Monitoring the Effectiveness of Riparian Planting Along the Upper Bulkley River

Prepared by LM Forest Resource Solutions Ltd. on behalf of Northwest Research and Monitoring, 2021

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Introduction And Context

According to the Upper Bulkley and Morice Water and Salmon Sustainability Views report released in 2019 by the Bulkley Valley Research Center, "*The Upper Bulkley Basin hosts a number of significant salmon populations, and is an important basin in terms of providing high quality fish habitat to many aquatic species. The effects of human caused alteration has been extensively recorded along the Upper Bulkley River; changes to channel morphology, water temperature, and flow rates are only among a few of the challenges associated with development activities throughout the basin*".[1]

In effort to ameliorate riparian vegetation, and reduce streambank erosion on the Upper Bulkley River, willow (*Salix Spp.*) cuttings were planted on four private land parcels along the banks of the river at four sites (Figure 1) owned by two different landowners (Strimbold and Groot). The sites ranged in size from 400 m^2 to 1400 m^2. Planting spots were prepared using a Waterjet Stinger, based on documentation from the United States Department of Agriculture on planting dormant unrooted cuttings of willows, cottonwoods, dogwoods, and other species[2]. Northwest Research and Monitoring built their own waterjets using a range of lengths to match the unique conditions found at each site.

Cuttings for planting were sourced locally by cutting stakes from naturally occurring willow in the surrounding area. Planting was completed by Whanau Forestry between May 5th and June 4th, 2021prior to the record setting high temperatures experienced in late June. In general, cuttings were planted at a depth of 1.0 to 2.0 m, and the above-ground stem length varied from 0.3 m to 1.7 m. The goal was to plant just below the base flow level of the river, however, there were situations where dense substrate or coarse gravels prevented the waterjet from reaching target depths and so some planting was shallower. Planting espacement averaged 1m but was variable with as little as 30 cm between stems in some instances. Prior to planting, a few sections at Sites 1 and 2 were also mulched with grass to reduce the effects of vegetation competition.

This paper summarizes the results of a monitoring project to evaluate the success of this riparian planting project. Planted willows were evaluated in terms of survival, condition, and growth, as well as root egress and root development. It is expected that the root development on willow cuttings with good vigour will penetrate the soil more deeply and more quickly than other types of riparian vegetation (shrubs and grasses), resulting in better stream bank stability.

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[1] Sharpe I.D. Upper Bulkley and Morice Water and Salmon Sustainability Views: Inventory of Interests, Activities and Potential Collaborative Opportunities Among 36 Organizations: http://bvcentre.ca/library.

[2] J. C. Hoag. 2001. Waterjet Stinger: A tool to plant dormant unrooted cuttings of willows, cottonwoods, dogwoods, and other species. USDA. Riparian/Wetland Project information series No. 17: idpmcarwproj17.pdf (usda.gov)

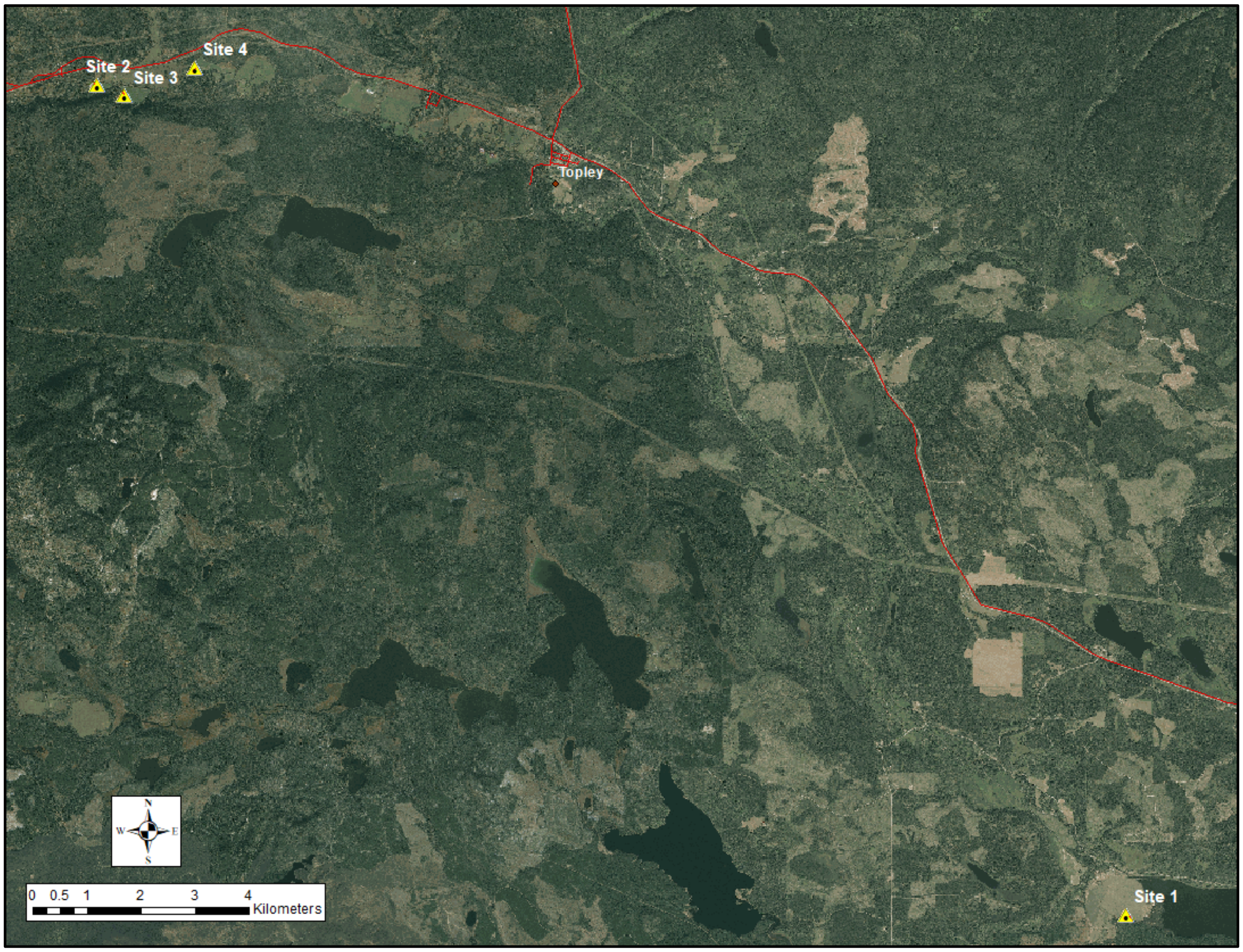


Figure 1: Location of the study sites in relation to Highway 16 and Topley, BC. All sites were located adjacent to the Upper Bulkley River, on private agricultural land.

Methodology

Phase 1: Image Acquisition

At each of the four riparian planting sites, a DJI Mavic Mini drone was used to capture high resolution (1.5 cm pixel) digital imagery at an above ground altitude of between 30 and 40m. Both oblique and nadir images were captured, ensuring that both the planting area and the stream bank area were captured in detail (Figures 2 and 3). Once imagery was obtained, images were processed using Agisoft Metashape Pro to create detailed, georeferenced orthomosaics. These orthomosaics will be helpful for long term monitoring because they will provide a visual reference and baseline for how riparian vegetation (species, height, percent cover) and streambank erosion are changing over time.

Figure 2: An example of an oblique image, taken at Site 3.

Figure 3: An example of a nadir image, taken at Site 4. The logs protruding from the streambanks installed in an earlier streambank stability project.

Phase 2: Data Collection and Monitoring

Once the orthomosaics for all four sites were completed, five monitoring transects were identified for each site using ESRI ArcGIS mapping software. These transects run perpendicular to the stream and were approximately 6 m long, on average. Transects were evenly spaced throughout the planting area. A planting area polygon was also digitized using ArcGIS to determine the actual size of the planting area, and to establish a permanent record of where planting occurred (Figure 4). In the field, at sites 1, 2, and 3, a metal stake (1.2 inch diameter aluminum tubing) was also hammered into the ground at the beginning of each transect to permanently mark the location of each transect line. At site four "pigtails" were used rather than aluminum tubing.

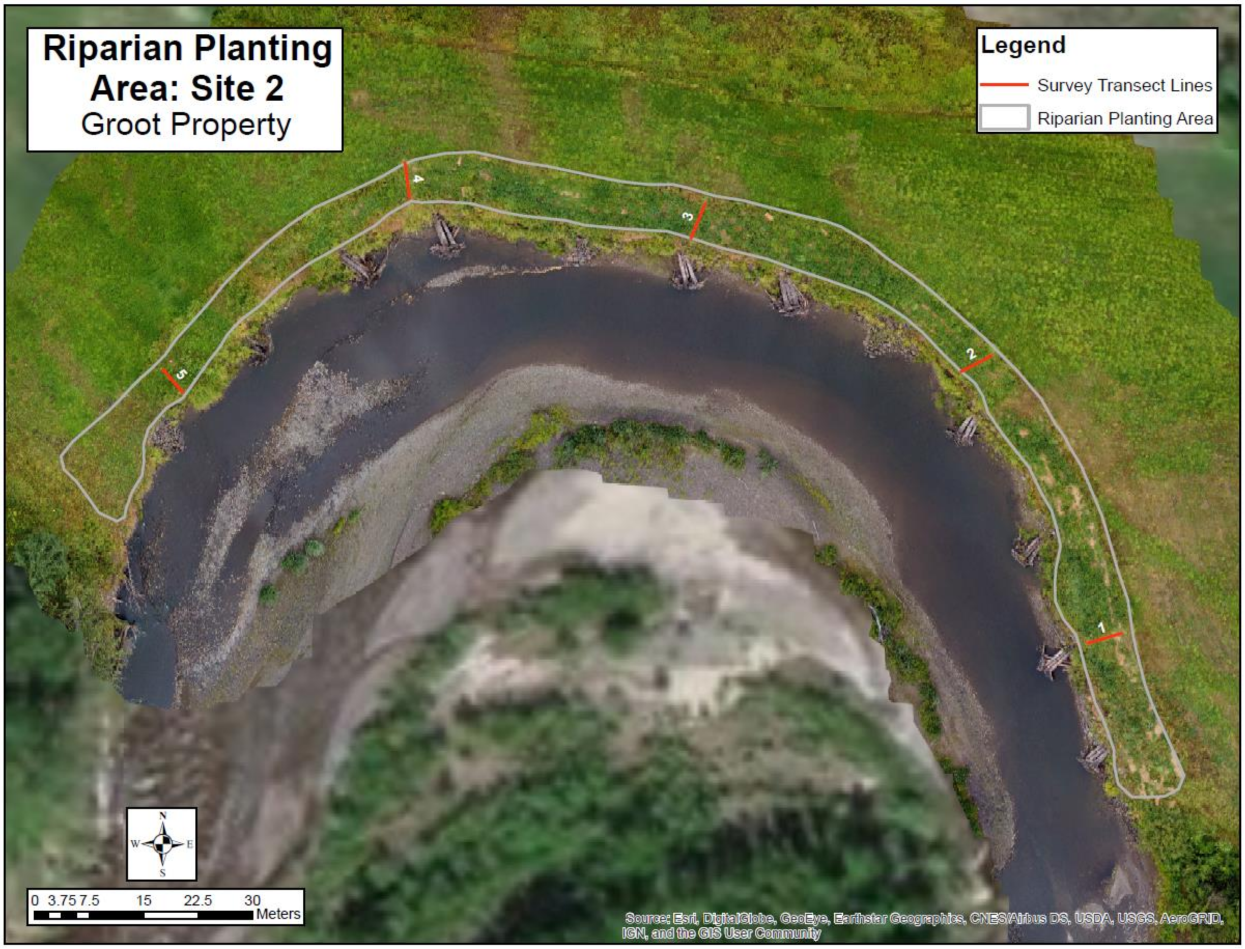


Figure 4: An example of a georeferenced orthomosaic for Site 2, showing the transect locations (red lines), the digitized planting area (grey polygon), and logs that were inserted perpendicular to the streambank as part of an earlier streambank stabilization project.

At each of the sampling transects, the following data was collected for each stem that fell within 50 cm of the pre-established transect line:

- Species of planted stem.
- Condition of stem (good, fair, poor, moribund, dead, or missing).
- Total height (cm).
- Diameter of the base of the stem at ground level (mm).
- Average sprout/leader length (cm).
- Comments on any treatments within the planting area (mulching or brushing).
- Measurements on competing vegetation within a 50 cm radius of the tree, including:
    - Height (cm).
    - % Cover.
    - Species.

In addition to the above ground measurements, an attempt was made to examine the below ground portion of at least one stem adjacent to each transect to measure root egress (% of the stem where roots had begun to grow) and average root length (cm). These stems were examined by pulling the cuttings out of the ground, and replacing them back into the same hole once root egress levels were measured and assessed. A “Tug Test” was also preformed on every stem in each transect at each of the four sites, to determine how firmly each stem was rooted in the ground.

In order to gain a better understanding of how well roots were growing laterally into the soil, two stems at Site 1 were partially excavated to provide a side view of the rooting system with the cutting still in the ground. The objective was to check whether roots were growing around the stem itself in the hole created by the waterjet, or growing laterally into the soil – the latter being crucial for achieving stream bank stability.

Post-planting measurements of survival, stem vigour, growth, and root egress were completed at all four sites in early September and in mid-October.

Results

Site 1

Site 1 (Strimbold property) was the only site where 100% of the planting was with Salix species, and was the only site that was fenced off and excluded from the impacts of cattle. This site also had the highest survival rates (only 3% mortality), the largest average root egress, and the highest proportion of stems firmly rooted in the ground - 80% (Table 1).

Table 1: Monitoring data for Site 1.

Site 1			
September		**October**	
Number of Trees	30	Number of Trees	30
% Good	53	% Good	53
% Fair	30	% Fair	30
% Poor	3	% Poor	0
% Moribund	10	% Moribund	13
% Dead	3	% Dead	3
% Missing	0	% Missing	0
% Of Surveyed Cuttings That Was Salix	100%		
Area Surveyed (m^2)	42	Area (m^2)	42
Total Planting Area (m^2)	982	Total Planting Area (m^2)	982
Total Live Stems Per Site	678	Total Live Stems Per Site	678
Total Dead Stems Per Site	23	Total Dead Stems Per Site	23
Average Height (cm)	107.6	Average Height (cm)	108.7
Average Diameter (mm)	18.8	Average Diameter (mm)	18.8
Average Sprout/Leader Length (cm)	22.1	Average Sprout/Leader Length (cm)	22.7
Tug Test (% of roots firmly in ground)	n/a	Tug Test (% of roots firmly in ground)	80
Average Root Egress (cm)	6.2	Average Root Egress (cm)	5.8

Competition from other vegetation at this site was moderate (85% cover, 83 cm tall on average) and included: grass, horsetail, clover, thimbleberry, and fireweed. Neither growth rates nor survival seemed to be significantly affected by mulching with average survival and height in areas that were treated of 97% and 106 cm respectively, versus average survival and height in areas that were not treated of 100% and 112 cm respectively.

Root egress at this site was good, with average root egress of excavated stems measuring at 5.8 cm. 80% of cuttings were also firmly placed in the ground. Some examples of root growth can be seen in Figures 5 and 6.

Figure 5: An example of good shoot growth one growing season after planting at Site 1 (photo taken in September).

Figure 6: An example showing good lateral root growth at Site 1 (photo taken in September).

Site 2:

Site 2 (Groot property) was planted with a species mix of Salix species (87%) and *Populus trichocarpa* (Black Cottonwood, Act, 13%). This site experienced moderate rates of mortality across all transect lines (17% mortality in September, and 23% mortality in October cumulatively) (Table 2). Of the 4 sites, Site 2 had the fewest firmly rooted stems (60%).

Table 2: Monitoring data for Site 2.

Site 2			
September		**October**	
Number of Trees	30	Number of Trees	30
% Good	53	% Good	50
% Fair	10	% Fair	17
% Poor	17	% Poor	3
% Moribund	3	% Moribund	7
% Dead	17	% Dead	23
% Missing	0	% Missing	0
Proportion of Salix That Were Surveyed	87%		
Proportion of Act That Were Surveyed	13%		

Area Surveyed (m^2)	25	Area (m^2)	25
Total Planting Area (m^2)	1422	Total Planting Area (m^2)	1422
Total Live Stems Per Site	1422	Total Live Stems Per Site	1308
Total Dead Stems Per Site	284	Total Dead Stems Per Site	398
Average Height (cm)	68.8	Average Height (cm)	69.8
Average Diameter (mm)	19.0	Average Diameter (mm)	20.0
Average Sprout/Leader Length (cm)	37.7	Average Sprout/Leader Length (cm)	38.0
Tug Test (% of roots firmly in ground)	n/a	Tug Test (% of roots firmly in ground)	60
Average Root Egress (cm)	3.8	Average Root Egress (cm)	4

Competition from other vegetation at this site was moderate (83% cover, 61 cm tall on average) and included: grass, yarrow, clover, and thistle. Neither growth rates nor survival seemed to be significantly affected by mulching with average survival and height in areas that were treated of 92% and 61 cm respectively, versus average survival and height in areas that were not treated of 88% and 71 cm respectively.

Root egress at this site was good, with average root egress of excavated stems measuring at 4.0 cm. 60% of cuttings were also firmly placed in the ground. An example of root egress and growth characteristics for one of the willow stems is shown in Figure 7.

Figure 7: An example of a willow displaying good shoot growth and good lateral root development at Site 2 after one growing season (photo taken in September).

Site 3:

Site 3 (the Groot property) was also planted with a species mix including Salix species (48%), *Populus trichocarpa* (Black Cottonwood, Act, 24%), *Picea glauca* (white spruce, Sw, 24%) and *Larix occidentalis* (Western larch, Lw, 4%). This site experienced the highest mortality rates of the 4 sites (41% in September, and 45% in October, cumulatively) (Table 3). One reason for the high rates of mortality observed here may be the relatively stony soils at this site. It is possible that cuttings were not able to penetrate deep enough into the ground here to compensate for the high temperatures and drought conditions experienced in the summer. This site was also planted later than Sites 1 and 2 (early June as opposed to early-mid May), and it is possible that these stems did not have enough time to become well established before the heat dome occurred in late June. Cuttings that were planted earlier would have had more time to develop an effective root system compared to cuttings planted at a later date.

Table 3: Monitoring Data for Site 3.

Site 3			
September		**October**	
Number of Trees	29	Number of Trees	29
% Good	31	% Good	31
% Fair	10	% Fair	7
% Poor	17	% Poor	10
% Moribund	0	% Moribund	7
% Dead	41	% Dead	45
% Missing	0	% Missing	0
Proportion of Salix That Were Surveyed	48%		
Proportion of Act That Were Surveyed	24%		
Proportion of Sw That Were Surveyed	24%		
Proportion of Lw That Were Surveyed	4%		
Area Surveyed (m^2)	27	Area (m^2)	27
Total Planting Area (m^2)	571	Total Planting Area (m^2)	571
Total Live Stems Per Site	360	Total Live Stems Per Site	338
Total Dead Stems Per Site	254	Total Dead Stems Per Site	275
Average Height (cm)	64.7	Average Height (cm)	65.6
Average Diameter (mm)	14.6	Average Diameter (mm)	14.7
Average Sprout/Leader Length (cm)	32.7	Average Sprout/Leader Length (cm)	33.9
Tug Test (% of roots firmly in ground)	n/a	Tug Test (% of roots firmly in ground)	64%
Average Root Egress (cm)	2.3	Average Root Egress (cm)	2.5

There was no brushing or mulching applied to this site. Root egress was also comparatively low at this site, compared to the other 3 sites (average root egress here was only 2.5 cm, compared to 5.8 cm at Site 1, 4.0 cm at Site 2, and 3.0 cm at Site 4). Figures 8 and 9 show examples of a dead stem, and a stem with low root egress.

Figure 8: An example of a dead willow stem found at Site 3 in October.

Figure 9: An example of a stem with poor root egress found at Site 3 in October.

<u>Site 4:</u>

Site 4 (the Groot property) was planted predominantly with Picea glauca (White spruce, Sw, 60%), followed by Salix species (35%), and Larix occidentalis (Western larch, Lw, 5%) (Table 4). Planted trees here displayed the second highest mortality rates here of the four sites (30% in September, and 30% in October, cumulatively).

Table 4: Monitoring data for Site 4

Site 4			
September		**October**	
Number of Trees	20	Number of Trees	16
% Good	50	% Good	40
% Fair	10	% Fair	5
% Poor	10	% Poor	5
% Moribund	0	% Moribund	0
% Dead	30	% Dead	30
% Missing	0	% Missing	20
Proportion of Salix That Was Surveyed	35%	Proportion of Salix That Was Surveyed	44%
Proportion of Sw That Was Surveyed	60%	Proportion of Sw That Was Surveyed	50%
Proportion of Lw That Was Surveyed	5%	Proportion of Lw That Was Surveyed	6%
Area Surveyed (m^2)	30	Area (m^2)	30

Total Planting Area (m^2)	420	Total Planting Area (m^2)	420
Total Live Stems Per Site	196	Total Live Stems Per Site	140
Total Dead Stems Per Site	84	Total Dead Stems Per Site	84
Average Height (cm)	57.7	Average Height (cm)	64.0
Average Diameter (mm)	12.3	Average Diameter (mm)	15.6
Average Sprout/Leader Length (cm)	14.2	Average Sprout/Leader Length (cm)	21.7
Tug Test (% of roots firmly in ground)	n/a	Tug Test (% of roots firmly in ground)	78%
Average Root Egress (cm)	2.7	Average Root Egress (cm)	3

Cattle grazing was observed at this site – between the surveys completed in September and October, four surveyed trees were ripped out of the ground (all Sw stems) by cattle. Evidence of grazing was also noticed at this site, but not at any of the other 3 sites. This site was brushed in late August, immediately prior to when the monitoring surveys began, and the treatment would not have impacted growth and survival in the current year. Treatment at this time of year could influence the amount of snow press that occurs in the winter however. Figure 10 shows an example of a stem with average root egress at this site.

Figure 10: An example of a willow cutting showing average root egress at Site 4 in September.

Graphs summarizing survival classes, height measurements, and diameter measurements for each site in both September and October can be found in Appendix I.

Conclusions and Recommendations

The following section includes some recommendations on trial maintenance and future monitoring protocols, as well as overall conclusions from the first year of monitoring.

Trial Maintenance:

Sites 3 and 4 displayed the highest mortality rates of the four sites that were surveyed. If funding permits, these sites should be replanted next spring to account for the mortality that occurred in the 2021 growing season. Species selection should be limited to Salix and Act, because survival and growth of conifers was relatively poor (possibly because of competing vegetation and much shallower rooting within the soil profile during the drought). One possible way to mitigate replanting costs would be to remove dead stems and use the same locations to plant new cuttings in the same residual holes. Cuttings should be inserted as deep as possible. Also, consider using whips instead of cuttings as whips will maintain the terminal bud at the top of the tree, which may result in improved early shoot growth.

In order to eliminate the effects of cattle grazing on these riparian planting sites, it may be beneficial to install an exclosure around the planting area at Sites 2, 3, and 4. There was evidence that cattle were ripping conifer stems out of the ground at Site 4, and it is expected that this will not be an isolated incident given that these sites are located on active, working farms.

In terms of applying treatments such as brushing or mulching to sites, it is recommended that brushing be completed on sites with tall grass before the middle of June next year. Although brushing/mulching did not yet appear to have a significant impact on the survival of the cuttings:

a) snow and vegetation press this winter may have a significant impact on survival next spring, and
b) brushing sites will make the monitoring process significantly more streamlined and efficient, allowing surveyors to find and assess stem condition quickly and effectively.

Future Monitoring:

Surveys should be completed once in the spring after bud break to assess winter mortality rates, and then once again at the end of the growing season to record how stems persisted throughout the summer (likely near the end of September) using the same methodology described in this report. Surveys do not need to be completed on a month-by-month basis, unless flooding, cattle damage, or drought create a need to collect more cuttings for replanting in the same year. Such a need could be identified during a periodic walk through of the site (as opposed to a formal survey). When assessing root egress during future surveys, be sure not to excavate stems that are located within the survey transect as it excavating stems could affect site statistics.

Conclusions

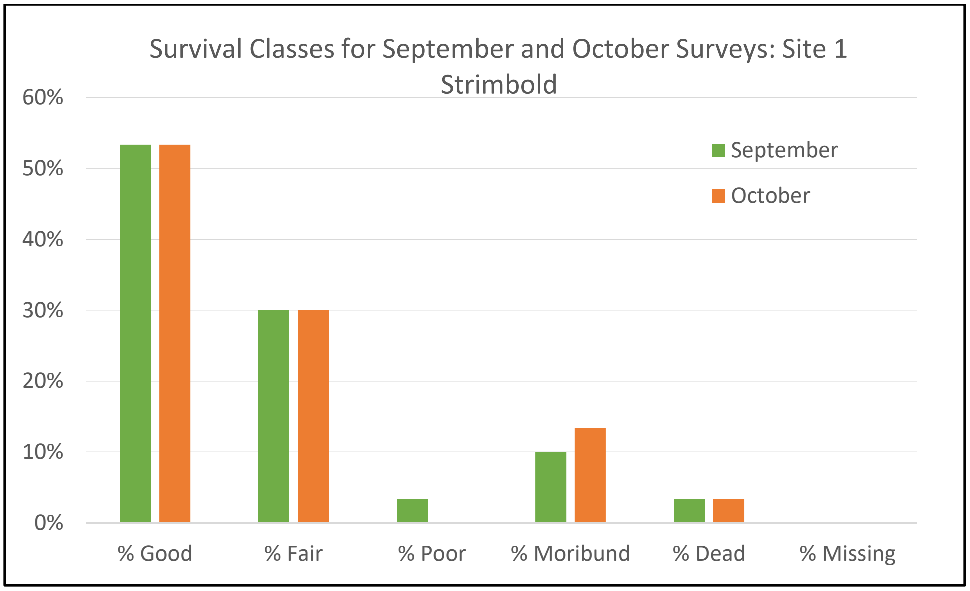
It is too early to tell weather the trial will achieve the streambank stability objectives set out in the beginning of this report. Although survival, growth rates, and lateral root egress levels were reasonable in most cases, they will not yet have had much impact on streambank stabilization. At the current rate of root extension, it will be many years before the desired affect is achieved. Other observations of note included that:

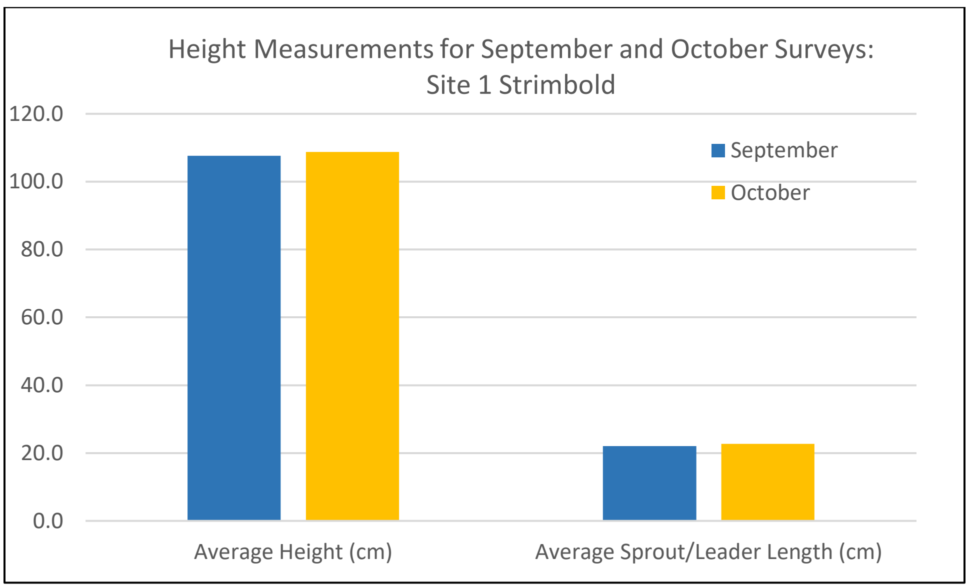
- The planting methodology was reasonable in terms of meeting project objectives, however in the future, it may be beneficial to fill plant Sites 3 and 4 to account for the higher levels of mortality, and to use whips instead of cuttings to encourage better growth rates.

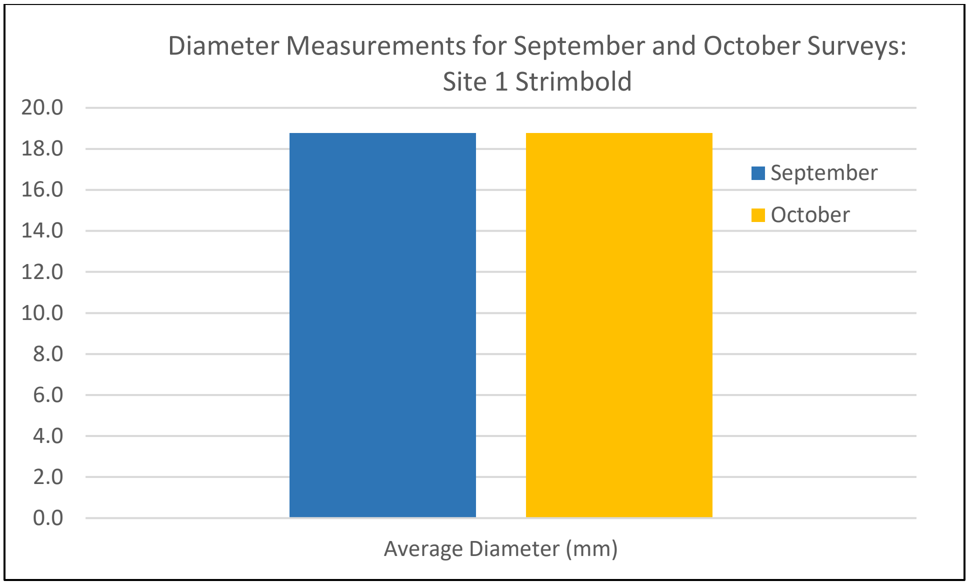
- The primary factors affecting the survival of the cuttings include the significant heat dome that occurred in late June (likely causing drought conditions and vapour pressure deficits affecting stems throughout all four sites), rooting depth (especially in regards to conifers on Sites 3 and 4), planting depth/quality in areas with rocky soils or other barriers to planting, and cattle grazing. Late planting timing, in conjunction with the drought, may have also impacted survival rates at Sites 3 and 4.
- Survival rates for Sites 1 and 2 were sufficient to meet project objectives. Survival rates for Sites 3 and 4 may necessitate additional fill planting to account for the mortality experienced over the summer.
- Brushing and mulching did not yet have a significant effect on the survival, growth, or root egress of stems as any of the four sites but this may change after winter snow press. Brushing may also be beneficial in streamlining the monitoring process during the next growing season.
- It is not yet clear whether project objectives will be met, and it is recommended that monitoring be continued for the next two years and possibly at year 5 from the original date of planting. Monitoring should be completed using the same methodology described in the methods section of this report.

Appendix I:

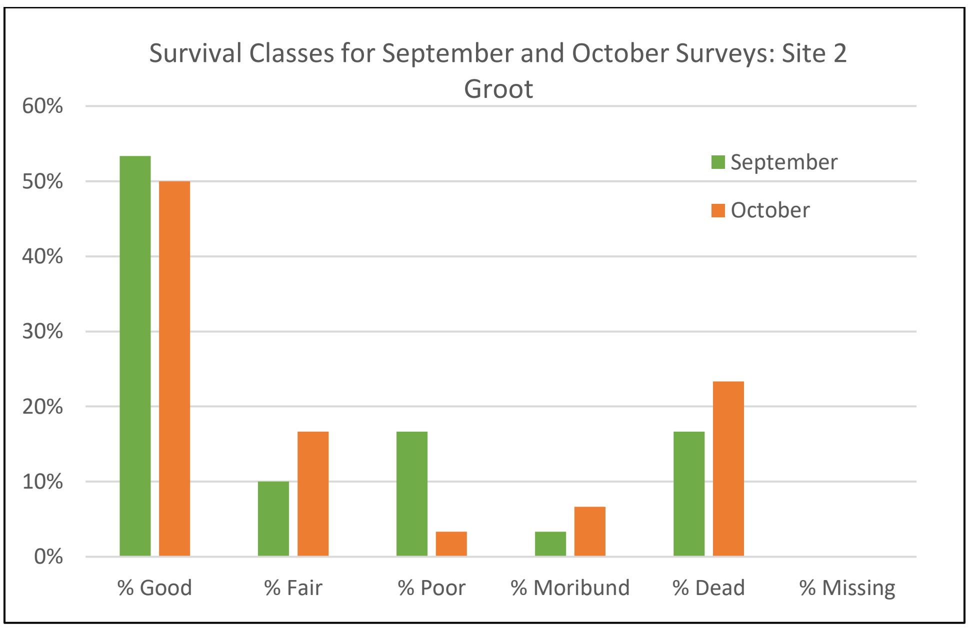
Site 1 Survival And Growth:

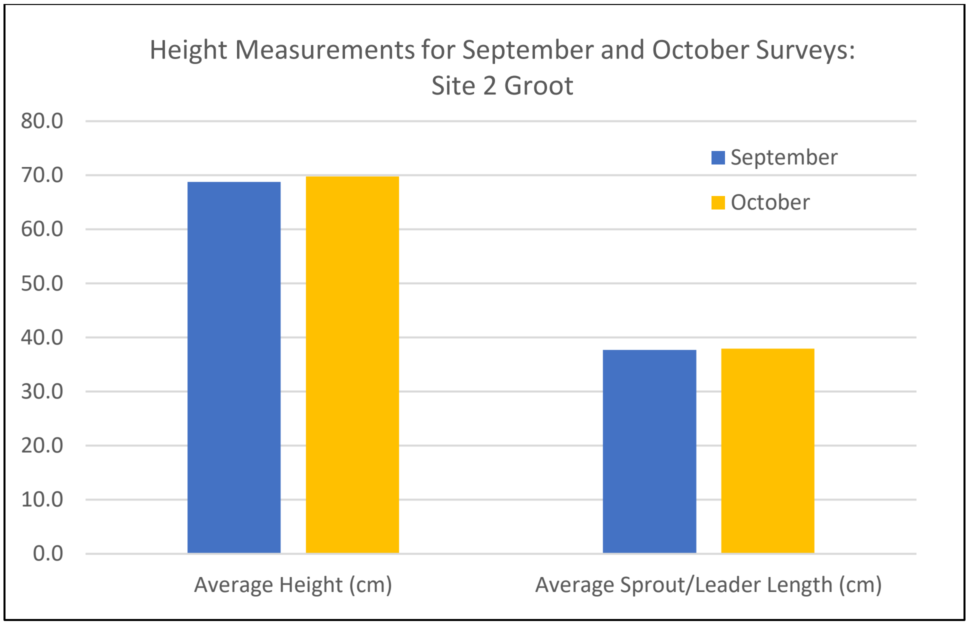


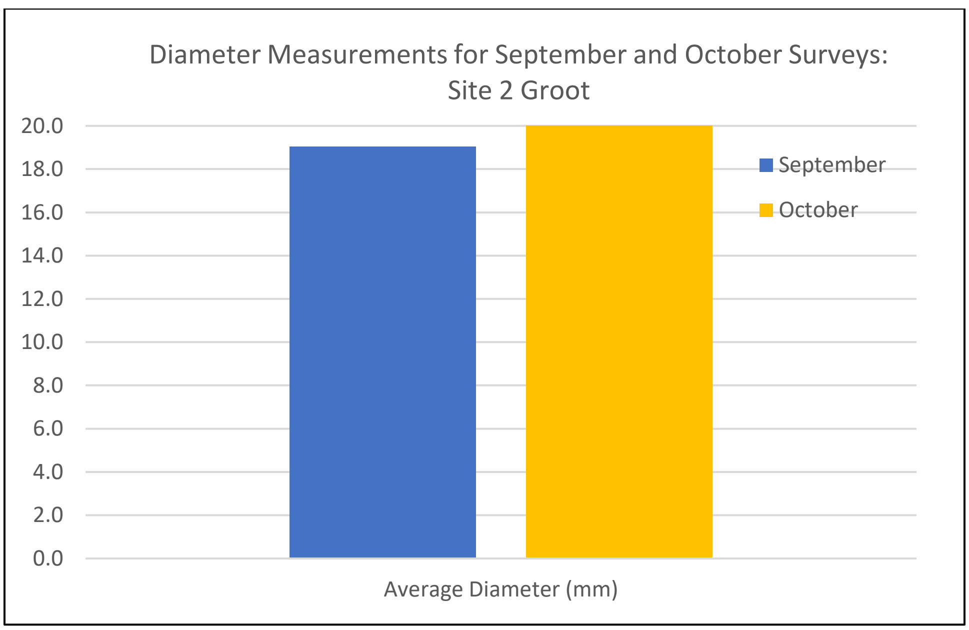




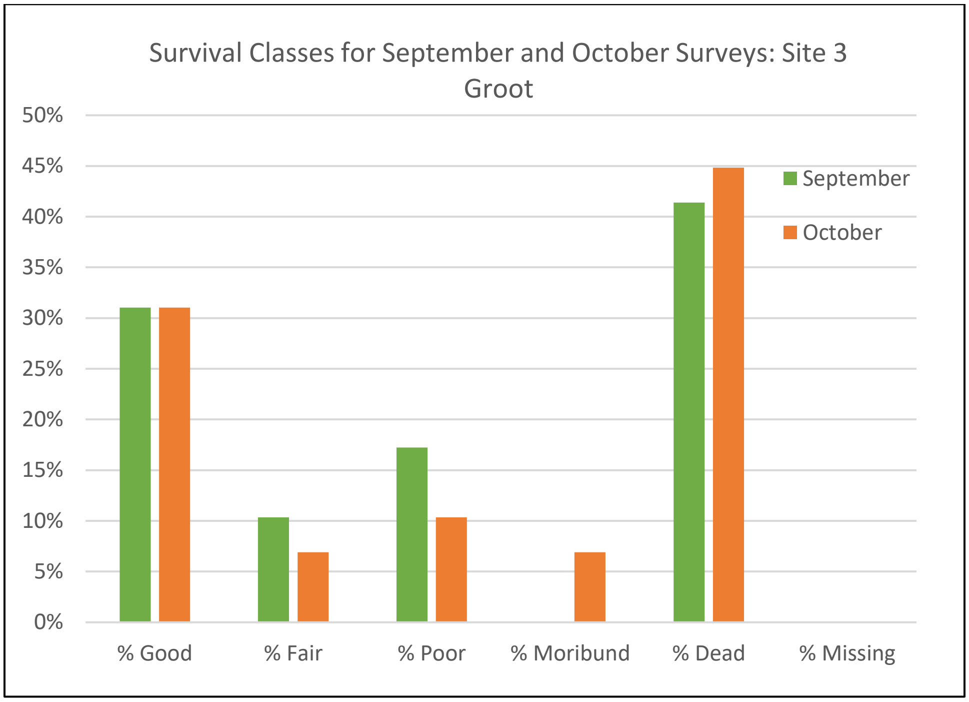
Site 2 Survival And Growth:

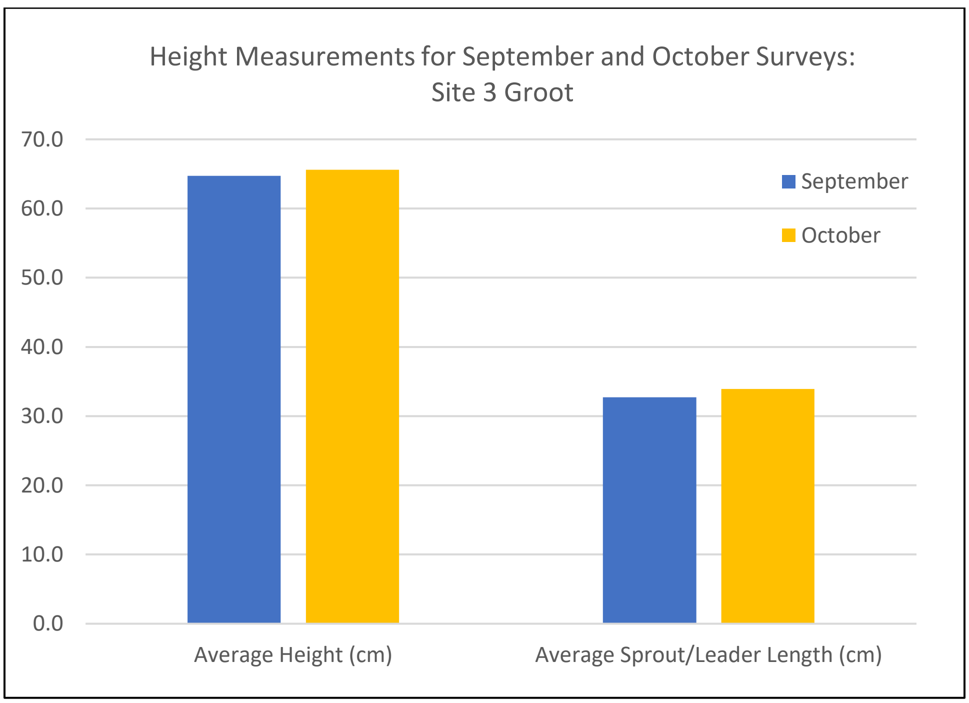


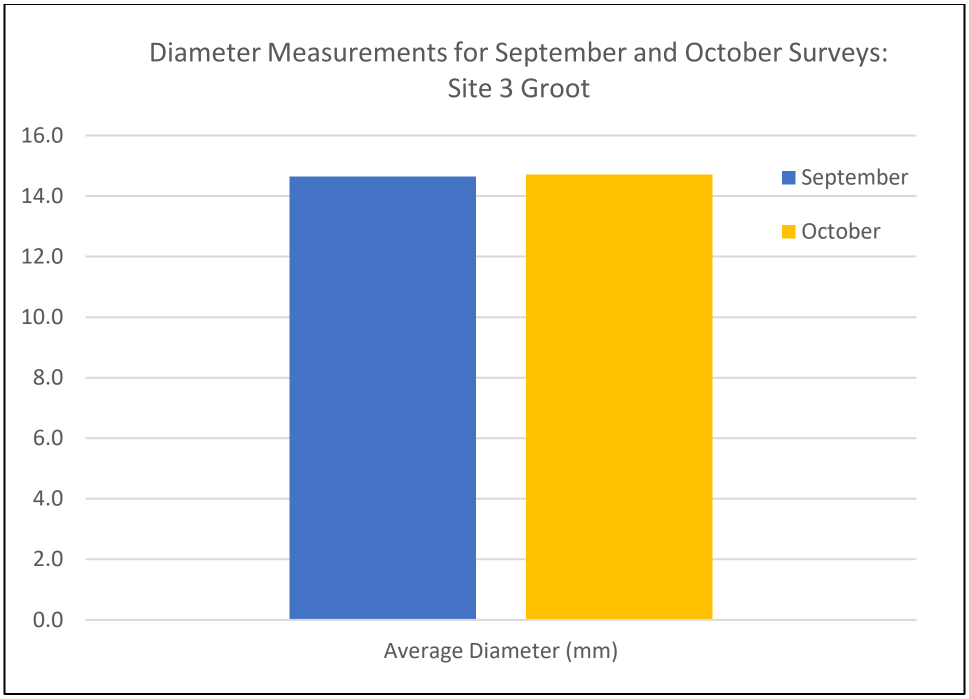

Height Measurements for September and October Surveys: Site 2 Groot
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
September
October
Average Height (cm)
Average Sprout/Leader Length (cm)


Diameter Measurements for September and October Surveys: Site 2 Groot
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
September
October
Average Diameter (mm)

Site 3 Survival And Growth:

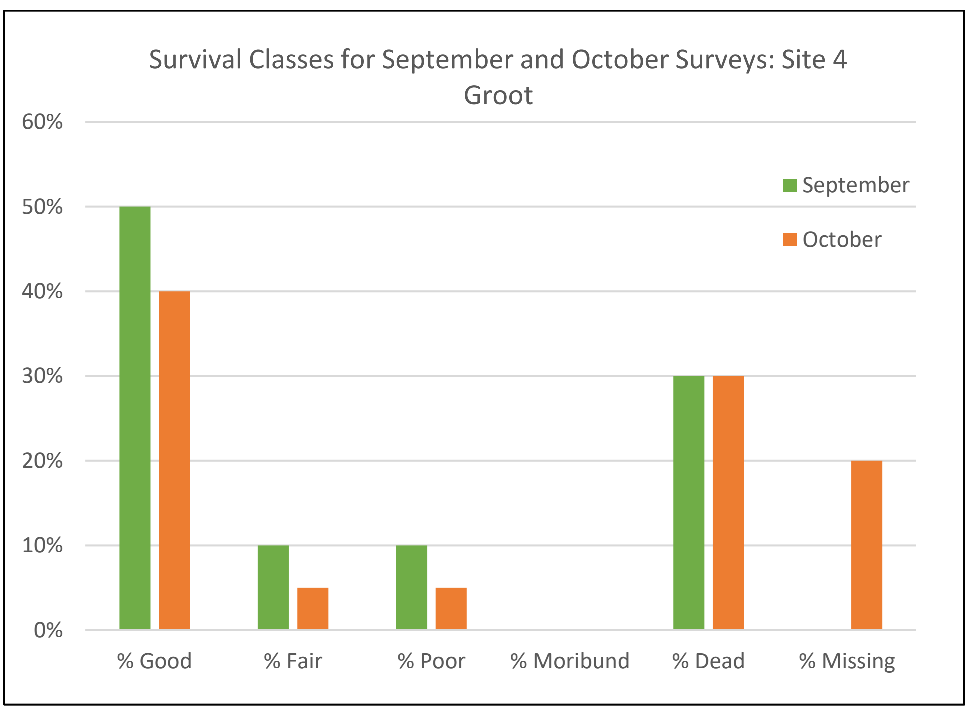


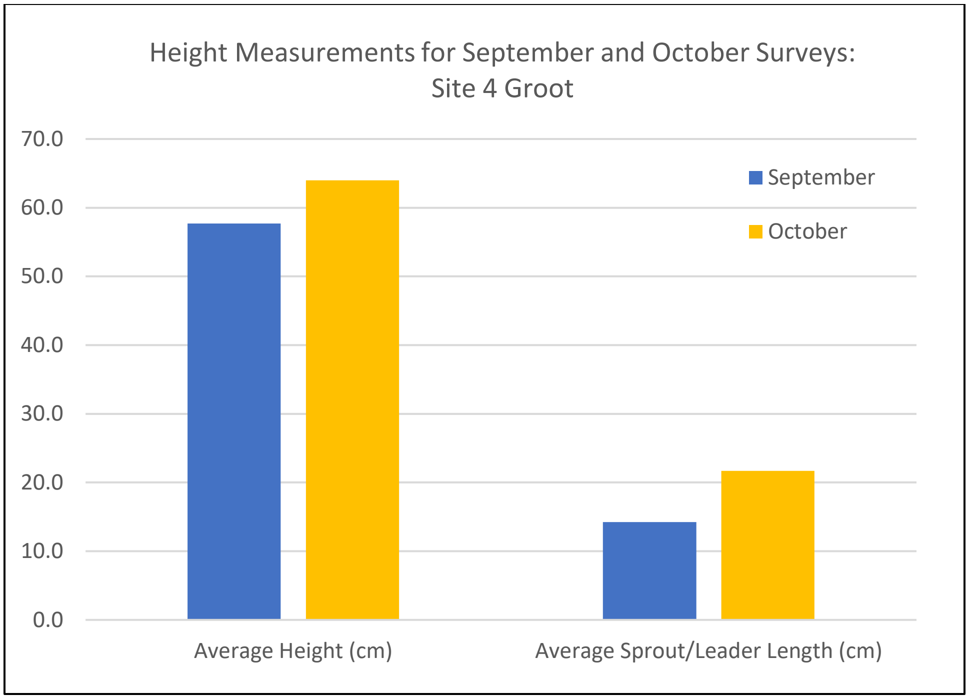


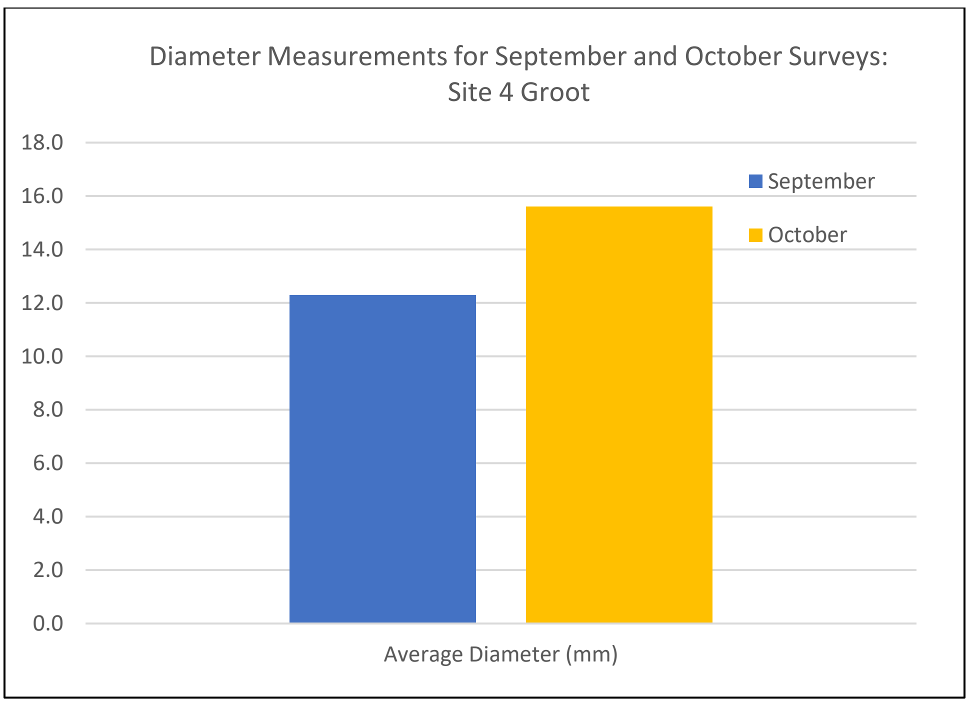


Site 4 Survival And Growth:

Note that the differences in survival, height, and diameter measurements for Site 4 were significantly impacted by missing trees between the two surveys completed in September and October. Twenty stems were surveyed in September, compared to 16 surveyed in October.




Height Measurements for September and October Surveys: Site 4 Groot
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
September
October
Average Height (cm)
Average Sprout/Leader Length (cm)


Diameter Measurements for September and October Surveys: Site 4 Groot
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
September
October
Average Diameter (mm)