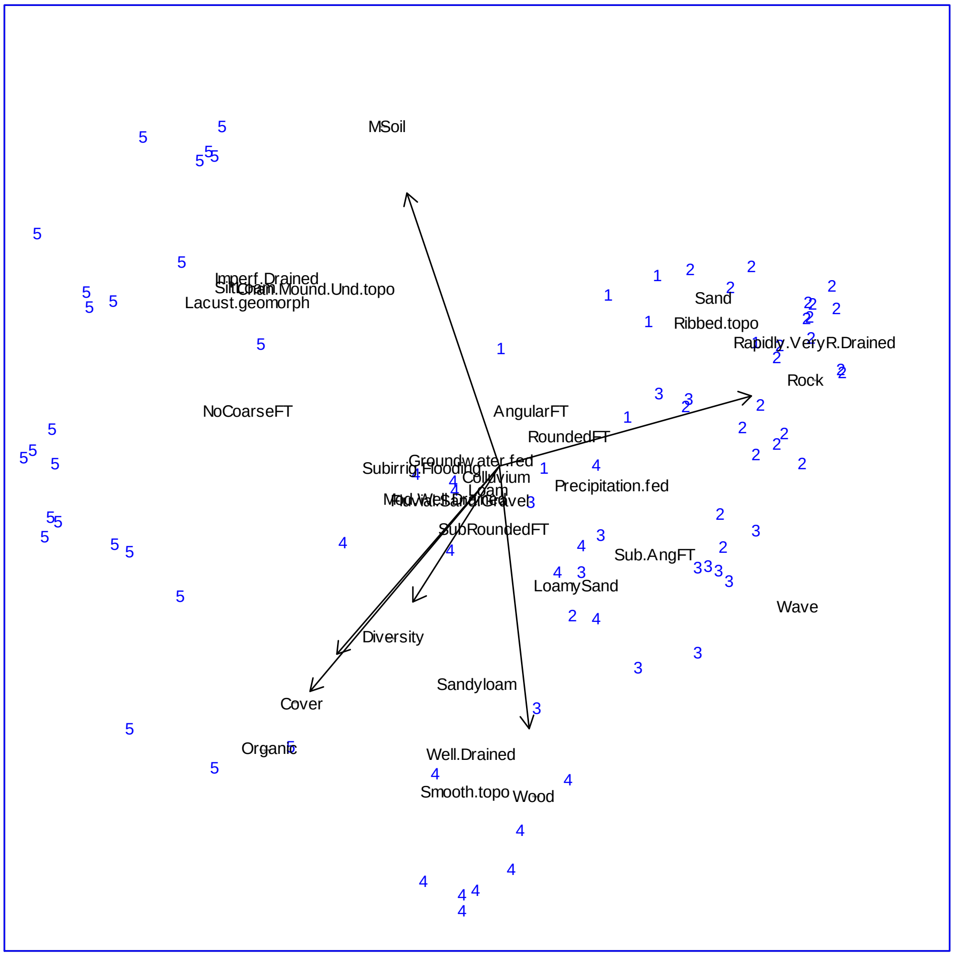


Figure 74. **PCA diagram showing variation in environmental variables among transects sampled in the Carpenter Reservoir in 2013. Axis 1 explains 29% of the variation in environmental variables, and axis 2, 14%. Numbers refer to groups of transects as formed by the clustering analysis based on environmental variables (Gower coefficient and WPGMA; see Table 8 for the names of transects per group).**

3.3.3 Vegetation Standing Crop

Biomass assessments were made based on photo interpretation of permanent photo point images (Appendix 4). For each photo, a height estimate was made, as well as a per cent cover of the 0.10m X 1m meter board. Thirty five transect samples were assessed for the biomass component of the project.

Table 9. Biomass sample represented by height X per cent cover of meter board

Transect Names	Avg ht	Average % cover meter board	Avg ht X % cov m board
LMF01	0.025	0.375	0.009375
LMF02	0.015	0.01	0.00015
LMF03	0.01	0.01	0.0001
LMF04	0.01	0.01	0.0001
LMF05	0.01	0.01	0.0001
LMF06	0.01	0.01	0.0001
MMF01	0.215	22.5	4.8375
MMF02	0.625	57.5	35.9375
MMF03	0.375	24.5	9.1875
MMF04	0.3	23.5	7.05
MMF05	0.245	11	2.695
MMF06	0.05	2.5	0.125
UMF01	0.51	32	16.32
UMF02	0.575	30.5	17.5375
UMF03	0.675	50	33.75
UMF04	0.885	56	49.56
UMF05	1.175	67.5	79.3125
UMF06	0.37	29	10.73
BMF01	2.75	50.5	138.875
BMF02	5	62.5	312.5
BMF03	3.5	27	94.5
BMF04	5	30.5	152.5
BMF05	4.5	100	450
GCF01MD	0.045	0.01	0.00045
GCF02MD	0.02	1	0.02
GCF03MD	0.01	0.01	0.0001
GCF01UD	0.07	0.505	0.03535
GCF02UD	0.125	2.5	0.3125
GCF03UD	0.505	0.505	0.255025
GCF01LB	0.35	15.5	5.425
GCF02LB	0.165	11	1.815
GCF03LB	0.175	0.01	0.00175
GCF01UB	0.105	0.505	0.053025

GCF02UB	3.75	32	120
GCF03UB	2	50	100

The mudflats and Gun Creek Fan transects were assessed. Biomass production was negligible for the LMF and Lower elevations on the Gun Creek Fan. The mudflats had the most significant amount of biomass with amounts increasing with elevation from the MMF to the BMF (Table 9). The upper buffer of Gun Creek Fan on the east side of the fan also had higher biomass values. The values from each transect provides a baseline reference for future repeat photographing and comparison.

3.3.4 Variation in the water levels of the reservoir

Over the last 30 years, the water levels in the Carpenter reservoir varied from 605m to about 653 m over the course of a year (Figure 1). The levels were very low in 1986 from March until late May, but then they were average; the opposite was true for 1985. There was a very quick drop in water levels in late June in 1988. 1993 and 2009 were years with lower water levels than average.

The last 10 years saw fewer variations in water levels than in the previous 20 years (Figure 75). Water levels were high in 2005, but lower than average in 2009. In 2012, waters were higher than average from mid-April until late May, while they were lower than average from January to early April but higher than average in May, in 2013.

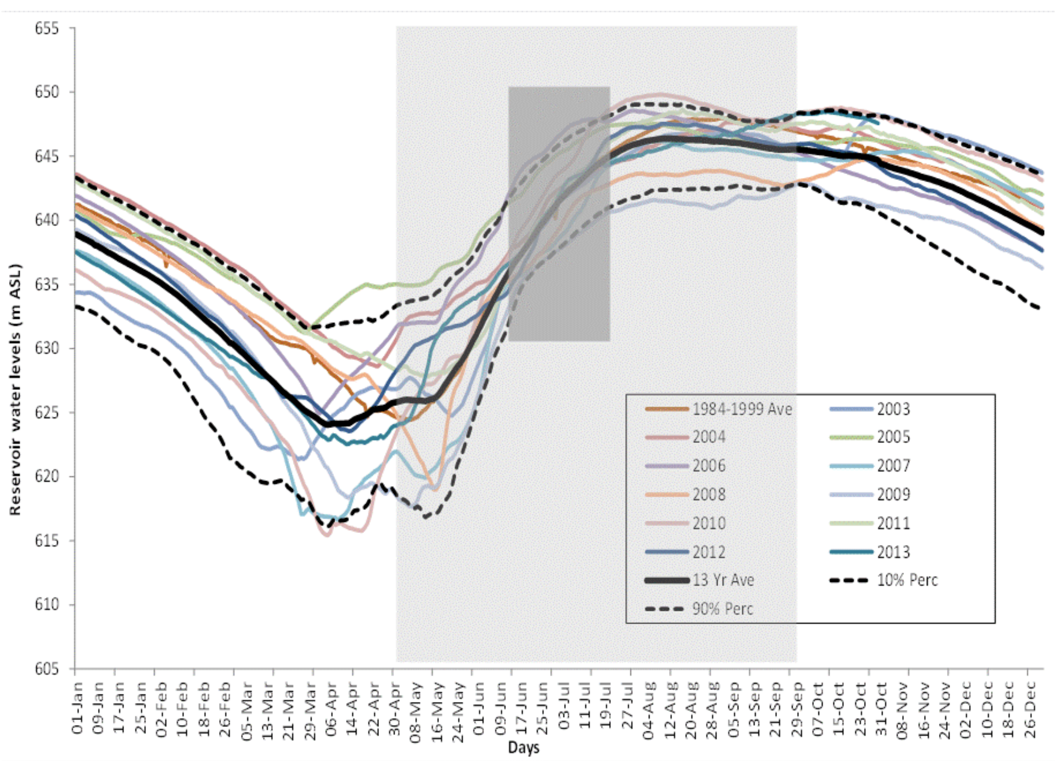


Figure 75. **Variation in water levels in Carpenter Reservoir over the year, from 2003 to 2012. Grey box study period.**

Consequently, 2009 had a higher proportion of growing days for which each elevation band was above the water levels in the reservoir, followed by 2008 and 2007 (Table 10). That was especially true for the low elevation band (642 m), for which the proportion of available days to vegetation was more than twice as much in 2009, than in 2010, 2011, 2012 or 2013 (100 per cent vs 43-48 per cent). The gap was not so great at higher elevation; in the past 11 years, the water levels ventured into the low buffer zone only once (in 2010). In comparison, the reservoir waters reached the low buffer zone eight times from 1984 to 1999 (data not shown).

Table 10. Proportion of the growing season (May 1 to September 30) for which each elevation band was above reservoir water levels, from 2003 to 2013.

Elevation band (m ASL)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
618	0	0	0	0	0	0	3	0	0	0	0
619	0	0	0	0	0	0	7	0	0	0	0
620	0	0	0	0	1	3	11	0	0	0	0
621	0	0	0	0	7	5	12	0	0	0	0
622	0	0	0	0	12	7	15	0	0	0	0
623	0	0	0	0	16	8	17	0	0	0	0
624	0	0	0	0	18	11	18	1	0	0	0
625	1	0	0	0	19	13	19	3	0	0	4
626	7	0	0	0	20	14	20	5	0	0	5
627	14	0	0	0	21	15	21	7	0	0	7
628	20	0	0	0	22	16	22	11	3	0	8
629	21	0	0	0	22	18	23	13	16	2	8
630	22	0	0	0	23	18	24	18	19	4	9
631	24	1	0	0	24	19	25	19	22	10	10
632	24	2	0	4	24	20	27	20	23	17	12
633	25	11	0	12	25	21	27	21	24	22	15
634	25	15	0	13	26	23	29	22	25	26	20
635	27	20	5	15	27	25	31	23	27	29	24
636	28	24	10	18	32	31	33	25	28	31	25
637	29	27	17	21	35	35	37	27	29	33	29
638	32	30	19	22	39	37	41	29	32	34	32
639	35	33	21	24	42	40	46	31	33	35	35
640	38	35	24	26	44	42	50	33	35	37	36
641	40	37	27	27	46	43	57	35	38	39	40
642	42	39	31	28	48	46	93	37	40	41	41
643	47	42	33	29	49	59	100	39	44	45	42
644	51	49	36	31	52	100	100	42	46	48	48
645	56	59	39	35	59	100	100	44	50	50	58
646	67	65	51	47	91	100	100	46	52	59	69
647	100	75	76	60	100	100	100	48	58	75	85
648	100	100	100	84	100	100	100	61	82	100	95
649	100	100	100	100	100	100	100	77	100	100	100
650	100	100	100	100	100	100	100	100	100	100	100
651	100	100	100	100	100	100	100	100	100	100	100

The low elevation band (642 m) was inundated in late June, early July in the past four years, but it was only inundated briefly in 2009, in late September (Table 11). The mid elevation band was inundated consistently in mid-July in the past four years too, but the dates at which the high elevation band was inundated varied; it was inundated only in early September in 2013, but as early as mid-July in 2010. The buffer zone was inundated for one month in 2010, from late July to late August.

Table 11. **Days at which each elevation band was inundated in 2013, and the four previous years (2009-2012).**

Elevation band (m ASL)	2009	2010	2011	2012	2013
630	07-Jun	28-May	May-30	07-May	15-May
631	09-Jun	30-May	03-Jun	17-May	17-May
632	11-Jun	31-May	06-Jun	28-May	21-May
633	13-Jun	02-Jun	08-Jun	03-Jun	24-May
634	15-Jun	03-Jun	09-Jun	11-Jun	01-Jun
635	17-Jun	05-Jun	11-Jun	14-Jun	06-Jun
636	21-Jun	09-Jun	13-Jun	17-Jun	10-Jun
637	27-Jun	12-Jun	16-Jun	20-Jun	15-Jun
638	04-Jul	14-Jun	19-Jun	22-Jun	20-Jun
639	10-Jul	17-Jun	21-Jun	24-Jun	23-Jun
640	16-Jul	20-Jun	24-Jun	26-Jun	25-Jun
641	Jul 27- Aug 26; Aug 30	23-Jun	29-Jun	30-Jun	01-Jul
642	Sept 21-Oct 11	26-Jun	01-Jul	03-Jul	02-Jul
643	--	29-Jun	07-Jul	09-Jul	05-Jul
644	--	04-Jul	12-Jul	13-Jul	14-Jul
645	--	08-Jul	16-Jul	Jul 16-Oct 24	30-Jul
646	--	11-Jul	21-Jul	Jul 19-Sept 18	14-Aug
647	--	13-Jul	Jul 28; Oct 29	Jul 26-Sept 1	08-Sep
648	--	July 18-Sept 9; Sept 28	Aug 7-Sept 1	--	Sept 24-Oct 25
649	--	Jul 24-Aug 26	--	--	--
650	--	--	--	--	--
651	--	--	--	--	--

The average amount of water lying on top of the low elevation band varied between 2.9 and 4.5 m from 2010 to 2012; it was as low as 0.1m in 2009 (Table 12, Figure 76). Little water was over the mid (1.6 to 3.2m) and upper elevation bands (0.2 to 1.2m), on average, for the four recent years; and an average of 26 cm of water sat on top of the lower buffer zone in 2010.

Table 12. Average depth of water above each given elevation band over 11 years, during the growing season (May 1 to September 30).

Elevation band (m ASL)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
616	19.9	21.6	23.0	23.0	18.4	18.2	16.2	21.8	21.0	21.0	20.8
617	19.0	20.8	22.2	22.1	17.6	17.4	15.3	21.0	20.2	20.2	19.9
618	18.2	19.9	21.4	21.3	16.7	16.5	14.8	20.2	19.3	19.3	19.1
619	17.4	19.1	20.5	20.5	15.9	15.7	14.5	19.3	18.5	18.5	18.3
620	16.5	18.3	19.7	19.6	15.1	15.2	14.3	18.5	17.7	17.7	17.4
621	15.7	17.4	18.9	18.8	15.2	14.6	13.7	17.7	16.8	16.8	16.6
622	14.9	16.6	18.0	18.0	15.0	14.1	13.2	16.8	16.0	16.0	15.8
623	14.0	15.7	17.2	17.1	14.7	13.5	12.6	16.0	15.2	15.2	14.9
624	13.2	14.9	16.3	16.3	14.2	13.0	11.9	15.3	14.3	14.3	14.1
625	12.5	14.1	15.5	15.5	13.6	12.4	11.2	14.7	13.5	13.5	13.7
626	12.2	13.2	14.7	14.6	12.9	11.6	10.6	14.1	12.6	12.6	13.1
627	12.2	12.4	13.8	13.8	12.2	11.0	9.8	13.5	11.8	11.8	12.4
628	12.1	11.6	13.0	13.0	11.5	10.3	9.2	13.2	11.3	11.0	11.7
629	11.4	10.7	12.2	12.1	10.8	9.6	8.4	12.6	11.8	10.3	10.9
630	10.8	9.9	11.3	11.3	10.1	8.9	7.7	12.4	11.3	9.7	10.2
631	10.1	9.1	10.5	10.4	9.3	8.1	7.0	11.7	10.8	9.3	9.5
632	9.4	8.4	9.7	9.9	8.6	7.4	6.3	11.0	10.2	9.1	8.8
633	8.7	8.2	8.8	9.8	7.9	6.7	5.6	10.3	9.5	8.7	8.2
634	7.9	7.7	8.0	9.1	7.2	6.0	4.9	9.6	8.9	8.3	7.8
635	7.3	7.2	7.4	8.5	6.5	5.4	4.2	8.9	8.2	7.8	7.3
636	6.6	6.8	7.0	7.9	6.0	4.9	3.6	8.4	7.5	7.2	6.6
637	5.9	6.1	6.6	7.3	5.4	4.3	2.9	7.8	6.8	6.5	6.1
638	5.3	5.6	5.9	6.6	4.9	3.7	2.3	7.1	6.3	5.9	5.5
639	4.6	5.0	5.2	5.9	4.3	3.0	1.7	6.4	5.6	5.2	4.9
640	4.0	4.3	4.6	5.3	3.7	2.3	1.0	5.8	4.9	4.5	4.2
641	3.4	3.6	3.9	4.5	3.1	1.6	0.4	5.2	4.3	3.8	3.6
642	2.7	2.9	3.3	3.8	2.4	0.9	0.1	4.5	3.7	3.2	2.9
643	2.1	2.3	2.6	3.1	1.7	0.3	0.0	3.8	3.1	2.6	2.2
644	1.5	1.8	1.9	2.3	1.0	0.0	0.0	3.2	2.4	2.0	1.6
645	0.9	1.3	1.2	1.6	0.4	0.0	0.0	2.6	1.8	1.3	1.1
646	0.4	0.7	0.6	1.1	0.0	0.0	0.0	1.9	1.1	0.7	0.6
647	0.0	0.2	0.2	0.6	0.0	0.0	0.0	1.2	0.5	0.2	0.3
648	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.7	0.1	0.0	0.0
649	0	0	0	0	0	0	0	0.26	0	0	0
650	0	0	0	0	0	0	0	0	0	0	0
651	0	0	0	0	0	0	0	0	0	0	0

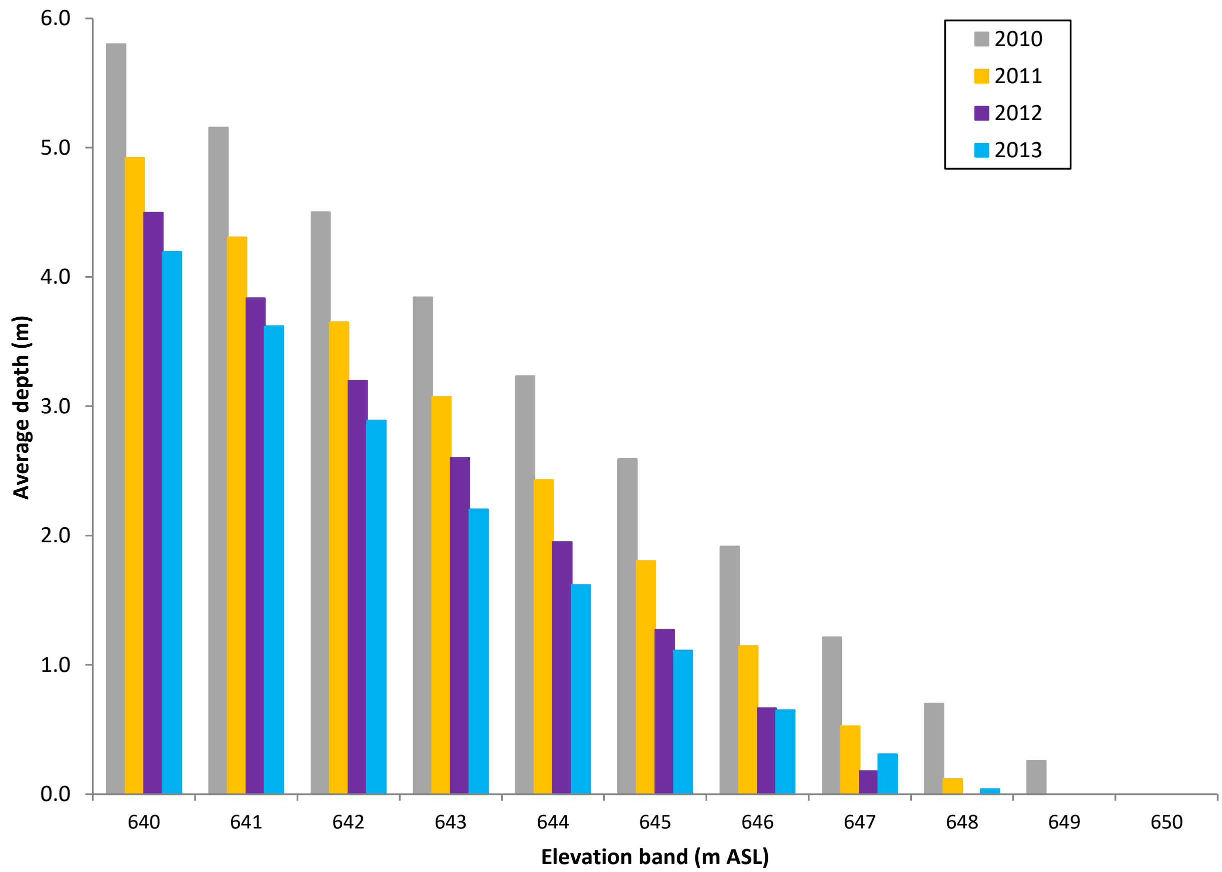


Figure 76. **Average depth (m) at each elevation band that were sampled in the field (640-650 m) from 2010 to 2013, during the growing season (April 1 to September 30).**

4.0 Discussion

4.1 Summary of characteristics of terrain classes

This study has shown that much of the terrain in the drawdown zone of the Carpenter Reservoir is sparsely vegetated based on per cent cover. The mudflats west of Gun Creek Fan had the highest vegetation cover over 55 per cent, on average. In general, the vegetation around Carpenter Reservoir is most complex in the western mudflat end, where there is high vegetation cover and structural diversity, and in some of the upper and lower buffer alluvial fan terrain. In terms of species richness at least 71 vegetation species were found in the flats, and 29 of those were unique to the mudflats west of Gun Creek Fan.

Spatially, the mudflats west of Gun Creek Fan are only about 14 per cent of the total drawdown zone of Carpenter Reservoir, but the contiguous expanse of the flats makes it a significant 208 ha, given their low gradient landscape, vegetation structural complexity, and higher biomass production. The mudflat region between Gun Creek fan and the town of Goldbridge is the region of the drawdown zone that would most closely resemble some of the historic river valley conditions that existed prior to the damming of the Bridge River at Terzaghi. The mudflats also had the greatest diversity and evidence of wildlife presence and use. In fact, much of the buffer mudflat area was designated a Wildlife habitat area for the western Screech Owl by the Ministry of Environment (Figure 77). In some areas, mountain alder (*Alnus incana*) formed a canopy in the heterogeneous zone where riparian forest and shrub ecosystems are growing in the landscape affected by fluvial and reservoir flooding. The high wildlife values of this region make it a good target for assessing the vegetation for change over the next 10 years.

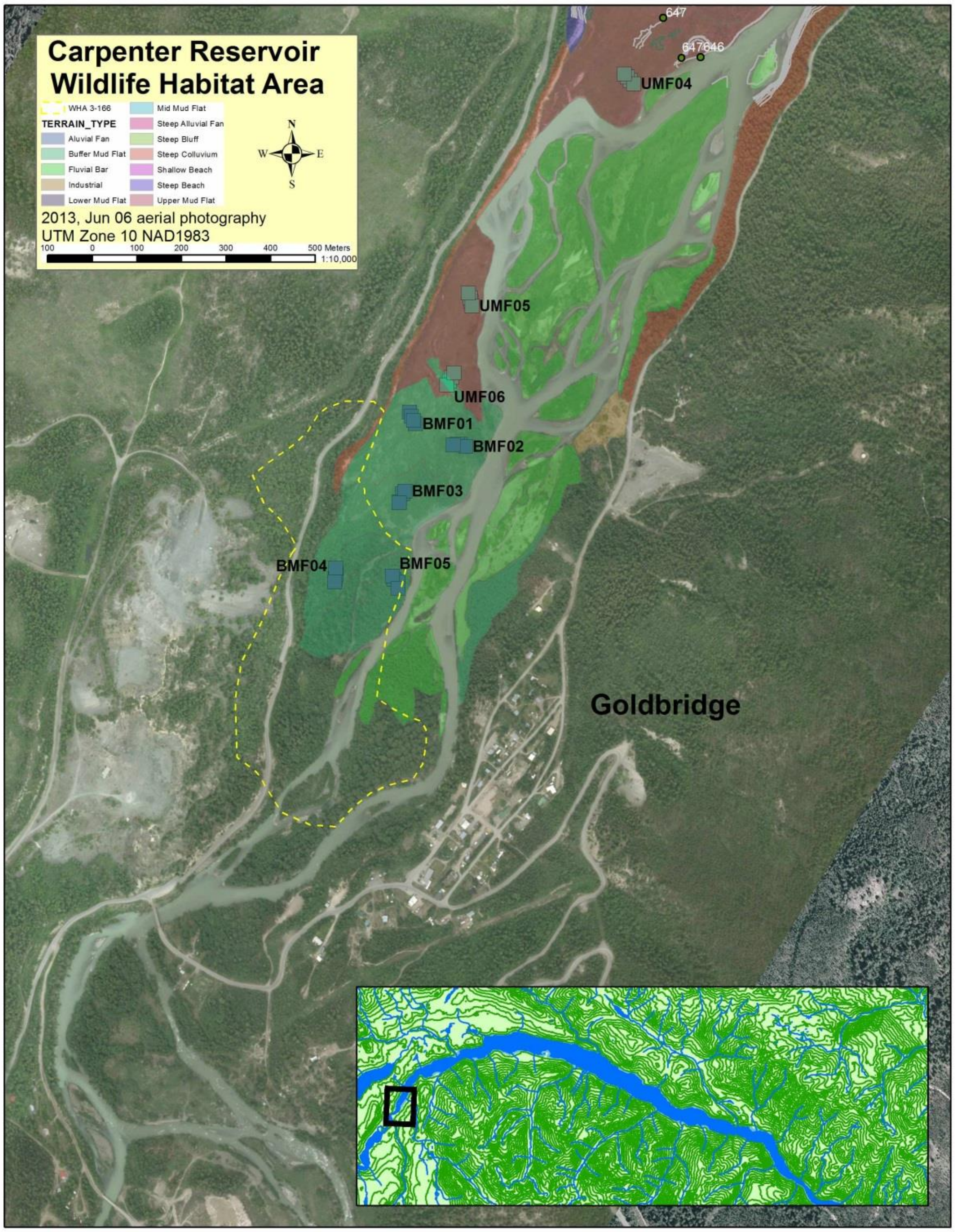


Figure 77. Zone of the buffer mudflat that is designated as Wildlife habitat area for the western Screech Owl by the Ministry of Environment

The statistical analysis supported the similarities among mudflat transects observed in the field. The same environmental characteristics were also found to define the mudflats, with fine soils, high cover of organic matter cover, as well as high diversity. The upper mudflat zone marks a transition where willow species have advanced and retreated in the past. This zone will be one to monitor closely as there could be shifts in the vegetation cover with encroachment or retreat in willow species. This monitoring could be carried out as a GIS exercise comparing the shrub distribution from the 2006 images with those taken in 10 years from now.

There was a general trend of increasing cover, diversity, and biomass with increasing elevation, in both the mudflats and the sloping terrain surrounding the reservoir. Annuals and moisture loving species defined the lower elevation, while weedy species and upland shrubs defined the higher elevations. The lowest elevation band where there was consistent vegetation cover was in the mid elevation mudflats. That elevation band could serve as a reference ecosystem site, as well as a seed gathering area, to guide and supply revegetation efforts on the east side of Gun Creek Fan. It has been shown that dams can have a significant impact on downstream seed dispersal (Merritt, D. M. and Wohl, E. E, 2006), and it is therefore possible that La Joie Dam, Gun Creek and its fan, and inundation from the reservoir act as a barrier to seed dispersal between the vegetated mudflats in the west, and the low mudflats in the east. There is also a back watering effect created by Gun Creek on the Middle Bridge River.

Unlike mudflats, alluvial fans were distributed across the whole drawdown zone in Carpenter Reservoir. Alluvial fans were formed at the mouths of steep valleys where creeks empty into the Bridge River. The upper buffer zone on several fans was within the edge of a structurally rich cottonwood forest. The upper and lower buffer zones of the alluvial fans will be sites to watch closely for any change in vegetation community, particularly where there is a forest edge. Exotic weedy species were common on the alluvial fans, and monitoring these species especially noxious weed species such as spotted knapweed (*Centaurea biebersteinii)*, and burdock (*Arctium lappa*) will also be important. The burdock was competing in several regions with a diversity of native shrubs and herbs, including cow parsnip (*Heracleum lanatum*), a valuable food resource for St'at'imc people as well as bears.

Steep beaches and steep colluvium were shaped by the energy of the waves from the reservoir, and generally supported little vegetation in the lower elevation bands. They, however, had upland perennial vegetation species encroaching at times into the buffer zones. These species are not as tolerant to inundation as other riparian species, and monitoring their distribution in the buffer zones in the coming years could be a good, and early, indicator of the effects of the changes in water regime on the vegetation in the reservoir.

4.2 Future of the monitoring program

4.2.1 Statistical limitations

The long-term monitoring program is observational in nature, as it is impossible to manipulate directly (and with replication) the independent variables that are, and will be, influencing the vegetation communities of the reservoir. The confrontation of observational findings to hypotheses may still allow inferential testing as long as hypotheses, sampling design and statistical analyses are adequately developed and interpreted.

The challenge lies in having statistical analyses robust and powerful enough to detect effects of the water operating regime and other environmental/spatial variables on the vegetation communities, over time. Robust tests are able to tolerate departure from the requirements of the tests (Scherrer 1984), which is important considering how little natural un-manipulated data usually complies with statistical assumptions. When needed, several methods to transform data to meet the requirements of test were considered before conducting tests. Also, tests by permutations were employed to reduce impacts of non-normal data distributions and spatial autocorrelation on the conclusions of the tests (Legendre and Legendre 1998, Borcard *et al.* 2011).

The power of a statistical test is defined as its capacity to provide the smallest β error for a given α error (Scherrer 1984). The probability of accepting a false null hypothesis corresponds to β error, while α error is the probability of rejecting a true null hypothesis (Sokal and Rohlf 1995). The potential consequence of a low power is that the null hypothesis of no-effects (H0) would not be rejected because the sampling size was small and/or the effect was weak (weaker than the random components), not because H0 was true (which represents a type II error). Given the complexity of the ecosystem studied and the fact that the sampling size is limited to 45 transects and two periods of sampling (10 years apart), it may be that no conclusions can be reached in 10 years as far as effect of the changes in water regimes on the vegetation communities. However, the interpretation of results is easier when H0 is rejected, and given the expected changes in water regime over the coming 10 years, we are confident that the current design will at least allow the detection of general trends in vegetation, and indicate potential impacts from the changes in water regime.

Other assumptions include the fact that differences in climate over time will not be confounded with effects from the water operating regime. It is also assumed that sampling will not alter the structure of the vegetation, that all variables of interest will be included in the models, and that no effects observed on dependent variables will be attributed to the wrong independent variables, i.e. that the effects of confounding variables will be acknowledged and controlled for, as much as possible.

4.2.2 General considerations and species of interest

The mudflats in the west end of the reservoir provide a good region to monitor the changes in spatial extent, composition, and biomass of vegetation over time. There are several dynamic areas in the south-eastern mid elevation mudflats that could experience changes in cover of vegetation through time. There are also zones of reduced vegetative cover due to a high and sustained water table in parts of the mid elevation mudflats, that could see shifts with a changing water regime. As well, there are regions where fluvial action and deposition of sands have kept growth of vegetation to a minimum (e.g. Figure 78). These areas could all be monitored over the 10 years of the project to see is any shifts in vegetation characteristics are related to reservoir management.

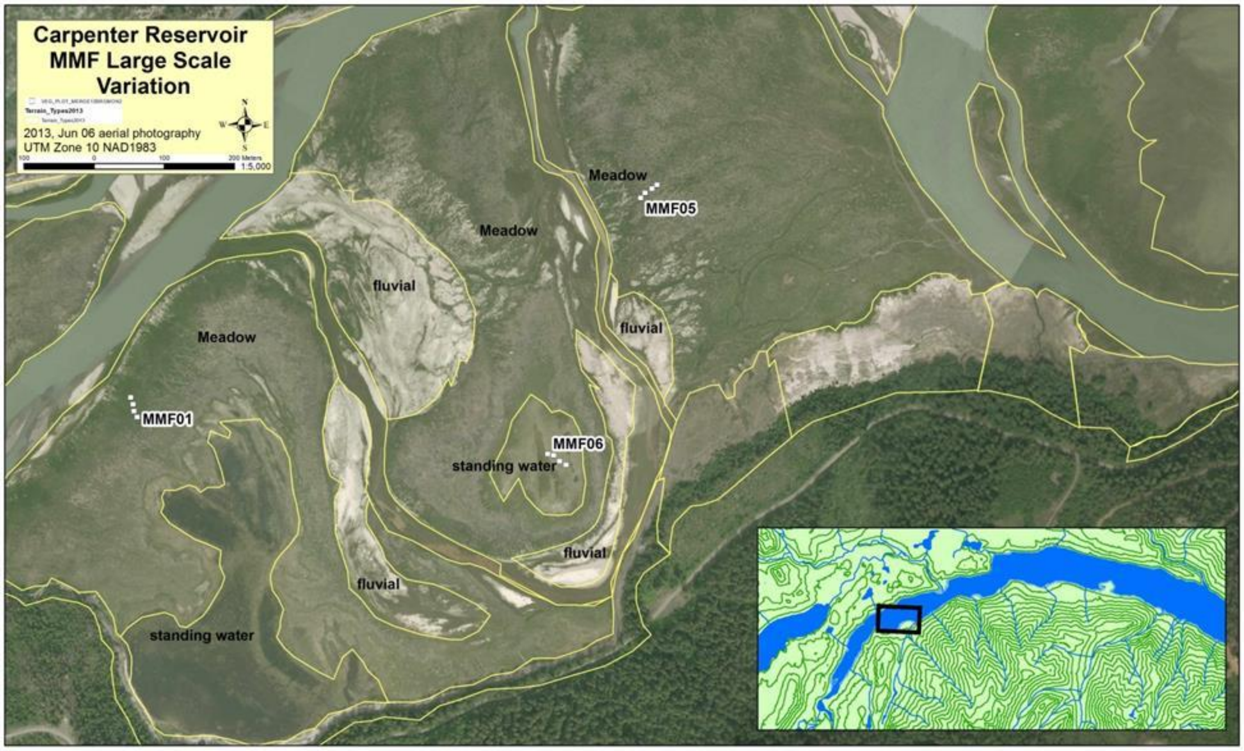


Figure 78. **Examples of regions where fluvial action and deposition of sands have kept growth of vegetation to a minimum.**

The low elevation band experiences harsher conditions, with extremes of flooding followed by periods of drought, which likely explains the low vegetation noted. The meager species cover in the low mudflats, and mid and upper elevation sites on the Gun Creek fan, are part of the reasons for the BRGWORKS-1 revegetation project. *Carex lenticularis* was found in one low elevation mudflat, albeit in trace cover. Still, the fact that *lenticularis* was persisting at this low elevation is an encouraging sign that revegetation success in the drawdown zone using perennial native sedges may be possible. *Carex lenticularis* was the most common and most widely distributed sedge found at all elevations during the survey.

Another species that is of interest for the revegetation efforts is foxtail barley (*Hordeum jubatum*). It was found in trace amounts in the mid elevation transects in the Gun Creek Fan, and may be a species to promote at higher elevations. Foxtail barley is not a range or agronomically desirable species, but it is a native grass that seems to have some tolerance to inundation. It could provide visual improvement and dust control in the drawdown zone of Carpenter Reservoir. Also, the presence of horses could be another negative pressure on the establishment of vegetation, and foxtail barley has inherent physical characteristics that make it a less desirable species to grazing animals. Other suitable species, in the upper elevation band and buffer zones, to consider for the revegetation efforts are Canada bluegrass (*Poa compressa*) and fowl bluegrass (*Poa palustris*). As well, meadow birds foot trefoil (*Lotus denticularis*), that grew is dense stands in the west end alluvial fans and steep beaches, and narrow leaved collomia (*Collomia linearis*), found throughout the reservoir, are two native annual species that should be considered for the revegetation efforts.

Micro-topography likely explains the success in the establishment of vegetation at low elevations in the reservoir. For example, the transect where the *Carex* was found at low elevation differed from the other low elevation mudflats with a mounded rather than flat micro-topography. Location in the reservoir also appears important, as some locations, as well as micro-topography relief, will likely allow ground water collection, and help alleviate symptoms of drought during low reservoir water periods.

Another factor to consider for both the long-term monitoring component and the revegetation efforts, is the importance of local disturbances caused by vehicle traffic (Figure 79). It is possible that the soil disturbance created by the vehicle traffic could have 'planted' the sedge seeds, or perhaps created microsite conditions that allowed the seeds to establish successfully. For example, work on the Upper Arrow Lakes indicated that the seeds inability to penetrate the substrate was a limiting factor in sedge establishment (A. Moody, personal communication). Such disturbances may, however, also increase the presence and dominance of exotic species. All in all, an assessment of the microsite conditions should be conducted prior to seeding, in order to favor the establishment and spread of the target species for revegetation. Sites where target species (ie. *Carex* or *Juncus* species) are already established at higher elevations could also be used as an indication of potentially good locations for revegetation efforts.

Figure 79. Example of tire tracks visible across the area in one low elevation mudflat polygon (around transect LMF 05).

A historic test plot planted in 1998 (Carr et al. 1999) in willows (*Salix* sp.) was observed and photographed near the Tyaughton Road turn off, on a steep beach site (Figure 80). The test plot was planted between the elevations of 640.5 m and 649.5 m. Based on field observations, the willow species were thriving at the higher elevations, but those planted below 647 m had died, some recently. It suggests that it is possible to successfully plant willows from the upper elevation up to the buffer zone, on steep beaches. Willows are known to be a valuable wildlife species

(Kuzovkina and Quigley 2005). During the field season in 2013, willow species were observed being utilized by snowshoe hare, beaver, moose, mule deer, and horses for browse, as well as by songbirds for nesting habitat. Wildlife habitat values in the drawdown zone of Carpenter Reservoir could be substantially increased if plantings similar to the test plot were implemented at suitable sites throughout the region.

Figure 80. **Aerial photography showing the location of the willow test plot south of Tyaughton Rd and Hwy 40 junction. Stands above the 647 m elevation contour are thriving, but plants below 647 m have died.**

5.0 Conclusion and Recommendations

The 2013 study year of the BRGMON-2 program was designed to set the foundation for addressing component 1 of the BRMGON-2 program covered under management question 1;

> Will implementation of the chosen operating alternative have negative, neutral or positive impacts on the quality and quantity (species composition, biological productivity, spatial area) of the riparian area surrounding Carpenter Reservoir?

Through the use of GIS polygon stratification of terrain classes and elevations throughout the Carpenter Reservoir drawdown zone and the establishment of 86 permanent monitoring transects a baseline has been established for future monitoring and analysis of change in the drawdown zone riparian zone. There were approximately 117 species of vegetation observed during the BRGMON-2 study in 2013, across eight terrain classes and four elevation bands. The mudflats in the west end of the reservoir have the most consistent and diverse vegetation species and cover down to the Mid mud flats. Below the low mud flats made up a vast majority of the drawdown zone and were only very sparsely vegetated with predominantly annual vegetation species. Vegetation cover, composition, diversity, and standing crop increased with increasing elevation particularly on the fine soiled mud flats at the west end of the reservoir. The low mudflats, and steep colluvium, tended to be the terrain with the least amount of vegetation cover. The former due to short growing season related to reservoir water management and the later likely attributable to the steep course textured slopes. Wave action and unconsolidated substrates wer large biophysical factors in steep beach sites and some of the alluvial fans. The buffer mudflats at the west end of the reservoir were the most diverse and densely vegetated with a high amount of structurally diversity of all terrain classes. The transition zones where vegetation is most likely to be changing under a different water regime are in the mid mudflats, the upper mudflats, as well as in the buffer zones of the steep beach and alluvial fans. Exotic weedy species were common throughout the study area in all terrain classes, and particularly prevalent in the steep terrain. Livestock grazing was a disturbance factor at several sites around the Carpenter Reservoir including the mid, upper and buffer mud flats west of the Gun Creek Fan.

The following table summarizes the state of the program relative to project hypothesis.

Project hypothesis	Year 1 Monitoring completed	Year 10 Monitoring future monitoring.
H_1: Implementation of the chosen alternative will not result in a reduction of riparian habitats in the area surrounding Carpenter Reservoir.	Riparian habitats mapped in 2013 based on 2005 aerial photography terrain classes and elevation data combined to classify riparian drawdown landscape. Baseline GIS and permanent monitoring location established.	Repeat GIS mapping exercise in year 10 with the 2013 ortho-imagery repeat with 2022 imagery and compare. Repeat monitor permanent transects in year 10 of the program will provide comparative data for assessing and obvious changes in area of riparian habitat.
H_{1A}: There is no significant change in the spatial extent of the vegetated area in the	Baseline data established and vegetated area terrain classes of the drawdown zone mapped using GIS, and	Repeat all levels of project in year 10 and compare findings with baseline data.

drawdown zone of Carpenter Reservoir.	sampled using permanent transects on the ground including photo point monitoring.	
H_{1B}: There is no significant change in the species composition of the plant community in the vegetated area of the drawdown zone of Carpenter Reservoir.	Permanent transects established by terrain class, species composition, diversity and cover recorded sampled to provide a baseline for future comparison.	Repeat monitoring permanent plots in year 10 and compare with baseline data to assess for change in species composition by terrain class.
H_{1C}: There is no significant change in the relative productivity of the plant community in the vegetated area of the drawdown zone of Carpenter Reservoir.	Standing crop approximated using photo point monitoring and percent cover estimates.	Repeat photo point monitoring and conduct biomass sampling in year 10 to provide an estimate of change in standing crop and biomass.
H_2: Incursions of less than 56 days into the reservoir buffer do not significantly impact the riparian community.	Baseline data collected from diversity of terrain types in the lower and upper buffer zones. This provides some baseline for monitoring this management question if the conditions are met.	Study would be implemented the year following a situation where these conditions were met.
H_3: Implementation of extensive riparian planting for 5 years will provide the basis for continued natural re-colonization of the drawdown zone between the Gun Creek Fan and the Tyaughton Lake Road Junction.	To be initiated in 2015	Evaluated in year 10
H_{3A}: Natural re-colonization is significantly greater at treated versus control locations.	To be initiated in 2015	Evaluated in year 10
H_{3B}: There is no significant difference in the species composition of naturally re-colonizing species in planted versus control areas.	To be initiated in 2015	Evaluated in year 10

The following recommendations are made:

- An assessment of the microsite conditions should be carried out to determine the conditions favorable for the establishment and spread of the species targeted for revegetation in the Lower Mud Flat.

- Summarize biophysical attributes that are acting on each of the vegetation communities that could be influencing vegetation composition ie. inundation period, depth of inundation, hydrologic impacts, elevation, climatic factors, substrate factors, cultural factors including livestock grazing pressures.

- Larger ground level plots, and/or more detailed spatial mapping and interpretation, may be necessary to monitor closely the buffer zone in the mudflats, which are an area of interest for capturing the influences of the changes in the operations of the water in the reservoir.

- Additional GIS analysis of the much finer resolution 2013 ortho-imagery may be integrated into the 10 year analysis to establish a stand level baseline of the composition, structure, and health of the deciduous shrub stands of the BMF area.

- Consider mid term monitoring of select transects to provide data on expected annual variation in vegetation species diversity and cover vs long term (10yr) variation.

- Conduct biomass sampling via clip plots to calibrate photo monitoring of standing crop.

6.0 References

B.C. Hydro and Compass Resource Management. 2003. Consultative Committee Report. Prepared on behalf of the consultative committee for the Bridge River Water Use Plan.

B.C. Hydro. 2011. Bridge River Power Development Water Use Plan. revised for acceptance for the comptroller of water rights. March 27th, 2011.

B.C. Ministry of Environment and B.C. Ministry of Forests And Range, 2010. Field Manual for Describing Terrestrial Ecosystems. 2nd Edition. Land Management Handbook 25.

Beyer, H.L. (2012). Geospatial Modelling Environment (Version 0.7.2.0). (software). URL: http://www.spatialecology.com/gme

Borcard, D., P. Legendre, and F. Gillet. 2011. Numerical Ecology with R. Springer, New York, 306 pages.

Carr W.W., Beer J.A., and A.I. Moody. 1999. Carpenter Reservoir Shoreline Revegetation Study Initial Scoping Study and Program Proposal. BC Hydro Contract. January.

Decamps H., Naiman R,J, and M. E. McClain. 2009. Riparian Zones: in River Ecosystem Ecology: A Global Perspective. Gene E. Likens edited. Pg. 182-189

Hawkes, V.C., C. Houwers, J.D. Fenneman and J.E. Muir. 2007. CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources. Annual Report – 2007. LGL Report EA1986. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation by LGL Consultants Limited, Sidney. 82 pp.

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs, 54(2): 187-211.

Hobbs Jared. 2014. Personal communication, MOE employee responsible for WHA establishment.

Kuzovkina, Yulia A. and Martin F. Quigley, 2005. Willows Beyond Wetlands: Uses of Salixl. Species for Environmental Projects in. Water, Air, and Soil Pollution (2005) 162: 183–204.

Legendre, P. and L. Legendre. 1998. Numerical Ecology, Developments in Environmental Modelling, Second English Edition. Elsevier, Amsterdam. 853 pp.

Legendre, P. and L. Legendre. 2012. Numerical Ecology, Developments in Environmental Modelling, Third English Edition. Elsevier, Amsterdam. 1006 pages.

Massart, D.L., J. Smeyers-Verbeke, X. Capron, and K. Schlesrer. 2005. Visual presentation of data by means of box-plots. Lc-Gc Europe 18: 215-218.

Merritt, D. M. and Wohl, E. E. (2006), Plant dispersal along rivers fragmented by dams. River Research Application, 22: 1–26.

Moody, Anne I. 2014. Personal Communications.

Pielou, E.C. 1966 *in* Legendre, P. and L. Legendre. 1998. Numerical Ecology, Developments in Environmental Modelling, Second English Edition. Elsevier, Amsterdam. 853 pp.

R Development Core Team. 2007. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Australia. Available from http://www.R-project.org.

Ralph D., Dr. B. Wikeem and Roy Cranston, 2007. Field Guide to Noxious and Other Selected Invasive Plants of British Columbia. B.C. Ministry of Agriculture and Lands, B.C. Ministry of Forests

Scherrer, B. 1984. Biostatistique. Gaetan Morin Editeur, Quebec, 850 pages.

Scholz, O., and P. Gibeau. 2014. BRGMON-5 Bridge-Seton Water Use Plan: Downton reservoir riparian vegetation monitoring project, Implementation Year 1. Splitrock Environmental. Unpublished report by Splitrock Environmental, Lillooet, BC, for BC Hydro Generation. 102 pp.

Sokal, R.R. and F.J. Rohlf. 1995. Biometry: the principles and practices of statistics in biological research. 3rd edition. New York, 887 pp.

Vermeire, L. T. and Robert L. Gillen, 2001. Estimating herbage standing crop with visual obstruction in tallgrass prairie. J. Range Management 54: 57–60 January 2001

Wood G. A., 1949. The Bridge River Region, A Geographical Study. Thesis submitted to The Department of Geography. University of British Columbia. Vancouver.

Appendix 1: Locations of transects and quadrats.

TRANSECT_N	VEG_PLOT	X	Y	Sats	PDOP	HOR_2SIG	Solution
BMF01	1	511376.1	5634361	14	1.4	0.689	DGNSS
BMF01	4	511364	5634387	12	1.3	0.544	DGNSS
BMF01	3	511367.7	5634378	0	0	0	
BMF01	2	511371.9	5634369	0	0	0	
BMF02	2	511473.7	5634311	6	3.3	23.81	GNSS
BMF02	3	511467.9	5634311	7	2.7	7.872	GNSS
BMF02	1	511486.5	5634305	5	2.8	2.882	DGNSS
BMF02	4	511458.7	5634310	7	2.5	2.463	DGNSS
BMF03	2	511340.9	5634206	9	1.8	7.016	DGNSS
BMF03	3	511331.9	5634188	6	4.6	15.009	DGNSS
BMF03	1	511345.8	5634212	9	2.5	2.754	DGNSS
BMF03	4	511332.3	5634186	12	1.6	1.152	DGNSS
BMF04	2	511181.6	5634023	9	2	12.364	GNSS
BMF04	3	511184.1	5634032	9	1.9	10.672	GNSS
BMF04	4	511183.9	5634046	6	3.5	13.103	DGNSS
BMF04	1	511180.2	5634015	8	4.8	3.157	DGNSS
BMF05	2	511313	5634015	8	2.1	10.952	GNSS
BMF05	3	511322.5	5634009	7	2	8.649	GNSS
BMF05	1	511309.8	5634023	12	1.7	1.56	DGNSS
BMF05	4	511321.3	5633995	6	2.7	10.538	DGNSS
GCF01LB	1	515690.1	5637788	5	4.8	8.437	GNSS
GCF01LB	2	515701.2	5637786	6	2.1	4.204	DGNSS
GCF01LB	3	515707.3	5637780	6	2.5	8.358	GNSS
GCF01LB	4	515715	5637775	6	2.2	7.991	DGNSS
GCF01MD	1	515558.6	5637615	11	1.9	9.922	GNSS
GCF01MD	4	515580.8	5637597	11	1.8	2.784	DGNSS
GCF01MD	3	515572.5	5637601	0	0	0	
GCF01MD	2	515564.6	5637607	0	0	0	
GCF01UB	1	515706.3	5637812	10	1.9	1.075	DGNSS
GCF01UB	2	515714.9	5637806	10	1.9	0.801	DGNSS
GCF01UB	3	515723	5637799	5	3.6	1.681	DGNSS
GCF01UB	4	515731.6	5637794	6	2.2	1.009	DGNSS
GCF01UD	1	515635.1	5637718	5	3.1	4.87	GNSS
GCF01UD	2	515644.7	5637712	5	4	5.799	GNSS
GCF01UD	3	515652.4	5637705	5	4.3	5.659	DGNSS
GCF01UD	4	515661.4	5637699	5	4.4	3.897	DGNSS
GCF02LB	1	516149.4	5637926	9	1.8	4.541	DGNSS
GCF02LB	2	516155.6	5637937	10	1.6	3.189	DGNSS
GCF02LB	3	516161.5	5637943	10	1.7	3.584	DGNSS
GCF02LB	4	516165.6	5637953	12	1.8	3.296	DGNSS
GCF02MD	1	516324.7	5637818	8	1.6	3.652	DGNSS
GCF02MD	2	516327.2	5637827	8	2.3	7.565	GNSS
GCF02MD	3	516333.1	5637836	9	1.7	4.97	DGNSS
GCF02MD	4	516338.1	5637845	8	2.3	4.316	GNSS
GCF02UB	1	516115.8	5637949	12	1.8	8.883	GNSS
GCF02UB	2	516118.3	5637959	11	1.8	4.509	DGNSS
GCF02UB	3	516124.3	5637966	12	1.6	6.879	GNSS
GCF02UB	4	516126.5	5637977	10	1.6	9.05	GNSS
GCF02UD	1	516215.2	5637886	14	1.4	0.484	DGNSS
GCF02UD	2	516220.1	5637895	19	1.3	0.353	DGNSS
GCF02UD	3	516225.1	5637903	12	1.5	0.48	DGNSS
GCF02UD	4	516230.9	5637912	16	1.3	0.407	DGNSS
GCF03LB	1	516269.3	5638071	9	1.7	1.746	DGNSS
GCF03LB	2	516274.1	5638080	14	1.4	0.426	DGNSS
GCF03LB	3	516279.4	5638089	13	1.3	0.428	DGNSS
GCF03LB	4	516285	5638098	12	2	0.693	DGNSS
GCF03MD	1	516417	5637954	7	2.1	4.647	DGNSS
GCF03MD	2	516421.2	5637961	5	2.2	6.751	DGNSS
GCF03MD	3	516427.7	5637970	6	2.3	6.588	DGNSS
GCF03MD	4	516434.1	5637977	6	2.9	7.207	GNSS
GCF03UB	1	516234.7	5638097	9	2.4	5.827	GNSS
GCF03UB	2	516238.8	5638108	9	2.3	3.796	GNSS
GCF03UB	3	516245	5638115	9	2	6.083	GNSS
GCF03UB	4	516249.7	5638124	8	2.1	4.271	GNSS
GCF03UD	1	516332.8	5638023	8	2.6	9.807	GNSS
GCF03UD	2	516338.3	5638028	9	1.5	4.783	DGNSS
GCF03UD	3	516344.7	5638035	9	1.8	9.362	GNSS
GCF03UD	4	516348.1	5638047	9	1.9	10.691	GNSS
LMF01	1	516798.7	5638217	15	1.2	0.418	DGNSS
LMF01	2	516808.6	5638220	15	1.2	0.516	DGNSS
LMF01	3	516818.2	5638221	13	1.4	0.535	DGNSS
LMF01	4	516828.2	5638222	14	1.3	0.541	DGNSS
LMF02	1	519582.9	5638358	10	1.8	0.88	DGNSS
LMF02	2	519593	5638361	14	1.4	0.489	DGNSS
LMF02	3	519602.4	5638365	16	1.3	0.395	DGNSS
LMF02	4	519611.8	5638369	17	1.4	0.391	DGNSS
LMF03	1	519628.4	5638926	19	1.2	0.375	DGNSS
LMF03	2	519620.2	5638931	18	1.3	0.365	DGNSS
LMF03	3	519611.4	5638937	17	1.3	0.366	DGNSS
LMF03	4	519603.2	5638942	16	1.3	0.383	DGNSS
LMF04	1	518192.7	5638465	13	1.3	0.556	DGNSS
LMF04	2	518194.2	5638476	15	1.3	0.622	DGNSS
LMF04	3	518195.8	5638485	14	1.4	0.463	DGNSS
LMF04	4	518196.4	5638495	13	1.5	0.777	DGNSS
LMF05	1	518013.8	5637898	13	1.7	0.543	DGNSS
LMF05	2	518013.8	5637908	12	1.4	0.505	DGNSS
LMF05	3	518013.2	5637918	17	1.3	0.391	DGNSS
LMF05	4	518014.1	5637929	10	1.7	2.782	DGNSS
LMF06	1	517614.2	5638205	17	1.4	0.386	DGNSS
LMF06	2	517607.2	5638213	17	1.5	0.41	DGNSS
LMF06	4	517594.5	5638228	15	1.3	0.416	DGNSS
LMF06	3	517602.4	5638219	9	1.8	3.038	DGNSS

TRANSECT_N	VEG_PLOT	X	Y	Sats	PDOP	HOR_2SIG	Solution
MMF01	1	513343.1	5636654	13	1.4	0.546	DGNSS
MMF01	3	513337.7	5636672	14	1.4	0.485	DGNSS
MMF01	2	513338.5	5636662	6	2.9	4.675	DGNSS
MMF01	4	513334.7	5636682	9	1.6	3.902	DGNSS
MMF02	1	512356.9	5635962	12	1.5	0.726	DGNSS
MMF02	2	512371.3	5635948	8	1.8	1.306	DGNSS
MMF02	3	512371.3	5635948	8	1.8	1.343	DGNSS
MMF02	4	512377.1	5635939	7	2	7.413	GNSS
MMF03	2	511936.2	5635695	8	2.8	6.329	GNSS
MMF03	3	511934	5635704	9	1.8	3.946	GNSS
MMF03	1	511940	5635683	15	1.5	0.419	DGNSS
MMF03	4	511931.5	5635712	17	1.4	0.419	DGNSS
MMF04	2	514584.8	5637514	9	1.9	5.518	GNSS
MMF04	3	514577.4	5637517	8	2	2.463	DGNSS
MMF04	1	514594.2	5637510	15	1.2	0.417	DGNSS
MMF04	4	514567.2	5637523	8	2	1.063	DGNSS
MMF05	2	514080.2	5636941	7	2.8	14.004	GNSS
MMF05	3	514090.1	5636947	8	2	3.145	DGNSS
MMF05	1	514073.5	5636934	13	1.5	0.51	DGNSS
MMF05	4	514097.8	5636952	13	1.7	0.55	DGNSS
MMF06	2	513934.2	5636574	11	1.6	3.202	DGNSS
MMF06	3	513942.1	5636566	8	1.6	4.317	DGNSS
MMF06	1	513925.9	5636577	19	1.3	0.428	DGNSS
MMF06	4	513951.2	5636560	16	1.4	0.383	DGNSS
SAF01LB	1	518347	5638072	0	0	0	
SAF01LB	2	518338	5638068	0	0	0	
SAF01LB	3	518328.7	5638067	0	0	0	
SAF01LB	4	518318.8	5638064	0	0	0	
SAF01MD	1	518336.9	5638106	0	0	0	
SAF01MD	2	518327.3	5638101	0	0	0	
SAF01MD	3	518317	5638100	0	0	0	
SAF01MD	4	518308.7	5638097	0	0	0	
SAF01UB	2	518340.1	5638060	6	2.6	9.392	GNSS
SAF01UB	1	518347.6	5638063	6	2.9	11.664	GNSS
SAF01UB	3	518334.1	5638056	7	2.5	5.675	GNSS
SAF01UB	4	518323.6	5638056	8	2.4	6.394	GNSS
SAF01UD	1	518344.9	5638087	10	2.5	8.167	GNSS
SAF01UD	2	518335.1	5638083	12	1.7	3.693	GNSS
SAF01UD	3	518320.4	5638079	9	2.2	11.714	GNSS
SAF01UD	4	518324.8	5638079	0	0	0	USER
SAF02LB	1	517528.3	5637749	4	4.8	0.91	DGNSS
SAF02LB	2	517519.9	5637755	0	0	0	
SAF02LB	3	517512.9	5637761	0	0	0	
SAF02LB	4	517503.3	5637766	0	0	0	
SAF02MD	4	517548.1	5637830	0	0	0	
SAF02MD	1	517573.8	5637814	0	0	0	
SAF02MD	2	517564.9	5637819	0	0	0	
SAF02MD	3	517556.9	5637825	0	0	0	
SAF02UB	1	517526.1	5637743	5	3	11.232	DGNSS
SAF02UB	2	517511.5	5637748	4	7.5	33.732	GNSS
SAF02UB	3	517506.1	5637752	5	5.3	11.698	DGNSS
SAF02UB	4	517492.9	5637755	6	2.5	6.446	DGNSS
SAF02UD	1	517547.7	5637775	6	2.4	5.696	DGNSS
SAF02UD	3	517531	5637784	7	2.8	9.046	GNSS
SAF02UD	4	517523.3	5637788	5	3.9	13.545	GNSS
SAF02UD	2	517537.5	5637780	0	0	0	
SAF03LB	1	539017.6	5632073	5	3.9	4.255	DGNSS
SAF03LB	2	539025.3	5632063	6	2.9	8.792	GNSS
SAF03LB	3	539030.2	5632055	6	2.5	8.45	GNSS
SAF03LB	4	539037.4	5632050	7	1.8	6.573	DGNSS
SAF03MD	1	538967.3	5632028	6	2.1	4.548	GNSS
SAF03MD	3	538982.6	5632014	6	2.5	11.607	GNSS
SAF03MD	2	538975.1	5632021	0	0	0	
SAF03MD	4	538989.2	5632006	0	0	0	
SAF03UB	1	539024.7	5632076	6	2.6	6.195	DGNSS
SAF03UB	2	539032.7	5632076	6	2.8	10.774	DGNSS
SAF03UB	3	539037.1	5632064	5	3	24.899	GNSS
SAF03UB	4	539045	5632055	5	2.8	7.741	DGNSS
SAF03UD	1	538997.5	5632053	12	1.3	0.428	DGNSS
SAF03UD	2	539004.3	5632046	9	2	0.599	DGNSS
SAF03UD	3	539010.7	5632039	11	1.8	0.649	DGNSS
SAF03UD	4	539017.4	5632030	10	1.8	0.719	DGNSS
SAF04LB	3	540895.4	5630954	7	3	1.478	DGNSS
SAF04LB	1	540878.8	5630966	12	1.5	0.492	DGNSS
SAF04LB	4	540903.1	5630949	5	3.8	1.692	DGNSS
SAF04LB	2	540886.6	5630960	12	1.6	0.447	DGNSS
SAF04MD	1	540849.7	5630924	17	1.4	0.393	DGNSS
SAF04MD	2	540858.1	5630918	13	1.5	0.464	DGNSS
SAF04MD	3	540865.6	5630912	12	1.5	0.483	DGNSS
SAF04MD	4	540873.4	5630906	14	1.4	1.799	DGNSS
SAF04UB	2	540894.5	5630971	10	1.9	1.186	DGNSS
SAF04UB	3	540901.3	5630965	8	2.4	6.269	DGNSS
SAF04UB	4	540913.7	5630959	6	2.1	5.133	DGNSS
SAF04UB	1	540886.6	5630978	5	4.3	10.607	DGNSS
SAF04UD	1	540865.3	5630949	8	1.8	2.741	DGNSS
SAF04UD	2	540872.2	5630944	7	2.7	6.547	GNSS
SAF04UD	3	540885.3	5630940	6	2.2	19.15	GNSS
SAF04UD	4	540890.2	5630928	5	3.1	11.738	GNSS
SAF05LB	1	539618.1	5632006	9	2.2	3.881	DGNSS
SAF05LB	2	539625.2	5632010	7	2.5	10.102	GNSS
SAF05LB	3	539636	5632022	7	2.4	13.118	GNSS
SAF05LB	4	539640.7	5632019	7	3	16.43	GNSS
SAF05MD	3	539673.9	5631967	15	1.6	0.519	DGNSS
SAF05MD	1	539657.5	5631957	12	1.6	0.512	DGNSS
SAF05MD	2	539665.3	5631963	7	2.1	9.967	GNSS
SAF05MD	4	539682.1	5631973	8	1.8	8.864	GNSS
SAF05UB	1	539609.7	5632006	6	4.7	28.558	GNSS
SAF05UB	2	539617.6	5632026	7	3	10.314	GNSS
SAF05UB	3	539625.7	5632027	9	1.9	12.546	GNSS
SAF05UB	4	539633.6	5632033	9	2	10.547	GNSS
SAF05UD	1	539636.5	5631983	18	1.4	0.373	DGNSS
SAF05UD	2	539644.3	5631989	15	1.3	0.404	DGNSS
SAF05UD	3	539652.4	5631995	13	1.5	0.468	DGNSS
SAF05UD	4	539659.9	5632001	14	1.2	0.525	DGNSS

TRANSECT_N	VEG_PLOT	X	Y	Sats	PDOP	HOR_2SIG	Solution
SC01LB	1	531005.1	5635574	12	2.2	0.577	DGNSS
SC01LB	2	531014	5635573	13	1.8	0.479	DGNSS
SC01LB	3	531024.4	5635572	12	1.8	0.81	DGNSS
SC01LB	4	531035	5635571	12	1.7	0.516	DGNSS
SC01MD	1	531004.3	5635569	9	2.2	4.572	GNSS
SC01MD	2	531013.4	5635566	11	1.9	3.327	GNSS
SC01MD	3	531025.9	5635566	11	1.9	3.398	DGNSS
SC01MD	4	531036.6	5635563	11	1.9	8.293	GNSS
SC01UB	1	531003.4	5635576	8	2.3	13.177	GNSS
SC01UB	2	531015	5635574	8	2.1	8.58	GNSS
SC01UB	3	531020.8	5635572	7	2.5	10.604	GNSS
SC01UB	4	531035.8	5635575	7	2.4	8.192	GNSS
SC01UD	1	531005.1	5635572	16	1.6	0.432	DGNSS
SC01UD	2	531014.2	5635570	17	1.5	0.387	DGNSS
SC01UD	3	531024.7	5635569	17	1.5	0.402	DGNSS
SC01UD	4	531034.4	5635569	19	1.5	0.432	DGNSS
SC02LB	1	523090.6	5639203	12	1.5	1.63	DGNSS
SC02LB	2	523101.2	5639203	12	1.9	0.62	DGNSS
SC02LB	3	523102.3	5639202	10	1.9	4.7	DGNSS
SC02LB	4	523120.5	5639202	9	2.3	1.754	DGNSS
SC02MD	1	523092	5639194	7	2.4	5.454	DGNSS
SC02MD	2	523102.7	5639195	7	2.3	5.308	DGNSS
SC02MD	3	523109.6	5639188	8	2.2	11.613	GNSS
SC02MD	4	523122	5639193	7	2.5	4.82	GNSS
SC02UB	1	523090.6	5639203	6	2.8	6.433	DGNSS
SC02UB	2	523102	5639209	5	3.4	14.16	GNSS
SC02UB	3	523111.9	5639202	6	2.9	11.857	GNSS
SC02UB	4	523122.9	5639208	6	2.6	12.109	GNSS
SC02UD	1	523091.8	5639200	0	0	0	USER
SC02UD	2	523101.8	5639201	10	1.9	0.959	DGNSS
SC02UD	3	523111.7	5639199	12	1.8	1.411	DGNSS
SC02UD	4	523121.1	5639199	12	1.6	0.667	DGNSS
SC03LB	1	518773.7	5638355	12	1.4	0.679	DGNSS
SC03LB	2	518770.2	5638346	12	1.4	0.525	DGNSS
SC03LB	3	518766.8	5638336	13	1.7	0.652	DGNSS
SC03LB	4	518761.1	5638328	11	1.7	0.555	DGNSS
SC03MD	1	518767	5638362	6	2.8	11.086	GNSS
SC03MD	2	518760.2	5638352	6	2.7	4.67	DGNSS
SC03MD	3	518752.9	5638341	5	3.7	10.513	GNSS
SC03MD	4	518754.8	5638335	6	3.7	11.247	DGNSS
SC03UB	2	518772.4	5638345	10	2	1.601	DGNSS
SC03UB	1	518777.4	5638354	10	2.6	0.877	DGNSS
SC03UB	3	518768.5	5638336	11	2.4	1.165	DGNSS
SC03UB	4	518762.3	5638327	0	0	0	
SC03UD	1	518770.5	5638356	7	3.2	17.024	GNSS
SC03UD	2	518769.1	5638346	7	3.3	9.956	GNSS
SC03UD	3	518762.8	5638337	7	3.4	6.063	GNSS
SC03UD	4	518759.2	5638329	6	3.4	7.334	GNSS
STB01LB	1	519758.6	5638193	0	0	0	
STB01LB	2	519749.3	5638195	0	0	0	
STB01LB	3	519738.7	5638196	0	0	0	
STB01LB	4	519730.5	5638198	0	0	0	
STB01MD	1	519761.8	5638212	17	1.3	0.365	DGNSS
STB01MD	2	519751.7	5638214	15	1.3	0.469	DGNSS
STB01MD	3	519741	5638215	14	1.3	0.445	DGNSS
STB01MD	4	519731.9	5638216	16	1.2	0.397	DGNSS
STB01UB	1	519758.3	5638190	10	2.4	7.351	GNSS
STB01UB	2	519750.7	5638188	10	2.1	16.378	GNSS
STB01UB	3	519738.1	5638190	0	0	0	
STB01UB	4	519729.5	5638191	0	0	0	
STB01UD	2	519750	5638204	0	0	0	
STB01UD	1	519759.3	5638204	0	0	0	
STB01UD	3	519739.7	5638206	0	0	0	
STB01UD	4	519729.6	5638207	0	0	0	
STB02LB	1	520613.8	5639770	11	1.9	0.723	DGNSS
STB02LB	2	520622.8	5639774	12	1.5	0.538	DGNSS
STB02LB	3	520633.4	5639776	12	2.2	0.776	DGNSS
STB02LB	4	520641.1	5639778	15	1.4	0.78	DGNSS
STB02MD	1	520618.8	5639753	12	1.6	1.976	DGNSS
STB02MD	2	520627.3	5639755	14	1.3	1.408	DGNSS
STB02MD	3	520636.7	5639758	14	1.5	0.483	DGNSS
STB02MD	4	520646.4	5639759	11	1.7	1.699	DGNSS
STB02UB	1	520612.3	5639781	12	2.8	1.976	DGNSS
STB02UB	2	520622.4	5639781	7	1.9	1.488	DGNSS
STB02UB	3	520631.9	5639781	13	2	0.805	DGNSS
STB02UB	4	520641.4	5639782	13	1.6	1.803	DGNSS
STB02UD	1	520615.6	5639765	15	1.3	0.655	DGNSS
STB02UD	2	520625.6	5639767	15	1.3	0.423	DGNSS
STB02UD	3	520634.5	5639769	10	1.9	1.328	DGNSS
STB02UD	4	520645.7	5639771	11	1.8	1.416	DGNSS
STB03LB	4	545394.6	5626563	0	0	0	
STB03LB	2	545386.5	5626581	0	0	0	
STB03LB	1	545382.1	5626591	0	0	0	
STB03LB	3	545390.7	5626572	0	0	0	
STB03MD	1	545363.3	5626581	16	1.5	0.404	DGNSS
STB03MD	2	545366.7	5626571	13	1.7	0.47	DGNSS
STB03MD	3	545370.9	5626557	5	3.4	14.273	GNSS
STB03MD	4	545377.8	5626554	10	2.1	3.347	DGNSS
STB03UB	1	545384.9	5626592	9	2	3.451	DGNSS
STB03UB	2	545390.9	5626583	0	0	0	
STB03UB	3	545394.3	5626575	0	0	0	
STB03UB	4	545398.9	5626566	0	0	0	
STB03UD	1	545376	5626586	10	2.1	11.054	GNSS
STB03UD	2	545380.2	5626578	10	2	2.6	DGNSS
STB03UD	3	545384.5	5626568	8	2.1	4.893	DGNSS
STB03UD	4	545389.3	5626560	7	1.9	10.525	DGNSS

TRANSECT_N	VEG_PLOT	X	Y	Sats	PDOP	HOR_2SIG	Solution
STB04LB	1	532417.1	5634470	0	0	0	
STB04LB	2	532421.8	5634461	0	0	0	
STB04LB	3	532425.4	5634451	0	0	0	
STB04LB	4	532428.9	5634442	0	0	0	
STB04MD	1	532394.6	5634460	7	2.5	5.171	GNSS
STB04MD	2	532399.9	5634451	6	2.9	4.309	DGNSS
STB04MD	3	532401.9	5634442	5	3	3.399	DGNSS
STB04MD	4	532406.2	5634432	7	2.4	5.861	DGNSS
STB04UB	1	532421.1	5634471	0	0	0	
STB04UB	2	532424.4	5634461	0	0	0	
STB04UB	3	532428	5634452	0	0	0	
STB04UB	4	532432.1	5634443	0	0	0	
STB04UD	1	532409.6	5634466	5	2.7	7.409	DGNSS
STB04UD	2	532412.6	5634455	4	5.3	35.226	GNSS
STB04UD	3	532416.7	5634445	5	3.7	4.877	DGNSS
STB04UD	4	532419.8	5634438	5	3.9	3.374	DGNSS
STB05LB	1	531740.3	5635336	0	0	0	
STB05LB	2	531748.2	5635330	0	0	0	
STB05LB	3	531755	5635324	0	0	0	
STB05LB	4	531764.2	5635318	0	0	0	
STB05MD	1	531727.1	5635313	7	2.4	6.848	DGNSS
STB05MD	2	531733.4	5635311	7	1.7	7.336	DGNSS
STB05MD	3	531741	5635302	7	1.9	5.573	DGNSS
STB05MD	4	531745	5635292	7	2	10.101	DGNSS
STB05UB	1	531743.2	5635339	13	1.7	0.532	DGNSS
STB05UB	2	531751.6	5635334	13	1.4	0.478	DGNSS
STB05UB	4	531767.4	5635322	0	0	0	
STB05UB	3	531760	5635328	0	0	0	
STB05UD	1	531731.9	5635327	4	5.9	10.383	DGNSS
STB05UD	2	531740.5	5635326	7	2.2	12.085	DGNSS
STB05UD	3	531752.4	5635315	6	3	7.288	DGNSS
STB05UD	4	531756.3	5635315	7	2.7	15.331	GNSS
UMF01	2	512522.3	5635847	8	2.5	9.878	GNSS
UMF01	3	512532.3	5635847	7	2.6	6.874	GNSS
UMF01	1	512515.7	5635841	14	1.3	0.424	DGNSS
UMF01	4	512543.9	5635851	14	1.5	0.442	DGNSS
UMF02	2	512166.9	5635694	7	2.3	5.198	DGNSS
UMF02	3	512168.4	5635683	6	3.2	11.349	GNSS
UMF02	1	512159.9	5635701	11	1.7	0.593	DGNSS
UMF02	4	512175.8	5635675	11	1.5	0.528	DGNSS
UMF03	2	512166.5	5635465	10	1.9	4.009	GNSS
UMF03	3	512164.9	5635456	9	1.6	2.171	DGNSS
UMF03	1	512168.7	5635474	16	1.7	0.897	DGNSS
UMF03	4	512164.5	5635445	18	1.3	0.504	DGNSS
UMF04	2	511890.4	5635109	8	2	5.403	DGNSS
UMF04	3	511883.6	5635116	9	2	9.421	GNSS
UMF04	1	511897.8	5635101	13	1.5	0.48	DGNSS
UMF04	4	511877.4	5635123	14	1.4	0.423	DGNSS
UMF05	2	511512.1	5634630	6	3.3	5.567	GNSS
UMF05	3	511511.2	5634638	9	2.2	4.027	DGNSS
UMF05	1	511514.1	5634619	13	1.5	3.09	DGNSS
UMF05	4	511507.4	5634649	15	1.5	1.064	DGNSS
UMF06	2	511456.1	5634454	7	2.3	5.045	DGNSS
UMF06	3	511461.5	5634461	8	1.7	5.331	DGNSS
UMF06	1	511449.9	5634445	14	1.3	0.423	DGNSS
UMF06	4	511467.1	5634472	0	0	0	

,Appendix 2: List of species and species by transect

Species	Common Name	Scientific Name	Perennial annual	Origin	family
LEPIDEN	Prairie pepper grass	*Lepidium densiflorum*	annual	native	Brassicaceae
LINAVUL	common toadflax	*Linaria vulgaris*	perennial	exotic	Scrophulariaceae
LONIINV	black twinberry	*Lonicera involucrata*	perennial	native	Caprifoliaceae
LOTUDEN	meadow birds-foot trefoil	*Lotus denticulatus*	annual	native	Fabaceae
MAHOAQU	tall Oregon grape	Mahonia aquifolium	perennial	native	Berberidaceae
MATRDIS	pineapple weed	*Matricaria discoidea*	annual	exotic	Asteraceae
MEDILUP	black medick	*Medicago lupulina*	annual	exotic	Fabaceae
MEDISAT	alfalfa	*Medicago sativa*	perennial	exotic	Fabaceae
MELIALB	white sweet clover	*Melilotus alba*	annual	exotic	Fabaceae
MENTALB	small flowered evening star	*Mentzelia albicaulis*	annual	native	Loasaceae
MENTARV	mint	*Mentha arvensis*	perennial	native	Lamiaceae
MOSS					
OSMOPUR	purple sweet-cicely	Osmorhiza purpurea	perennial	native	Apiaceae
PERSAMP	water smartweed	*Persicaria amphibia*	perennial	native	Polygonaceae
PERSMAC	lady's thumb	*Persicaria maculosa*	annual	exotic	Polygonaceae
PHACHAS	silverleaf phacelia	Phacelia hastata	perennial	native	hydrophyllaceae
PHLEPRA	common Timothy	Phleum pratense	perennial	exotic	Poaceae
PICEENC	Engelman spruce hybrid	*Picea engelmannii*	perennial	native	Pinaceae
PINUPON	Ponderosa pine	*Pinus ponderosa*	perennial	native	Pinaceae
PLAGSCO	Scouler's popcornflower	*Plagiobothrys scouleri*	annual	native	Boraginaceae
PLANMAJ	common plantain	*Plantago major*	perennial	exotic	Plantaginaceae
PLATSTR	slender bog orchid	Platanthera stricta	perennial	native	orchidaceae
POA COM	Canada bluegrass	Poa compressa	perennial	exotic	Poaceae
POA PAL	fowl bluegrass	*Poa palustris*	perennial	native	Poaceae
POAPRAT	Kentucky bluegrass	*Poa pratensis*	perennial	exotic	Poaceae
POA sp.	poa species	*Poa sp.*			
POLEPUL	Jacob's ladder	Polemonium pulcherrimum	perennial	native	Polemoniaceae
POLYCON	black bindweed	*Polygonum convolvulus*	annual	exotic	Polygonaceae
POLYFOW	Fowler's knotweed	*Polygonum fowleri*	annual	native	Polygonaceae
POPUBAL	black cottonwood	*Populus balsamifera ssp. trichocarpa*	perennial	native	Salicaceae
POTEARG	silvery cinquefoil	*Potentilla argentea*	perennial	exotic	Rosaceae
POTEBIE	biennial cinquefoil	*Potentilla biennis*	annual/biennial	native	Rosaceae
POTENsp	cinquefoil sp.	*Potentilla sp.*			
PRUNVIR	choke cherry	*Prunus virginiana*	perennial	native	Rosaceae
PSEUMEN	Douglas-fir	Pseudotsuga menziesii	perennial	native	Pinaceae
PSEUSPI	bluebunch wheatgrass	Pseudoroegneria spicata	perennial	native	Poaceae
PYROASC	pink wintergreen	*Pyrola asarifolia*	perennial	native	Pyrolaceae
RORIPAL	marsh yellow cress	*Rorippa palustris*	a/b/slp*	native	Brassicaceae
ROSAACI	prickly rose	*Rosa acicularis*	perennial	native	Rosaceae
RUBUIDA	red raspberry	*Rubus idaeus*	perennial	native	Rosaceae
RUBULEU	blackcap raspberry	Rubus leucodermis	perennial	native	rosaceae
RUBUPAR	thimbleberry	*Rubus parviflorus*	perennial	native	Rosaceae
RUMECRI	curly dock	*Rumex crispus*	perennial	exotic	Polygonaceae
SAGIPRO	birdseye pearlwort	*Sagina procumbens*	perennial	unkn	Caryophyllaceae
SALIBEB	Bebb's willow	*Salix bebbiana*	perennial	native	Salicaceae
SALILUC	Pacific willow	*Salix lucida ssp. Lasiandra*	perennial	native	Salicaceae
SALIXSP	willow species	*salix species*	perennial	native	Salicaceae
SALSKAL	Russian thistle	Salsola kali	annual	exotic	chenopodiaceae
SHEPCAN	soap berry	*Sheperdia canadensis*	perennial	native	Elaeagnaceae
SILELAT	white cockle	*Silene latifolia*	biennial	exotic	Caryophyllaceae
SISYALT	tall tumbleweed	*Sisymbrium altissimum*	annual	exotic	Brassicaceae
SOLISPA	spikelike goldenrod	*Solidago spathulatum*	perennial	native	Asteraceae
STELMED	common chickweed	*Stellaria media*	perennial	exotic	Caryophyllaceae
STIPOCC	sitiff needle grass	Stipa occidentalis	perennial	native	Poaceae
SYMPALB	snowberry	*Symphoricarpos albus*	perennial	native	Caprifoliaceae
TARAOFF	dandelion	*Taraxacum officinale*	perennial	exotic	Asteraceae
THALARV	field pennycress	*Thlaspi arvense*	annual	exotic	Brassicaceae
TRAGDUB	yellow salsify	*Tragopogon dubius*	biennial	exotic	Asteraceae
TRIFOLI	clover species	Trifolium sp.	perennial	exotic	Fabaceae
TRIFPRA	red clover	*Trifolium pratense*	biennial	exotic	Fabaceae
TRIFREP	white clover	*Trifolium repens*	perennial	exotic	Fabaceae
VERBTHA	great mullein	*Verbascum thapsus*	biennial	exotic	Scrophulariaceae
VEROPER	pursulane speedwell	*Veronica peregrina*	annual	exotic	Scrophulariaceae
VIOLLAN	Alaska violet	*Viola langsdorfii*	perennial	native	Violaceae

Species by transect, average per cent cover.

					Mud Flats				Gun Creek Fan				Steep Beach				Steep Alluvial Fan				Steep Colluvium		
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
ACERGLA	Douglas maple	*Acer glabrum*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ACHIMIL	yarrow	*Achillea millifolium*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.03	0.00	0.00	0.08	0.05	0.00	0.00	0.00
AGROGIG	redtop	Agrostis gigantea	perennial	exotic	0.00	1.52	19.25	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ALNUINC	mountain alder	*Alnus incana*	perennial	native	0.00	0.00	0.00	37.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
AMELALN	Saskatoon berry	*Amelanchier alnifolia*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AMSINKsp	amsinkia species	amsinkia sp.	annual	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
APOCAND	spreading dogbane	*Apocynum androsaemifolium*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.50
ARABHOL	Holboell's rock cress	*Arabis holboellii*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
ARCTLAP	great burdock	*Arctium lappa*	biennial	exotic	0.00	0.00	0.00	12.90	0.00	0.00	0.00	0.00	0.00	0.15	0.10	0.25	0.00	0.00	0.10	5.50	0.00	0.00	0.00
BETUPAP	paper birch	*Betula papyrifera*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BROMCIL	fringed brome	*Bromus ciliatus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BROMTEC	cheat grass	Bromus tectorum	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.15	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CALACAN	bluejoint grass	*Calamagrostis canadensis*	perennial	native	0.00	6.35	0.02	5.70	0.00	0.16	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CARDOLI	little western bitter-cress	*Cardamine oligosperma*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREAQU	water sedge	*Carex aquatilis*	perennial	native	0.00	0.33	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CARELEN	Lakeshore sedge	*Carex lenticularis*	perennial	native	0.00	3.35	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREPHA	Dunhead sedge	*Carex phaeocephala*	perennial	native	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAREROS	Ross' sedge	*Carex rossii*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach				Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
CAREUTR	beaked sedge	Carex utriculata	perennial	native	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CASTMIN	Indian paint brush	*Castilleja miniata*	perennial	native	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEANVEL	snowbrush	Ceanothus velutinus	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CENTBIE	spotted knapweed	Centaurea biebersteinii	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
CENTDIF	diffuse knapweed	Centaurea diffuse	biennial	exotic	0.00	0.00	0.00		0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHENALB	lamb's quarters	*Chenopodium album*	annual	exotic	0.48	0.02	0.00	0.00	0.59	0.09	0.00	0.00	0.23	0.20	0.00	0.00	0.23	0.10	0.00	0.00	0.00	0.00	0.00
CIRSARV	Canada thistle	Cirsium arvense	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.15	0.00	0.00	0.00
CIRSEDU	Eible thistle	Cirsium arvense	biennial	native	0.00	0.00	0.08	0.00	0.00		0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIRSVUL	bull thistle	Cirsium vulgare	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COLLLIN	narrow-leafed Collomia	*Collomia linearis*	annual	native	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	2.50	0.48	0.00	0.00	1.00	0.03	0.08	0.15	0.00	0.00	0.00
COMMUMB	commandra, pale	*Comandra umbellata*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CONYCAN	horseweed	*Conyza canadensis*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CORNSTO	red-osier dogwood	*Cornus stolonifera*	perennial	native	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
CORYAUR	golden corydalis	*Corydalis aurea*	biennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CREPATR	Slender hawksbeard	Crepis atribarba originalis	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
DESCSOP	flixweed	*Descurainia sophia*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DYSPBOT	Jerusalem oak	*Dysphania botrys*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.17
ELYMGLA	blue wildrye	*Elymus glaucus*	perennial	native	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats				Gun Creek Fan				Steep Beach				Steep Alluvial Fan				Steep Colluvium		
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
ELYMTRA	slender wheat-grass	*Elymus trachycaulus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.25	0.00	0.00	0.53	0.25	0.00	0.00	0.75
ELYTREP	quack grass	*Elytrigia repens*	perennial	exotic	0.00	0.00	2.63	0.00	0.00	3.41	0.08	0.09	0.00	0.20	1.58	0.70	0.00	0.03	2.25	1.68	0.00	0.00	0.00
EPILBRA	tall willowherb	*Epilobium brachycarpum*	annual	native	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00
EPILCIL	purple-leafed willowherb	*Epilobium ciliatum*	perennial	native	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EPILOBIsp	willowherb species	Epilobium sp.			0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00
EQUIARV	common horsetail	*Equisetum arvense*	perennial	native	0.00	19.79	1.71	3.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.03	0.00	0.00	3.03	0.00	0.00	0.00
EQUIHYE	scouring rush	*Equisetum hyemale*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUILAE	smooth scouring rush	*Equisetum laevigatum*	perennial	native	0.00	0.17	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUIPAL	swamp horsetail	*Equisetum palustre*	perennial	native	0.13	9.35	3.25	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUIPRA	meadow horsetail	Equisetum pratense	perennial	native	0.29	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EQUIVAR	northern scouring rush	*Equisetum variegatum*	perennial	native	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ERYSCHE	worm seed mustard	*Erysimum cheiranthoides*	biennial	native	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
ERYSINC	worm seed mustard	*Erysimum inconspicuum*	biennial	native	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
FILAARV	field filago	*Filago arvensis*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FRAGVIR	wild strawberry	*Fragaria virginiana*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GALITRI	bedstraw, Sweet scented	*Galium triflorum*	perennial	native	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
HERALAN	cow parsnip	*Heracleum lanatum*	perennial	native	0.00	0.00	0.00	2.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HIERGRA	hawkweed, slender	*Hieracium gracile*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
HORDJUB	Foxtail barley	Hordeum jubatum	perennial	native	0.00	0.00	3.29	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.20	0.35	0.00	0.00	0.00
JUNCBAL	Baltic Rush	*Juncus balticus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JUNCEFF	common rush	*Juncus effusus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LACTMUR	wall lettuce	*Lactuca muralis*	biennial	exotic	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LACTSER	Prickly lettuce	Lactuca serriola	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LEPIDEN	Prairie pepper grass	*Lepidium densiflorum*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LINAVUL	common toadflax	*Linaria vulgaris*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.03	0.00	0.00	0.25	0.00	0.00	0.00	0.00
LONIINV	black twinberry	*Lonicera involucrata*	perennial	native	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LOTUDEN	meadow birds-foot trefoil	*Lotus denticulatus*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.20	10.80	0.25	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAHOAQU	tall Oregon grape	Mahonia aquifolium	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATRDIS	pineapple weed	*Matricaria discoidea*	annual	exotic	0.00	0.15	0.08	0.00	0.05	0.09	0.00	0.00	0.00	0.03	0.00	0.00	0.46	0.25	0.00	0.00	0.00	0.00	0.00
MEDILUP	black medick	*Medicago lupulina*	annual	exotic	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.03	0.38	1.30	0.70	7.40	1.93	0.70	0.08	0.00	0.00	0.00
MEDISAT	alfalfa	*Medicago sativa*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.80	0.00	1.25	0.42
MELIALB	white sweet clover	*Melilotus alba*	annual	exotic	0.00	0.00	1.42	0.40	0.00	0.00	0.00	0.00	0.95	3.61	13.10	0.38	0.25	2.58	#####	0.00	1.38	5.21	0.17
MENTALB	small flowered evening star	*Mentzelia albicaulis*	annual	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
MENTARV	mint	*Mentha arvensis*	perennial	native	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MOSS					0.40	0.00	0.02	0.00	0.00	0.00	0.00	3.75	0.00	0.00	0.25	0.35	0.00	0.00	0.00	0.60	0.00	0.00	0.00
OSMOPUR	purple sweet-cicely	Osmorhiza purpurea	perennial	native	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERSAMP	water smartweed	*Persicaria amphibia*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERSMAC	lady's thumb	*Persicaria maculosa*	annual	exotic	0.48	2.40	0.00	0.00	0.08	0.00	0.00	0.00	0.18	0.08	0.00	0.00	0.63	0.03	0.00	0.00	0.17	0.00	0.00
PHACHAS	silverleaf phacelia	Phacelia hastata	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PHLEPRA	common Timothy	Phleum pratense	perennial	exotic	0.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PICEENC	Engelman spruce hybrid	*Picea engelmannii*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PINUPON	Ponderosa pine	*Pinus ponderosa*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PLAGSCO	Scouler's popcornflower	*Plagiobothrys scouleri*	annual	native	0.00	3.13	0.00	0.00	0.25	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.00	0.00	0.00
PLANMAJ	common plantain	*Plantago major*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PLATSTR	slender bog orchid	Platanthera stricta	perennial	native	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POA COM	Canada bluegrass	Poa compressa	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.79	7.17	2.83	0.00	0.03	0.90	0.00	0.00	0.20	7.55	2.53	0.00	0.00	0.00
POA PAL	fowl bluegrass	*Poa palustris*	perennial	native	0.00	0.96	5.23	2.17	0.00	0.00	0.00	0.00	0.00	0.03	0.50	0.20	0.00	0.00	0.00	0.06	0.00	0.00	0.00
POAPRAT	Kentucky bluegrass	*Poa pratensis*	perennial	exotic	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.03	0.10	0.00	0.08	2.52	1.75	0.00	0.00	0.00
POA sp.					0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POLEPUL	Jacob's ladder	Polemonium pulcherrimum	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00

Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach					Steep Alluvial Fan			Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
POLYCON	black bindweed	*Polygonum convolvulus*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.67	0.00
POLYFOW	Fowler's knotweed	*Polygonum fowleri*	annual	native	5.00	0.54	0.02	0.00	0.55	0.01	0.00	0.00	0.10	0.10	0.00	0.00	0.38	0.68	0.00	0.00	0.00	0.00	0.00
POPUBAL	black cottonwood	*Populus balsamifera ssp. trichocarpa*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.66	0.00	0.45	0.95	7.10	0.00	0.00	3.40	29.20	0.00	1.17	0.50
POTEARG	silvery cinquefoil	*Potentilla argentea*	perennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	6.92	0.92	0.00	0.03	0.00	0.00	0.00	0.00	4.20	1.45	0.00	0.00	0.00
POTEBIE	biennial cinquefoil	*Potentilla biennis*	annual/biennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.08	0.08	0.00	1.35	1.35	0.18	0.00	0.00	0.00
POTENsp					0.00	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRUNVIR	choke cherry	*Prunus virginiana*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PSEUMEN	Douglas-fir	Pseudotsuga menziesii	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	2.65	0.00	0.00	0.20	0.03	0.00	0.00	1.25
PSEUSPI	bluebunch wheatgrass	Pseudoroegneria spicata	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PYROASC	pink wintergreen	*Pyrola asarifolia*	perennial	native	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RORIPAL	marsh yellow cress	*Rorippa palustris*	a/b/slp*	native	0.13	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ROSAACI	prickly rose	*Rosa acicularis*	perennial	native	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.92	0.00	0.00	0.00	1.40	0.00	0.00	0.40	0.00	0.00	0.00	0.00
RUBUIDA	red raspberry	*Rubus idaeus*	perennial	native	0.00	0.00	0.00	5.80	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
RUBULEU	blackcap raspberry	Rubus leucodermis	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RUBUPAR	thimbleberry	*Rubus parviflorus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RUMECRI	curly dock	*Rumex crispus*	perennial	exotic	0.00	0.31	8.31	0.00	0.00	0.00	0.42	0.00	0.00	0.10	0.23	0.00	0.00	0.50	0.45	0.55	0.00	0.00	0.00
SAGIPRO	birdseye pearlwort	*Sagina procumbens*	perennial	unkn	1.02	0.21	0.00	0.00	15.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

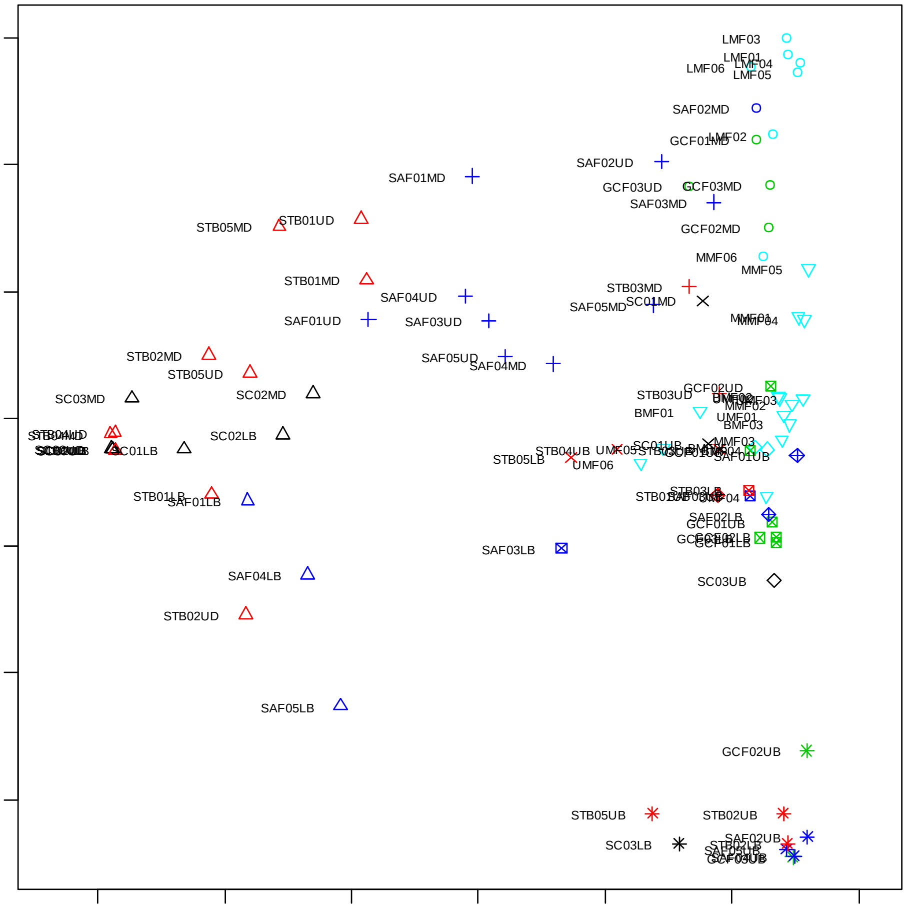
Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach				Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
SALIBEB	Bebb's willow	*Salix bebbiana*	perennial	native	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SALILUC	Pacific willow	*Salix lucida ssp. Lasiandra*	perennial	native	0.00	0.00	3.67	28.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SALIXSP	willow species	*salix species*	perennial	native	0.00	0.00	3.92	6.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
SALSKAL	Russian thistle	Salsola kali	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.04
SHEPCAN	soap berry	*Sheperdia canadensis*	perennial	native	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
SILELAT	white cockle	*Silene latifolia*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.33	0.85	0.00	0.00	0.08	0.00	0.00	0.00	0.00
SISYALT	tall tumbleweed	*Sisymbrium altissimum*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
SOLISPA	spikelike goldenrod	*Solidago spathulatum*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STELMED	common chickweed	*Stellaria media*	perennial	exotic	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STIPOCC	sitiff needle grass	Stipa occidentalis	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SYMPALB	snowberry	*Symphoricarpos albus*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	3.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TARAOFF	dandelion	*Taraxacum officinale*	perennial	exotic	0.00	0.00	0.69	0.35	0.00	0.00	0.00	0.08	0.00	0.00	0.10	0.30	0.00	0.09	0.20	0.08	0.00	0.00	0.00
THALARV	field pennycress	*Thlaspi arvense*	annual	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRAGDUB	yellow salsify	*Tragopogon dubius*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRIFOLI	clover species	Trifolium sp.	perennial	exotic	0.00	0.63	18.04	0.35	0.00	0.00	0.00	0.42	0.03	0.65	1.40	1.10	0.00	0.13	3.23	1.00	0.00	0.00	0.00
TRIFPRA	red clover	*Trifolium pratense*	biennial	exotic	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.03	0.05	0.25	0.00	0.00	0.00	1.18	0.25	0.00	0.00	0.00
TRIFREP	white clover	*Trifolium repens*	perennial	exotic	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00

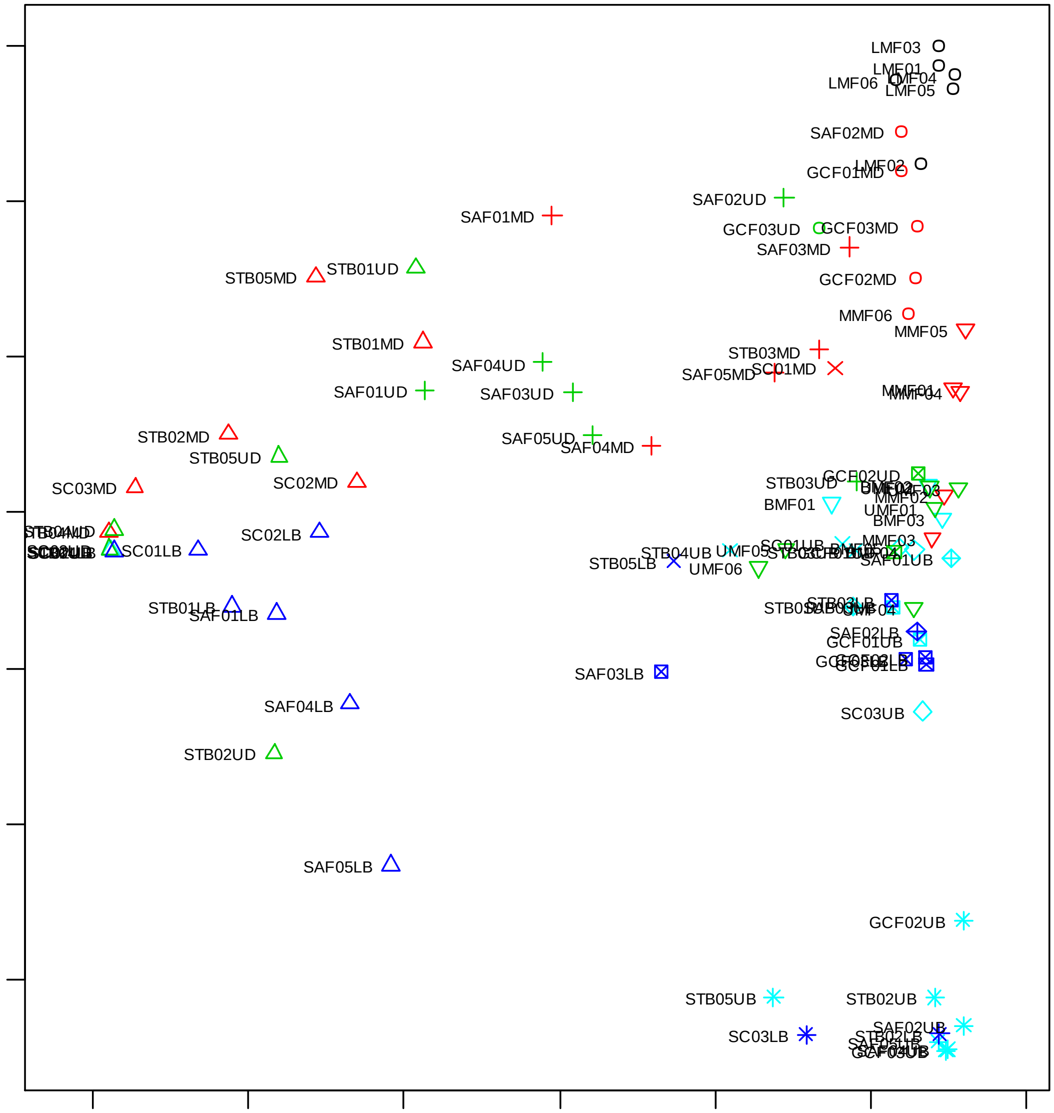
Species by transect, average per cent cover.

					Mud Flats					Gun Creek Fan				Steep Beach				Steep Alluvial Fan				Steep Colluvium	
Species	**Common Name**	**Scientific Name**	**Perennial annual**	**Origin**	**LMF**	**MMF**	**UMF**	**BMF**	**GCF MD**	**GCF UD**	**GCF LB**	**GCF UB**	**STB MD**	**STB UD**	**STB LB**	**STB UB**	**SAF MD**	**SAF UD**	**SAF LB**	**SAF UB**	**SC MD**	**SC LB**	**SC UB**
unknown					0.00	5.17	0.00	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.13	0.00	0.00	0.00	0.00	0.00
VERBTHA	great mullein	*Verbascum thapsus*	biennial	exotic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.78	0.00	0.00	1.33	0.00	0.00	0.00	0.00
VEROPER	pursulane speedwell	*Veronica peregrina*	annual	exotic	0.04	0.75	0.13	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
VIOLLAN	Alaska violet	*Viola langsdorfii*	perennial	native	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total				8.0	63.0	75.2	119.3	17.5	5.7	14.6	24.1	21.4	20.4	25.3	32.8	12.0	9.1	53.1	49.9	1.9	9.1	9.0

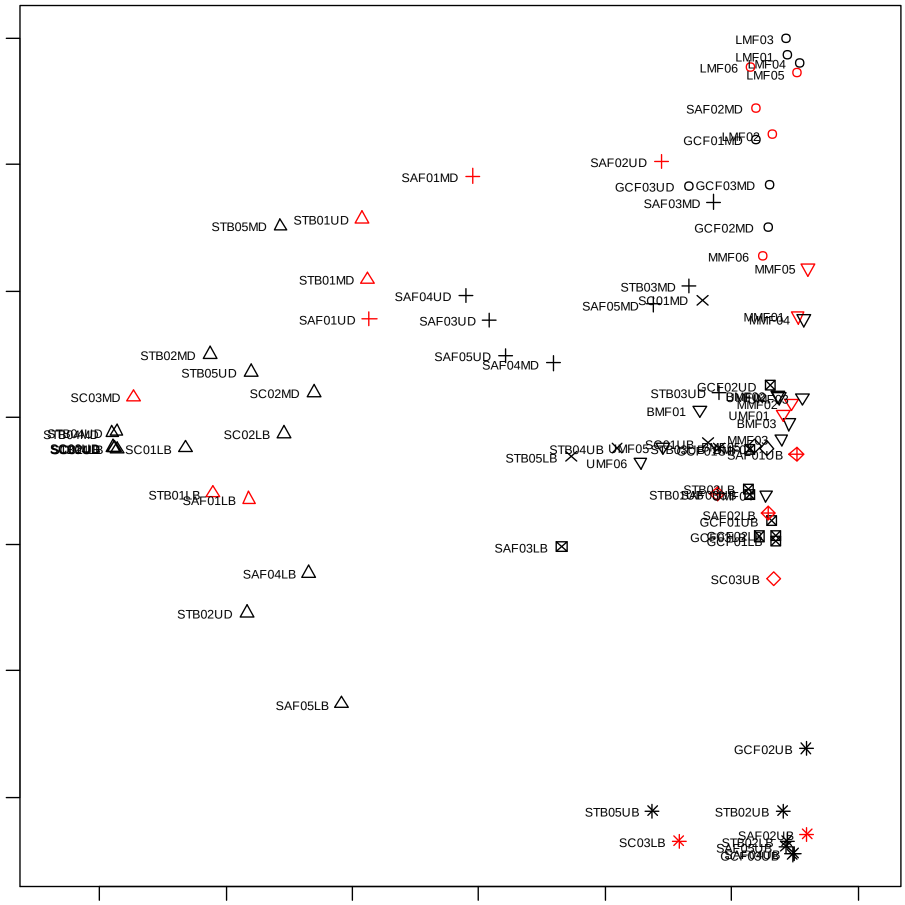
Appendix 3: Clustering analysis based on species composition and environmental variables



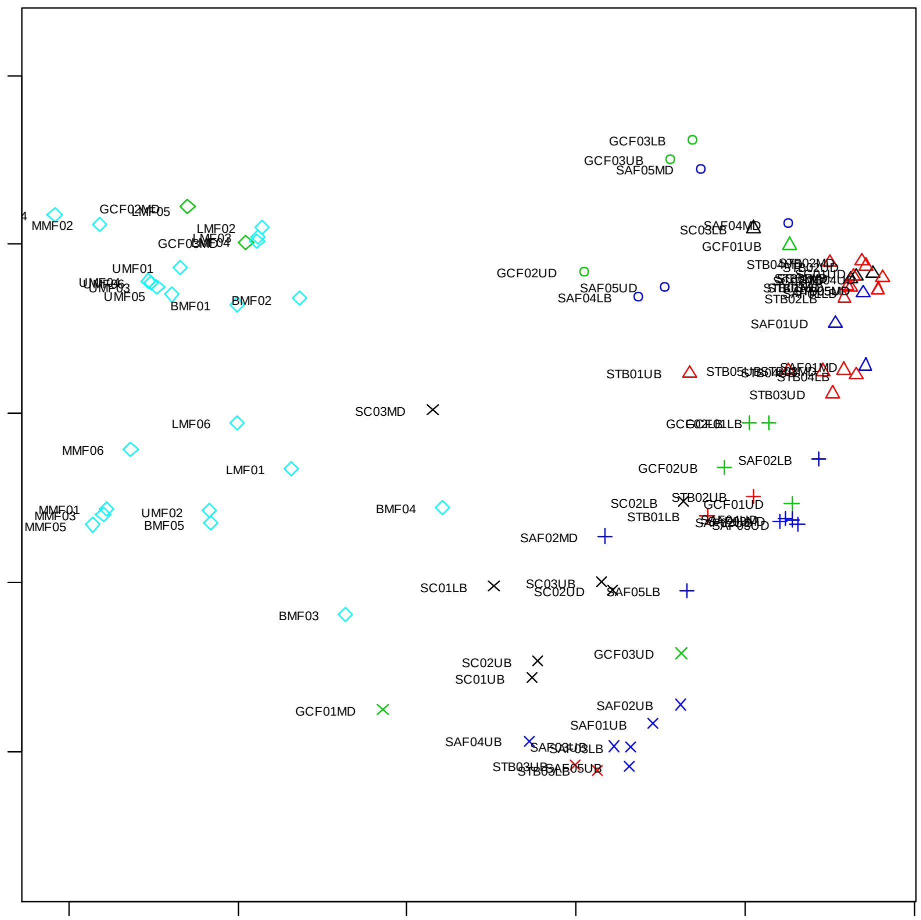
PCoA diagram showing the similarity among transects in the Carpenter Reservoir in 2013. Axis 1 explains 16% of the variation in similarities, and axis 2, 12%. Numbers refer to groups of transects as formed by the clustering analysis based on their species composition (D17 coefficient and WPGMA). Symbols are: °: Group 1, Δ: Group 2, +: Group 3, χ: Group 4, ◊: Group 5, Ỉ: reversed Δ: Group 6, Group 7,*: Group 8,⊕ : Group 9. Colors code for terrain classes: black: steep colluvium, red: steep beaches, green: Gun Creek fan, blue: steep alluvial fan, turquoise: mud flats.



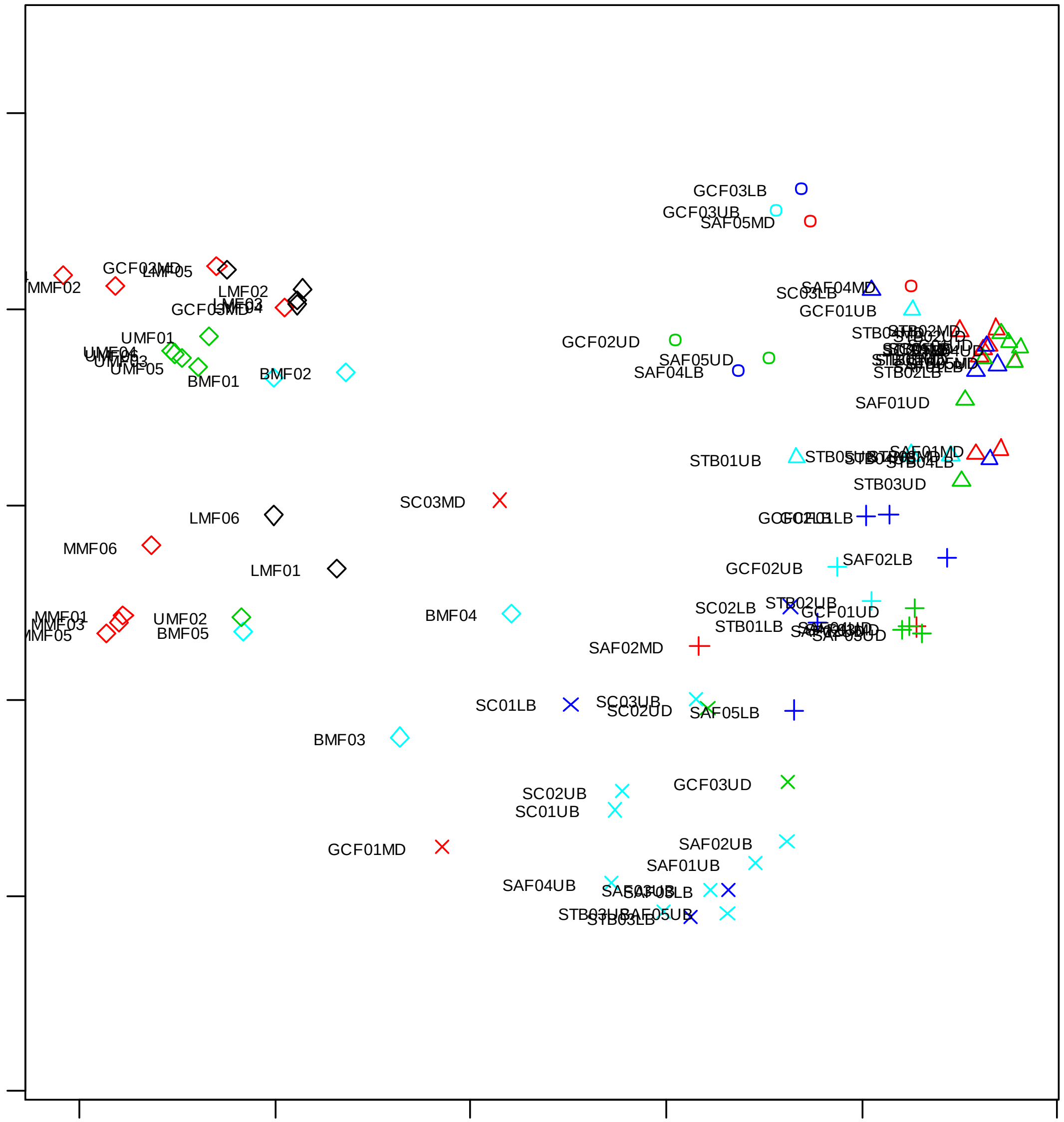
PCoA diagram showing the similarity among transects in the Carpenter Reservoir in 2013. Axis 1 explains 16% of the variation in similarities, and axis 2, 12%. Numbers refer to groups of transects as formed by the clustering analysis based on species composition (D17 coefficient and WPGMA). Symbols are: °: Group 1, Δ: Group 2, +: Group 3, χ: Group 4, ◊: Group 5, Ѝ: reversed Δ: Group 6, Group 7,*: Group 8,⊕: Group 9. Colors code for elevation: black: low, red: middle, green: upper, blue: buffer zone.



PCoA diagram showing the similarity among transects in the Carpenter Reservoir in 2013. Axis 1 explains 16% of the variation in similarities, and axis 2, 12%. Numbers refer to groups of transects as formed by the clustering analysis based on species composition (D17 coefficient and WPGMA). Symbols are: °: Group 1, Δ: Group 2, +: Group 3, χ: Group 4, ◊: Group 5, Ѝ: reversed Δ: Group 6, Group 7,*: Group 8,⊕: Group 9. Colors code for the location in the reservoir, from north to south: black: north, red: south.

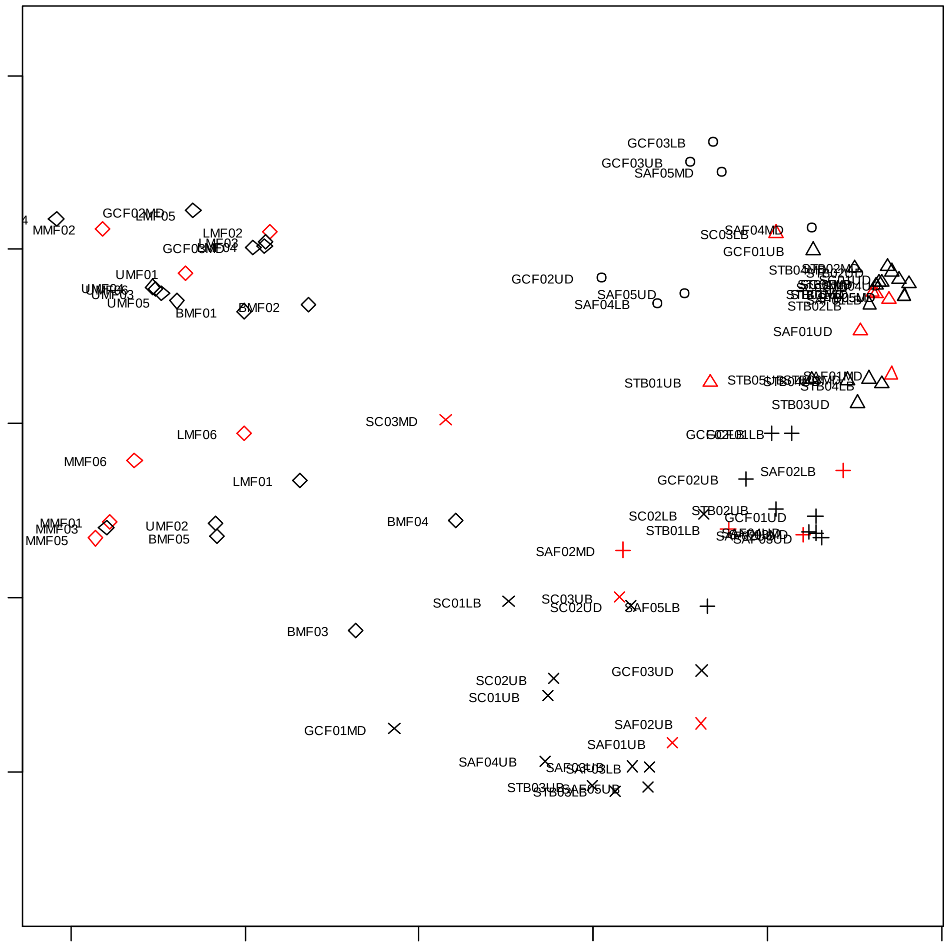


PCoA diagram showing the similarity among transects in the Carpenter Reservoir in 2013. Axis 1 explains 47% of the variation in similarities, and axis 2, 20%. Numbers refer to groups of transects as formed by the clustering analysis based on environmental variables (Gower coefficient and WPGMA). Symbols are: °: Group 1, Δ: Group 2, +: Group 3, χ: Group 4, ◊: Group 5. Colors code for terrain classes: black: steep colluvium, red: steep beaches, green: Gun Creek fan, blue: steep alluvial fan, turquoise: mud flats.



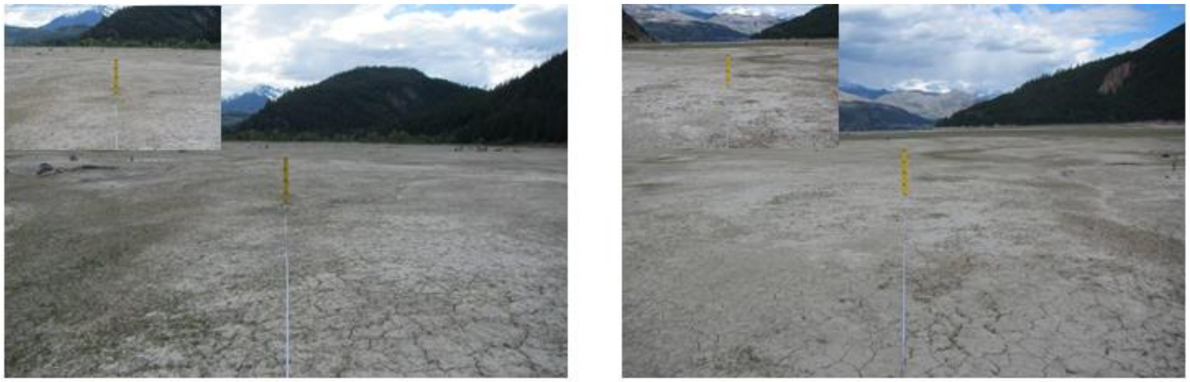
PCoA diagram showing the similarity among transects in the Carpenter Reservoir in 2013. Axis 1 explains 47% of the variation in similarities, and axis 2, 20%. Numbers refer to groups of transects as formed by the clustering analysis based on environmental variables (Gower coefficient

and WPGMA). Symbols are: °: Group 1, Δ: Group 2, +: Group 3, χ: Group 4, ◊: Group 5. Colors code for elevation: black: low, red: middle, green: upper, blue: lower buffer zone, pale blue: upper buffer zone.



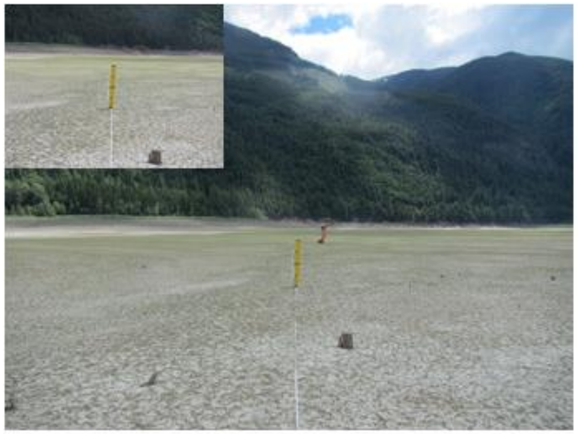
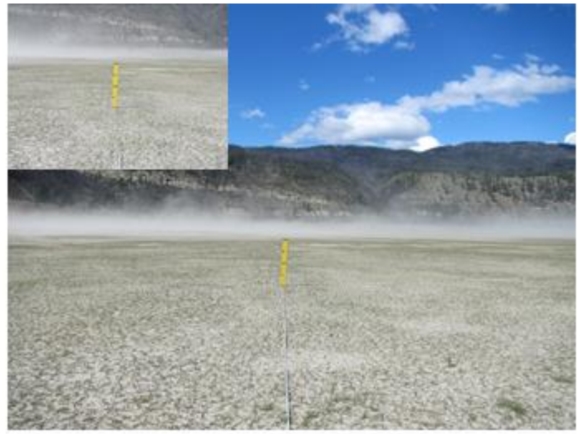
PCoA diagram showing the similarity among transects in the Carpenter Reservoir in 2013. Axis 1 explains 47% of the variation in similarities, and axis 2, 20%. Numbers refer to groups of transects as formed by the clustering analysis based on environmental variables (Gower coefficient and WPGMA). Symbols are: °: Group 1, Δ: Group 2, +: Group 3, χ: Group 4, ◊: Group 5. Colors code for the location in the reservoir, from north to south: black: north, red: south.

Appendix 4: Photopoint monitoring

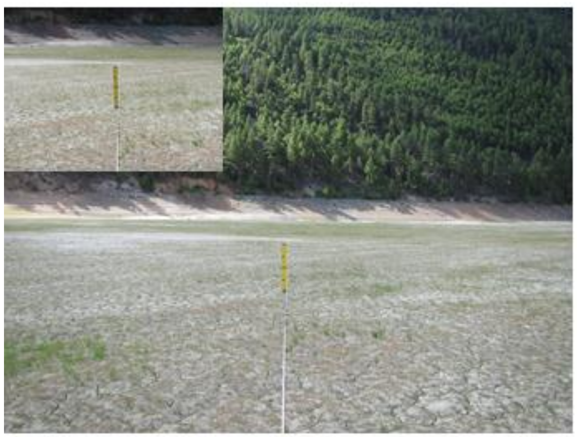
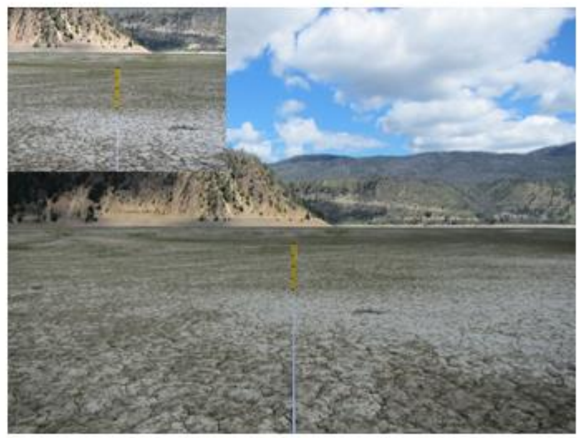


LMF01 A: bearing 260°. B: bearing 80°. Camera height 1.3 m.

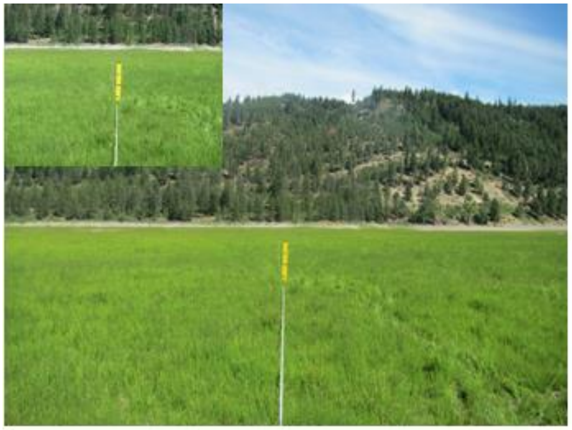
LMF02 A: bearing 68°. B: bearing 248°. Camera height 1.3.

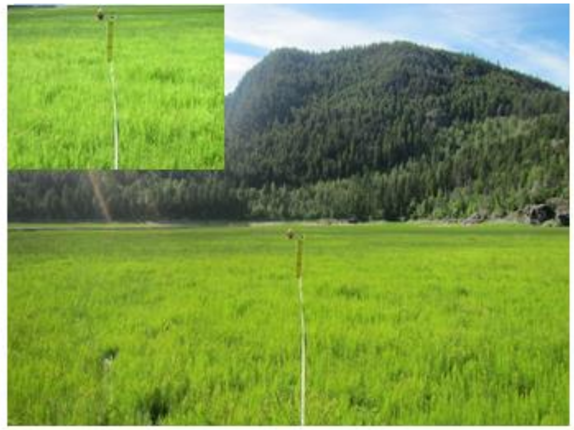



LMF04 A: bearing 187°. B: bearing 007°. Camera height 1.3 m.

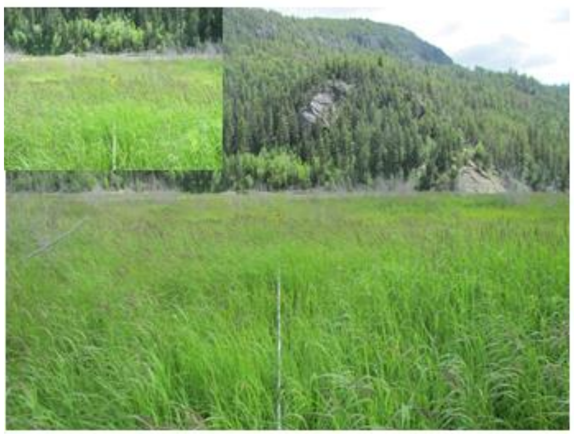



LMF05 A: bearing 358°. B: bearing 178°. Camera height 1.3 m.

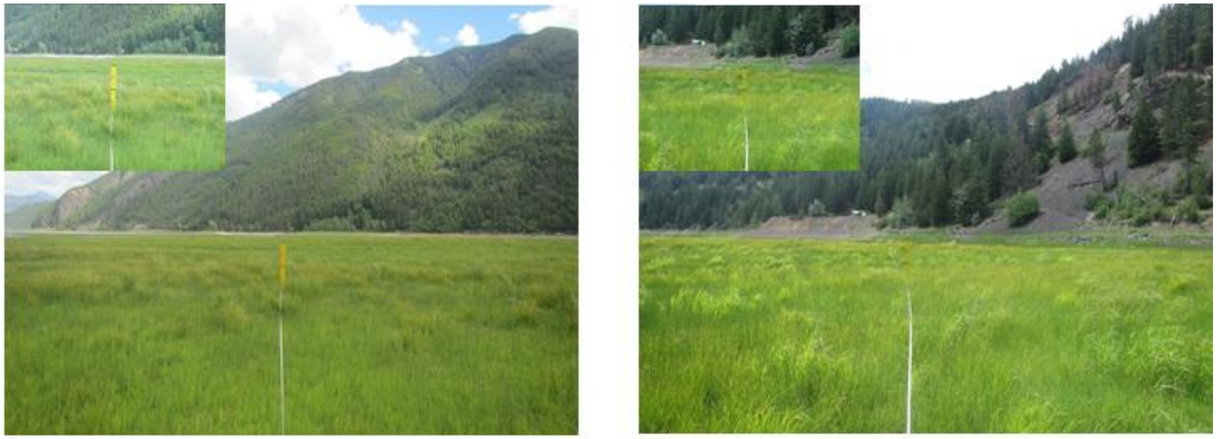





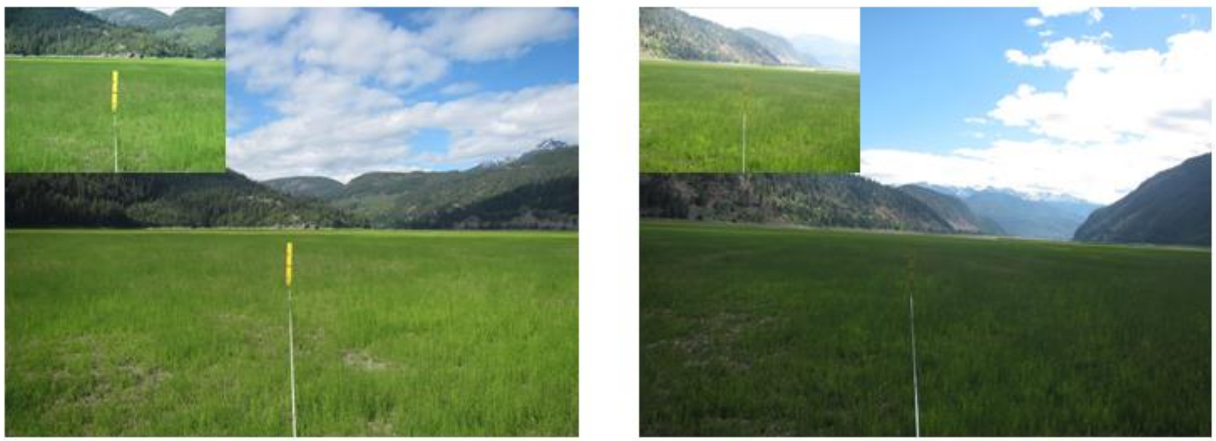
MMF01 A: bearing 345°. B: bearing 165°. Camera height 1.3m.



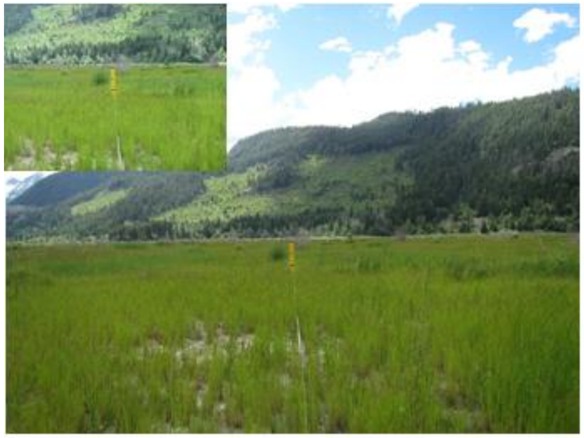
MMF02 A: bearing 140°. B: bearing 320°. Camera height 1.3 m.



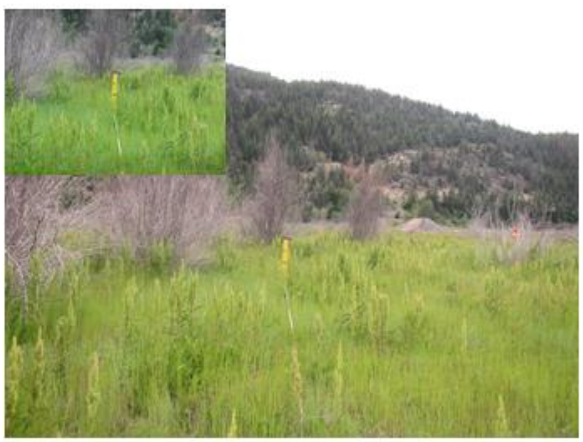
MMF04 A: bearing 114°. B: bearing 294°. Camera height 1.3 m.



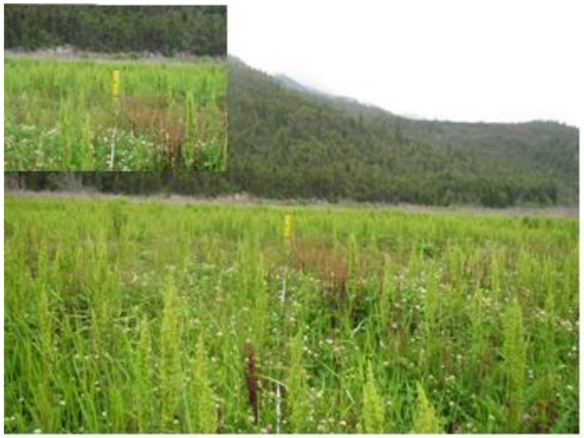
MMF05 A: bearing 234°. B: bearing 56. Camera height 1.3 m.



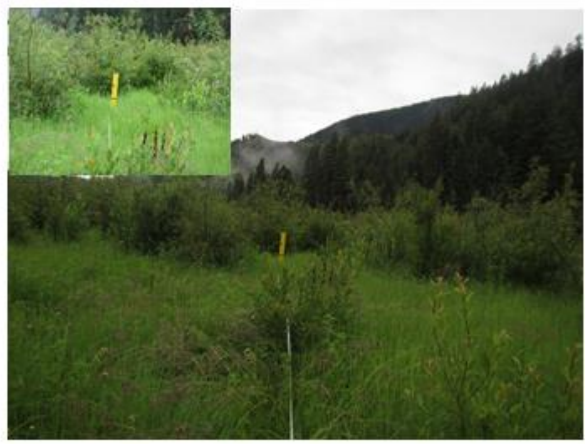
UMF01 A: bearing 254°. B: bearing 75°. Camera height 1.3 m.



UMF02 A: bearing 328°. B: bearing 148°. Camera height 1.3 m.



UMF04 A: bearing 136°. B: bearing 316°. Camera height 1.3 m.



UMF05 A: bearing 164°. B: bearing 344°. Camera height 1.3 m.

BMF01 A: bearing 80°. B: bearing 260°. Camera height 1.0 m (large photos), 1.3 m (inset photos).

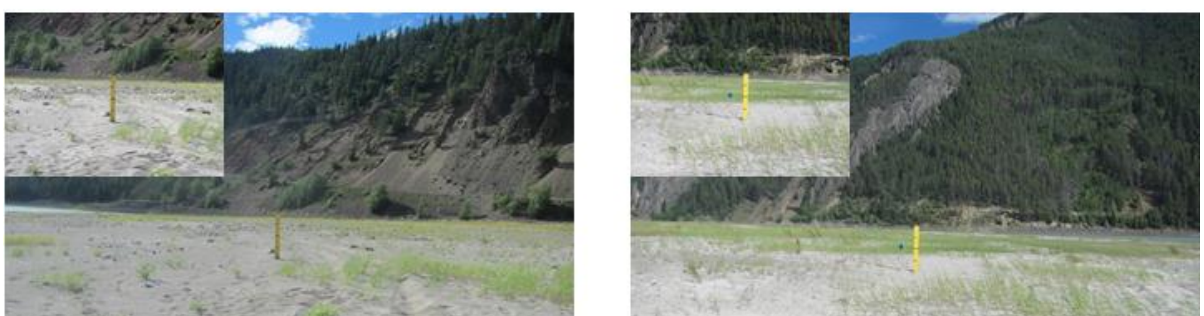
BMF02 A: bearing 94°. B: bearing 274°. Camera height 1.0 m (large photos), 1.3 m (inset photos).

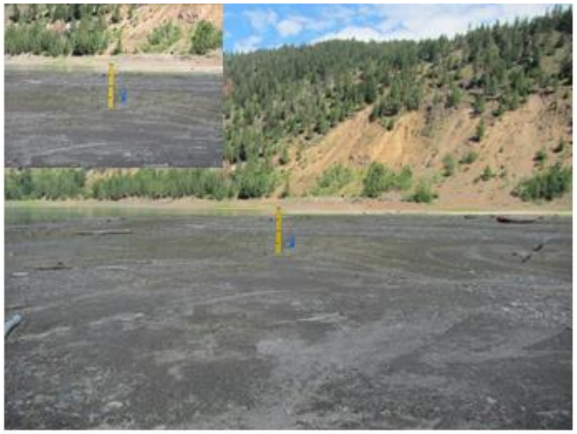
BMF04 A: bearing 184°. B: bearing 4°. Camera height 1.0 m (large photos), 1.3 m (inset photos).

BMF05 A: bearing 330°. B: bearing 150°. Camera height 1.0 m (large photos), 1.6 m (inset photos).

GCF01-UB A: bearing 306°. B: bearing 126°. Camera height 1.0 m.

GCF01-LB A: bearing 306°. B: bearing 126°. Camera height 1.0 m.



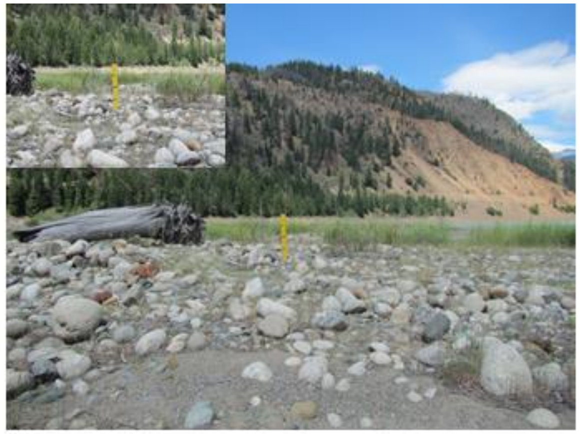


GCF01-MD A: bearing 306°. B: bearing 126°. Camera height 1.0 m.

GCF02-UB A: bearing 212°. B: bearing 32°. Camera height 1.0 m.

GCF02-UD A: bearing 212°. B: bearing 32°. Camera height 1.0 m.

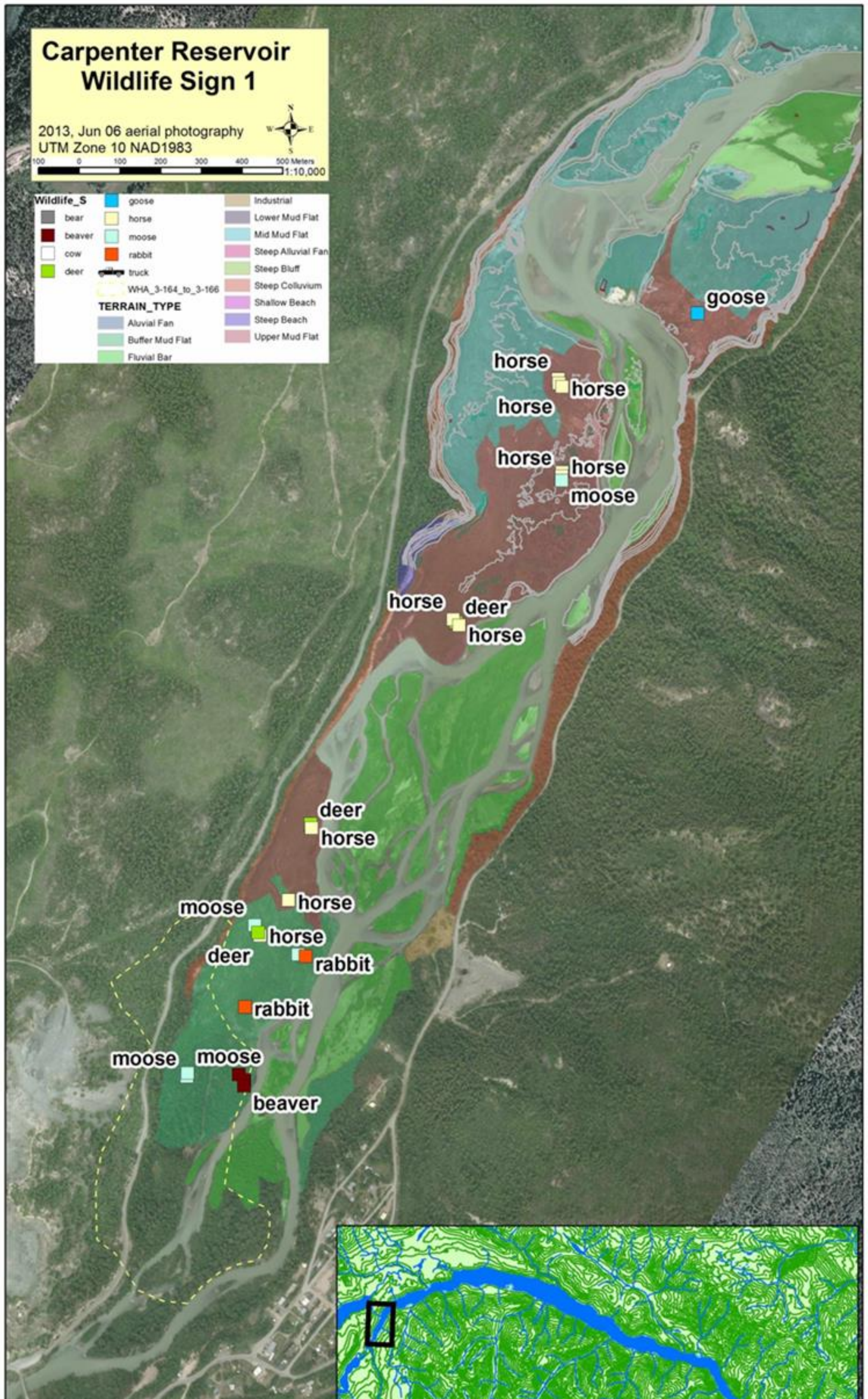
GCF02-MD A: bearing 212°. B: bearing 32°. Camera height 1.0 m.

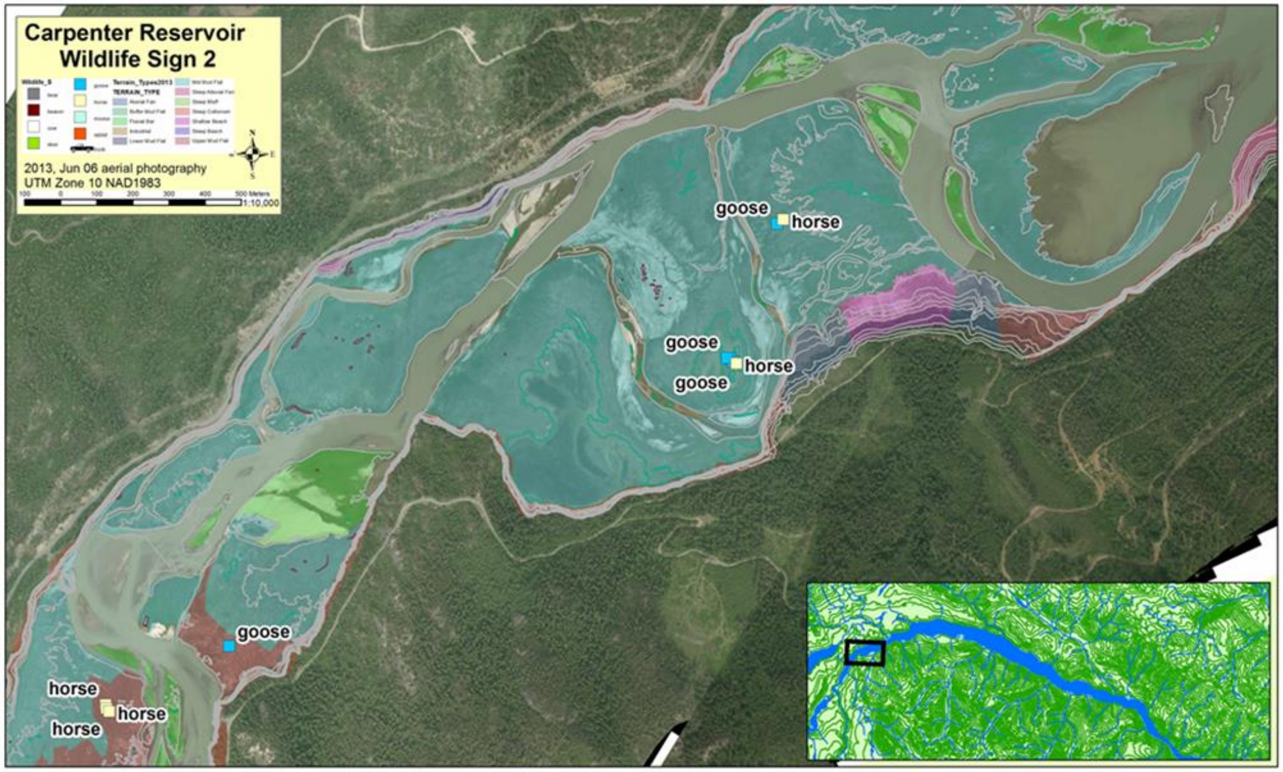



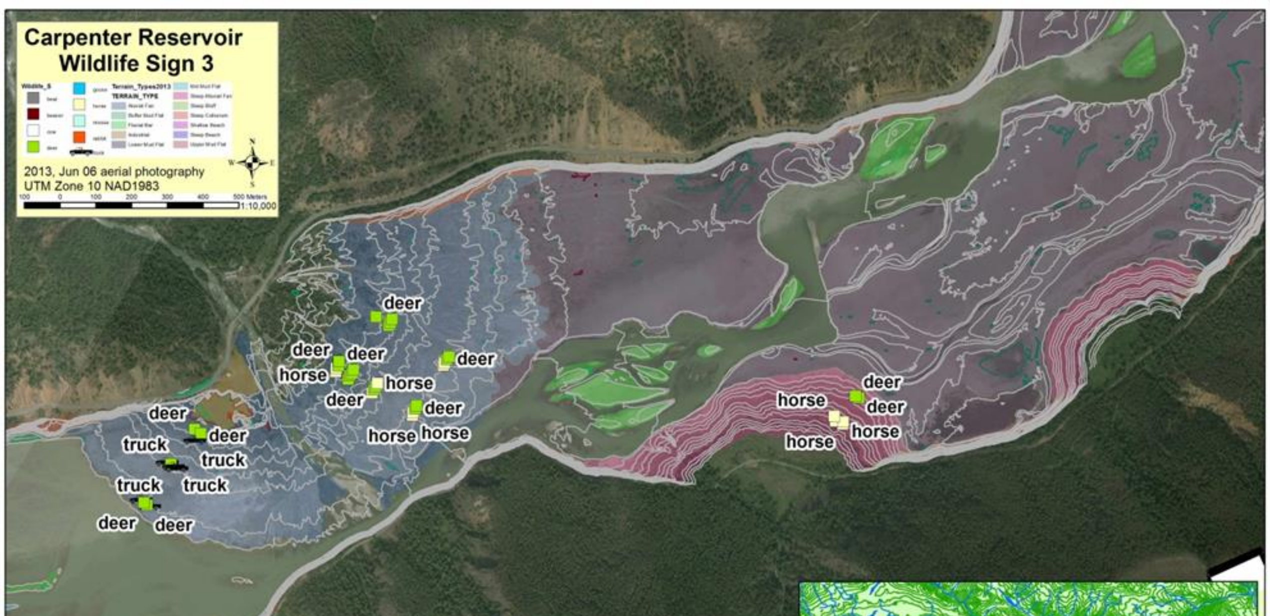
GCF03-LB A: bearing 216°. B: bearing 36°. Camera height 1.0 m.

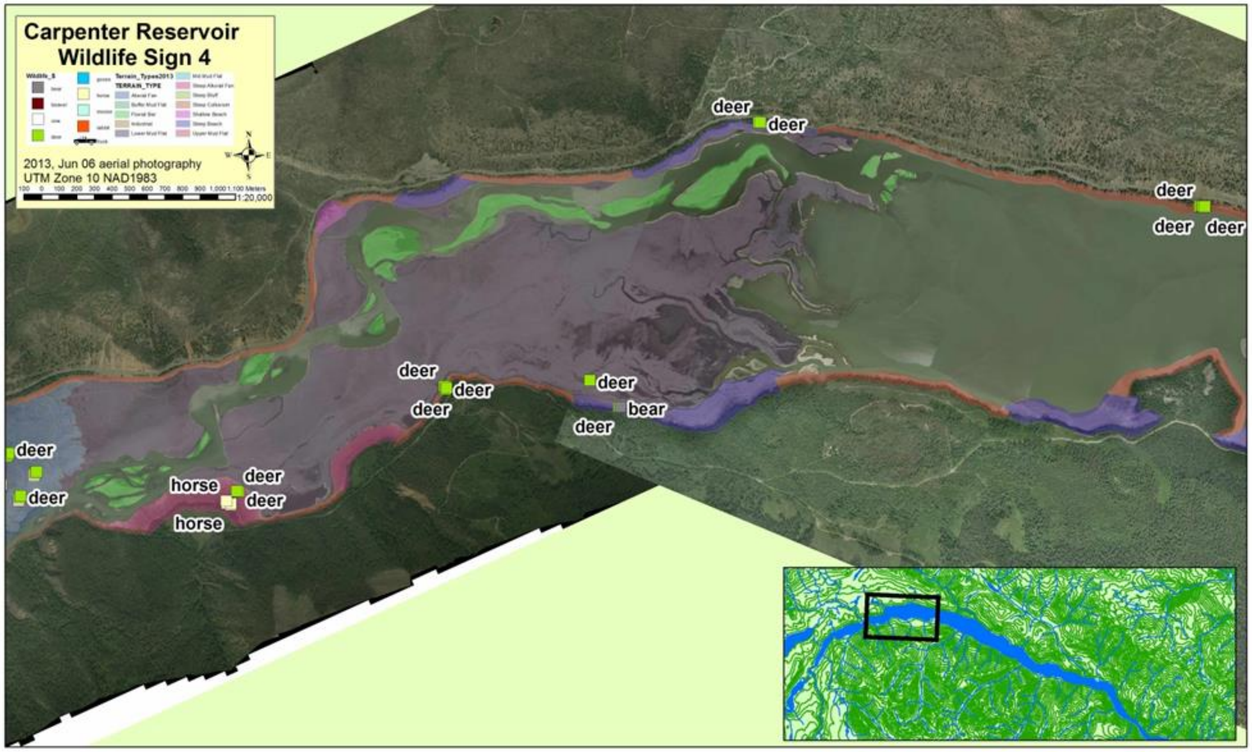

GCF03-UD A: bearing 216°. B: bearing 36°. Camera height 1.0 m.


Appendix 5: Wildlife sign observations

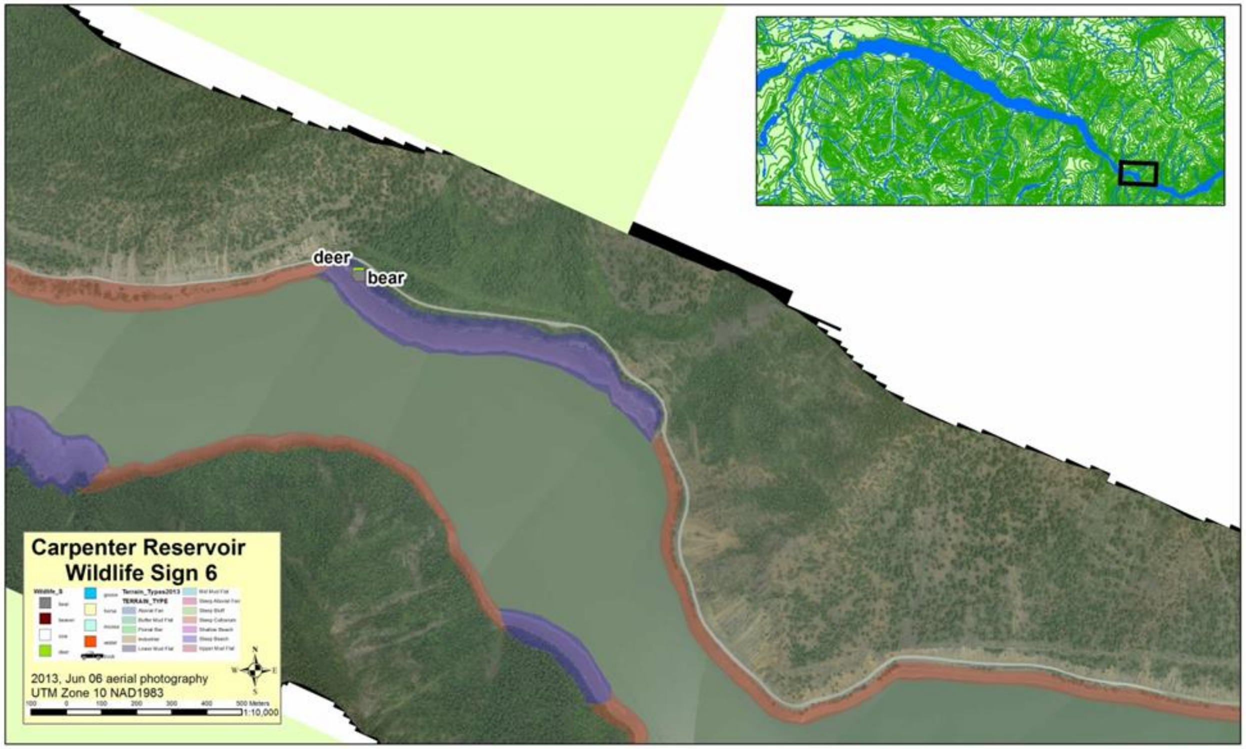

Carpenter Reservoir
Wildlife Sign 1
2013, Jun 06 aerial photography
UTM Zone 10 NAD1983
N
W
E
S
100
0
100
200
300
400
500 Meters
1:10,000
Wildlife_S
bear
beaver
cow
deer
goose
horse
moose
rabbit
truck
WHA_3-164_to_3-166
TERRAIN_TYPE
Aluvial Fan
Buffer Mud Flat
Fluvial Bar
Industrial
Lower Mud Flat
Mid Mud Flat
Steep Alluvial Fan
Steep Bluff
Steep Colluvium
Shallow Beach
Steep Beach
Upper Mud Flat
goose
horse
horse
horse
horse
horse
moose
horse
deer
horse
deer
horse
moose
horse
horse
deer
rabbit
rabbit
moose
moose
beaver


Carpenter Reservoir
Wildlife Sign 2
2013, Jun 06 aerial photography
UTM Zone 10 NAD1983
1:10,000
goose
horse
goose
horse
goose
goose
horse
horse
horse


Carpenter Reservoir
Wildlife Sign 3
2013, Jun 06 aerial photography
UTM Zone 10 NAD1983
1:10,000
deer
deer
deer
deer
horse
horse
deer
deer
deer
horse
horse
deer
truck
deer
truck
truck
truck
deer
deer
horse
deer
deer
horse
horse


Carpenter Reservoir
Wildlife Sign 4
2013, Jun 06 aerial photography
UTM Zone 10 NAD1983
1:20,000
deer
deer
deer
deer
deer
deer
deer
deer
deer
deer
bear
deer
deer
deer
horse
deer
deer
horse


deer
deer
Jone's Creek
bear
deer
deer
Bighorn Creek
Carpenter Reservoir
Wildlife Sign 5


deer
bear
Carpenter Reservoir
Wildlife Sign 6
2013, Jun 06 aerial photography
UTM Zone 10 NAD1983
1:10,000