Bridge River Project Water Use Plan

BRGMON-2 Carpenter Reservoir Riparian Vegetation Monitoring

Implementation Year 5

Reference: BRGMON-2

Study Period: 2017

Produced by;

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Executive Summary

The 2017 BRGMON-2 monitoring program looked at four years of riparian enhancement treatments on Carpenter Reservoir, north-west of Lillooet, British Columbia. Treatments dated back to 2014 and techniques varied in type and location from planting, seeding and live-stake cuttings trials, to machine contouring trials in 2017. Monitoring in 2017 was targeted to a select number of treatments at five different terrains on the western end of Carpenter Reservoir.

Results were mixed with many treatments failing or having meager results. Planting and seeding treatments in 2016 have met with the most success to date. Trial plantings of lakeshore sedge (*Carex lenticularis*) plugs in 2015 indicated successful establishment was possible on the LMF. In 2016 polygons were planted proximate to the 2015 treatments, 6 polygons located at 640m elevation between 30m and 120m distance of the Bridge River were planted. The polygons located close to the Rivers edge (approximately 0.1ha in area each) grew extremely well and produced 10 times as much biomass and cover as other areas within the treatment zone. An expansive area was also seeded with fall rye (*Cereale secale*) in 2016, and we observed a higher frequency and density of naturally recruiting lakeshore sedge seedlings colonizing the fall rye seeded area than neighboring controls, which suggests a beneficial effect of fall rye seeding on sedge seedling recruitment. Bluejoint reedgrass (*Calamagrostis canadensis*) plantings have also established well in patches on the Gun Creek Fan with early signs of vegetative expansion and reproduction. Live-stake cuttings trials have met with mixed results with tendency for initial successes to decline over time. Many of the live-stake cutting sites have maintained moderate to low survival.

New treatments were carried out in 2017 using machine contouring to create mounds and depressions on the otherwise level drawdown zone landscape. Baseline data were collected in 2017 to monitor effects on vegetation cover, vegetation recruitment, soil moisture levels and lasting effect of the mounding treatments. Although four years into the monitoring program, answers to the management questions will need several more years of observations to be addressed with confidence.

OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after 2015				
Study Objectives	**Management Questions**	**Year 2017 (MQ Status)**	**Management Hypotheses**	**Year 2017 (Hypothesis Status)**
1. To characterize and describe the riparian vegetation surrounding Carpenter Reservoir, assess changes over a 10-year period of time and infer relationships to water management.	To determine if implementation of the chosen operating alternative have had negative, neutral or positive impacts on the quality and quantity (species composition, biological productivity, spatial area) of the riparian area surrounding Carpenter Reservoir.	NOT YET ADDRESSED Baseline data collected in 2013. Monitoring to be repeated in year 10.	H_1: Implementation of the chosen alternative will not result in a reduction of riparian habitats in the area surrounding Carpenter Reservoir. $H1_A$: There is no significant change in the spatial extent of the vegetated area in the drawdown zone of Carpenter Reservoir. $H1_B$: There is no significant change in the species composition of the plant community in the vegetated area of the drawdown zone of Carpenter Reservoir. $H1_C$: There is no significant change in the relative productivity of the plant community in the vegetated area of the drawdown zone of Carpenter Reservoir.	NOT YET ADDRESSED

2. To assess impacts to the buffer zone vegetation in the event of a year of prolonged flooding >56 days.	To determine if implementation of the chosen operating alternative have had negative, neutral or positive impacts on the quality and quantity (species composition, biological productivity, spatial area) of the riparian area surrounding Carpenter Reservoir.	NOT CURRENTLY APPLICABLE	H_2 Incursions of less than 56 days into the reservoir buffer do not significantly impact riparian community.	NOT CURRENTLY APPLICABLE Baseline vegetation data was collected from permanent plots established in 2013. No significant incursions into the buffer zone for over 56 days have occurred to date. Slight incursions in 2015 prompt a closer look into origin of Hypothesis.

3. To conduct evaluations of the BRGWORKS-1 program to assess the degree to which the planting program helps to establish natural re-colonization of the area from Tyaughton Lake Road Junction to Gun Creek Fan.	Does the implementation of a short term (5yr) 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?	H_3. Implementation of extensive riparian planting for 5 years will provide the bases 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.	Monitoring of Year One BRGWORKS-1 re-vegetation trials was carried out in late summer 2014 and in June of 2015. Findings of initial year show relatively low rates of success in most trials, possibly related to the combined late project start in 2014, summer drought, and relatively low full pool of Carpenter in 2014 (643.95 mASL). Control locations will be established in Year Two of re-vegetation treatment.	H_3: BRGWORKS-1 treatments have been diverse. Monitoring observations to date indicate that the fall rye seeding treatment has increased colonization by lakeshore sedge. It is unknown whether the observed sedge seedlings will survive to establish and grow into mature plants. Lakeshore sedge plantings have produced mature plants at a number of polygons. These plants have been observed seeding, it is possible these stands may increase in density and spread. Bluejoint reedgrass is establishing well and has been observed spreading via rhizomes and increasing native plant cover in some polygons. H_{3A}: The introduction of native plants to treatment polygons directly affects species diversity. There seems to be little effect on other recruitment to date. If planted plants seed then this treatment can be considered to positively affect distribution, abundance as well as diversity of treatment polygons. Biomass measurements were limited but based on the results of the 2016 planting of lakeshore sedge plugs there is at least at some locations, the potential for increasing biomass 10-fold. Success at this level has been mixed and additional treatments will be required at some locations. H_{3B}: For many treatment sites, vegetation resulting from planting and seeding is not producing a significant amount of native vegetation cover. However, results vary from treatment to treatment and site to site. In the Low Mud Flat we see a dramatic increase in native species cover with dense planting treatments. Likewise, certain areas planted with bluejoint reedgrass show a dramatic

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1.0 Introduction

The BRGMON-2 program comes out of the Bridge-Seton Consultative Committee Report from 2003 (B.C. Hydro and Compass Resource Management, 2003). The general aim is to monitor riparian vegetation surrounding Carpenter Reservoir. BRGMON-2 has two specific monitoring components focused on studying the riparian vegetation in the drawdown zone of Carpenter Reservoir:

- Component 1: Monitoring the existing riparian vegetation in the Carpenter Reservoir drawdown zone, to be carried out in Year 1 (2013) and Year 10 (2022).
- Component 2: Monitoring the 7-year riparian enhancement project in the drawdown zone of the Carpenter Reservoir (BRGWORKS-1): Years 3 – 9 of BRGMON-2 (2015 to 2020).

The re-vegetation program under BRGWORKS-1 started in June 2014 and continued in 2015 and 2016. The Terms of Reference were revised in January 2017 to match a revision of the TOR of the BRGWORKS-1 program (BC Hydro, 2017). The BRGWORKS-1 program was modified to increase from a five to a seven-year project and include a lag year with no treatments (2018). As a result, the schedule for BRGMON-2 Component 2 was also adjusted to include two additional years of monitoring, for a total of seven years. The TOR added a mid-term comprehensive report to be compiled in 2018.

H1: Implementation of operations will not result in a reduction of riparian habitat in the surrounding Carpenter Reservoir.

H1 is directed at component 1 of the program and is not addressed in this report.

H2: Incursions of less than 56 days into the reservoir buffer do not significantly impact riparian community.

H2: only applies if the criterium of incursions over 56 days is met. The criterium was not met in 2016 and therefore Hypothesis 2 is not addressed in this report.

The management question being addressed under component 2 of BRGMON-2 is: does the implementation of a short-term (seven year) intensive riparian enhancement program expands the quality (as measured by diversity, distribution and vigour) and quantity (as measured by cover, abundance and biomass) of riparian habitats in the drawdown zone of Carpenter Reservoir?

H3: Implementation of a riparian enhancement program between the Gun Creek Fan and the Tyaughton Lake Road Junction within the drawdown zone will support the basis for continued natural re-colonization of native vegetation communities and species.

H3A: There is no significant difference in native vegetation establishment (based on species distribution, diversity, vigour, biomass and abundance) at control versus treatment locations.

H3B: There is no significant difference in the cover of native vegetation in control versus treatment locations.

H3C: There is no significant difference in native vegetation establishment and the cover of native vegetation communities (based on species distribution, diversity, vigour, biomass and abundance) arising from different revegetation prescriptions.

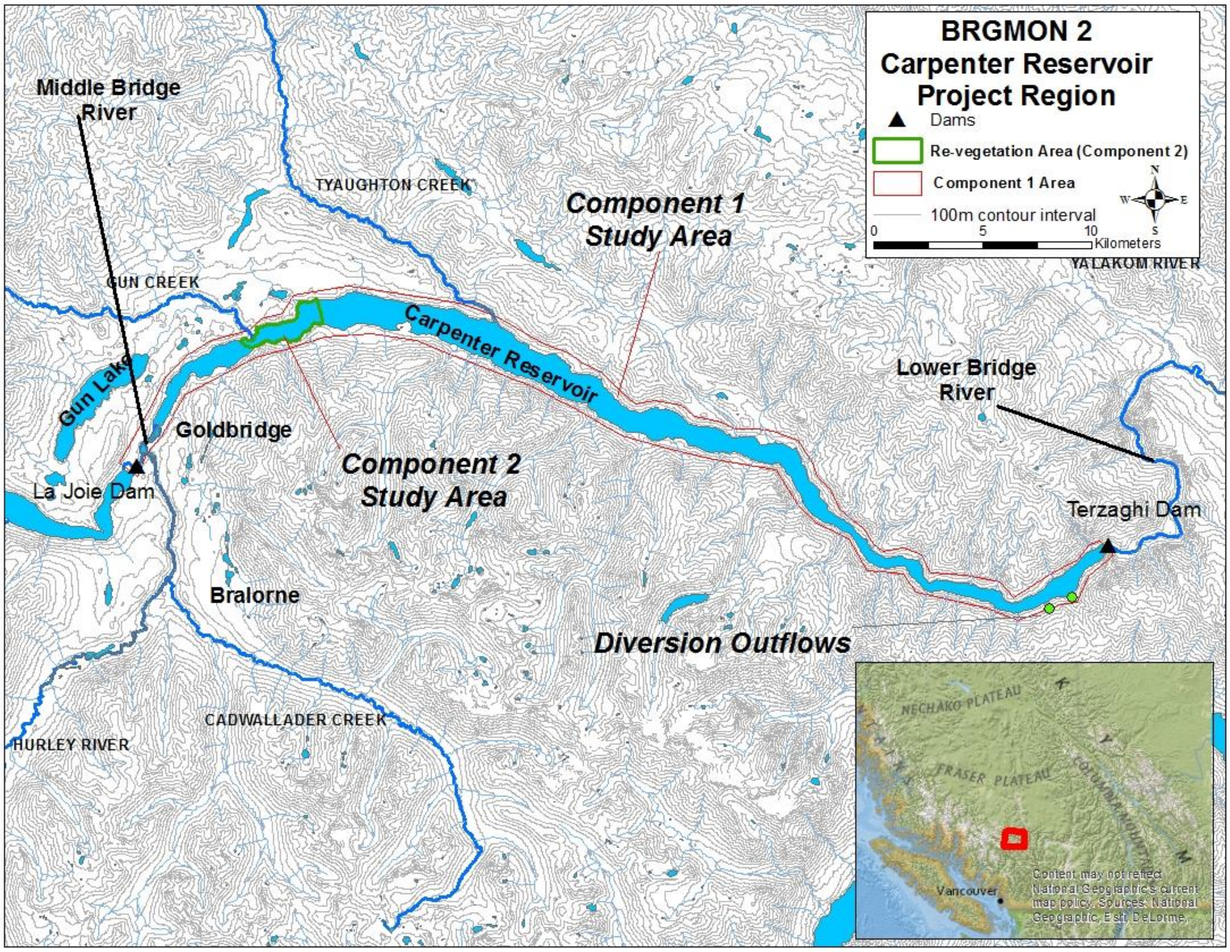
H3D: There is no significant difference in the species composition of naturally re-colonizing vegetation in treated versus control areas.

This report summarizes the methods and treatments for BRGWORKS-1 in 2016 and 2017, presents the annual inundation patterns in Carpenter Reservoir for 2016, summarizes the annual weather patterns during the growing season, highlights successful survival and establishment of native species including ongoing colonization. We also discuss where we observe failures of treatments including a lack of survival and establishment of native species propagules and no increased colonization and establishment of native vegetation as a result of treatments. The report makes recommendations for future treatments aimed at enhancing the riparian vegetation through an adaptive management approach. In addition, we report a monitoring baseline collected in advance of the 2017 BRGWORKS-1 treatments including before and after treatment data for physical treatments and control areas.

2.0 Background

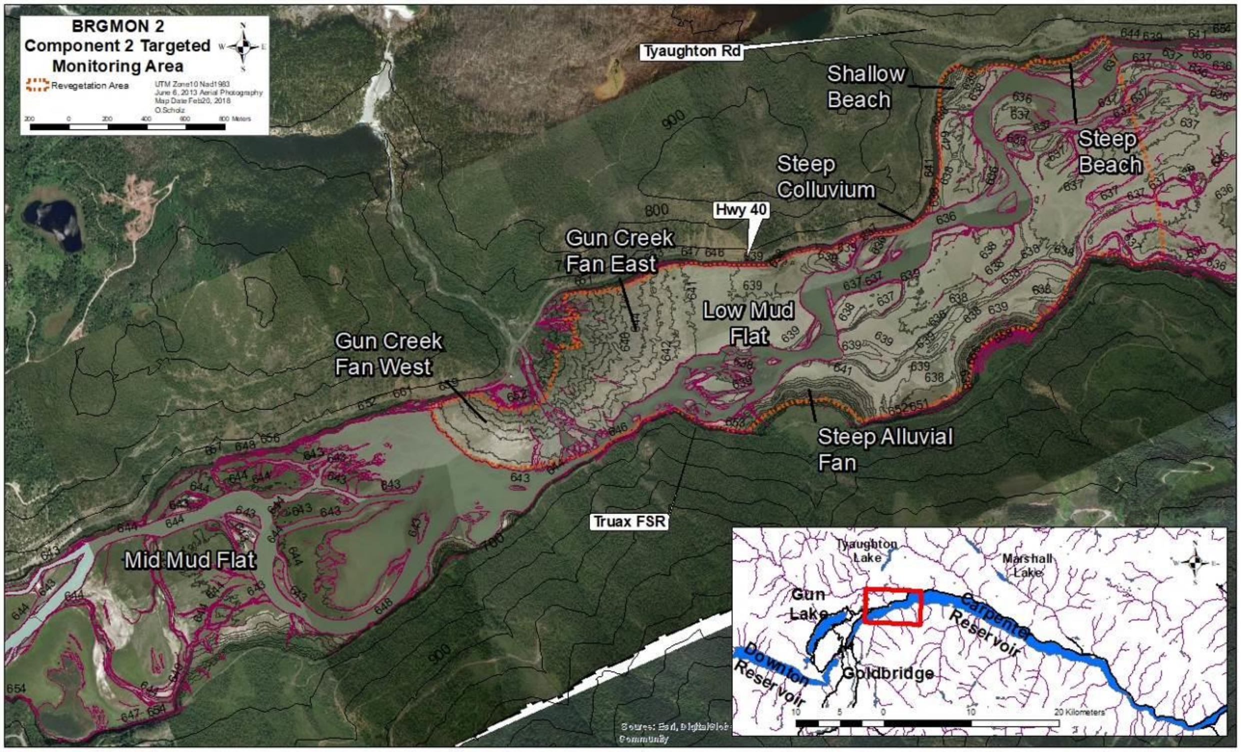
The initial element (Component 1) of BRGMON-2 started in 2013. The drawdown zone in Carpenter Reservoir was stratified into terrain types and randomly sampled with permanent transects designed to characterize the range of riparian vegetation found around Carpenter Reservoir (Map 1). The terrain types were largely based on site-specific geomorphic conditions and elevation (Scholz and Gibeau, 2014).

Normal operations of Carpenter Reservoir keep the water pool level in the drawdown zone above a low of 606.55 mASL and a targeted maximum of 648.00 mASL (the absolute capacity of the reservoir is achieved at 651.08 mASL). The 3m zone between 648.00 mASL and 651.08mASL is considered a buffer zone which is inundated only when necessary. In an average year, elevations below 642 mASL are exposed to the air for less than 50% of the growing season (Scholz and Gibeau, 2014). Based on analysis of historic drafting and inundation timing, it is highly unlikely that perennial native vegetation could survive below 640 mASL. Restoration treatments under BRGWORKS-1 have been completed over a 10m vertical range, between 640 mASL and 650 mASL.



Map 1. Targeted study areas for Components 1 and 2 of BRGMON-2.

For Component 2 of BRGMON-2, at the landscape scale, five terrain types were targeted for re-vegetation trials under BRGWORKS-1 in 2014: Steep Beach (STB), Shallow Beach (SHB), Gun Creek Fan East (GCFE), Gun Creek Fan West (GCFW) and Steep Alluvial Fan (SAF) (Map 2). In 2015, treatments were expanded to include a sixth terrain type called the Low Mud Flat (LMF), located at lower elevations (639m-642m). Re-vegetation trials focused on seeding, planting rooted-container plants, and planting live-stake cuttings in 2014 and 2015. Details on 2014 and 2015 treatments are reported in BRGWORKS-11 annual reports (Scholz, 2014 and Scholz 2015).



Map 2. Targeted monitoring area and associated terrain types for Component 2 of BRGMON-2.

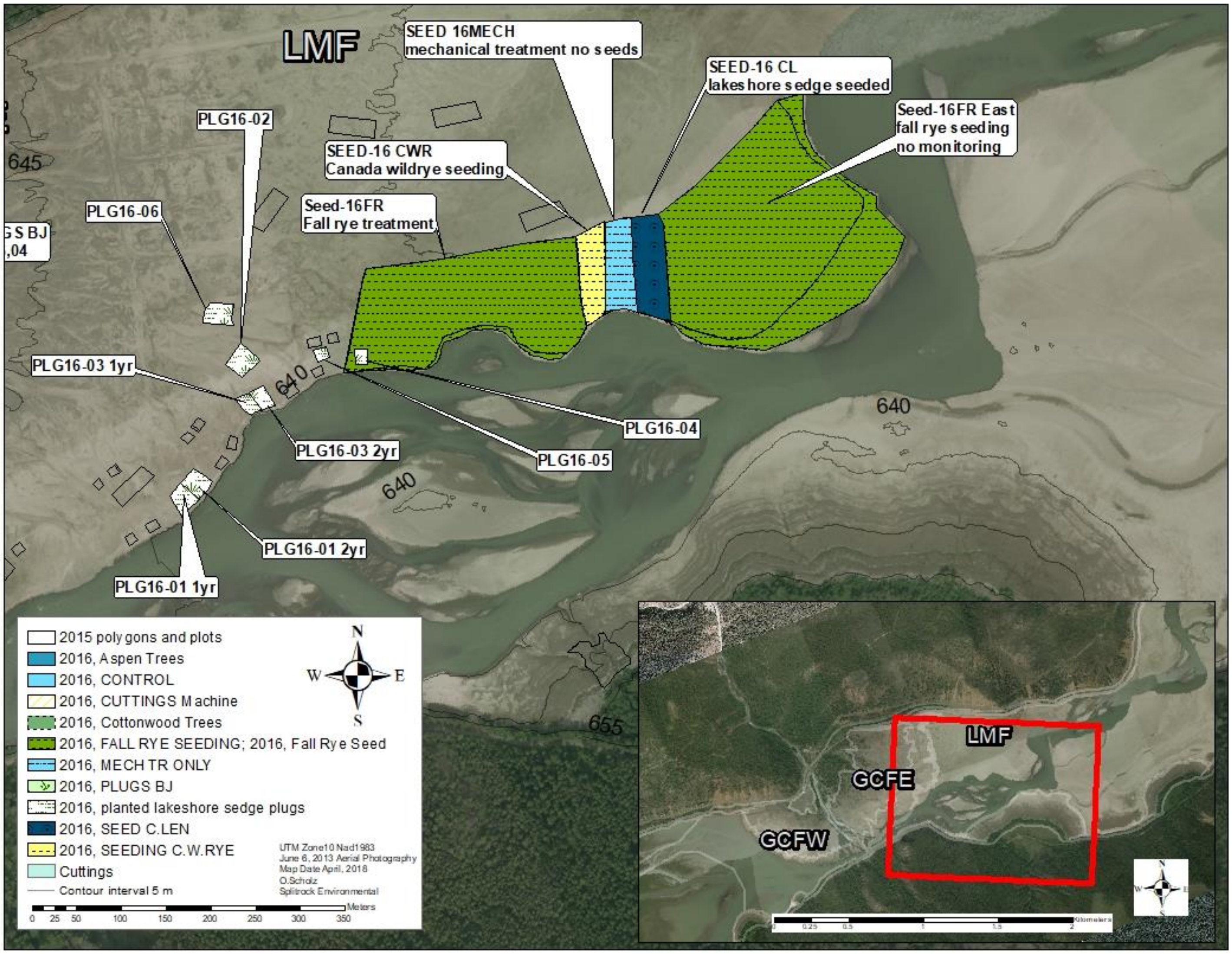
In 2016 BRGWORKS-1-1 treatments were an expansion of treatment trials conducted in 2014 and 2015. Treatments in 2016 were diverse and included planting, seeding and live-stake cuttings carried out on four terrain types (LMF, GCFE, GCFW and SHB terrains) (Table 1, Map 2).

Table 1. Summary of treatments performed in 2016 for BRGWORKS-1 (from 2016 annual report Scholz, 2018)

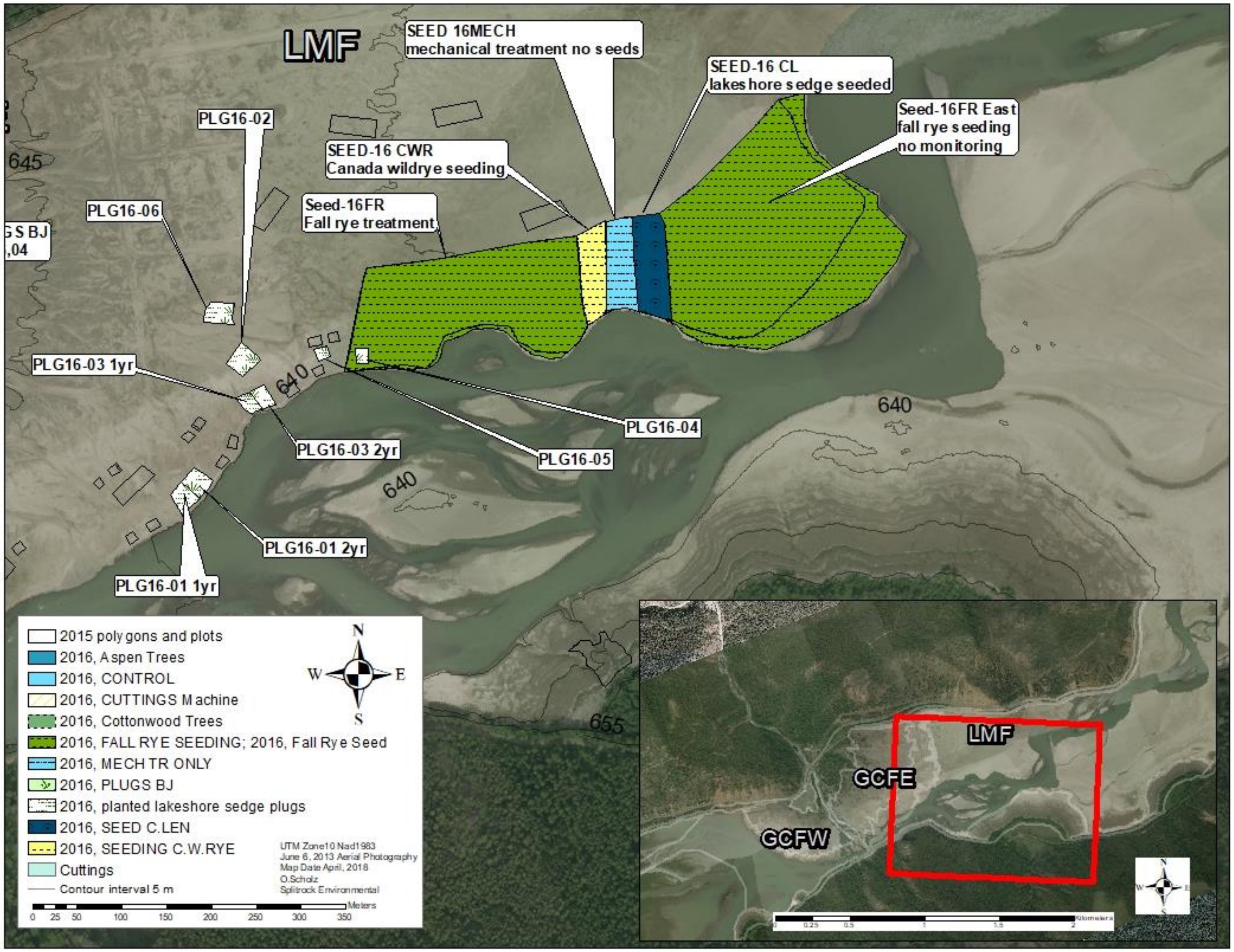
		CONTAINER PLANTS						**CUTTINGS**		**SEEDING**			
CODE	**TERRAIN TYPE**	**Sedge Plugs**	**BJ Plugs**	**Foxtail Plugs**	**CWR**	**Cotton wood trees**	**Trembling aspen**	**No. Cuttings Willow**	**No. Cuttings Cottonwood**	**Seed Fall Rye (m^2)**	**Seed C. lenticularis (m^2)**	**Mech. treatment (m^2)**	**seed C. Wildrye (m^2)**
STB	Steep Beach	***No Treatment***											
SHB	Shallow Beach							132	73				
LMF	Low Mud Flat	10312								9.6ha (480kg)	0.4ha (0.95kg)	0.32ha	0.3ha (1.4kg)
GCFE	Gun Creek Alluvial Fan East		2360	2960	30	75							
GCFW	Gun Creek Alluvial Fan West		9225			25	25	360	629				
SAF	Steep Alluvial Fan	***No Treatment***											
SC	Steep Colluvium	***No Treatment***											
	TOTAL	10312	11585	2960	30	100	25	492	702				

2.1 Seeding trials

In 2016, the seeding trials for BRGWORKS-1 were completed across a 10-ha area on the Low Mud Flat terrain (



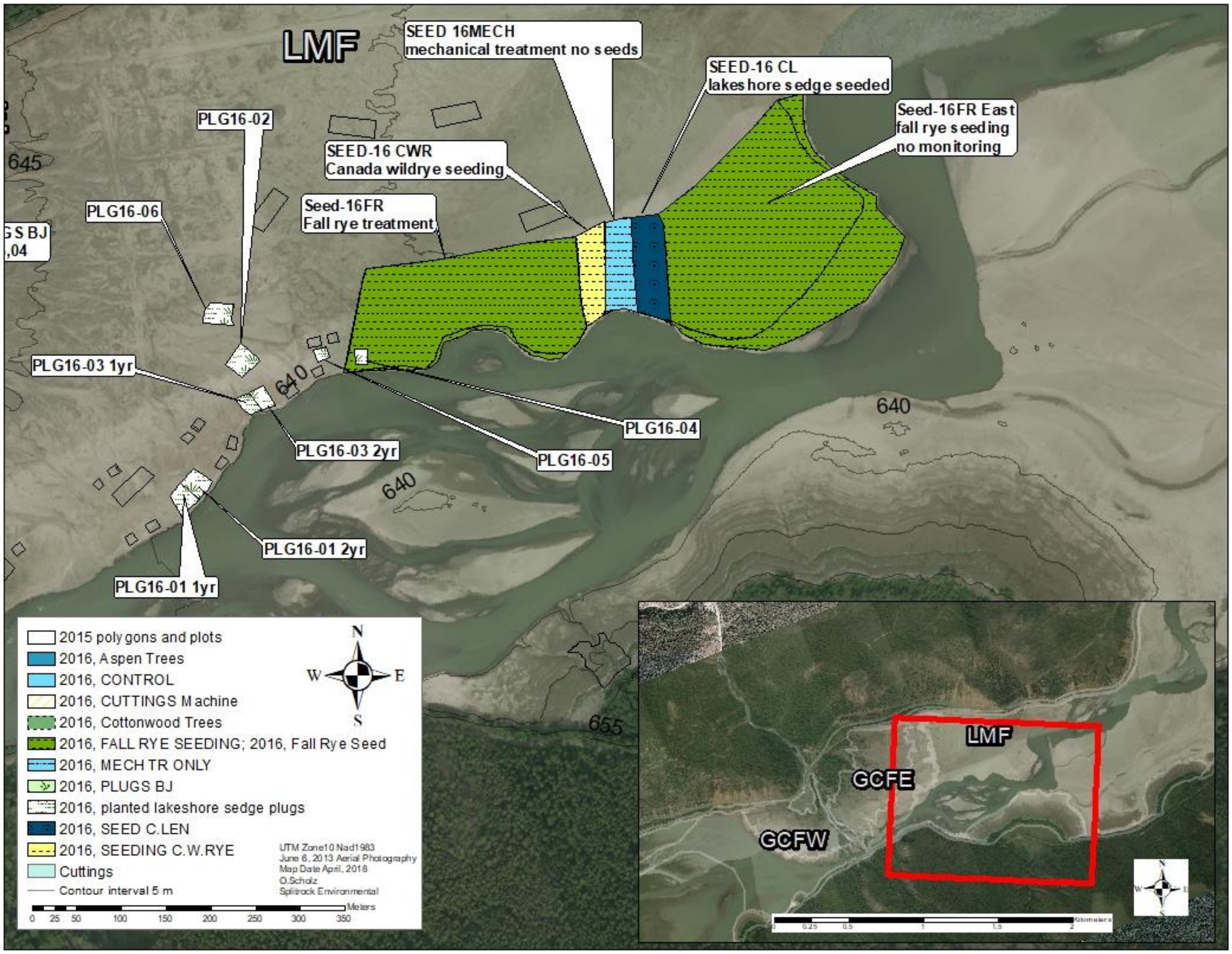
Map 3). The bulk of the seeded area was treated by seeding fall rye (*Secale cereale*). Three polygon areas were created as control sites, with one receiving mechanical treatment only, one seeded with lakeshore sedge (*Carex lenticularis*), and one seeded with Canada wildrye (*Elymus canadensis).* All seeding was done using at tractor and seeder except for a thin band along the river bank that was broadcast seeded with a walk-behind seeder.



Map 3. Map of the treatment polygons on the Low Mud Flat terrain (BRGWORKS-1).

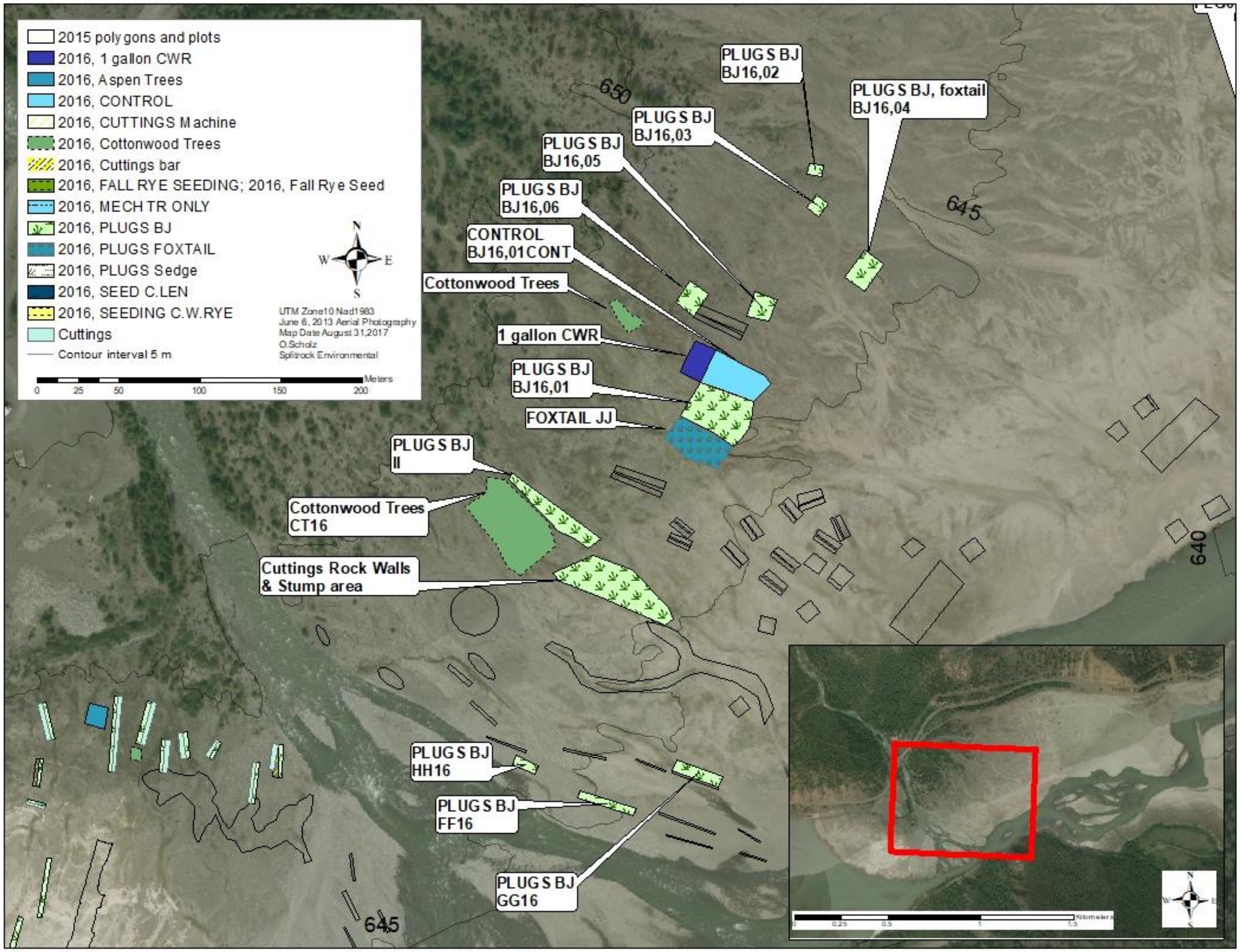
2.2 Planting container stock

In 2016, rooted plugs of container-grown stock from locally harvested seed were planted across polygon areas on the LMF, GCFE, and GCFW terrains. On the Low mud flat terrain, six polygons were established and planted with Lakeshore sedge plugs (

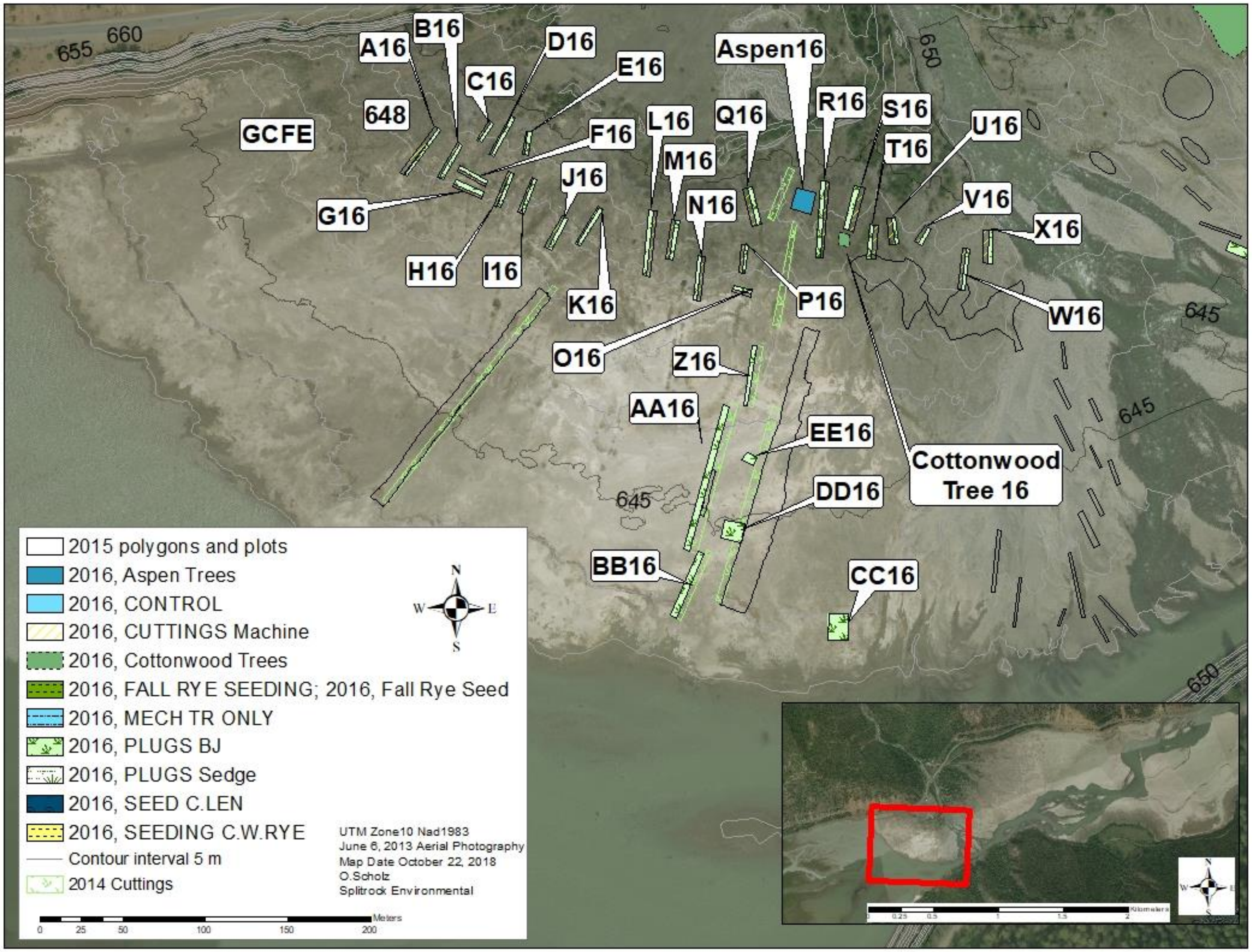


Map 3). On the Gun Creek Fan East, 14 individual polygon areas were planted with native grasses and two polygons were planted with container rooted cottonwood trees (Map 4.).

On the Gun Creek Fan West, 30 polygons were planted with native grass or sedge species, one polygon was planted with trembling aspen (*Populus tremuloides*), and one with black cottonwood tree seedlings (Map 5).



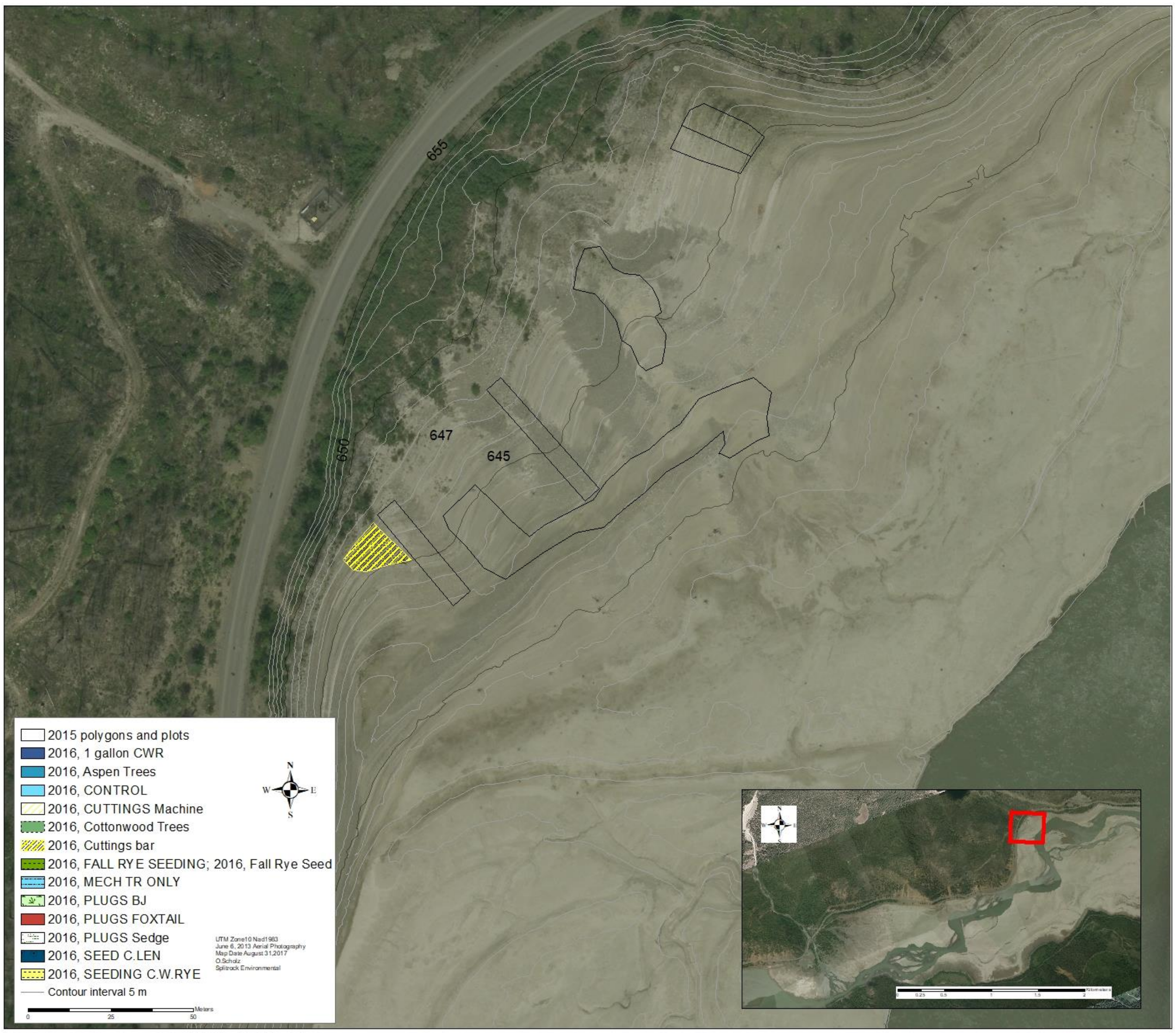
Map 4. Map of the Gun Creek Fan East (GCFE) showing polygons treated with rooted container stock.



Map 5. Map of treatments performed on the Gun Creek Fan West (GCFW) in 2016.

2.3 Planting of live-stake cuttings

Locally harvested live-stake cuttings of black cottonwood (*Populus balsamifera ssp. trichocarpa*) and willow species (*Salix sp*.) were planted in 2016 on the Gun Creek Fan West side (Map 5**Error! Reference source not found.**). Two techniques were employed in planting the cuttings: hand-planting using steel planting bars and planting in trenches dug by an excavator. Twenty-four trenches were planted above an elevation of 646 mASL on the Gun Creek Fan West. A polygon of mixed cottonwood and willow cuttings was also planted on the west end of the Shallow Beach (SHB) terrain (Map 6).



Map 6. Map of the polygons hand-planted with live-stake cuttings in 2016 on the Shallow Beach terrain (SHB).

2.4 Riparian enhancement treatments (2017)

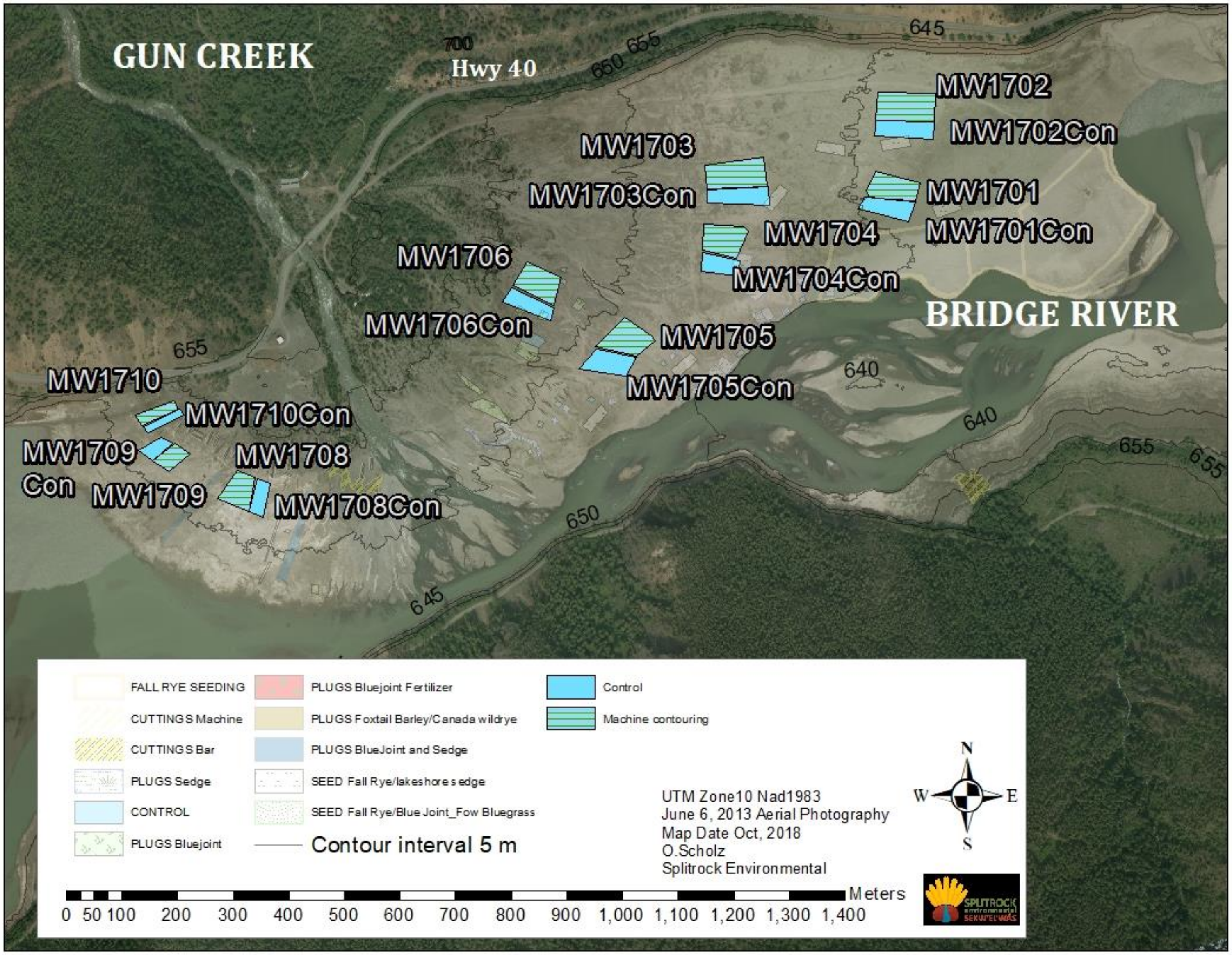
The treatments in 2017 focused on the use of an excavator to treat polygon areas similarly to what has been called "rough and loose treatment" applied in terrestrial restoration (Polster, 2009). Nine polygon areas were treated that way in 2017: two on the LMF terrain, four on the GCFE terrain, and three on the GCFW terrain (Map 7). Treated polygons were about a half hectare in size.

3.0 Methods

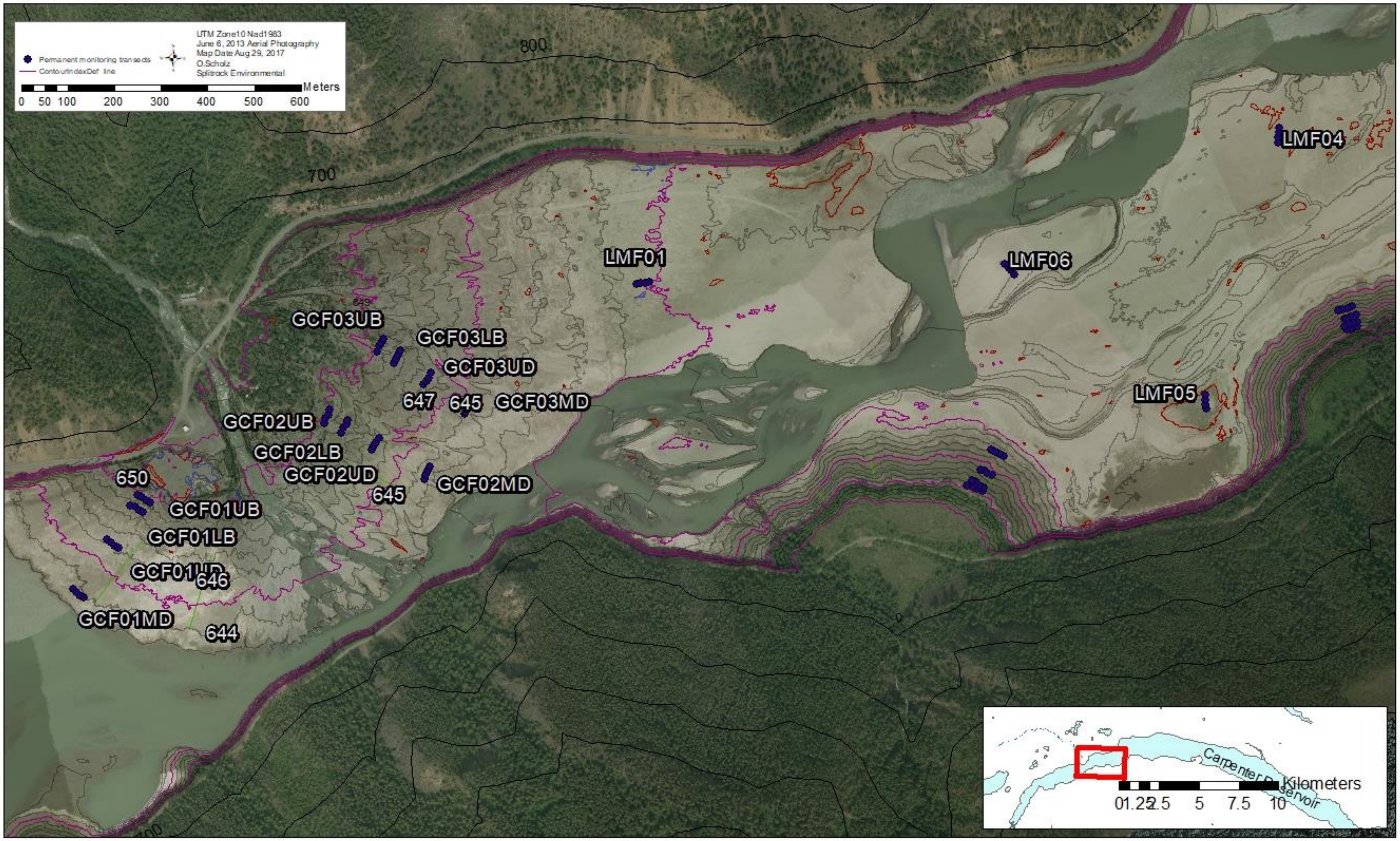
Annual monitoring for BRGMON-2 includes using data from BC Hydro Power records to analyse the water levels in Carpenter Reservoir and determine how water levels impact the growing season for vegetation in treatment areas. Data from the 5-mile ridge weather station was used to determine precipitation and temperature through the growing season.

Monitoring in 2017 also included sampling select re-vegetation treatments established in 2014, 2015 and 2016 as well as collecting baseline data for the treatments under BRGWORKS-1 that were performed later in 2017. Due to the somewhat new approach of using machine treatments over broad areas, the monitoring in 2017 focused on including collection of baseline, and establishing and monitoring control areas that were set aside adjacent to the nine treatment polygons.

Finally, the field program in 2017 also included the monitoring of 13 of the permanent monitoring transects established in 2013 for Component 1 of BRGMON-2 (Map 8). These data were collected in 2013, 2016 and 2017 to provide controls for natural background variation in spatial distribution, diversity, and cover of vegetation throughout the study area of Component 2 (riparian enhancement area).



Map 7. Locations of machine-worked rough and loose treatment sites and associated control areas in 2017.



Map 8. Locations of the permanent transects established in 2013 within the riparian enhancement treatment area (Component 1 of BRGMON-2).

3.1 Water levels and weather

The water levels in Carpenter Reservoir are monitored by BC Hydro Power Records who issue daily reports. Water level data were collated and presented in a graph showing the water levels for the study areas in 2017 as well as the levels from previous years. In addition, the average water level from 2000 to 2017 was graphed to place the current year in context of water level management patterns since the inception of the WUP.

Local weather patterns for 2016 are presented based on data provided by the Ministry of Forests Range and Natural Resource Operations at the Fire Zone weather station located on 5 Mile ridge. The 5 Mile ridge station is within 5 km of the monitoring sites for Component 2 of BRGMON-2. Precipitation and temperature were summarized for 2017, and accumulated growing degree days (AGDD) were computed based on the BC government range readiness approach (Fraser, 2006). Growing degree days were tabulated beginning after snow melt and no sooner than March 15th. There must be five consecutive days when the daily average temperature exceeds 0°C before growing degree days begin to accumulate.

The base temperature is the temperature below which plant growth is impeded. This varies by plant species and was for this study conservatively presumed to be 0°C (as in range management). AGDD are calculated using formula:

[daily Max. temp (°C) + Daily Min. temp (°C)]/2 – base temperature 0 (°C).

Growing degree days for many crops species recognize that plants do not grow any faster when temperatures are over 30°C (Rawson and Macpherson, 2000) and therefore to take a conservative estimate of GDD the mean daily temperatures were filtered to cap the high temperature days at 30°C. Growing degree days were presented to highlight the length and proportion of growing season experienced by vegetation at different elevations within the drawdown zone since 2014.

3.2 Monitoring of trial plots from 2014

Fifty-one plots planted in 2014 were selected for monitoring in 2017. In the 2016 surveys, most plots had very low to nil survival and were therefore dropped from monitoring in 2017 (Scholz and Gibeau, 2016). The plots that were monitored in 2017 were all located on either the Steep or Shallow Beach (STB or SHB) terrains where trials had shown some survival in 2016 (Scholz and Gibeau, 2016). The trial plots were relocated using GPS coordinates and, since plots were marked with a metal pin in the center of each plot, a metal detector was used to locate buried pins. At each location, 1 m by 1 m plot frames were placed over the center pins to carry assessments for seedlings and planted plugs. Data collected in each plot included:

- Date,
- GPS waypoints,

- Unique Plot number,
- Species planted,
- Number of planted plants,
- Number of plants observed surviving,
- % cover of planted vegetation,
- % cover of all vegetation,
- Average height of planted plants,
- Average base width of planted plants,
- Plant vigor (5 classes subjective rating: 0=dead, 1= poor, 2= fair, 3= good, 4=excellent),
- Utilization (present use for browse or forage: 0=0%, 1=1-15 %, 2= 16-36%, 3=36-65%, 4= 66-80%, 5=>80%),
- Vegetative phenology of planted plants (0=without shoots above ground, 1=shoots without unfolded leaves, 2=first leaf unfolded,3=2 or 3 leaves unfolded, 4=several leaves unfolded, 5= almost all leaves unfolded, 6=plant fully developed, 7=stem and or first leaves fading, 8= yellowing up to 50%, 9=yellowing over 50%, 10=dead),
- Generative phenology of planted plants (0=without blossom buds, 1=Blossom buds recognizable, 2= Blossom buds strongly swollen, 3=shortly before flowering, 4=beginning flowering, 5=in bloom up to 25%, 6= in bloom up to 50%, 7=full bloom, 8=fading, 9=completely faded, 10=bearing green fruit, 11=bearing ripe fruit, 12=bearing overripe fruit, 13=fruit or seed dispersal).
- Number of plants producing seed,
- Wildlife sign,
- Wildlife species,
- Pin height relative to the ground level,
- Extra notes.

Plot data were digitally recorded in the field using ipads and software made specifically for the monitoring project via the Doforms © software. Photographs were taken for each plot from the horizontal and vertical perspectives. A meter board was placed at the top (upslope) center of each plot frame of each picture. Collected data were transferred into Microsoft Excel for storage and analysis.

3.3 Monitoring of trial polygons from 2015

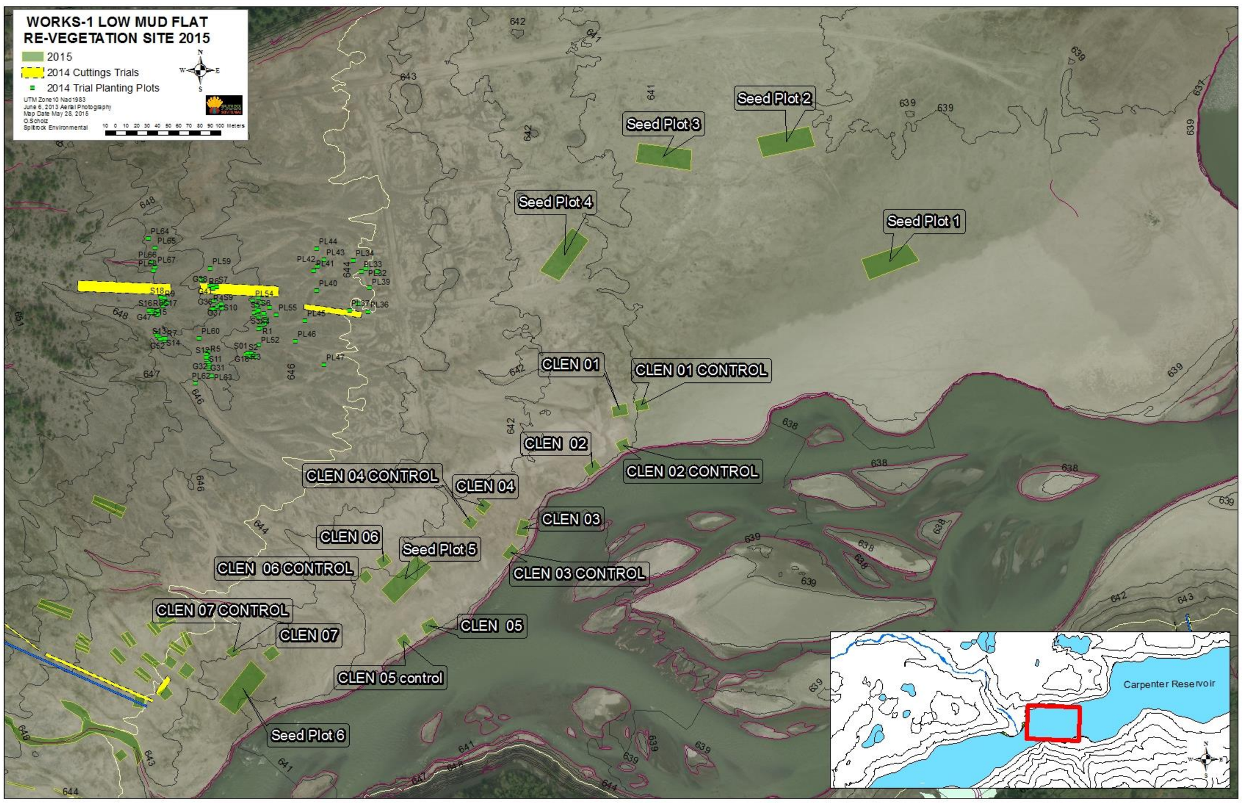
A selection of polygons treated in 2015 were monitored in 2017 by sampling 1m by 1m plots. Polygons sampled were planted in 2015 with lakeshore sedge, seeded or were control polygons (Map 9). The 2015 polygons were located on the Low Mud Flats (LMF) and the Gun Creek Fan East (GCFE) terrains. Five plots were randomly placed within polygon areas to record descriptions of planted vegetation as well as overall vegetation and wildlife within the plot. Observations included total vegetation percent cover, planted vegetation per cent cover, exotic vegetation per cent cover, total number of species, vigor of planted vegetation, plant generative and vegetative phenology, as well as notes of wildlife signs and species. Dominant naturally recruited species were also recorded. Photos were taken of each monitored plot and a GPS location was captured.

Table 2. List of the 2-year-old polygons (treated in 2015) sampled using 1x1m plots in 2017 (Map 9).

Polygon ID	Number of plots	Polygon area (m^2)	Treatment
CLEN1501	5	152	Planted sedge plugs
CLEN1501CON	5	126	Control
CLEN1502	5	140	Planted sedge plugs
CLEN1502CON	5	104	Control
CLEN1503	5	146	Planted sedge plugs
CLEN1503CON	5	122	Control
CLEN1504	5	109	Planted sedge plugs
CLEN1504CON	5	100	Control
CLEN1505	5	141	Planted sedge plugs
CLEN1505CON	5	109	Control
CLEN1506	5	116	Planted sedge plugs
CLEN1506CON	5	90	Control
CLEN1507	5	126	Planted sedge plugs
CLEN1507CON	5	91	Control
CLEN1508	5	136	Planted sedge plugs
CLEN1508CON	5	97	Control
CLEN1509	5	108	Planted sedge plugs
CLEN1509CON	5	94	Control
Seed 15-01 CL	5	100	Seeded Lakeshore sedge
Seed 15-01 FR	5	100	Seeded fall rye
Seed 15-1con	5	100	Control
Seed 15-1FR/Cl	5	100	Seeded mix fall rye and lakeshore sedge
Seed 15-1mech	5	100	Mechanical treatment only

One of the six seeding trial polygons established in 2015 to test the efficacy of treatments to increase recruitment of lakeshore sedge was also monitored in 2017 (Seed Plot1, Map 9). The seeding trial polygon sampled was the lowest in elevation on the LMF terrain. The polygon was comprised of five sub-polygons of approximately 2m by 50m. Each of the five sub-polygons were sampled with five 1m by 1m plots. Transects were stretched for the length of the 50m and sample plots were placed at 10m intervals.

Finally, the success of 2015 planting of live-stake cuttings and other plugs was assessed in 2017 with live tallies per polygon area over all areas treated. Polygons treated with live-stake cuttings planted in 2015 were located on the Steep Beach (STB), Shallow Beach (SHB), Gun Creek fan East (GCFE) terrains. We were unable to monitor cuttings in Gun Creek Fan West (GCFW) terrain due to time limitations.



Map 9. Map of the treatment polygons established in LMF terrain in 2015.

3.4 Monitoring of trial polygons from 2016

Treatments in 2016 focused on an expansion of planting, seeding and live-stake cuttings largely on the Gun Creek Fan East and West (GCFE and GCFW) terrains. As with the monitoring of 2015 treatments (Section 3.3), small 1m by 1m plots were used to sub-sample the 2016 polygon areas. The number of plots used to sub sample treatment polygons varied depending on the size of the polygon area and other factors such as time in the field. The number of plots sampled in 2017 per polygon seeded in 2016 varied (Table 3).

Monitored polygons included LMF polygons planted with lakeshore sedge as well as large polygon areas seeded with fall rye, lakeshore sedge and Canada wildrye, and upland plots planted with rooted container stock of native grasses bluejoint reedgrass (*Calamagrostis canadensis*), foxtail barley (*Hordeum jubatum*) and Canada wildrye. Polygon areas were also planted in 2016 with rooted black cottonwood (*Populus balsamifera ssp. trichocarpa*) and trembling aspen (*Populus tremuloides*), and live-stake cuttings. Tree seedling and live-stake cuttings were monitored in 2017 for survival, vigor and wildlife use.

Table 3. Number of plots sampled in 2017 in the polygons treated in 2016.

Polygon	Plot Area	Number of Plots
Seed 16-Fall rye (FR)	$1m^2$	15
Seed 16-lakshore sedge (CL)	$1m^2$	12
Seed 16-Canada wild rye (CWR)	$1m^2$	16
Seed 16-Mechanical Treatment only (MECH)	$1m^2$	10

3.5 Monitoring of 2017 Machine-worked treatment polygons

Prior to the implementation of the machine worked treatments in 2017, monitoring was carried out at the future prescribed treatment sites. Data collected included topographic measurements using a laser level and measuring staff, soil moisture readings, and vegetation diversity and cover. The same type of data was also gathered within control areas established adjacent to each of the treatment polygons (Map 7). All measurements were repeated both in control and treated polygons following treatments later in the summer.

The procedure for establishing topographic data involved running a Elyson tape approximately 100m through the center of both treatment and control polygons. A Spectra LL300N laser level was set up at a base location. Height measurements were taken relative to the base station every 3m along the tape measure to establish base elevations.

Soil moisture readings were taken at randomly selected sampling locations within each polygon. At each random location, three sample readings were taken using an Aquaterr EC 350 multimeter that measured the proportion of water in the soil. Soil temperature was also recorded at each of the sampling locations. Interpretation of the moisture reading scale is given in Table 4.

Vegetation species were recorded based on a general walking survey of the entire polygon areas. Species diversity and a coarse estimate of cover were recorded.

Table 4. Reading scale for the Aquaterr moisture metre.

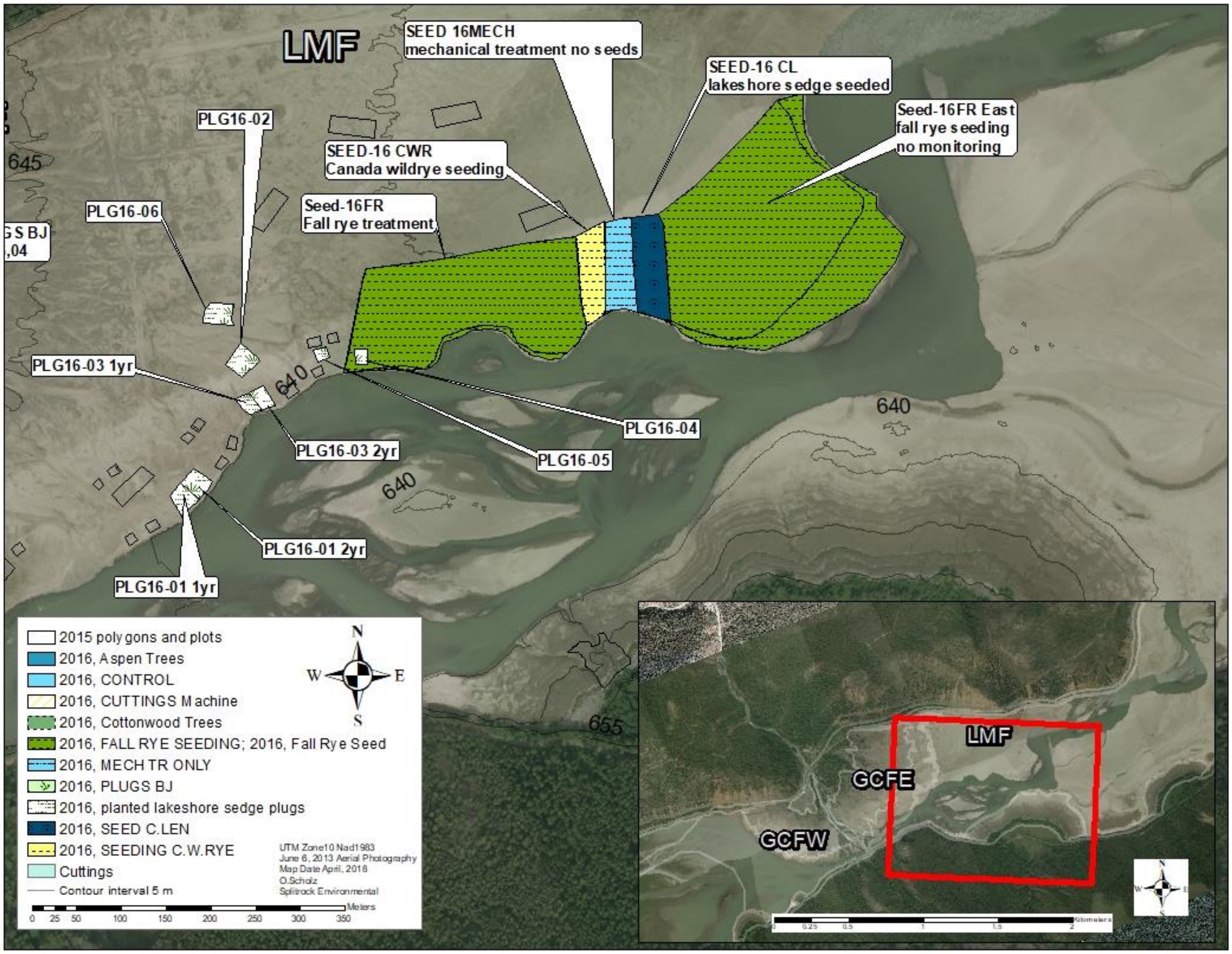
Per cent moisture		**Interpretation**[1]
Silts (plots MW1701-02)	**Sand (plots MW1703-10)**	
98-100	96-100	Free water present. [2]
71-97	61-95	Ample soil moisture for all plant growth.
48-70	39-60	Water level is approaching stress conditions. For even drought tolerant plants, irrigation is highly recommended at the lower end of this class.
37-47	29-38	Stress is apt to occur; most plants will survive if conditions are temporary.
26-36	11-28	Damaging stress to most plants.
0-25	0-10	Permanent wilting death.

3.6 Biomass monitoring

Biomass samples were taken using 1m by 1m plots offset from permanent transects established in 2013 including LMF01, GCF02MD, GCF02UD, GCF02LB, GCF02UB, GCF03MD, GCF03UD, GCF03LB and GCF03UB (Map 8). All herbaceous vegetation was clipped within each plot. The vegetation communities found throughout the reservoirs disturbed drawdown zone is largely comprised of exotic species (Scholz and Gibeau, 2014). We did not separate out exotic from native species when clipping biomass. Clippings were collected in paper bags in the field and transported for drying and weighing. Biomass samples were also

[1] Reference chart from Aquaterr Instruments M, T & EC-300 and 350 user guide (https://www.forestry-suppliers.com/Documents/2364_msds.pdf), Coding is meant as a reference and “does not provide an optimal guide to all plant species and soil types during all stages of growth”
[2] Moisture metre unit calibrated regularly in the field to read 100 in strait water.

collected from what was visually assessed as the most productive trial site to date, PLG1601 (



Map 3). PLG1601 was planted with lakeshore sedge plugs in 2016. Four plots were collected on permanent transects and three plots were collected on the east and west side of PLG1601.

3.7 Analysis of monitoring data

Survival, cover of planted and total vegetation, and basal area of vegetation were summarized per treatment (plug, seeds or live-stake cuttings), year, elevation and terrain, and results are displayed with a series of figures and maps.

4.0 Results

4.1 2016 Hydrograph

The low pool water level for 2016 was at 632.69 mASL on April 19th. The low pool elevation was around the 90th percentile for low pool levels over the past 18-year period. The reservoir was held around the low pool level until late June when levels started to rise steadily. Levels peaked mid-October at 645.98 mASL. Reservoir levels stayed below 639 mASL (the lowest elevation of BRGWORKS-1 treatments) for 134 days between mid-April and the end of July. The low mud flat areas were not fully inundated until September. Water levels peaked 2 m below the lower edge of the buffer zone.

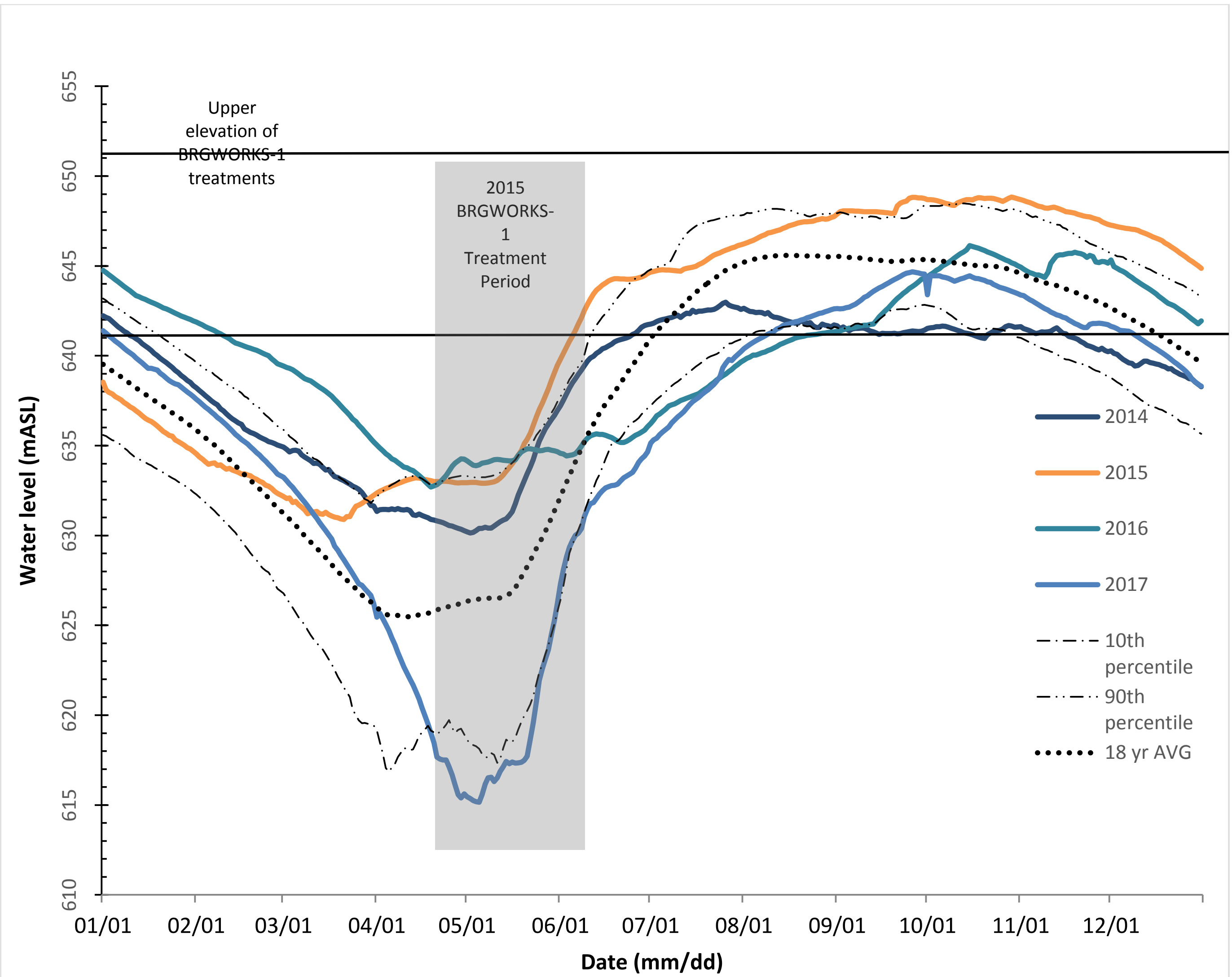


Figure 1. Hydrograph showing the water levels in Carpenter Reservoir in 2014, 2015, and 2016, as well as the 18-years average.

4.2 Weather patterns in 2016

The earliest images from the dust monitoring camera indicate that ice was gone from the Gun Creek Fan prior to April 11, 2016. The calculated average daily temperatures were above zero degrees for 22 days prior to March 15th and remained above 0°C until the fall. Based on this data, March 15th was used as date of inception of the vegetation growing season and used for tabulating growing degree days (Figure 2).

The lowest treated sites at 639 mASL consequently had the shortest growing season before inundation from the reservoir water levels. Vegetation growing at 639 mASL accumulated 1647 growing degree days through mid-July (Table 5, Table 6). Sites at mid elevation (between 645-647m ASL) had a full growing season with between 2736 and 2870 AGDD and were not inundated until October 2016. The buffer zone sites (648-651m) experienced between 2437 and a full growing season of 2999 AGDD.

Table 5. Per cent of vegetation growing season per elevation band by year and month in Carpenter Reservoir in 2016. Green indicates growing season conditions that would result in little to no negative affect on plant growth, while yellow=moderate impact, and red= high impact on vegetation.

		Low (LMF)					**Mid Drawdown**		**Upper Drawdown**		**BUFFER**		
		639	**640**	**641**	**642**	**643**	**644**	**645**	**646**	**647**	**648**	**649**	**650**
March	2014	100	100	100	100	100	100	100	100	100	100	100	100
	2015	100	100	100	100	100	100	100	100	100	100	100	100
	2016	100	100	100	100	100	100	100	100	100	100	100	100
April	2014	100	100	100	100	100	100	100	100	100	100	100	100
	2015	100	100	100	100	100	100	100	100	100	100	100	100
	2016	100	100	100	100	100	100	100	100	100	100	100	100
May	2014	100	100	100	100	100	100	100	100	100	100	100	100
	2015	23.1	100	100	100	100	100	100	100	100	100	100	100
	2016	100	100	100	100	100	100	100	100	100	100	100	100
June	2014	0.25	27.5	32.3	100	100	100	100	100	100	100	100	100
	2015	0	24.7	26.3	28.4	30.3	32.9	100	100	100	100	100	100
	2016	100	100	100	100	100	100	100	100	100	100	100	100
July	2014	0	0	0	39.1	100	100	100	100	100	100	100	100
	2015	0	0	0	0	0	0	53.4	60.9	100	100	100	100
	2016	58.9	100	100	100	100	100	100	100	100	100	100	100
Aug	2014	100	100	100	100	100	100	100	100	100	100	100	100
	2015	0	0	0	0	0	0	0	0	70.6	100	100	100
	2016	0	64.0	74.3	100	100	100	100	100	100	100	100	100
Sept	2014	100	100	100	100	100	100	100	100	100	100	100	100
	2015	0	0	0	0	0	0	0	0	0	100	100	100
	2016	0	0	0	88.4	90.3	93.4	100	100	100	100	100	100
Oct	2014	100	100	100	100	100	100	100	100	100	100	100	100
	2015	0	0	0	0	0	0	0	0	0	0	100	100
	2016	0	0	0	0	0	0	95.8	97.1	100	100	100	100

Table 6. Total accumulated degree days (AGDD) at low and mid elevations from 2014 to 2016, as well as for the full vegetation growing season and precipitation levels.

Year	AGDD 639m (Low)	AGDD 645m (mid)	AGDD March-Oct	Total Precipitation (mm, March 15-Oct31)	Number of days with minimum of 5mm precipitation through growing season.
2014	770	3032	3032	262	17
2015	987	2109	2999	260	15
2016	1647	2736	2870	244	15

During the growing season in 2016, a total of 244 mm of precipitation was recorded in the re-vegetation study area over 73 days (Table 6). However, only fifteen of those days had precipitation amounts greater than 5mm (Figure 2). Precipitation levels were slightly lower than in 2015 and 2014.

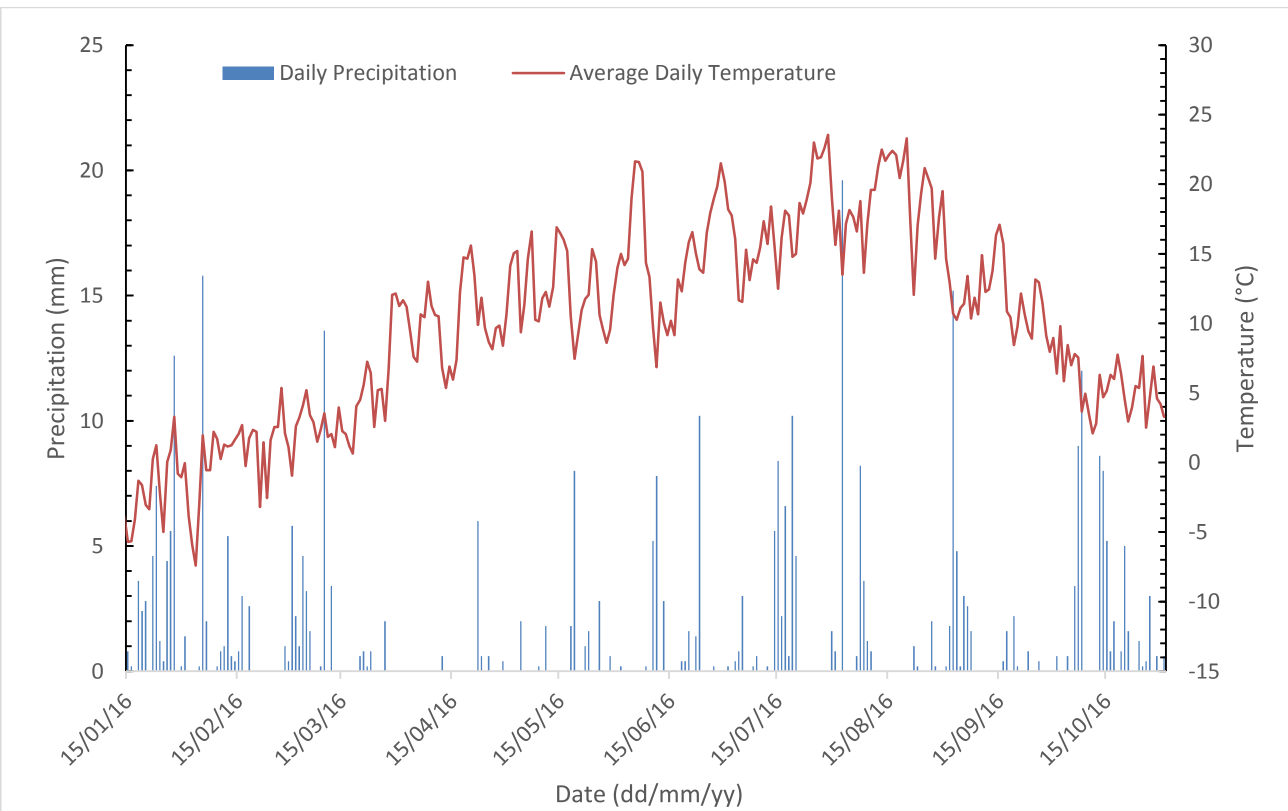


Figure 2. Average daily temperature (℃) and total daily precipitation (mm) over the study area for BRGMON-2 in 2016. The grey box area represents the vegetation growing season.

4.3 Results of monitoring the 2014 treatments

Re-vegetation trials in 2014 were focused on testing the efficacy of planting different native graminoid species at each of the main terrain types in the target riparian enhancement area. Fifty-one 1X1m plots were monitored in 2017 on the Steep Beach (STB) and Shallow Beach (SHB) terrains. Twenty-seven of the plots monitored (53%) had surviving plants three years post planting (Figure 3, Figure 4). Ten of 29 plots planted with grasses (34%) had between one and four surviving plants, of poor to fair vigour. Species surviving were Fowl bluegrass (*Poa palustris*) in four plots, Foxtail barley (*Hordeum jubatum*) in three plots and slender wheatgrass (*Elymus trachycaulus*) in two plots. Seventeen of 21 lakeshore sedge plots (81%) surveyed had between two and 16 surviving plants. Most plants were classified as in fair vigour. Five sedge plots were given a vigour rating of fair to good. In general, plant survival in 2017 was the same or lower than in 2016. Lakeshore sedge in plots on the Shallow beach continued to survive in 2017 although their vigour rating is decreasing over time. Basal width growth was on the lower end of the growth rate observed in 2016 planting sites, where site conditions are more favourable (see PLG16-01 polygon results, below).

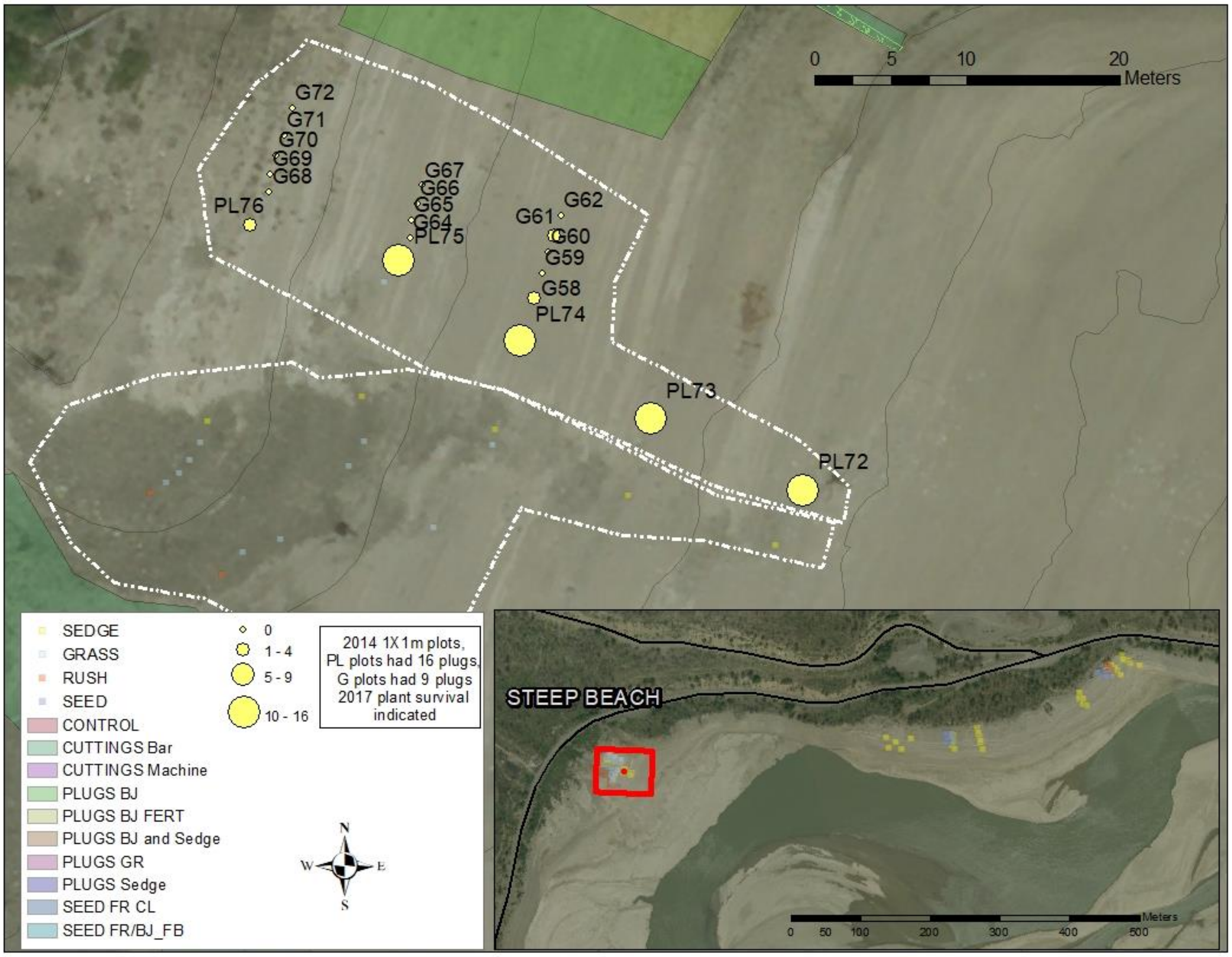


Figure 3. Plots planted out in 2014 and monitored in 2017 at the Shallow Beach (SHB) terrain. Yellow points are scaled to represent proportionate survival. PL plots = plots planted with 16 plugs of lakeshore sedge, G= plots planted with 9 plugs of grass species (see Appendix table for species details).

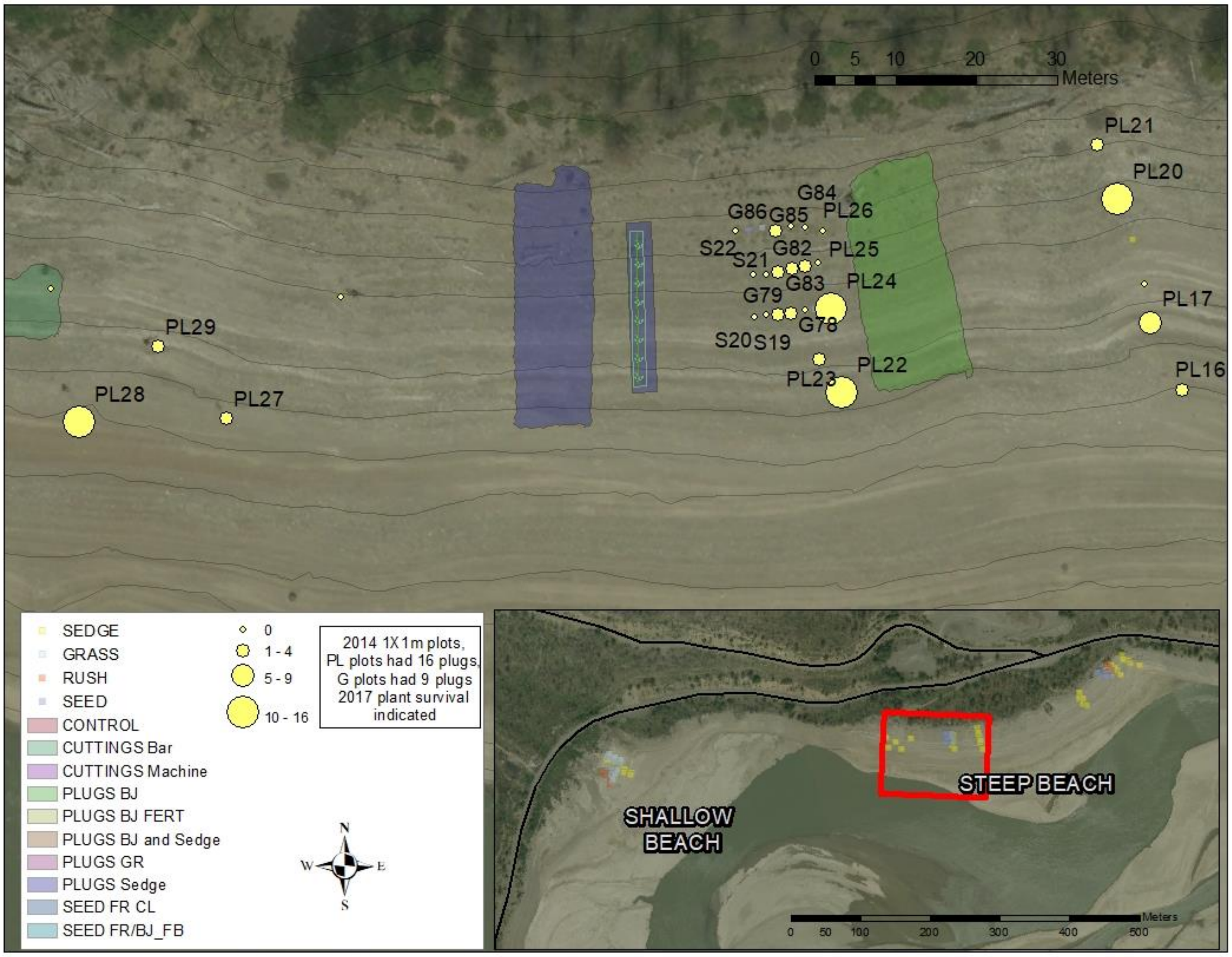


Figure 4. Plots planted out in 2014 and monitored in 2017 at the Steep Beach (STB) terrain. Yellow points are scaled to represent proportionate survival. PL plots = plots planted with 16 plugs of lakeshore sedge, G= plots planted with 9 plugs of grass species (see Appendix table for species details).

4.4 Results of monitoring the 2015 treatments

4.4.1 Polygons planted with Lakeshore sedge

Survival of Lakeshore sedge plug (CLEN) within polygons planted in 2015 was high again in 2017. Some plots even came out with slightly higher survival in 2017 than in 2016 (Figure 5).

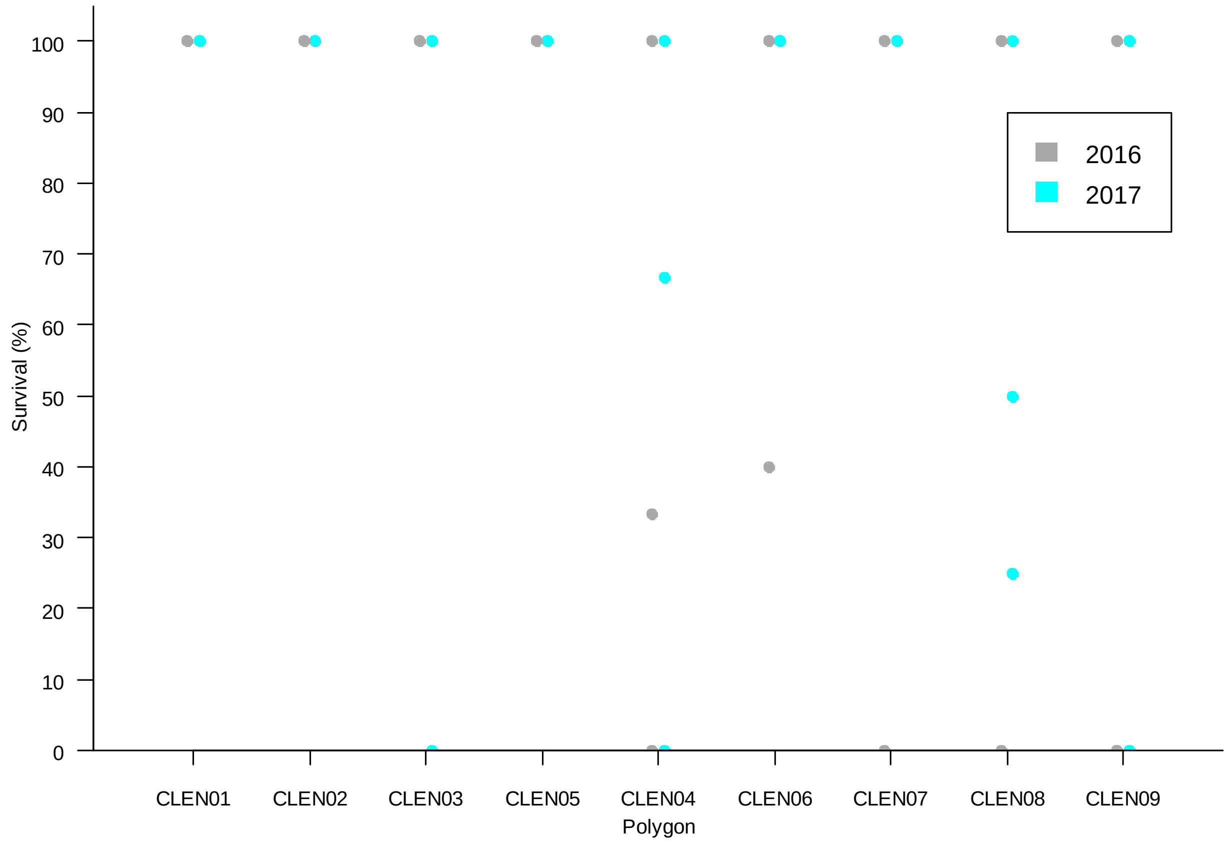


Figure 5. Variation in survival (%) in 2016 and 2017 of the CLEN plugs planted in 2015 at nine polygons. Polygons are ordered from low (641m, CLEN01 to CLEN05), to mid elevations (CLEN04 and 06 at 642m, CLEN07 at 643m, CLEN08 at 643.5m, and CLEN09 at 644m).

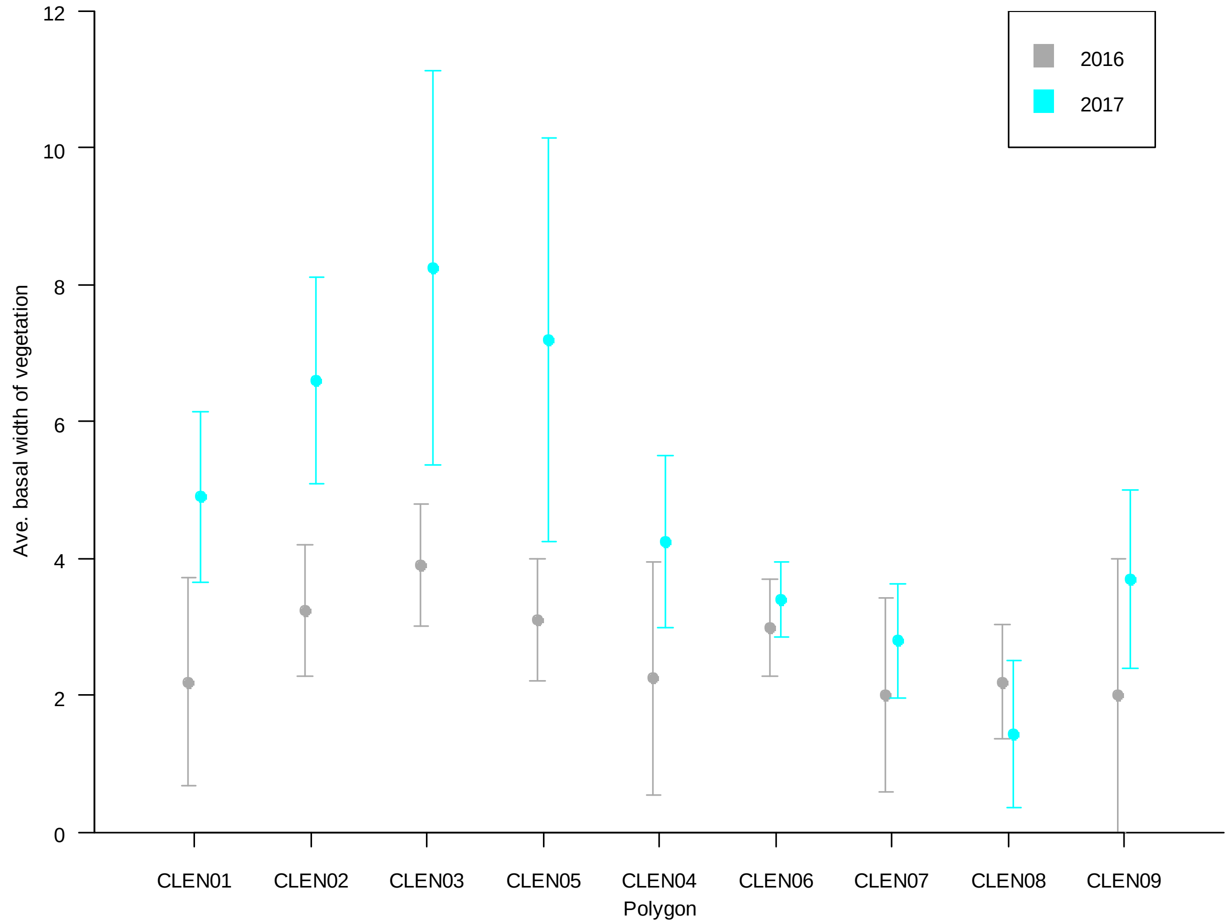


Figure 6. Average basal width area (cm) in 2016 and 2017 of the CLEN plugs planted in 2015 at nine polygons. Polygons are ordered from low (641m, CLEN01 to CLEN05), to mid elevations (CLEN04 and 06 at 642m, CLEN07 at 643m, CLEN08 at 643.5m, and CLEN09 at 644m). Error bars represent STDev.

Basal area of sedges has been observed to be a better measure of vegetation growth and age than height of plant (A. Moody personal communication). Basal area measurements of planted plugs in most 2015 polygons indicates growth in sedges between 2016 and 2017. Polygon CLEN 08 seemed to show a slight decline in growth. Polygons CLEN 03 and 05 had some of the biggest growth. Basal width increases were greater in polygons located below 642 m ASL (CLEN 01-02-03 & 05) than those above 642 m ASL. The plots closest to the river had the greatest amount of growth (CLEN 01-02-03-05).

The qualitative vigor rating of planted plants in all CLEN plots increased between 2016 and 2017; in 2016, 86% of the plugs were of fair vigour while only 2% were good and none were in excellent conditions. In 2017, 7% were in excellent condition, 80% were in fair or good conditions, and 14% were in poor conditions.

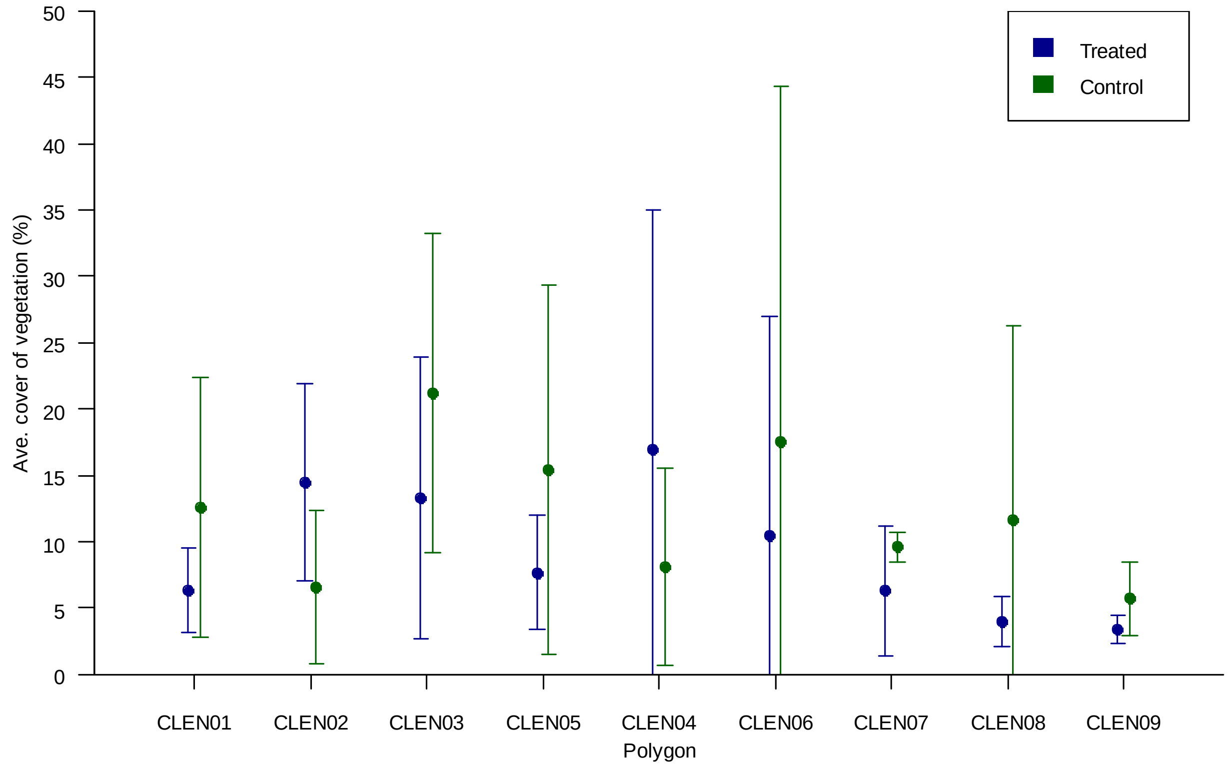


Figure 7. Average cover of vegetation (%) in 2017 of the CLEN plugs planted in 2015 at nine polygons. Polygons are ordered from low (641m, CLEN01 to CLEN05), to mid elevations (CLEN04 and 06 at 642m, CLEN07 at 643m, CLEN08 at 643.5m, and CLEN09 at 644m). Error bars represent STDev.

There was higher cover of vegetation on average in some control and treated plots in 2017 (Figure 7) than in 2016 (see 2016 report).

Average cover in vegetation was comparable between treatment and control plots in most polygons in 2017 surveys. The average cover provided by planted lakeshore sedge plants among 2015 CLEN polygons was fairly even in 2017 (Figure 8). Plant cover values ranged between 1 and 8 per cent. Polygons CLEN 03 and CLEN 05 had higher average planted plant cover but cover ranged widely in these polygons.

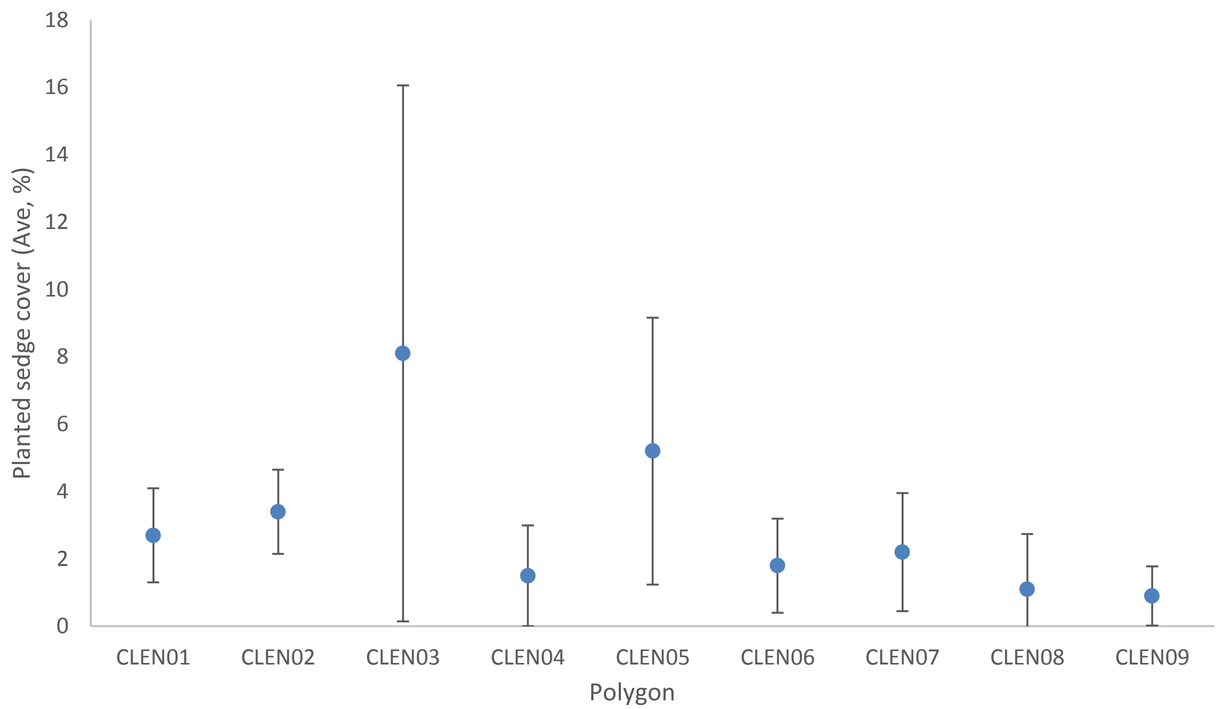


Figure 8. Average cover of planted sedges in 2015 *C.lenticularis* polygon.

The vegetation cover reported in 2017 for each plot included native, exotic, and (native) planted vegetation but the majority of plant cover was made up of exotic species (Figure 9). The non-planted species that dominated vegetation cover in CLEN plots in 2017 was a suite of small annual exotic species. The most common exotic species in the low mud flat vegetation was sand spurry (*Spergularia rubra*), but other exotic species commonly found included lady's thumb (*Persicaria maculosa*), common knotweed (*Polygonum aviculare*), pineapple weed (*Matricaria discoidea*), and lamb's quarters (*Chenopodium album*). Rare occurrences of native species included marsh yellowcress (*Rorippa palustris*), foxtail barley (*Hordeum jubatum*), and common horsetail (*Equisetum arvense*) at the higher elevation polygon CLEN09. While total vegetation cover rarely exceeded 50 % (Figure 7), per cent of total vegetation that was comprised of exotic species was consistently higher in control plots in 2017 and often equalled 100 % of all cover (Figure 9).

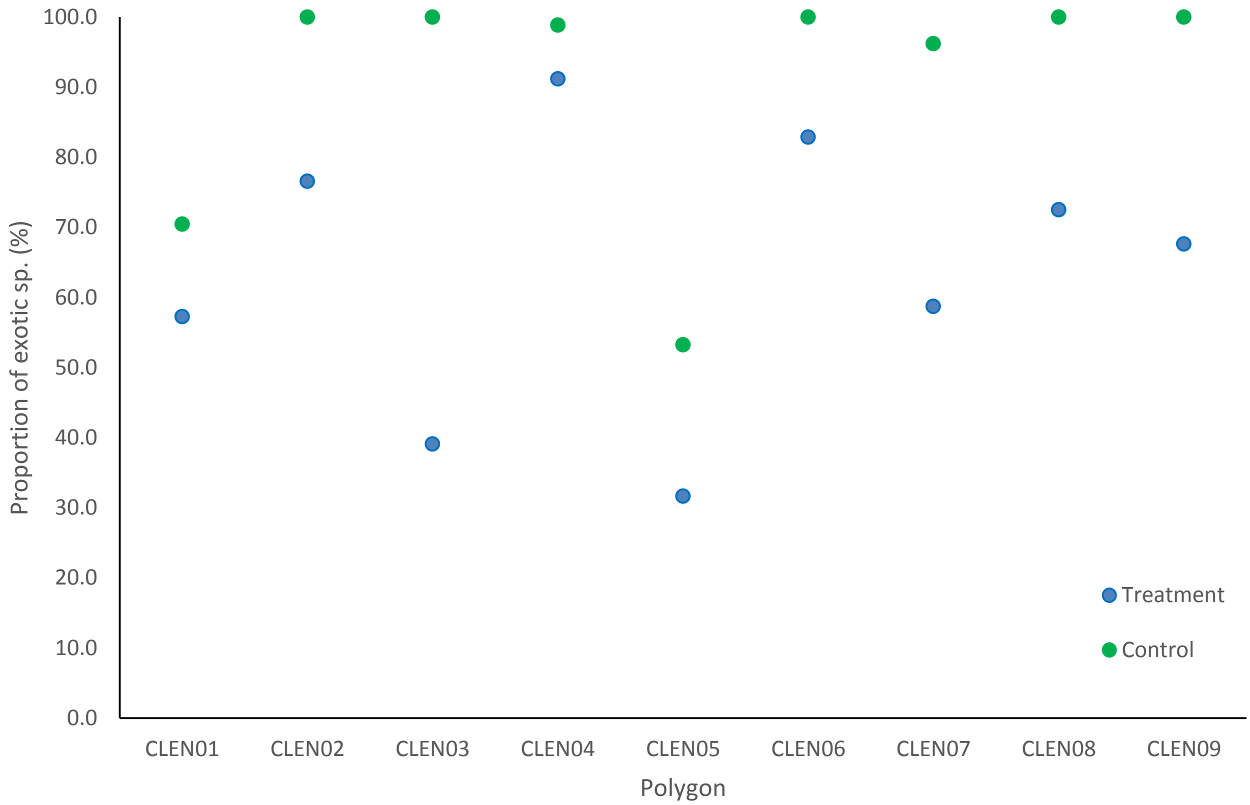


Figure 9. Proportion of total vegetation cover that was made up of exotic species in 2017 in the polygons treated in 2015.

4.4.2 Monitoring Seed Plot 01

The 2015 seeding trials were intended to assess if seeding treatments would recruit native species, particularly lakeshore sedge seedlings. Vegetation cover was similar across treatments and varied between 2 and 25 per cent of total vegetation (Figure 10). The highest and most variable cover were in fall rye (FR) treatments. Cover of exotic species was very high. Lakeshore sedge seedlings were tallied within each plot. Numbers of observed sedge seedlings was very low with seedlings observed in 6 of 25 plots (

Table 7). Only nine seedlings were observed in total. The polygon where the highest frequency of plots with seedlings was observed was within the FR/CLEN treatment. Although numbers were very low, seedlings were observed in polygons where treatment included sowing seeds of either fall rye or lakeshore sedge, or a combination of both.

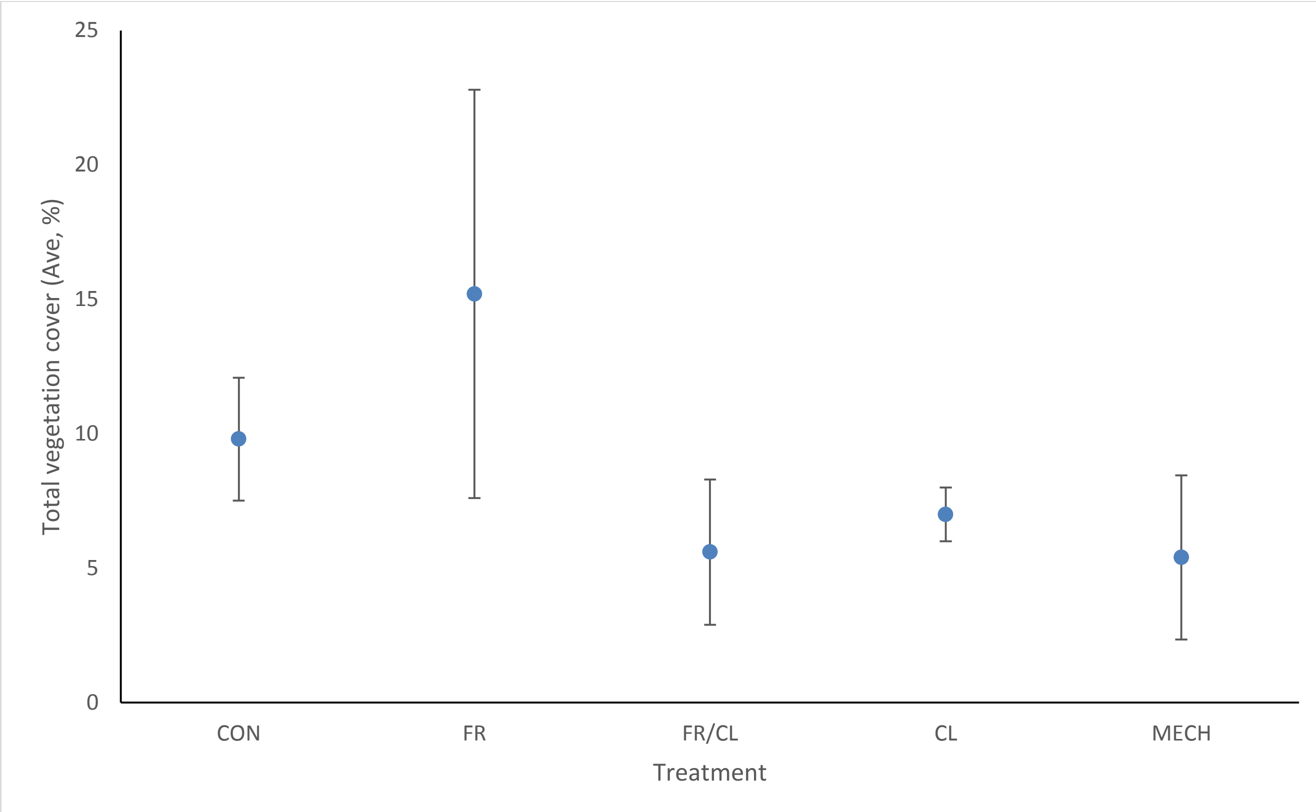


Figure 10. Average cover of all vegetation (%) observed in 2017 per 2015 seed plot01 treatment. CON=control no treatment, FR=seeded fall rye, FR/CL=seeded fall rye and lakeshore sedge, CL=seeded lakeshore sedge, MECH=mechanical treatment only. Error bars represent STDev.

Table 7. Density of Lakeshore sedge seedlings observed in 2017 in the seed polygon trials of 2015.

Treatment	Frequency of Occurrence	Total number of Seedlings	Avg. No. seedlings/m²
Seed 15-01 CL	2	3	0.6
Seed 15-01 FR	1	1	0.2
Seed 15-1con	0	0	0
Seed 15-1FR/Cl	3	5	1
Seed 15-1mech	0	0	0
Total	6	9	0.36

4.5 Results of monitoring the 2016 treatments

4.5.1 *C. lenticularis* polygons

Polygons planted with plugs of lakeshore sedge (*C. lenticularis*) had good survival in 2017 in seven polygons planted in 2016 (Figure 11); only one plot was sampled with less than 70% survival, and a large majority of plots had 100% survival.

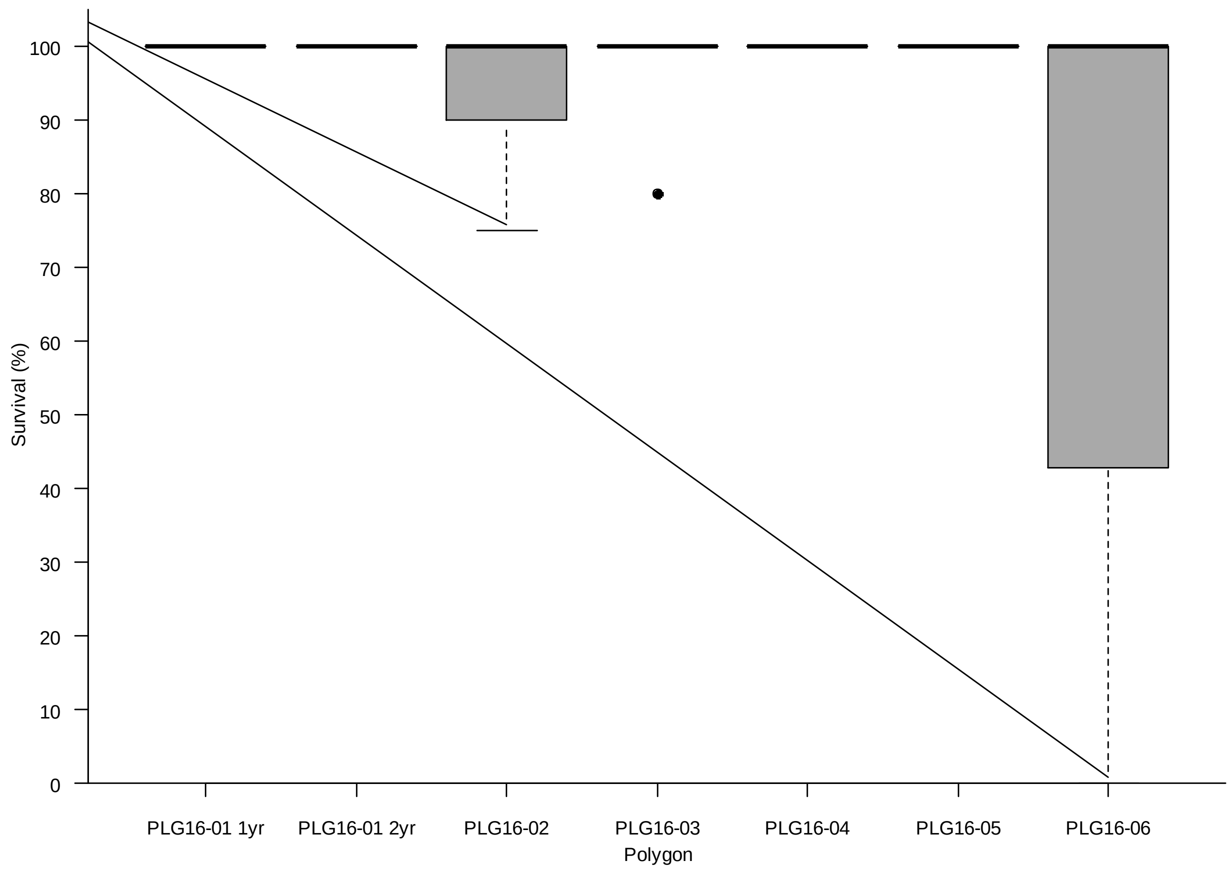


Figure 11. Survival (%) in 2017 of the lakeshore sedge plugs planted in 2016 at seven polygons. Four to nine plots were randomly sampled within each polygon.

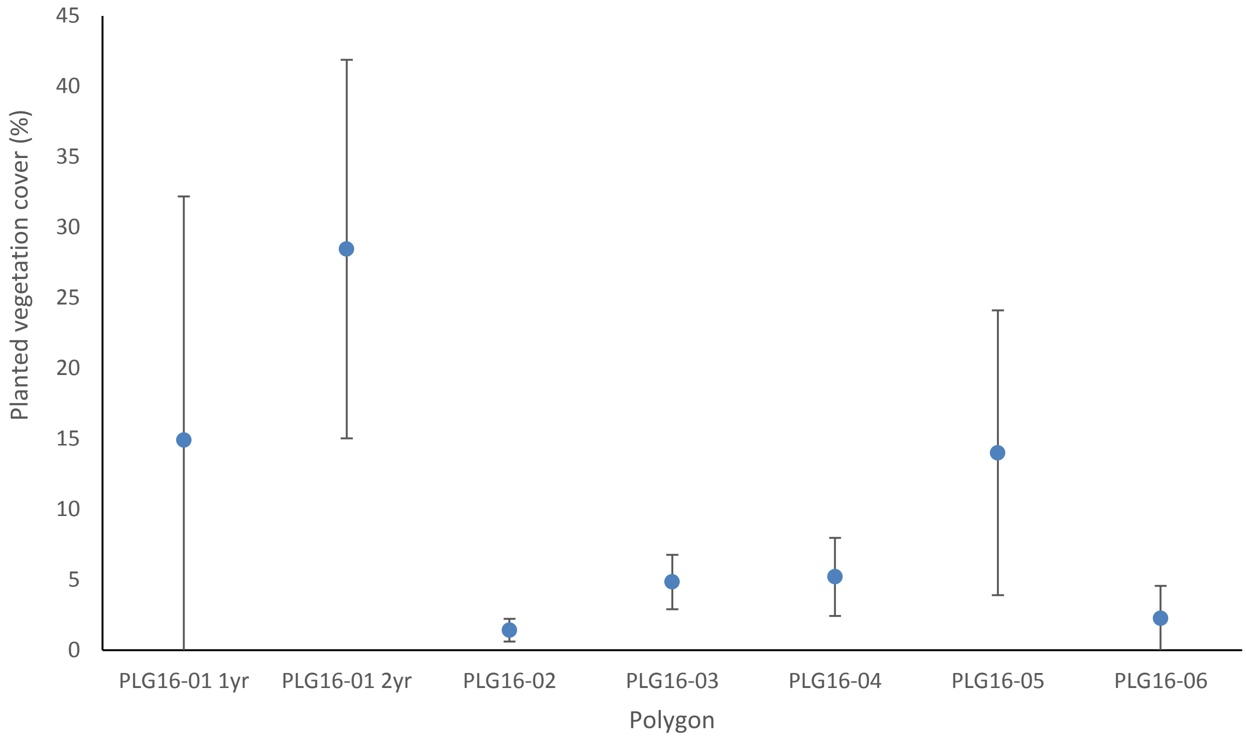


Figure 12. Average cover in 2017 of lakeshore sedge planted in 2016 on the Low Mud Flat (LMF). Error bars represent STDev.

Planted plugs made up the majority of vegetation cover in all of the polygons from 2016 monitored in 2017 (Figure 12, Figure 13, Figure 14). Cover of planted vegetation (*C. lenticularis*) was highest in polygon PLG16-01 2yr. The higher cover was markedly greater in this polygon than polygons PLG-02, 03, 04, and 06 (Figure 12).

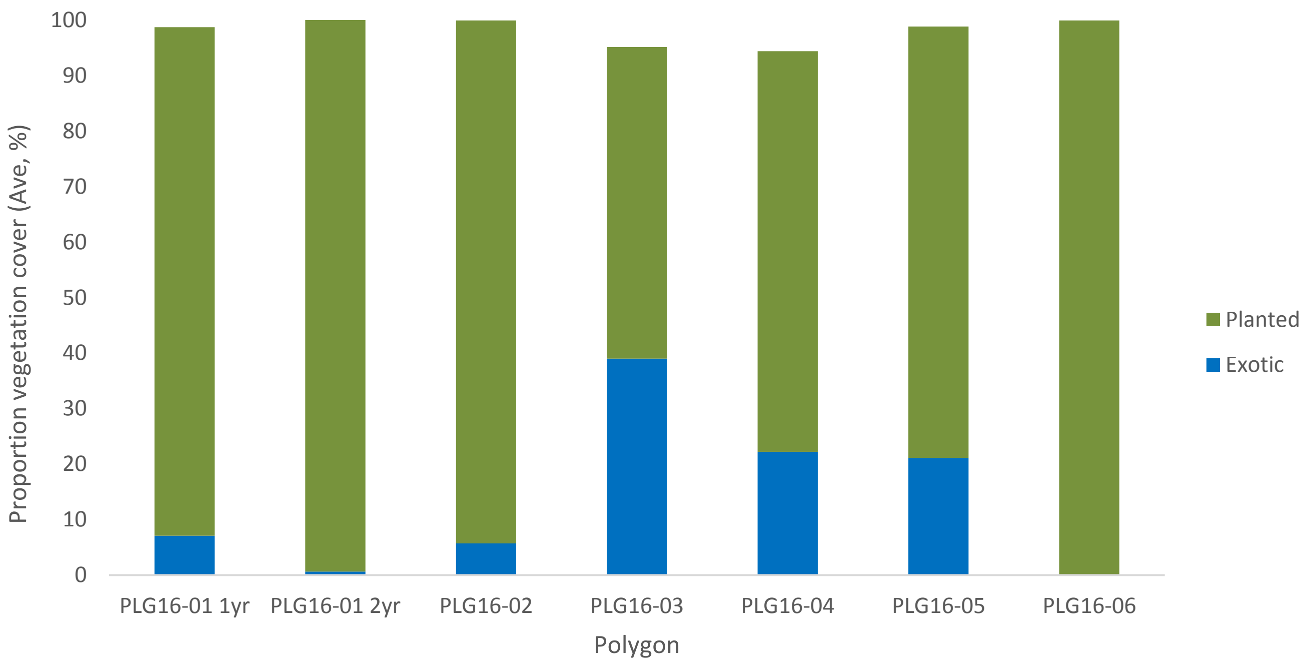


Figure 13. Proportion of vegetation cover (ave., %) from planted and exotic species in 2016 polygons sampled in 2017. The amount of vegetation cover varied by polygon (Figure 12, Figure 14).

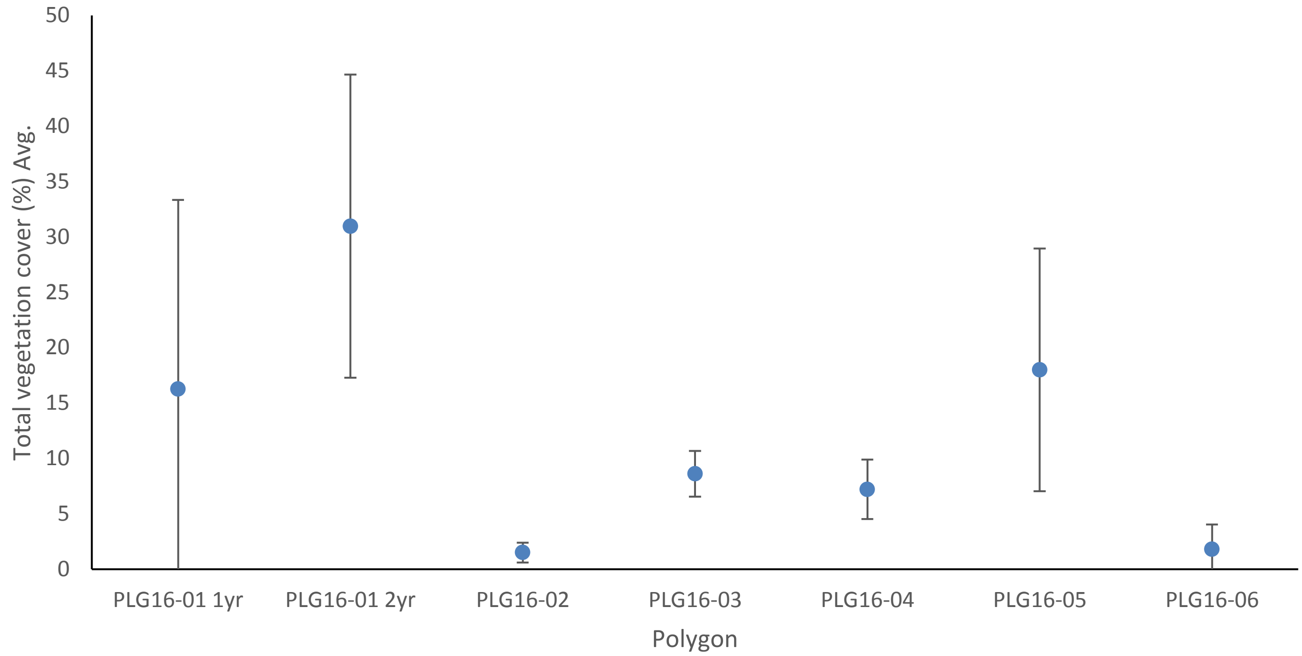


Figure 14. Total cover of vegetation (ave, %) in 2016 polygons sampled in 2017. Error bars represent STDev.

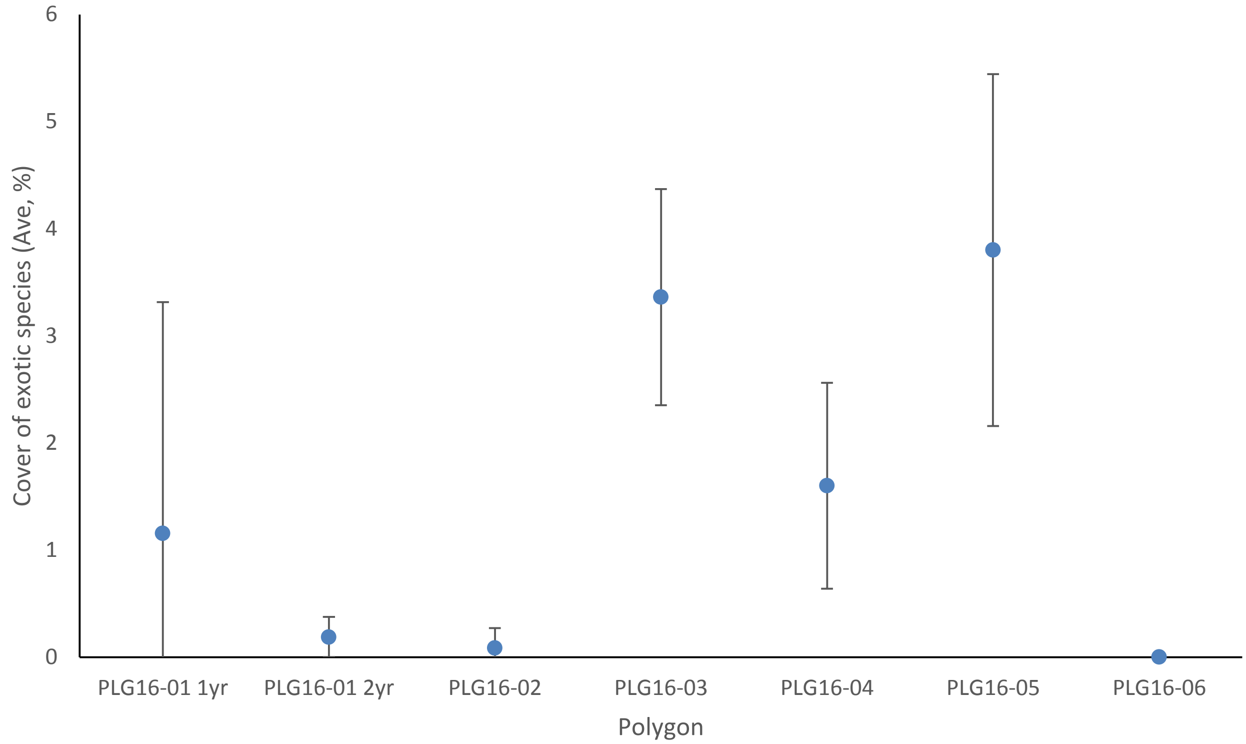


Figure 15. Total cover of exotic species (ave, %) in 2016 polygons sampled in 2017. Error bars represent STDev.

Exotic species cover was generally low (<5%, Figure 15) but made up the bulk of cover besides planted vegetation (Figure 13). Exotic species were from the same suite of exotic annuals described in section 4.4.1.

4.5.2 Seeding trials

Polygons treated with fall rye seeds, lakeshore sedge seeds, Canada wildrye seeds, and by mechanical treatment only had low overall vegetation cover that differed little between treatment types (Figure 16). Very low total vegetation cover was noted in the sampled plots, ranging from <1 per cent to 9 per cent across all treatment polygons (Figure 16).

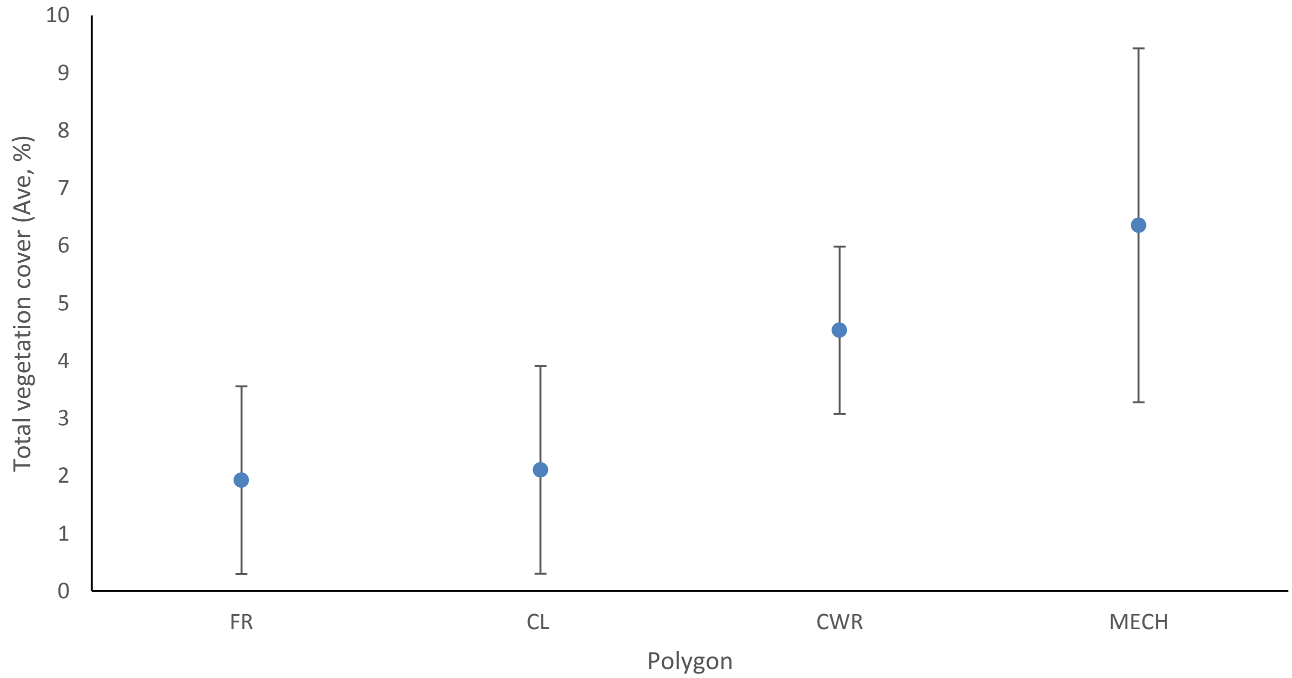


Figure 16. Total vegetation cover (%) in the 2016 seeded plots monitored in 2017. FR=Fall Rye seeded, CL= lakeshore sedge seeded, CWR=Canada wildrye seeded, MECH= mechanical treatment only. Error bars represent STDev.

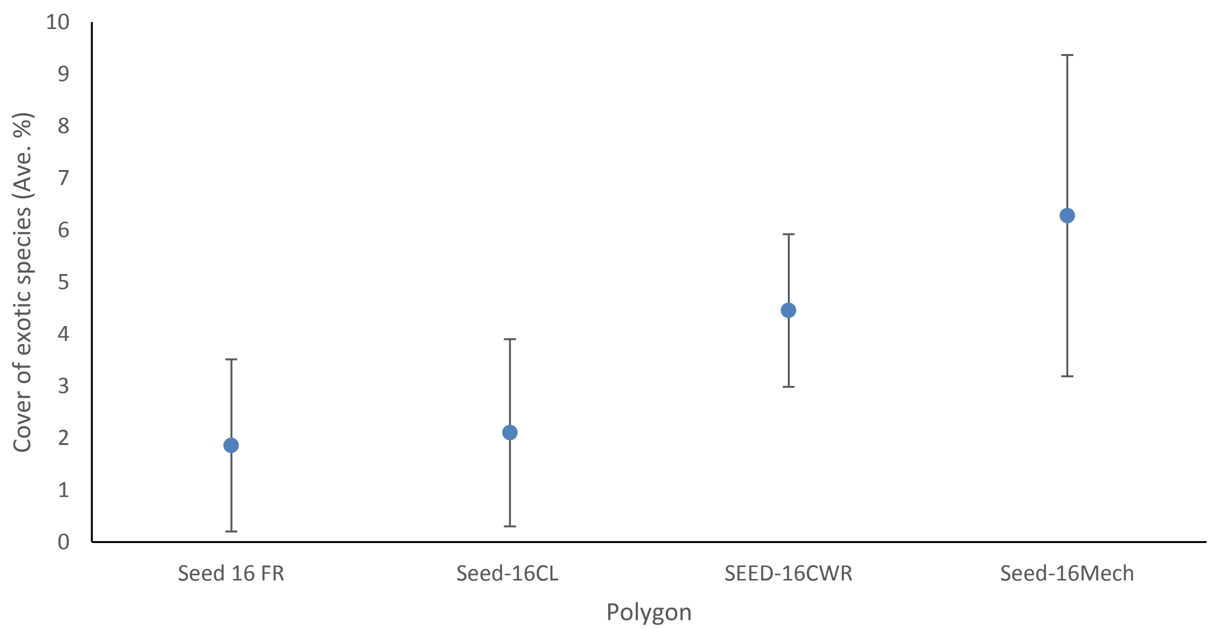


Figure 17. Cover of exotic species (Ave., %) in the plots seeded in 2016 and monitored in 2017. Error bars STDev

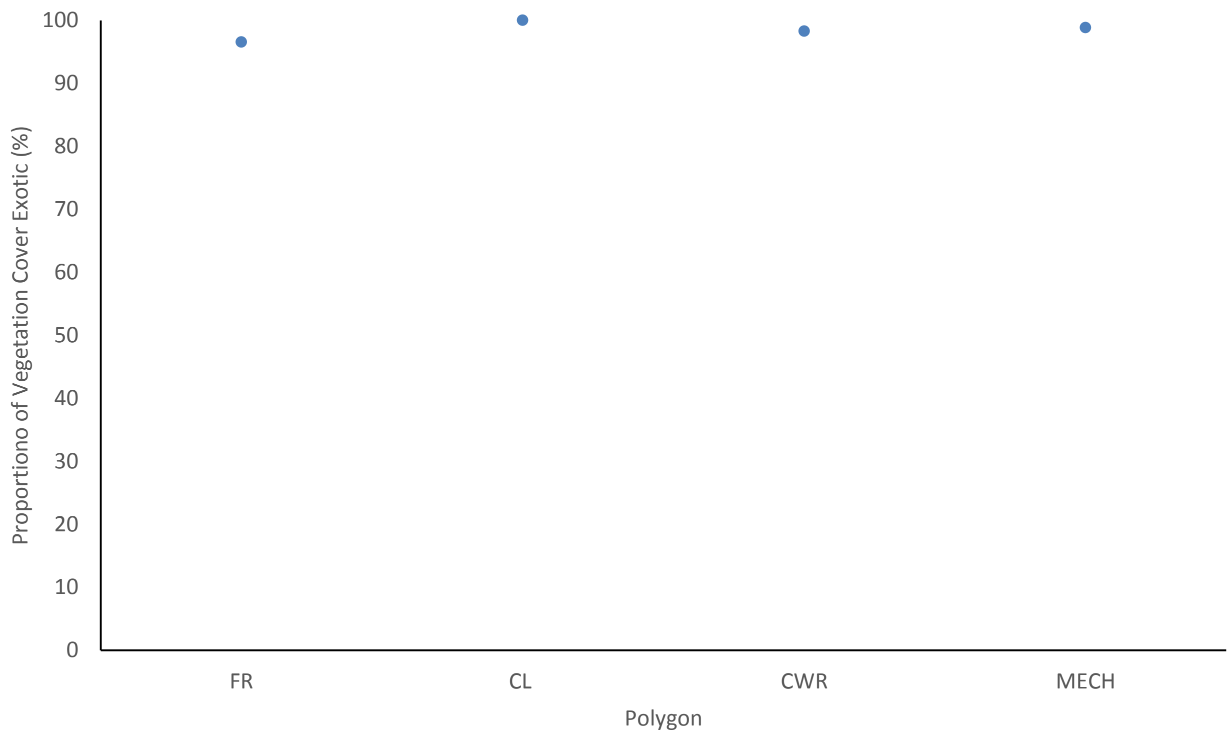


Figure 18. Proportion of total vegetation cover made up by exotic species in the plots seeded in 2016 and monitored in 2017.

The cover of exotic species was generally low (below 10%, Figure 17), but comprised close to 100 % of the vegetation cover in most plots (Figure 18). The same species as in the 2015 CLEN plots dominated the exotic vegetation cover: sand spurry, lamb's quarters, lady's thumb, and common knotweed. Marsh yellow cress was the most frequently occurring native species. The size of all plants was typically on the low end of the species growth potential (plants rarely over 5cm in height).

Percent cover of *C. lenticularis* seedlings was minimal, and therefore density tallies of *C. lenticularis* seedlings were recorded in 1X1m plots and in 3.99m (50m²) diameter circular plots. Only five 1mX1m plots, all located within the fall rye (FR) seed treatment, had *C. lenticularis* seedlings. No seedlings occurred in the 1X1m plots in the CWR, CL or MECH polygons.

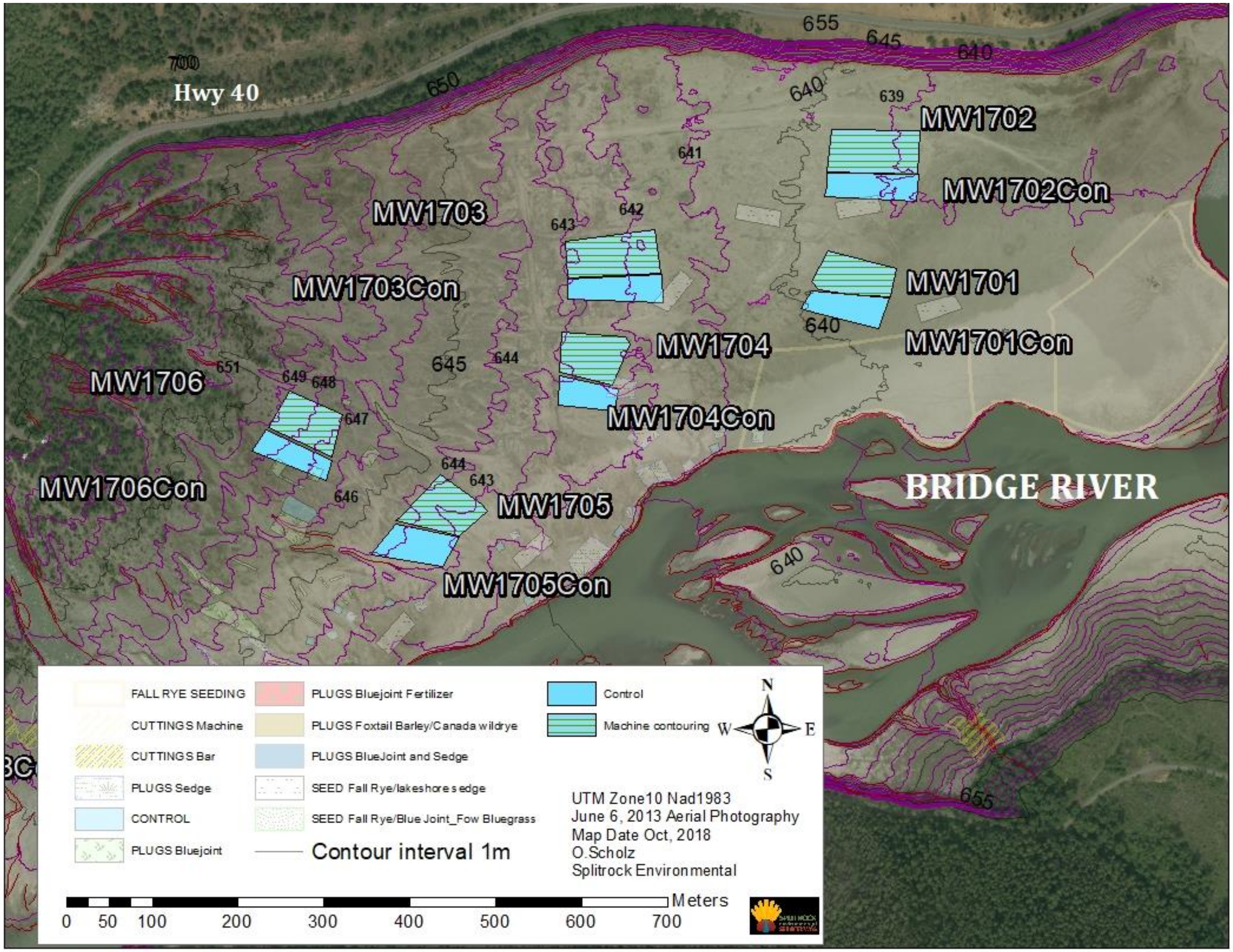
Within the 50m² plots, *C. lenticularis* colonization was observed in each of the polygon types. The area with the highest density of *C. lenticularis* seedlings was the fall rye (FR) treatment polygon (Table 8). *C. lenticularis* seedlings were recorded in 50% of plots within the polygon seeded.

Table 8 . Frequency of occurrence of *C. lenticularis* seedlings and total number of seedlings recorded in the 3.99m diameter ($50m^2$) plots in 2017. The average number of seedlings was statistically significant among polygons (F=7.2, p=0.0014).

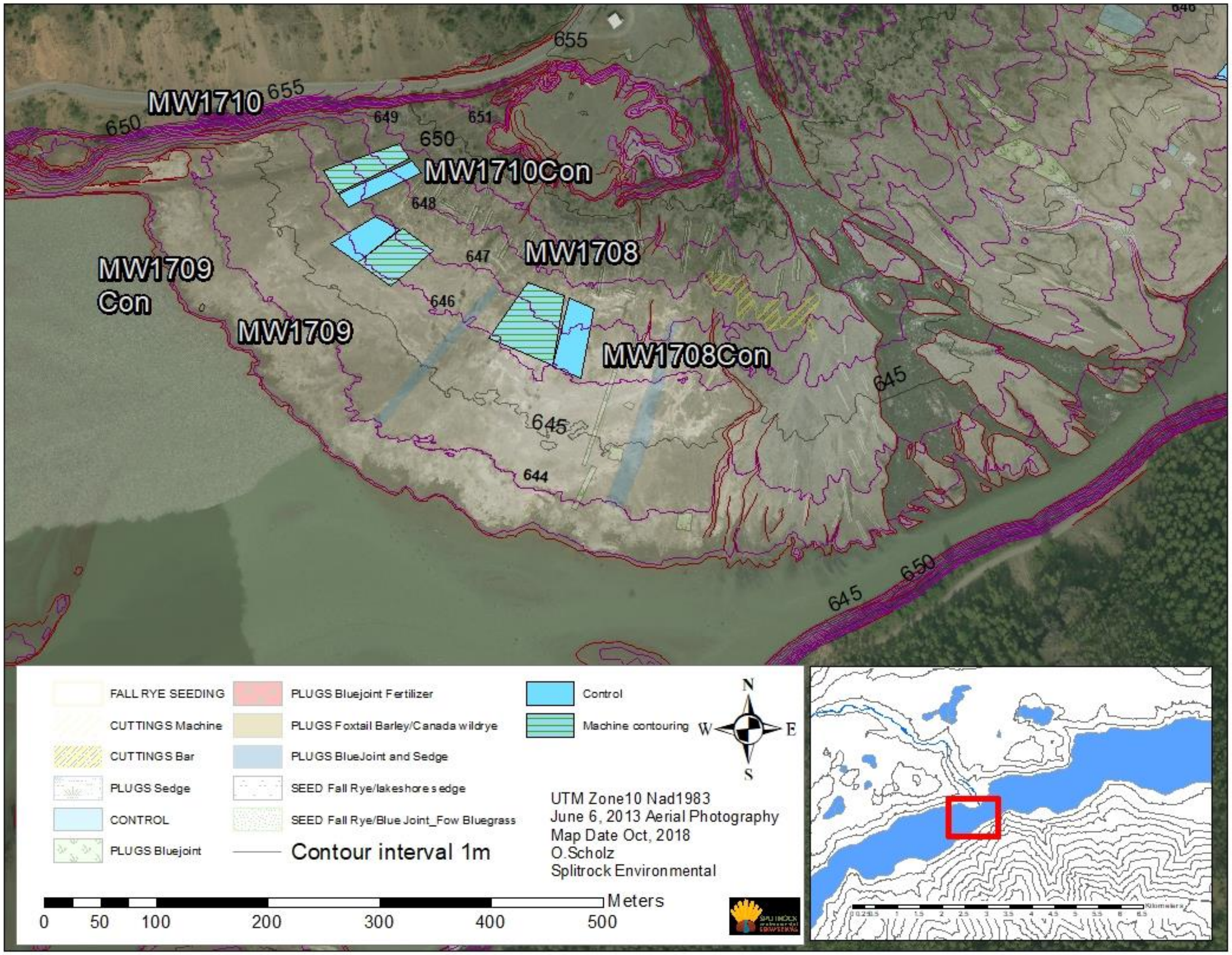
Polygon	Number of plots	Frequency of occurrence (# plots)	Total number of seedlings	Average number of seedlings per polygon
CWR	4	1	3	0.75
MECH	9	1	1	0.11
CL	10	5	8	0.8
FR	8	7	140	17.5
Total	31	14	152	4.9

4.6. Results of monitoring the 2017 treatments

The polygons dedicated for machine-work riparian treatment in 2017 were characterized prior to treatment with collection of site, vegetation, topographic and soil moisture data. The treated polygons varied in aspect and elevation, from a low of 639 m ASL to a high of 650 m ASL (Map 10, Map 11).



Map 10. Map of the polygons treated by machine work in the Low Mud Flats (LMF) and Gun Creek Fan East (GCFE) terrains in 2017, along with control areas.



Map 11. Map of the polygons treated by machine work in the Gun Creek Fan West (GCFW) terrains in 2017, along with control areas.

Substrate and soil characteristics were gathered for each treatment and control polygon. Broad differences in elevation and substrate were observed. The lowest elevation polygons were in the Low Mud Flat (LMF) terrain, situated at 639-640 m ASL. The trend moving from low to higher elevation polygons showed a progression from fine silts to coarse sandy textured soils. Coarse fragment content also rose with elevation, and the substrate composition and cover changed from a dominance of mineral soil to predominantly rock at higher elevations (Table 9). Drainage ratings increased and therefore water retention capacity of soils decreased with increasing elevation.

Table 9. Site characteristics of control polygons and polygons treated by machine work in 2017.

Site ID	Soil Drainage	Est. Soil moisture regime	Coarse Fragment Content	Soil Texture	Substrate Cover					
					Rock	**Mineral**	**Organics**	**Water**	**Wood**	**Bedrock**
MW1701	Imperfectly Drained	Hygric	<35%	Silt	0	100	0	0	0	0
MW1701 con	Imperfectly Drained	Sub-Hygric	<35%	Silt	0	100	0	0	0	0
MW1702	Imperfectly Drained	Sub-Hygric	<35%	Silt	0.2	98.8	0	0	1	0
MW1702 con	Imperfectly Drained	Sub-Hygric	<35%	Silt	0.1	98.99	0	0	1	0
Mw 1703	Well Drained	Sub-Hygric	>35% <70%	Loam	42	55	0	0	3	0
MW1703 con	Well Drained	Sub-Hygric	>35% <70%	Loam	39	60	0	0	1	0
MW1704con	Imperfectly Drained	Sub-Hygric	>35% <70%	Loam	43	67	0	0	0	0
MW1704	Imperfectly Drained	Sub-Hygric	>35% <70%	Loam	35	64.5	0	0	0.5	0
MW1705	Imperfectly Drained	SubXeric	>35% <70%	Loam	60	39.5	0	0	0.5	0
MW1705 con	Imperfectly Drained	SubXeric	<35%	Loam	30	68	0	0	2	0
MW1706	Imperfectly Drained	SubXeric	>70%	Sand	70	25	0	0	5	0
MW1706con	Moderately Well	SubXeric	>35% <70%	Sand	50	40	0	0	10	0
MW1708	Rapidly Drained	SubXeric	>35% <70%	Sand	25	75	0	0	0	0
MW1708con	Rapidly Drained	SubXeric	>35% <70%	Sand	5	95	0	0	0	0
MW1709	Rapidly Drained	SubXeric	>70%	Sand	75	25	0	0	0	0
MW1709con	Rapidly Drained	SubXeric	>70%	Loamy Sand	75	25	0	0	0	0
MW1710	Rapidly Drained	Sub Xeric	>70%	Loamy Sand	81	10	1	0	8	0
MW1710con	Rapidly Drained	SubXeric	>70%	Loamy Sand	86	8	1	0	5	0

Post-treatment results of monitoring vegetation species, cover and distribution across each of the treated polygons indicated an overall immediate decline in species richness and cover as compared to control polygons (Figure 19). This result is explained by the fact that the machined polygons were completely disturbed with most of the original vegetation buried during the mounding process. Some plants did however survive the mounding process, particularly in higher elevation polygons that had higher (10-20%) initial vegetation cover.

In total, 26 exotic and 21 native species were recorded across all polygons. Higher elevation polygons had increased species diversity and cover (Figure 19, Figure 20).

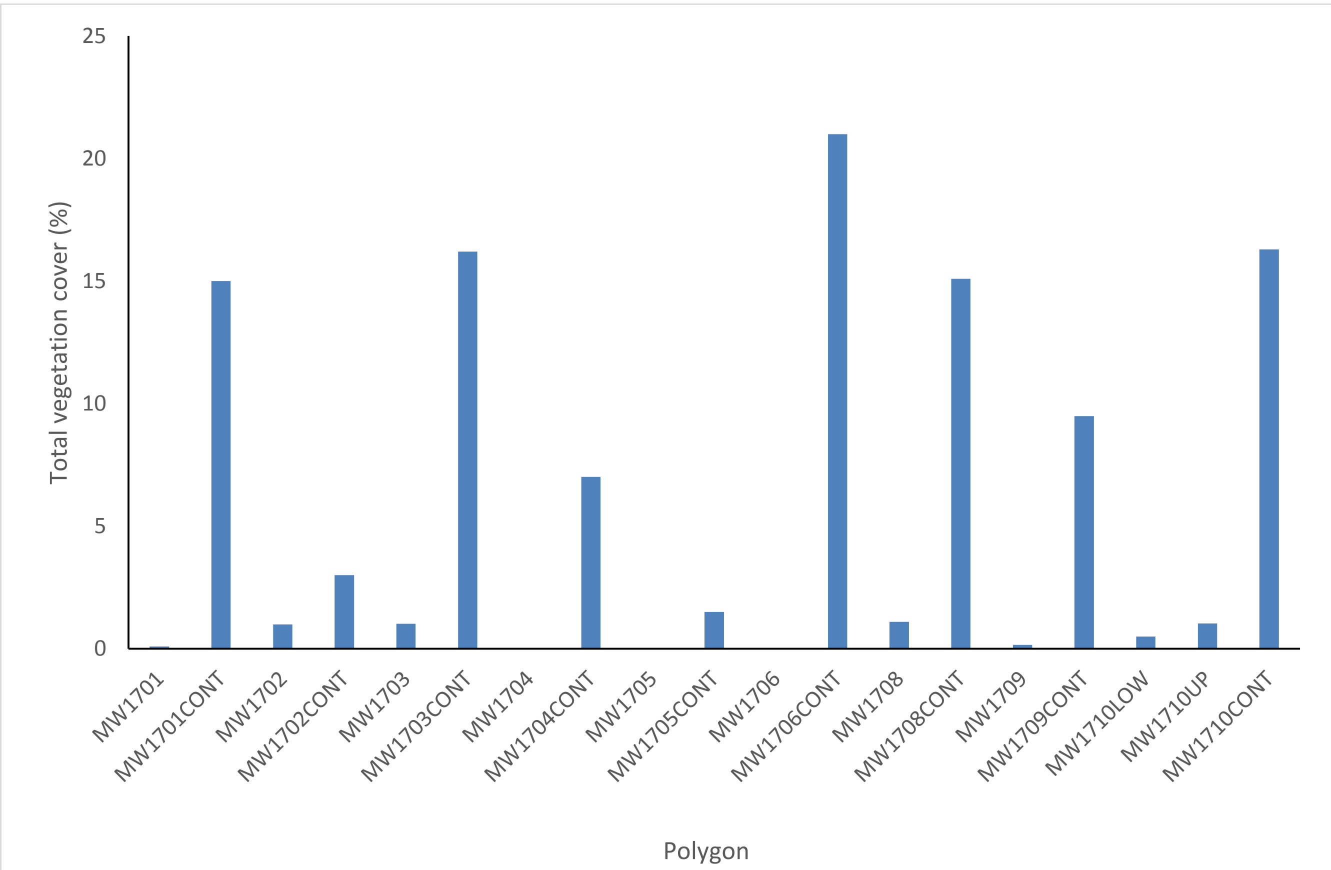


Figure 19. Total cover of vegetation (%) following treatment in 2017 within the riparian enhancement polygons.

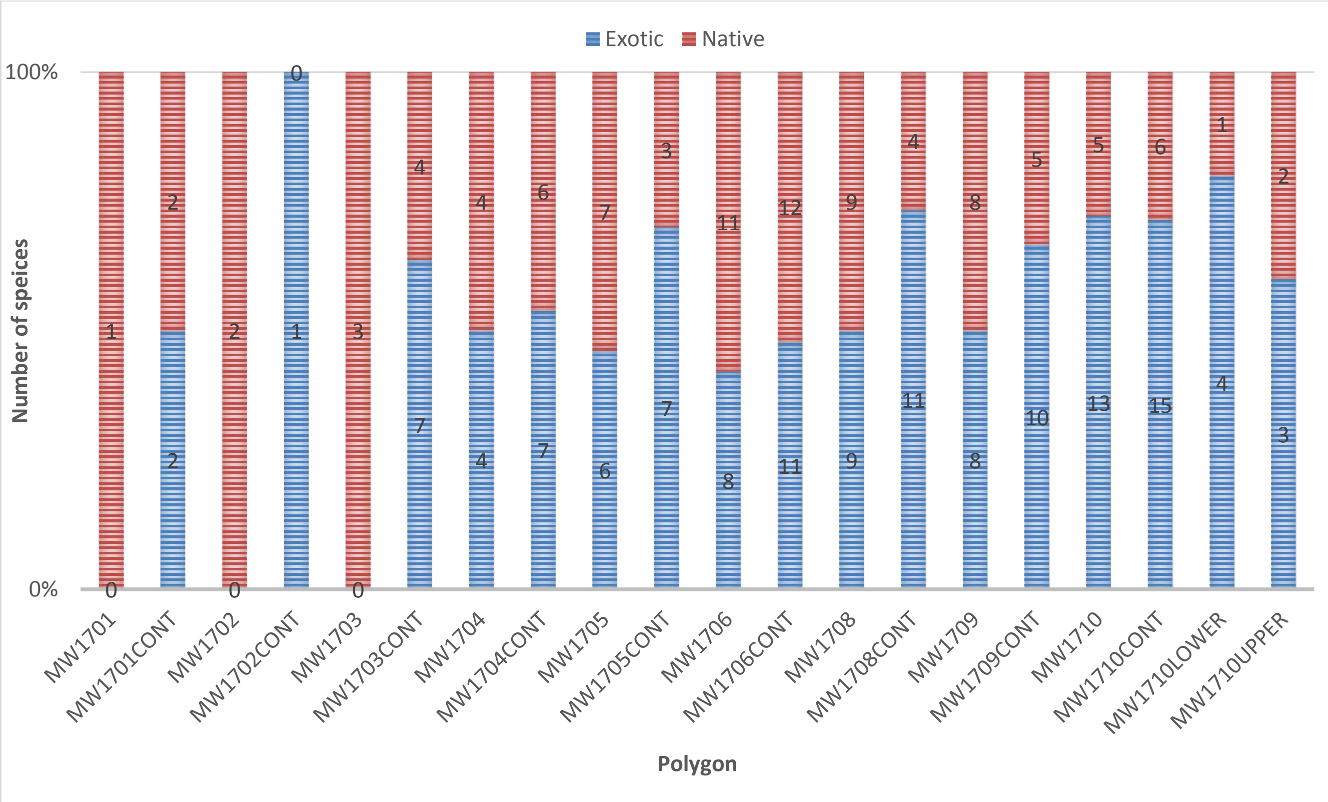


Figure 20. Proportion of native and exotic species in the riparian enhancement polygons following treatment in 2017.

4.6.1 Soil moisture and temperature in machine-worked polygons

Soil moisture was recorded at polygons treated by machine and associated control sites through the growing season in 2017. Data was collected in April, May and June at as many of the treatment sites as time would allow. April readings preceded treatments.

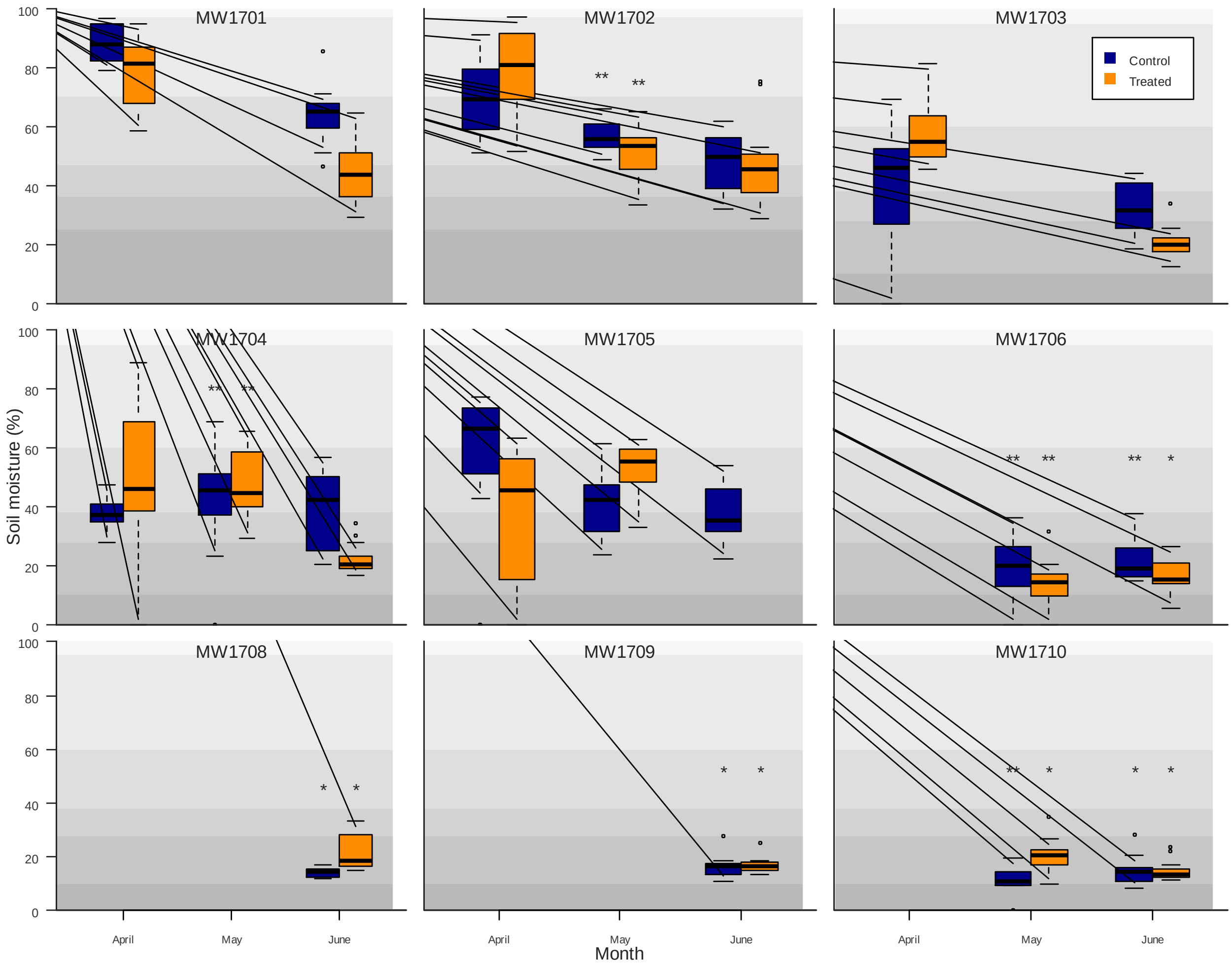


Figure 21. Soil moisture over the three spring months (April, May and June) for each machine-worked plot. * means sampled in AM, ** means sampled in PM, no asterisk means no info on sampling time. Shading illustrates the water moisture interpretation (silt for MW1701 and MW1702, sand for the other plots; see Table 4. Reading scale for the for interpretation of the grey scale colours.)

Both treated and control polygons situated at higher elevations in the drawdown (MW1706-08-09-10) had lower moisture readings than lower elevation polygons (Figure 21). This moisture trend fits with increase in coarseness of soils and substrates with increasing elevation. By June, high elevation polygons had moisture levels considered stressful for plant survival and growth. There tended to be a broad range of moisture readings with both treated and control polygons.

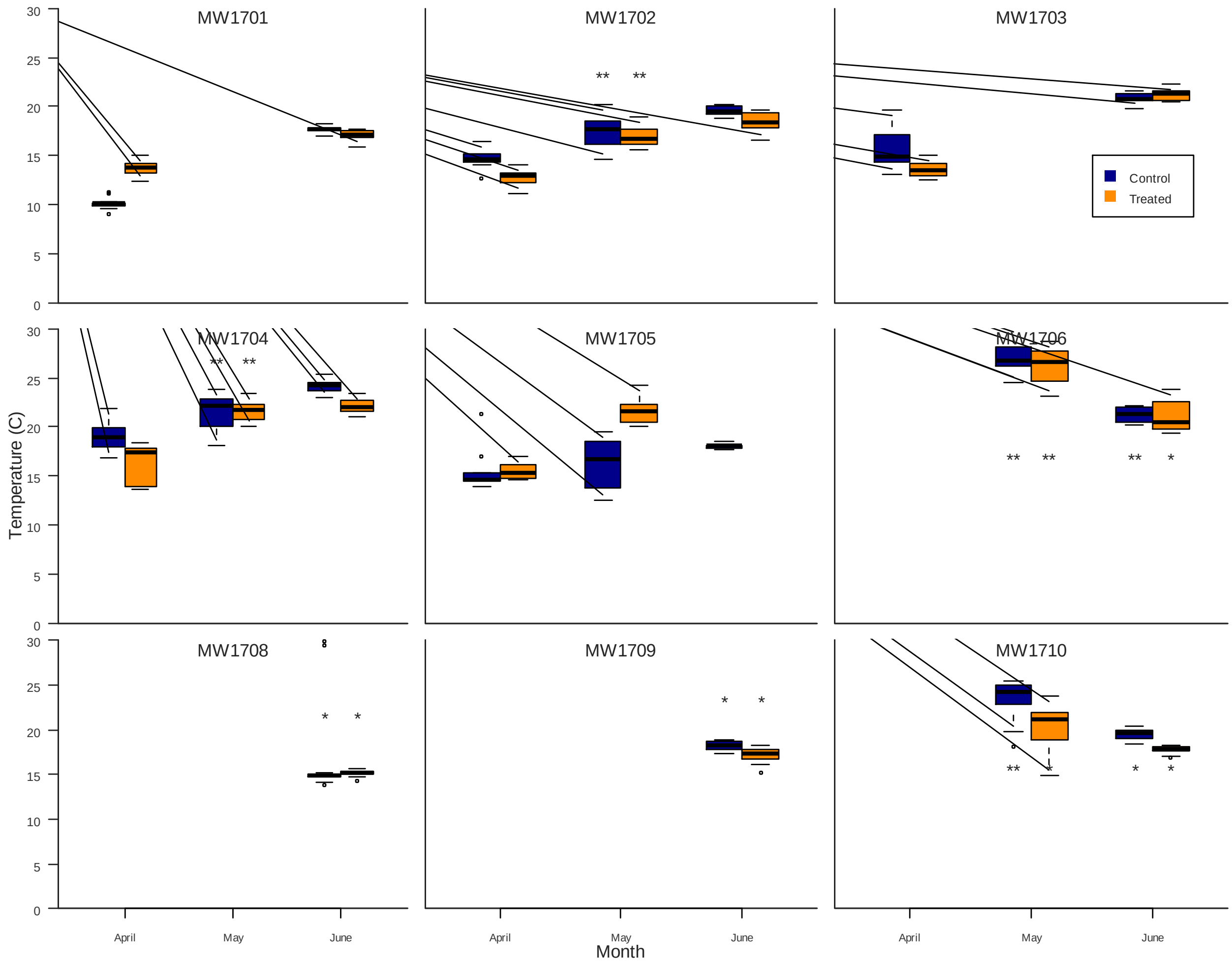


Figure 22. Soil temperature (°C) over the three spring months (April, May and June) for each of the machine-worked plots. * means sampled in AM, ** means sampled in PM, no asterisk means no info on sampling time.

Temperatures recorded in April preceded any machine-work treatment. Temperature readings differed by several degrees between control and treatment polygons pre-treatment in MW1701 and Mw1702 (Figure 22). Temperatures were fairly consistent between control and treated polygons post treatment (May and June readings, Figure 22). Temperatures were equal to or slightly lower in treated polygons in May and June for MW1701, 02, 03, 04, 06, 08, 09, and 10. The only polygon where temperatures were equal or higher in treatment polygons was in MW1705 in May, by up to 4.5°C. Readings in the control of MW1705 were taken in the morning while the readings in the adjacent treated polygon were taken in the mid-afternoon of the previous day. It is thus likely the variation seen in May at this polygon is reflective of the daily variation in temperature rather than difference between the control and treated sites.

4.6.2 Topographic change in machine-worked polygons

Elevation readings were taken before and after contouring the machine-worked polygons. Ground-level change was typically in the order of 30 cm +/- post machine treatments (Figure 23, Figure 24). Polygon MW1702 was an exception, as it is a polygon where an effort was made to create much greater difference in elevation. Ground elevations in sections of MW1702 were increased by 2m above previous levels (Figure 25, Figure 26).

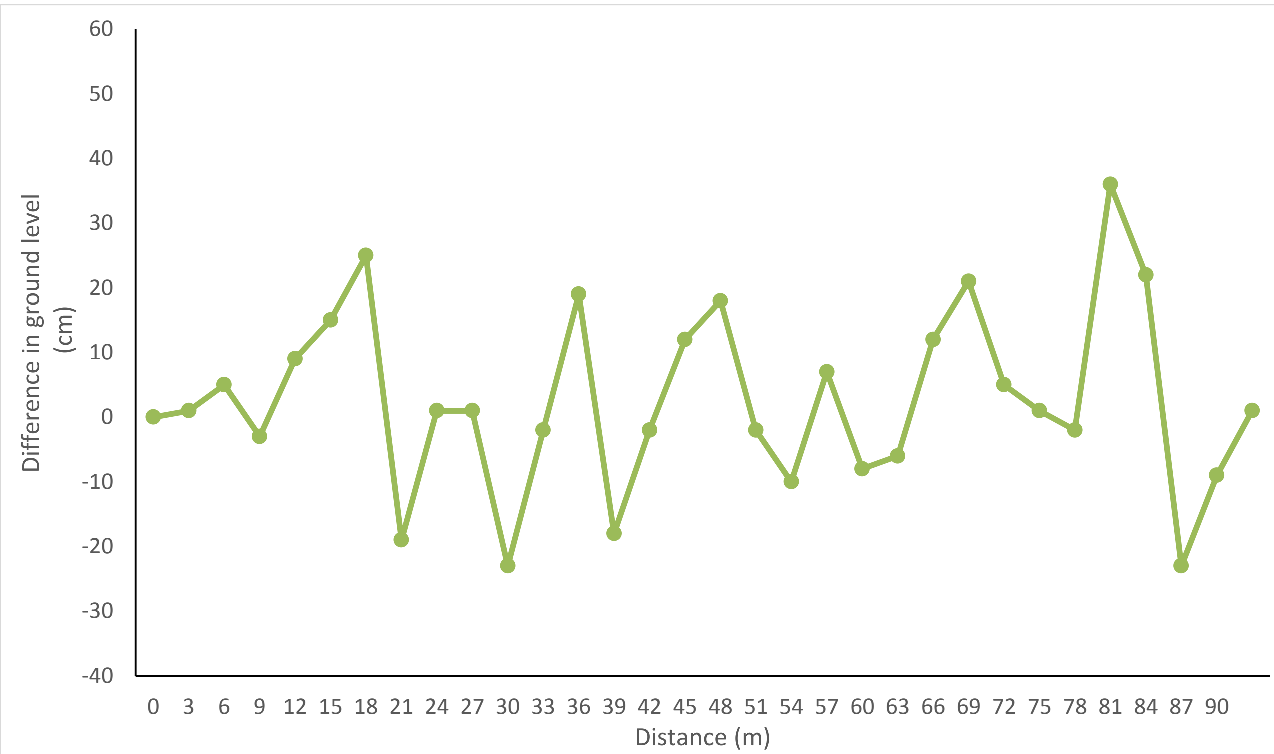


Figure 23. Difference in elevations (cm) after treatment by machine relative to ground level (0 cm) in MW1701 in 2017.

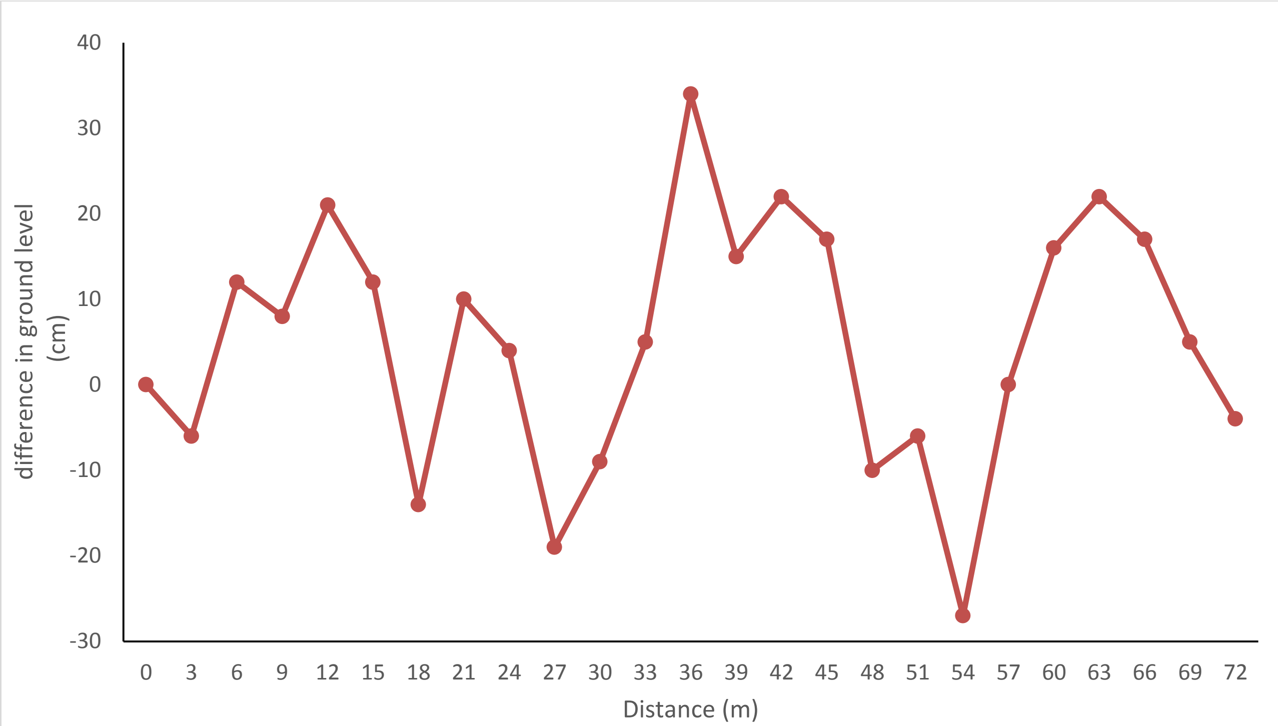


Figure 24. Difference in ground level elevations (cm) after treatment by machine relative to ground level (0 cm) in MW1706 in May 2017.

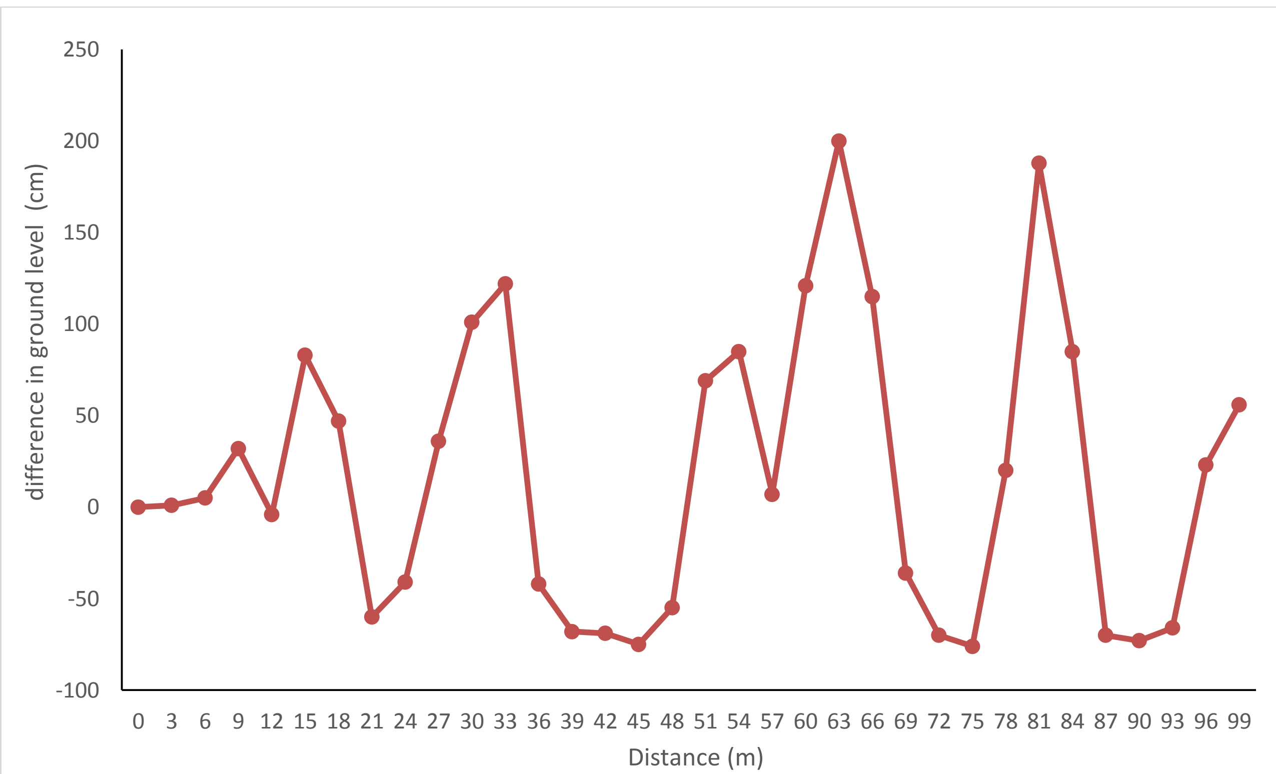


Figure 25. Difference in ground level elevations (cm) after treatment by machine relative to ground level (0 cm) in MW1702 in 2017.

Figure 26. Permanent photo-point showing before and after machine-work enhancement at polygon MW1702 in 2017.

4.7 Biomass sampling

Biomass samples collected at permanent monitoring transects Low Mud flat 01 (LMF01, 640 mASL) were very low averaging <50kg/ha (Figure 27). Mid drawdown plots Gun Creek Fan Mid Drawdown (GCFMD, 644 mASL) also produced low but wide-ranging biomass weights (between 1 and 75 kg/ha). Samples at permanent transect Gun Creek Fan Mid Drawdown 02 (GCFMD02) were low and likely lower than they would have been due to two plots falling within MW1705 machine-works treatment polygon. Gun Creek Fan upper drawdown (GCFUD 647.5 m ASL) biomass samples weighed up to 135 kg/ha. Sample plots in the lower buffer zone produced some of the highest biomass weights among permanent transects plots (between 150-300 kg/ha). Finally, samples from Gun Creek Fan Upper Buffer (GCFUB) zone at the two Gun Creek Fan sites produced a range of biomass between (19-177 kg/ha). Overall, samples taken within 2016 treatment polygon PLG1601 (640, Map 3) produced significantly higher biomass than other samples with an average biomass sample weighing over 1500 kg/ha. The bulk of the PLG sample was made up of mature C. lenticularis plants that had been planted as a treatment

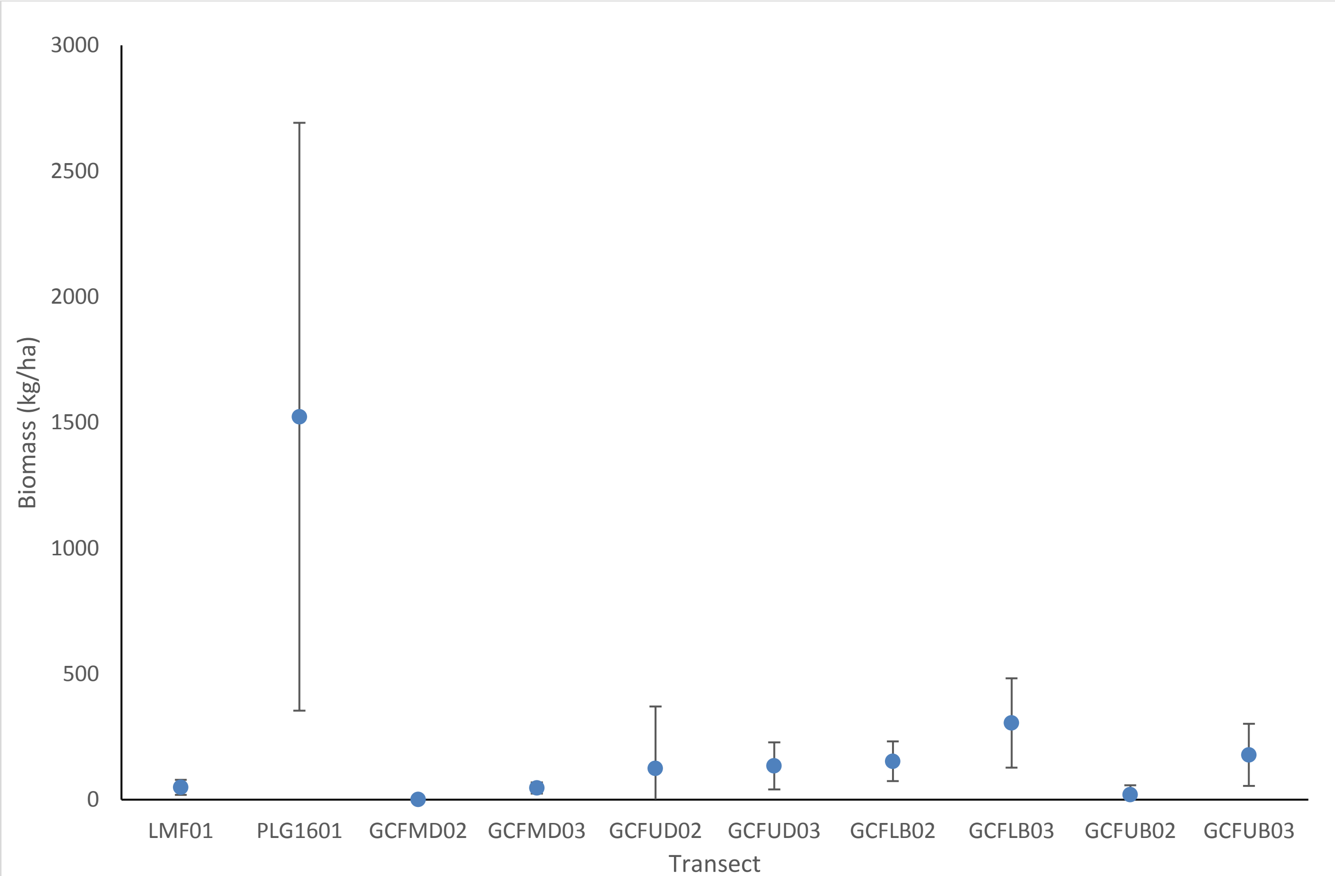


Figure 27. Biomass (kg/ha) collected in 2017 at permanent transect sites and at treatment site PLG1601, all herbaceous vegetation sampled. Error bars STDev.

4.8 Live-stake cuttings and general grass survival in 2017

Polygons located at the Steep Beach (STB), Shallow Beach (SHB), and Gun Creek Fan East (GCFE) terrains were monitored for survival of live-stake cuttings and plantings of bluejoint wildrye and or lakeshore sedge in 2017.

4.8.1 Steep Beach (STB) revegetation polygons

Survival of live-stake cuttings planted in polygons of Steep Beach terrain (in 2014 or 2015) remained relatively stable with some slight declines between 2016 and 2017 (Figure 28). The polygons planted in 2015 and located at mid beach continued to sustain the best survival with around 30 per cent. The polygons on the west end rock wall had the lowest survival in live-stake cuttings.

Polygons planted with nursery-grown plugs maintained in 2017 survival rates similar to 2016, though with some slight declines (Figure 28). The sedge strip planted in 2014 had a large decline in survival in 2017 as compared to 2016, as the numbers of live planted sedges dropped by half.

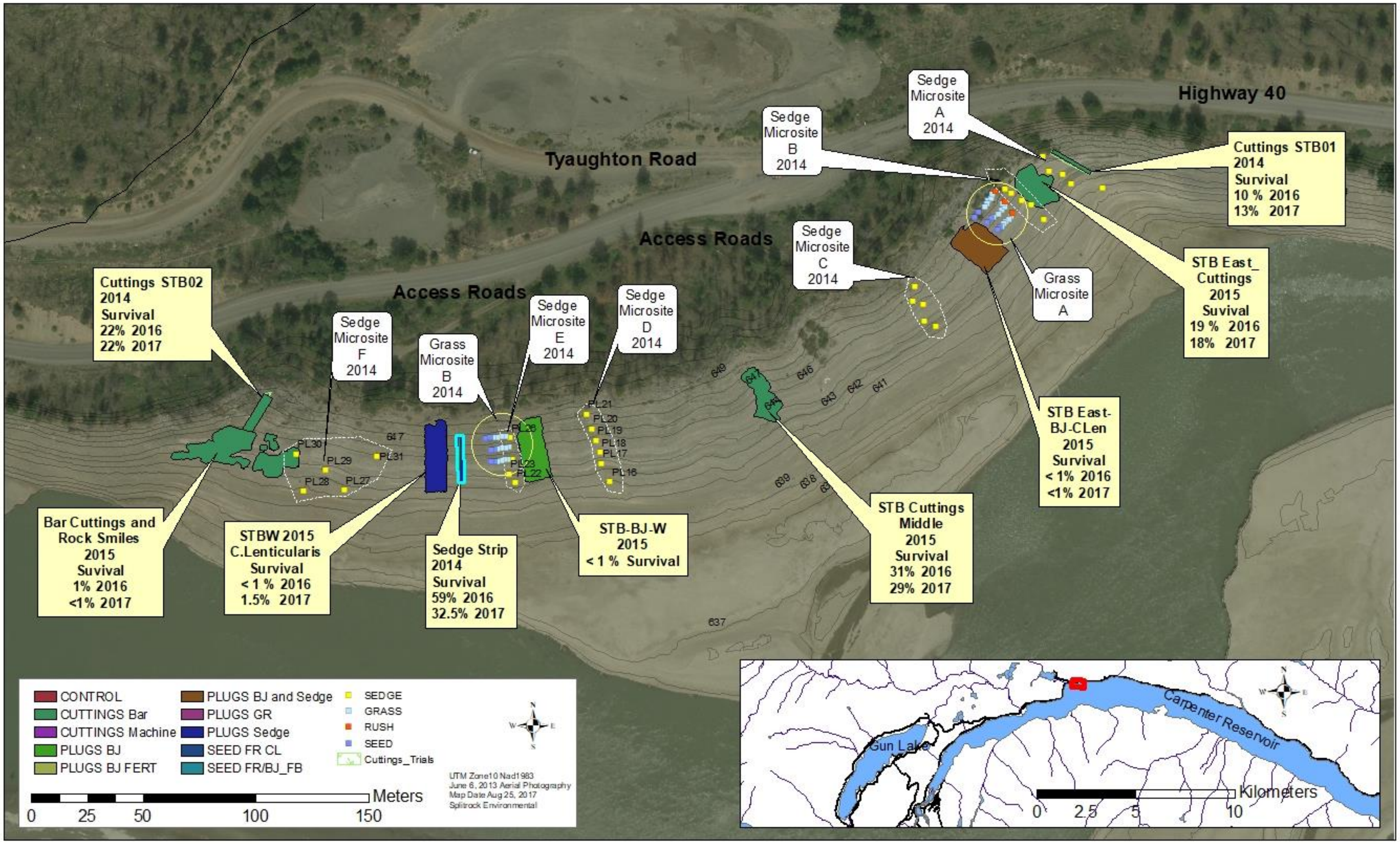


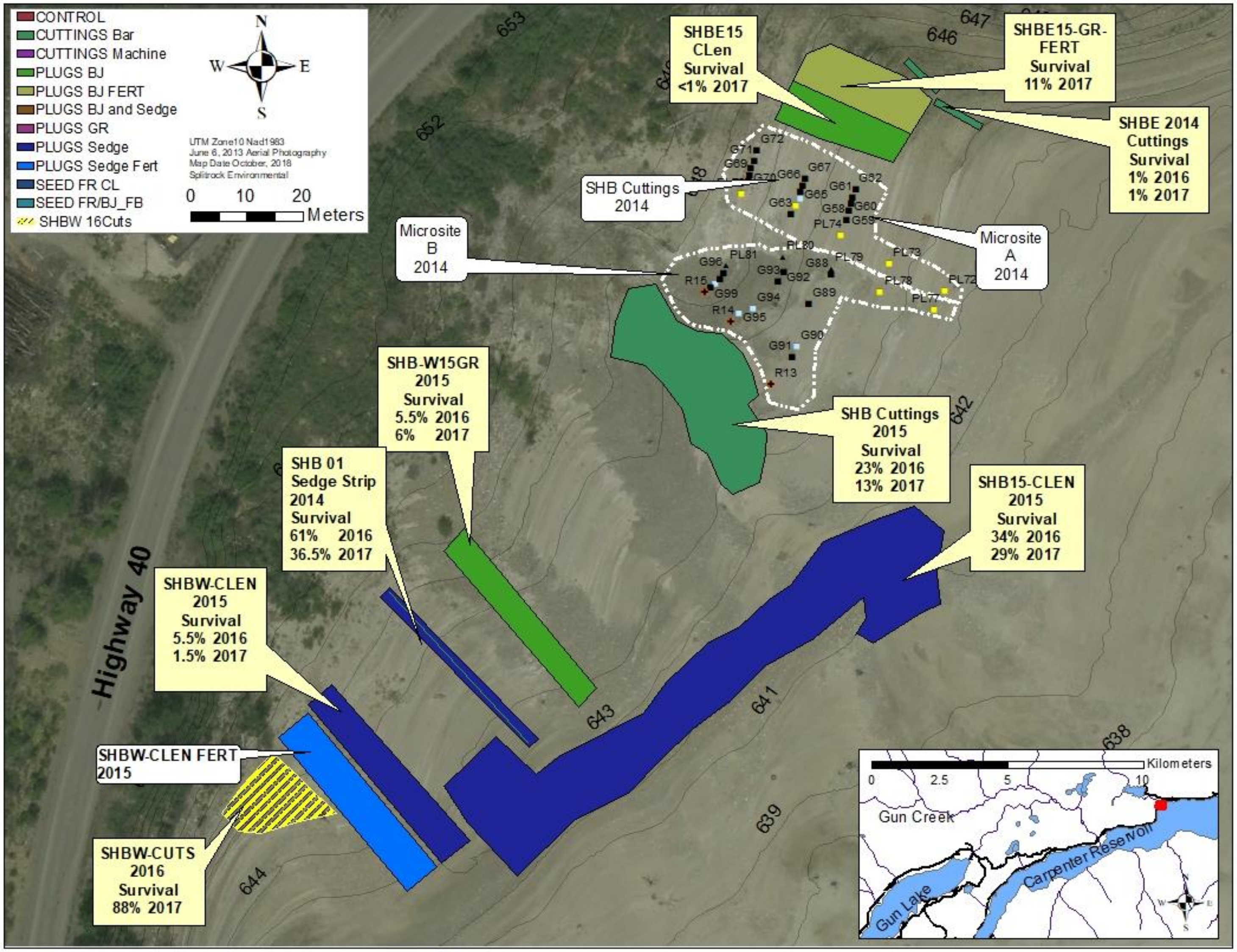
Figure 28. Polygons monitored for survival in 2017 on the Steep Beach (STB) terrain. Yellow text boxes indicate area monitored in 2017.

4.8.2 Shallow Beach (SHB) revegetation polygons

Three polygons of live-stake cuttings have been planted since 2014 at the Shallow Beach terrain (**Error! Reference source not found.**). Survival was highest at the polygon located at the est end and planted in 2016, followed by the centrally located polygon planted in 2015. Survival at the 2015 polygon declined by 10% from 2016. The single surviving live-stake stem from the 2014 plantings observed in 2016 continued to survive in 2017.

Six polygons planted with plugs on SHB terrain were visually monitored in 2017. Two polygons planted with bluejoint reedgrass had low survival similar to 2016, with additional slight declines. The east end polygon that was reportedly disrupted by animal activity in 2016 (see 2016 BRGMON 2 final report Scholz and Gibeau, 2016) still had very low survival. The other three lakeshore sedge polygons showed declines in sedge survival. The 2014 planted sedge strip saw a 50% drop in survival in 2017 from 2016. The polygon planted across the lowest treated elevations (642m) (SHB15-CLEN 2015,) maintained a relatively high rate of surviving plants. Plants in the SHB15-CLEN were observed to be producing seed (Figure 29).

Cuttings trials at the Shallow Beach spanned 3 years (2014 -2016, Map 12). 2014 treatments had only one surviving cutting, the 2015 polygon's survival per cent declined by 10% from 2016 monitoring results. The 2016 planted polygon had high survival post one year since treatment.



Map 12 Polygons monitored for survival in 2017 on the Shallow Beach (SHB) terrain. Yellow text boxes indicate area monitored in 2017.

Figure 29. Mature and seeding plants of lakeshore sedge in Shallow Beach terrain in 2017 (polygon SHB15-CLEN).

4.8.3 Gun Creek Fan East (GCFE) revegetation polygons

Polygons planted with live-stake cuttings in 2014, 2015 and 2016 on the Gun Creek Fan East were monitored for survival in 2017. Overall survival was either similar to or slightly declined from 2016 ranging from 0 to 70% (Figure 30). Live-stake cuttings planted below 644 mASL in 2015 and 2014 had no survival. Many plantings have not survived, treatments located closer to Gun Creek and at higher elevations have had higher survival rates. A majority of surviving cuttings were willow.

Rooted black cottonwood stock was planted into two polygons in 2016 (GCFE_Cots and CT16_stumps), and monitoring in 2017 indicated sapling survival rates of 68% and 88%, respectively (Figure 30). Sixty-three per cent of surviving cottonwoods in polygon CT16_stumps were rated in good or excellent vigor.

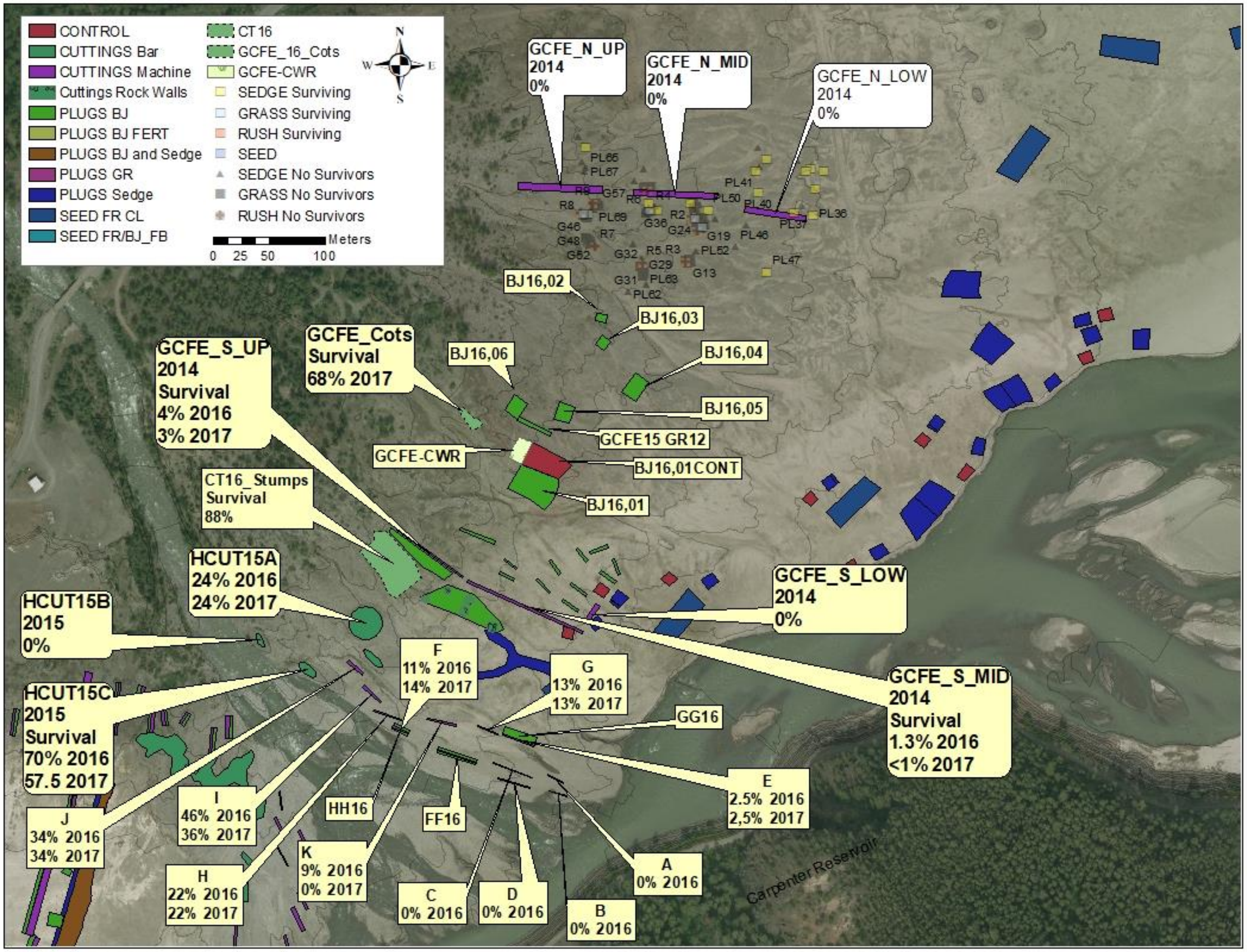


Figure 30. Polygons monitored for survival in 2017 on the Gun Creek Fan East (GCFE) terrain. Yellow text boxes indicate area monitored in 2017.

Three polygons planted with bluejoint reedgrass (HH16, FF16 and GG16) were visually assessed for plant establishment and survival in 2017. Bluejoint plants were establishing well in each of these polygons with vigor good to excellent (Figure 31). Polygons located to the north were also observed to have good survival. Grass planted in polygons BJ1601, BJ1602, BJ1603, and BJ1604 were observed to be surviving well with good vigor. Polygons BJ1605 and BJ1606 were upper elevation polygons planted with bluejoint reedgrass, and plants in those two polygons were struggling (Figure 32). Both polygons had compact coarse substrates with historic rubble from buildings dating to Minto town days.

Figure 31. Example of surviving and vigorous bluejoint reedgrass planted in 2016 in Gun Creek Fan East (polygon FF16).

Figure 32. Small bluejoint planted in 2016 struggling to grow in the coarse compact substrate of polygon BJ16-05 in 2017.

5.0 Discussion

5.1 Hydrograph and climate for the growing season in 2016

The hydrograph in Carpenter Reservoir was abnormal for the 2016 growing season. The low pool elevation achieved in 2016 was well above the 90th percentile for low pool elevations recorded over the past 18 years but was held longer at low pool than most other years, as rising water levels did not begin to impact riparian enhancement treatment areas until July. The low mud flat areas below 642 mASL, where trials of seeding and sedge planting in 2015 and 2016 were situated, were affected by flooding only in late August 2016. Thus, the low mud flat polygons had a relatively extended growing season that would have enabled mature plants to produce and disperse seed. Moreover, the growing season of vegetation at elevations above 642 mASL was not affected by inundation at all in 2016. Therefore, a growing season shortened by inundation was not a factor affecting revegetation trials in 2016. Adversely, plants adapted to inundation and higher moisture levels did not experience the benefits of inundation in 2016.

A slightly lower amount of precipitation fell during the late spring and summer months of 2016 than in other treatment years. However, the number of precipitation events with a reasonable amount of rainfall was the same as in 2015. Soil moisture sampling indicate that by June, vegetation at mid and upper elevations experienced moisture conditions low enough to be classified as dry enough to be 'Damaging stress to most plants'. It is evident that at higher elevations, periodic moisture stress was a key environmental factor during the 2016 growing season. It is likely this was the case on all terrains where precipitation was the predominant source of moisture and the substrate was coarse. We observed a range in soil temperature throughout the day by as much as 5°. A similar variation in soil moisture may be exist, further investigation would be required to determine if soil moisture levels fluctuate enough on a daily basis to affect plant stress levels.

Microsite moisture retention is of greater concern in the upper drawdown zone where soils are coarse and access to surface and ground water is limited to nil. Riparian enhancement trials initiated in 2017 with machine contouring should increase diversity of site moisture retention. South facing slopes will be warmer and drier than north facing slopes. We did not detect a variation in soil moisture with our randomized moisture sampling. It may be worth investigating to what extend the slopes vary the moisture retention by stratifying moisture sampling within slopes and aspects, to determine if there is an optimum planting zone within the micro-topography. It would also help to decide if additional action is required to improve site moisture retention such as mulching or supplemental watering.

5.2 Success of revegetation on Steep Beach terrain (STB)

The monitoring in 2017 of riparian enhancement treatments from 2014-2016 on Steep Beach (STB) terrain indicate low survival with a general decline through time. Most of the losses were experienced in the first season after treatment (See BRGMON 2 findings in Scholz and Gibeau, 2015 and 2016). Treatments from 2014 yielded examples of surviving lakeshore sedge and bluejoint reedgrass plugs with plants of fair vigor. For example, sedge plants were usually short, sparsely leaved, and showing little growth (Figure 33). Without the nutrient inputs typically contributed from decomposition of organic matter in natural ecosystems, there are few organic inputs to support long-term healthy plant growth in the STB terrain. Supplemental fertilization will likely be required on STB terrain to support robust growth among surviving plants.

At the steep beach some of the 2014 *C. lenticularis* planting trials are surviving. There does not appear to be any elevation pattern with survival, plots at low (642 mASL) and upper drawdown elevations (647 mASL) have had high survival. It was obvious again in 2017 that the unconsolidated substrate of the steep beach terrain is a physical factor negatively affecting plant survival. Under flood conditions, the loose substrate and sloping terrain of the steep beach is mobilized by wave and water forces. Such erosion has lead to plugs being extruded from soil and to exposure of plant roots, eventually leading to plants dying. This is likely the cause of the massive losses from the 2015 polygons planted with grass and sedge plugs, as the 2015 plantings were flooded after a short first growing season. On the contrary, the 2014 plantings were not flooded until after two growing seasons, allowing roots to anchor plants and enabling them to withstand better the erosive forces of waves and water.

Figure 33.	Example of planted sedges on STB terrain surviving with fair vigor but showing little growth (plot PL22 at 644 mASL; left in the initial growing season in 2014, right three years later in 2017).

Plantings of live-stake cuttings follow a similar trend at the steep beach terrain, with initial high losses followed by slow declines in survival. The polygon with the best survival and vigor (Figure 35) in planted live-stake cuttings was located centrally on the steep beach between 644m and 648m. Good vigor and growth were also observed among the surviving live-stake cuttings planted in 2014 at the west end of the beach 644m-649m elevation. This polygon had a south west aspect vs a south east aspect held by the other 2014 and 2015 polygons.

For the majority of surviving willow live-stake cuttings, growth was from new sprouts emerging from the base of the stems (Figure 34). Our results suggest that planting cuttings with only a short amount of stem above ground is the best approach in the reservoir environment and the treatments have shifted to this planting technique since 2016 in Carpenter Reservoir (Scholz, 2018).

Personal experience with numerous terrestrial restoration projects in the Lillooet area have shown that supplemental watering is necessary for project success if cuttings are not in very close proximity to water. With adequate maintenance, post-planting survival could likely be increased at the STB terrain. Similarly, improved live-stake cuttings survival might occur if it was possible to implement physical modifications such as rough-and-loose treatments at the steep beach terrain. Results of the future monitoring of live-stake cuttings planted into riparian enhancement polygons in 2017 at the Gun Creek Fan West terrain may help determine if there is a benefit to planting live-stake cuttings within rough-and-loose machine-worked sites in the drawdown zone environment.

Figure 34. Typical form of surviving live-stake cuttings at the steep beach (STB) terrain in 2017.

Monitoring plots and polygons at the East end of the Steep Beach terrain lead to the observation that that there was a fair amount of black cottonwood encroachment (Figure 36). Cottonwoods were spreading from parent trees established above the reservoir buffer zone. It was also notable that white sweet clover cover was high throughout the upper drawdown zone in 2017. It may be beneficial to look for potential restoration sites above the drawdown zone that could be treated with *Populus* species with the potential to spread propagules into the drawdown.

Figure 35. Image showing one of the best examples of surviving live-stake cuttings from the STB terrain in 2017.

Figure 36. Example of sprouting cottonwood in 2015 (left), with prominent establishment among sweet clover (*M. alba*) in 2017 (right) (plot G08 located at 646 mASL at the west end of STB terrain).

5.3 Success of revegetation on Shallow Beach terrain (SHB)

A similar trend in survival was observed at the Shallow Beach (SHB) as at the Steep Beach (STB) terrains, with high initial losses, particularly for the 2015 plantings, followed by a slow decline in survival through to 2017. Sedges planted in 2014 were persisting at the east end and in the linear strips in 2017. As was the case for the Steep Beach terrain, plant form was small in the Shallow Beach terrain, though sedges planted low in the drawdown in 2015 (SHB15-CLEN) (641-642m) were faring well in 2017 (Figure 37). Overall, many of the surviving plants were flowering and producing seed at the time of survey in 2017. It is possible we see soon some recruitment of seedlings from mature planted sedges.

Figure 37. Example of surviving planted lakeshore sedges with seed production at lower elevation in 2017 in shallow beach terrain (SHB15_CLEN).

Three polygons were planted over three years with live-stake cuttings on the SHB terrain. Only one live-stake cutting persists from the 2014 effort. Survival of the live-stake cuttings at the SHB site in 2015 was 42% (Scholz and Gibeau, 2015) but was followed by a drastic decline to 1 only one percent in 2016 (Scholz and Gibeau, 2016). Ice damage and deer rubbing were stressors that likely contributed to the high mortality in 2016. The lone survivor stake continued to persist in 2017.

The pattern of decline seen in the 2014 cuttings (significant declines in both first and second growing season) was not repeated for the 2015 planted cuttings. Live-stake cuttings planted at the SHB terrain in 2015 had a lower first year survival (23%) compared to 2014 cuttings (42%), but the survival of the 2015 live-stake cuttings to the second season was 10% to 15% after two growing seasons, which is higher than the 97% decline observed in the second-year survival of 2014 cuttings. It would appear that the 2015-2016 period was hard on live-stake cuttings possibly due to higher water levels and ice damage.

Live-stake cuttings planted in 2016 at the shallow beach had the highest initial year of growth survival at 88% (Figure 38). Planting of the live-stake cuttings in 2016 differed slightly as live-stakes were cut short after planting. Based on the other year's trials we can expect declines in survival of 2016 cuttings over the next year. It will be interesting to see how survival in 2018 compares with other trials.

Figure 38. Example of survival in 2017 of live-stake cuttings planted in 2016 on the shallow beach (SHB) terrain. The matrix of herbaceous vegetation between live-stake cuttings is predominantly composed of exotic species.

5.4 Success of revegetation on Low Mud Flat terrain (LMF)

Lakeshore sedge plantings on the Low Mud Flat (LMF) terrain had high rates of survival in 2017 from both 2015 and 2016 trials. It seemed evident that polygons located closer to the river and below 642 mASL performed better in both trials. The 2016 plantings grew exceptionally well, though it is unclear what is driving the improved growth. Polygon PLG16-01 (640m elevation, Map 3) had particularly high survival and growth of plants, with biomass 10 times greater than any of the untreated sites within the drawdown zone. Plugs planted at this site were of two age classes (one lot sown 10 months prior to plating, one sown 5 months prior to planting), growth was comparable between both age classes. The plants in this polygon were also observed producing vast amounts of seeds that may yield increased colonization by sedge seedlings in the coming years (Figure 39).

Figure 39. Example of planted lakeshore sedges with seed dispersal at the end of July 2017. Plants had gone dormant under hot dry summer conditions.

Although performing exceptionally well overall, there were two patches within polygon PLG16-01 that were obviously not as productive as surrounding areas (Figure 40). This inconsistent growth between and within polygons needs further investigation and explanation. It would be helpful to the program to conduct chemical and physical sampling of soil conditions within PLG16-01 patches where sedges have performed very well and where growth has been sluggish. Sampling should be extended to other 2016 and 2015 LMF polygons in an attempt to determine if there are obvious factors affecting plant survival and vigor that may be better accounted for through approach to treatments.

Figure 40. Image showing both highly productive growth of lakeshore sedge as well as patches where growth was not so vigorous (PLG01).

It is apparent that the LMF area along the river has high potential for revegetation via planting treatments, but it is also obvious that this zone is subject to extensive erosion from the river (Figure 41). It is possible that there will be some stabilization of the river bank as plants develop, but more likely it may be necessary and desirable to add some form of armour to the river bank in conjunction with plantings. These eroding edges are also notable sources of dust generation.

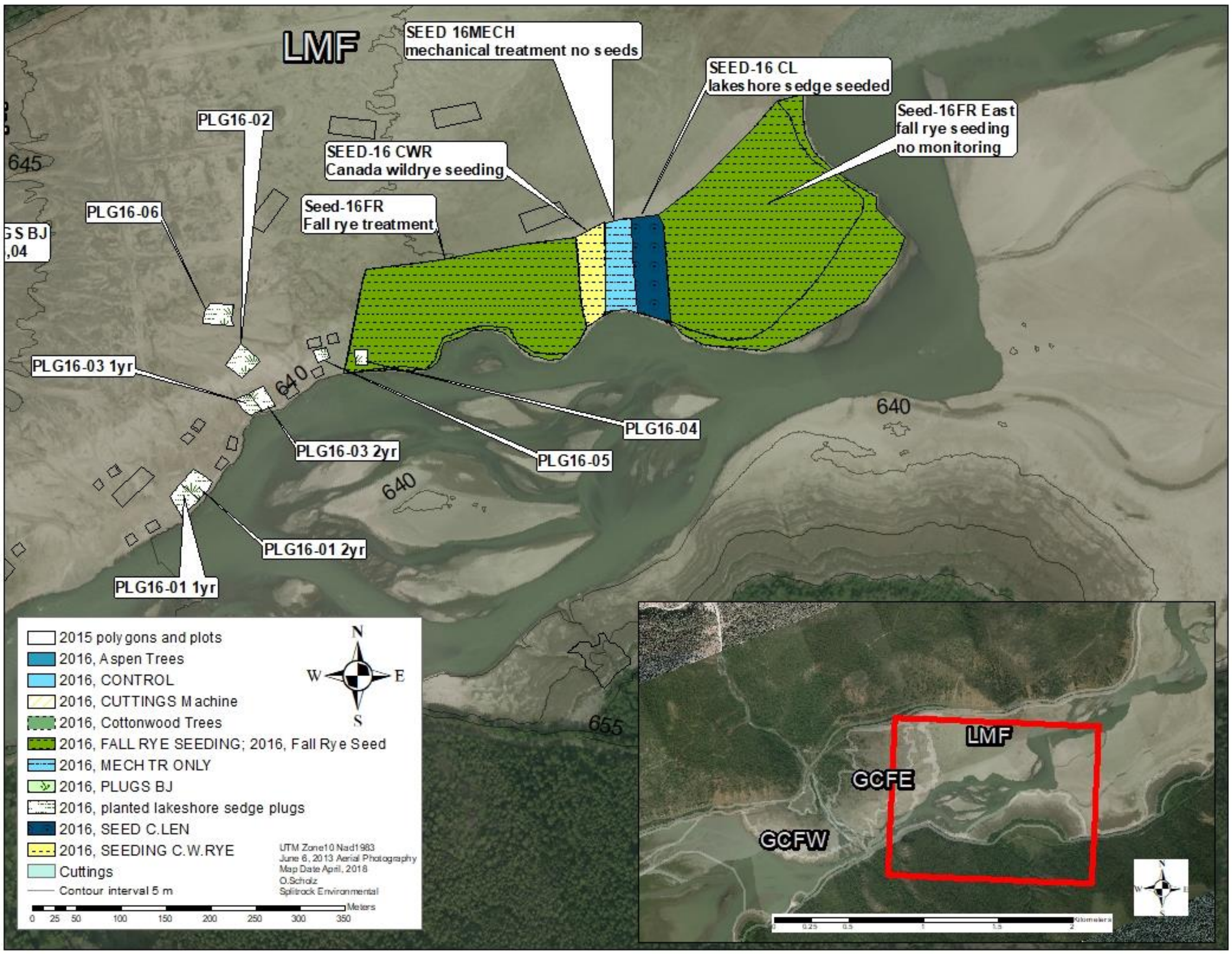
Figure 41. Example of extensive erosion of the drawdown zone along the river bank in 2017 (PLG16-04).

Only one of the five seed trials planted in 2015 was monitored in 2017 and results suggest polygons where seed was planted (either fall rye, lakeshore sedge or a combination) had a higher incidence of lakeshore sedge colonization than controls. Incidentally, the large areas of the LMF seeded with fall rye in 2016 showed in 2017 much higher densities of lakeshore sedge seedlings than neighbouring control polygons. This strongly suggests that seeding fall rye has had a beneficial effect on sedge seedling recruitment. This result may corroborate similar observations from the Upper Arrow Reservoir (Carr et. al., 1994) where it was suggested that the biomass produced by the fall rye was improving conditions for colonization of native species.

It has been suggested that the mechanical disturbance of seeding may be what is needed to recruit seedlings (A. Moodie, personal communication). Comparative treatment polygons were in place to test this part of the hypothesis and we found similar seedling density in the lakeshore sedge seeded, Canada wildrye seeded and mechanical treatment only polygons. Only the fall rye seeded polygon showed significant increase in recruited sedge seedlings. All four areas had the same mechanical disturbance from the tractor seeder. The main difference in treatments was that fall rye grew across the seeded area where the other polygons did not produce any additional growth apart from the pervasive suite of exotic annuals.

It is possible that we are detecting a broader scale affect in the fall rye plot location that is affecting seedling recruitment. It could be that the fall rye seeding area is directly on the edge of a transition zone where there is an increase in recruitment of native vegetation moving from east to west. This trend is apparent at the small scale as the mud flats west of the Gun Creek Fan have significant vegetation cover largely by perennial native species (Scholz and Gibeau, 2014). There is a higher density of native species along the edge of the Bridge River east of the confluence with Gun Creek but this quickly peters out towards the treatment polygons. It is possible that the Fall rye area planted in 2016 marks the edge of this zone of natural recruitment.

To verify this hypothesis, sampling in the east side fall rye seeding area (Seed16-FR East, Map 3) should be repeated with additional sampling within the fall rye seeded polygon located east of the control polygons (



Map 3). This west side area was not sampled in 2017. Future sampling should emphasize identifying lakeshore sedge seedling recruitment and in particular look for successful establishment of plants older than one year of age. If it appears there is a connection between fall

rye seeding and lakeshore sedge recruitment it is recommend that fall rye seeding trials be expanded into untreated areas

5.5 Success of revegetation on Gun Creek Fan East terrain (GCFE)

The Gun Creek Fan East (GCFE) has been the focus of numerous treatments over the years, and planting trials in the mid and upper elevations employing native grasses were visually monitored in 2017. Bluejoint reedgrass, foxtail barley plugs, and Canada wildrye have all been planted in polygons around the east side of the fan. Bluejoint was performing well in 2017 at a number of polygons, and particularly close to the banks of Gun Creek. If the planted stands of bluejoint persist along the banks of Gun Creek they will enhance the habitat and should reduce some of the dust that is generated from this area. Foxtail barley is surviving well where it has been planted although the biomass generated is small relative to bluejoint. Canada wildrye plants are surviving and appear to grow similarly to bluejoint. Canada wildrye appears to be a good species to continue trials within the upper drawdown area. Monitoring the CWR polygon for recruitment from self-seedling is recommended. Success would be marked if planted plants are observed to be successfully reproducing from seed. We have already observed seed production from planted plugs in PLG16-01 (Map 3).

The upper drawdown zone near Gun Creek appears to have a high potential for successfully supporting live-stake cuttings. Hand-planted live-stake cuttings were surviving well although growth was sparse in 2017 (Figure 42). It is recommended that live-cutting cuttings trials include Coyote willow (*Salix exigua*) in future. S.*exigua* is a strongly rhizomatous species of willow that may be suitable for trials along the Gun Creek Fan, particularly close to Gun Creek on the east side.

Figure 42. Example of hand-planted willow cuttings surviving through their second growing season in 2017 (HCUT15).

Initial survival rates of planted black cottonwood suggest that rooted saplings of black cottonwoods can, in the short term, perform well in the upper drawdown zone, and likely better than live-stake cuttings of cottonwoods which have performed poorly.

Monitoring in 2017 on the Gun Creek Fan West (GCFW) was limited to the 2017 riparian enhancement polygons to collect baseline information. Success of revegetation at other planting polygons and live-stake cuttings sites will need to be monitored in 2018.

5.6 Status of the Management Questions

The overarching management question for component 2 of the BRGMON-2 monitoring program is: does the implementation of a short-term (seven year) intensive riparian enhancement program expand the quality (as measured by diversity, distribution and vigour) and quantity (as measured by cover, abundance and biomass) of riparian habitats in the drawdown zone of Carpenter Reservoir?

Several types of treatments are showing some success under the BRGWORKS-1-1 program are. Monitoring observations to date indicate that the fall rye seeding treatment has increased colonization by lakeshore sedge on the Low Mud Flat. It is unknown whether the observed sedge seedlings will survive to establish and grow into mature productive plants. Lakeshore sedge plantings have produced mature plants at a number of polygons. These plants have been observed self-seeding, and it is possible that these stands may increase in density and spread spatially going forward. Evidence of germination success will be monitored in the self-seeding areas. Bluejoint reedgrass plantings are establishing well in some polygons and have been observed spreading via rhizomes which is increasing native plant cover. Several cuttings sites have survived multiple growing seasons and may yet produce productive habitat and reproductive plants.

H3A: There is no significant difference in native vegetation establishment (based on species distribution, diversity, vigour, biomass and abundance) at control versus treatment locations.

The introduction of native plants in treatment polygons directly affects species diversity in a positive way by adding the introduced native plant species to the treatment sites. No other effect on species diversity is apparent from treatment thus far. The majority of naturally colonizing vegetation species observed in control sites were exotic, annual species. The occurrence and distribution of these annuals is fairly consistent throughout much of the drawdown zone, particularly in the low mud flat terrain. Seed produced by mature planted plants in treatment locations may increase diversity, density, distribution and abundance of the planted native species in and around treatment polygons adding diversity when compared with the control locations. Biomass measurement samples were somewhat limited in scope but it is apparent that planting of lakeshore sedge plugs in treatment sites has the potential for increasing biomass 10-fold (as suggested by 2016 results) vs control locations. The same could be said for bluejoint reedgrass. The observed variation in survival, growth and vigour of planted plants in treatment locations warrants further site-specific investigation to isolate possible site-specific factors that are controlling success.

H3B: There is no significant difference in the cover of native vegetation in control versus treatment locations.

For many treatment sites, vegetation resulting from planting and seeding is not producing a significant amount of native vegetation cover yet when compared with control areas. However, results vary from treatment to treatment and site to site. In the Low Mud Flat, we see a dramatic increase in native species cover with dense planting treatments. Likewise, certain areas planted with bluejoint reedgrass show a dramatic increase in native species cover relative to control sites.

H3C: There is no significant difference in native vegetation establishment and the cover of native vegetation communities (based on species distribution, diversity, vigour, biomass and abundance) arising from different revegetation prescriptions.

We have observed significant differences in cover with different treatments at different sites. Planting native species may have an effect on native vegetation establishment, at least within the relatively short period of this monitoring program.

H3D: There is no significant difference in the species composition of naturally re-colonizing vegetation in treated versus control areas.

Species composition of naturally re-colonizing vegetation in treatment and control areas at present does not seem to vary significantly. The only indication thus far of increased colonization has been observed in fall rye seeding trials that appear beneficial to increasing recruitment of lakeshore sedge. We did not see a similar trend in control sites and conclude that seedling recruitment densities seem to have benefitted from seeding and growth of fall rye perhaps due to it functioning as a nurse crop.

6. Recommendations

The following recommendations are intended to inform future monitoring efforts for BRGMON-2 as well as to increase treatment effectiveness of the BRGWORKS-1physical program.

BRGMON-2 Monitoring

- Stratify the monitoring on machine-contoured polygons by aspect and microsite (i.e. South-facing mid slope and north-facing mid slope, upper slope and lower slope) to look for variation in soil moisture retention and soil temperatures. This may influence where to focus additional seeding and planting efforts within the machined areas.
- Keep monitoring the survival of live-stake cuttings, particularly on the west end of the shallow beach terrain (SHB), to determine if the observed trend of decreasing survival continues or if survival was improved by cutting stems shores.
- Monitor the treatments of live-stake cuttings and plantings that were missed in 2017 on the Gun Creek Fan West due to time constraints.
- Monitor successful plantings in PLG01 to determine if sedge seedling recruitment has occurred from self-seeding by planted C. lenticularis plugs.
- Sample soils within PLG01 stratifying areas where plants have grown exceptionally well vs patches of moderate growth. Apply this stratification to other treatment polygons and conduct similar sampling. Look at:
  - Soil depth, compaction, texture, drainage.

    - Sample across patches and polygons with homogenous growth and have soils analyzed for fertility.
- Sample in the east end of the fall rye seeded polygon on the Low Mud Flat to determine if sedge seedling recruitment is higher at this site and to look for establishment post colonization.
- Monitor Canada wildrye for seed dispersal and seedling recruitment.
- Monitor machine-treated polygons for survival and recruitment of seedlings.

BRGWORKS-1 treatment efforts

- Consider adding rock to the eroding river banks around PLG01, PLG03, PLG04.
- Consider expanding the fall rye treatment to other previously untreated sections of the low mud flat.
- Expand C. lenticularis plantings on the Low Mud Flat.
- Plant more patches of bluejoint reedgrass around Gun Creek.
- Experiment with fertilizing around surviving live-stake cuttings, e.g. by seeding native legumes, such as *Lotus denticulatus* found growing in the drawdown adding fertilizer, and/or perhaps adding mulches higher in the drawdown zone where the probability of flooding is lower.
- Experiment with planting *Ponderosa pine* in the buffer zone (648 – 651 mASL).
- Experiment with planting live-stakes of *Salix exigua*, particularly along Gun Creek.
- Assess the fringe of the reservoir throughout the treatment area for possible sites located above reservoir full pool where black cottonwood or trembling aspen S*alix exigua* may grow and could in future spread into the drawdown zone via suckering. Gun Creek fan West may have the most appropriate sites for trials.

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