Columbia River Project Water Use Plan

Duncan Watershed Riparian and Cottonwood Monitoring

Implementation Year 8

Reference: DDMMON#8-1

Lower Duncan River Riparian Cottonwood Monitoring Annual Report

Study Period: April 2017 – January 2018

VAST Resource Solutions Inc.
Cranbrook, B.C.
Contact: Dr. Mary Louise Polzin
MaryLouise.Polzin@vastresource.com

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VAST RESOURCE SOLUTIONS

Lower Duncan River Riparian Cottonwood Monitoring Year 8 Annual Report (2017)

Final

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BC Hydro
601-18th Street
Castlegar, B.C., V1N 2N1

Prepared by:
Mary Louise Polzin[1] and Stewart B. Rood[2]
[1]VAST Resource Solutions Inc., and
[2] University of Lethbridge, Alberta.

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Cover photo

Lower Duncan River, 2009, Segment 3, Transect line 11 on mid-channel bar, looking towards the Point Of Commencement (POC) which is on the point bar behind the mid-channel bar. The second photo is 2017, Segment 3, Transect line 11 on mid-channel bar, looking towards the End Of Transect (EOT). Photos © Mary Louise Polzin, VAST Resource Solutions Inc.

EXECUTIVE SUMMARY

A ten-year riparian vegetation monitoring program was initiated along the lower Duncan River in 2009 as part of the Duncan Dam Project Water Use Plan (WUP). This study is intended to evaluate the impacts of the flow regime Alternative S73 (Alt S73) on black cottonwood (*Populus trichocarpa* Torr. & Gray) and other vegetation. The Alt S73 flow regime criteria are:

- Sufficient time between the spring freshet recession and late summer/fall dam releases to allow seedlings to establish;
- Short intervals for late summer through winter high flows (<3 weeks); and
- Lower winter flows relative to spring freshet flows.

The study provides site-specific results to guide river flow regulation and better understand the relationships between flow regime, physical environmental conditions, and riparian vegetation. This report describes study Year 8 of the monitoring project that includes the lower Duncan River and the adjacent free-flowing lower Lardeau River as a comparative reference reach.

The floodplain zones, riparian vegetation, and black cottonwood recruitment are being assessed in order to address two integral management questions and their associated hypotheses (see the following table):

1) Are there changes in black cottonwood recruitment or riparian vegetation communities?

2) What are the drivers of black cottonwood success since Alt S73 was implemented?

The performance assessment of Alt S73 on the lower Duncan River riparian community will combine all years of the study and the 2017 results extend that data set.

In 2017, the lower Duncan reach had significantly higher densities of cottonwood seedlings than the Lardeau reach ($P = 0.003$). Patterns in 2017 deviated from some prior sampling years but were similar to 2016, with lower establishment densities and more seedling establishment occurring at lower elevations within the active channel.

Compared to past years, seedling survival patterns were reversed with the Duncan and the Lardeau reaches having higher first-year survival rates versus lower second and third-year survival rates compared to the study averages. This was attributed to extensive mortality before the mid-summer survey. Cottonwood phenology in 2017 was similar to past years although no August seed release occurred.

The results from 2017 are consistent with previous years' data, suggesting that the river flow regime is the primary influence on cottonwood seedling establishment and survival along the Duncan River. The flow regime determines inundation timing and duration as well as sediment erosion and deposition. These have major impacts on cottonwood establishment and recruitment success. Colonization requirements are linked to an elevational position with reference to stream stage pattern, geomorphic context, sediment substrate, longitudinal position (upstream-downstream), tributary inflows, and channel morphology. Influences from these multiple environmental factors were demonstrated in the 2017 data. The exceptionally low precipitation in July was the main factor contributing to the reduced seedling establishment levels along both rivers in 2017.

Keywords – black cottonwood, Duncan River, Lardeau River, river flow regime, seedling recruitment

DDMMON#8-1 Status of Objectives, Management Questions, and Hypotheses after Year 8 monitoring. Hypotheses testing was not part of year 8 analyses.

Objectives	Management Questions	Management Hypotheses	Year 8 (2017) Status
1) To assess the performance of Alt S73 on the lower Duncan River riparian community and specifically black cottonwood, through comparisons of field-based performance measures.	1) Will the implementation of Alt S73 result in neutral, positive, or negative changes for black cottonwood and riparian habitat diversity along the lower Duncan River as compared to past-regulated regimes?	H_{01}: There is no change in black cottonwood establishment or survival resulting from the implementation of Alt S73.	The 2017 results showed that seedling establishment, survival, and recruitment continue to display variability. There has been a trend of continual decline in cottonwood establishment levels since the implementation of Alt S73. The reference reach shows a similar decline.
2) To quantify the relationships between abiotic influences and biological responses based on analyses of field data.	2) What are the key drivers of black cottonwood recruitment success along the lower Duncan River floodplain? How are these drivers influenced by river regulation?	H_{02}: Black cottonwood establishment and survival along the lower Duncan River are not affected by the river flow regime.	Cottonwood establishment and survival are linked to water inundation duration, river stage during the growth season, sediment erosion and deposition, establishment elevation, and the growth season weather. These factors, except the weather, are influenced by river regulation. The past 8 years results show strong trends indicating that river flow regime does influence establishment and survival along the Duncan River. Rigorous hypothesis testing will follow in 2018.
3) To utilize the derived relationships in conceptual models for predicting the long-term response of black cottonwood and other riparian plant communities to a variety of flow regimes		H_{03}: The river flow regime is the primary driver of black cottonwood establishment and survival along the lower Duncan River.	The analyses from Year 8 along the lower Duncan River continue to indicate that the river flow regime is a primary driver of black cottonwood establishment and survival along the lower Duncan River. Deliberate hypothesis testing will also occur in 2018.

ACKNOWLEDGEMENTS

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1 INTRODUCTION

1.1 Overview

Located in southeastern British Columbia, the Duncan River is the major river that flows into the north end of Kootenay Lake. The Duncan River was first dammed in 1967, as the first of four major dams built on rivers in the upper reaches of the Columbia River Basin. Following the 1964 Columbia River Treaty between Canada and the United States, dams and reservoirs were built to provide flood control and hydroelectric power generation. The Duncan Dam installation resulted in extensive flooding of the full 25 km length of Duncan Lake and its adjacent wetlands along with river segments. This flooding created a reservoir that reaches approximately 45 km in length. The Duncan Dam has no hydroelectric power station, thereby increasing its operational flexibility. Water is released downstream from the dam to be stored in Kootenay Lake and subsequent reservoirs with passage through an extensive sequence of hydroelectric turbines of downstream dams along the Kootenay and Columbia Rivers.

In 2001, BC Hydro, the owner, and operator of the Duncan Dam initiated a Water Use Planning (WUP) process to consider alternate river regulation regimes. Following hydrologic modeling and a multi-stakeholder consultative process, the flow scenario Alternative (Alt) S73 was selected for implementation. The aim of Alt S73 was to balance the flood control and hydropower objectives with environmental benefits for fish in the Duncan and Lardeau Rivers, and Kootenay Lake, and for reproduction of black cottonwood, *Populus trichocarpa*. This study investigated black cottonwoods and other riparian vegetation and additional studies are underway to investigate fish and other environmental aspects. The resulting flow regime includes peak flows of ~400 m^3/s from May 16 to July 31, with declining flows to ~250 m^3/s from August through September, and then further decline to 73 m^3/s for October. The flows gradually increase to mid-May peak for the new Alt S73 targets. In 2009, it was projected that the Alt S73 would result in a narrow seedling survivable 'safe site zone' and some successful recruitment in any given year when:

- The free-flowing spring freshet peak is higher than 300 m^3/s; and
- Winter dam release flows are significantly lower than this for several subsequent years, or alternatively infrequently with a duration less than three weeks.

Minimal recruitment was expected when the spring freshet peak was less than 250 m^3/s, a late summer peak greater than the spring freshet peak occurs, or when the fall and winter high flows were above 250 m^3/s for more than four weeks. The actual annual flow regime is being monitored during this ten-year study relative to effects on black cottonwood recruitment.

Black cottonwood provides the foundation for the floodplain forests and associated wildlife habitat along the lower Duncan and Lardeau rivers as well as along Kootenay Lake. Past research has demonstrated strong links between black cottonwood recruitment and river flows, especially below dams (Polzin 1998, Polzin and Rood 2000). Studies by Naiman et al. (2005) have also revealed the links between cottonwood, wildlife habitat, and overall ecosystem function. Accordingly, black cottonwood was identified by the WUP as the indicator species for monitoring the effects of Alt S73 on riparian biological diversity along the lower Duncan River.

The operation regime was implemented in 2008 and VAST Resource Solutions Inc. (VAST) (formerly Interior Reforestation Company Ltd.) have been investigating the environmental responses along the lower Duncan River and along the adjacent free-flowing Lardeau River as a reference for comparison, since 2009. A more detailed description of the background to this project is provided in the initial Year 1 report (Polzin et al. 2010). This riparian black cottonwood monitoring program was designated as DDMMON#8-1 (BC Hydro 2009).

Two key management questions were developed by BC Hydro (2009) to help address uncertainty associated with black cottonwood hydrograph performance measures:

1) Will the implementation of Alt S73 result in neutral, positive, or negative changes for black cottonwood and riparian habitat diversity along the lower Duncan River, as compared to past-regulated regimes?
2) What are the key factors enabling successful black cottonwood recruitment along the lower Duncan River floodplain, and how are these influenced by river regulation?

Declines in cottonwood populations downstream from dams along other river systems have been documented (see Rood and Mahoney 1990, Polzin and Rood 2000, Merritt and Cooper 2000). However, the lower Duncan River differs from most other studied dammed systems for three main reasons:

First, 50 to 60 per cent of the flow below the Duncan Dam comes from the free-flowing Lardeau River and two smaller tributaries, Hamill and Copper Creeks. The input from the Lardeau River and the creeks result in substantial sediment and woody debris inputs below the dam. In contrast, most other dammed systems experience a 'silt shadow', or zone of sediment depletion, and the loss of large woody debris downstream of the dam (Williams and Wolman 1984, Dunne 1988, Debano and Schmidt 1990, Rood and Mahoney 1995, Polzin 1998).

Second, the Duncan Dam has reduced spring peak flow release into the Lower Duncan River since the completion of the Duncan Dam and Alt S73 did not change this. The reduced spring peak freshet cannot effectively transport the sediment and woody debris entering the Lower Duncan River system from the free-flowing tributaries (i.e. Lardeau River) as it did before the dam was installed. This has resulted in extensive large woody debris deposition along the lower Duncan River as well as aggradation from the net sediment deposition.

Third, the lower Duncan River is situated in a humid, mountainous region, which results in extensive groundwater inflows from the adjacent mountain uplands. Consequently, the alluvial groundwater in the floodplain zone is recharged by upland groundwater, rather than being more dependent upon infiltration from river flow, as is the case in prairie semi-arid ecoregions.

The data collected during the DDMMON#8-1 monitoring project will thus characterize the unusual hydrogeomorphic conditions along the lower Duncan River and the subsequent influences on black cottonwood recruitment and the broader influence on the riparian woodlands.

1.2 Objectives

The objectives of the DDMMON#8-1 monitoring program are designed to be achieved over a 10-year study period (BC Hydro 2009). They are:

- To assess the performance of Alt S73 on the lower Duncan River riparian community and specifically black cottonwood through comparison of field-based performance measures;
- To quantify the relationships between abiotic influences (e.g., river hydrology or groundwater hydrology) and biological responses (i.e., black cottonwood recruitment), based on analyses of field data; and
- To utilize the above-derived relationships in conceptual models for predicting the long-term response of black cottonwood and other riparian plant communities to a variety of flow regimes.

To meet the objectives and address the management questions, BC Hydro (2009) has identified three hypotheses:

Hypothesis 1

H$_{01}$: There is no change in black cottonwood establishment or survival resulting from the implementation of Alt S73; versus

H$_{A1}$: The implementation of Alt S73 results in either (a) a positive or (b) a negative influence on black cottonwood establishment or survival.

Hypothesis 2

H$_{02}$: Black cottonwood establishment and survival along the lower Duncan River are not affected by the river flow regime; versus

H$_{A2}$: Black cottonwood establishment and survival along the lower Duncan River are affected by the river flow regime.

Hypothesis 3

H$_{03}$: The river flow regime is the primary driver of black cottonwood establishment and survival along the lower Duncan River; versus

H$_{A3}$: The river flow regime is not the primary driver of black cottonwood establishment and survival along the lower Duncan River.

Guided by the above long-term objectives and hypotheses, the primary objectives in study Year 8 were to:

- Collect black cottonwood seedling data for 2015, 2016, and 2017 to add to the previous data sets (2009 – 2016).

The black cottonwood seedling establishment and recruitment analyses at the transect level for study Year 8 were analyzed relative to the key management questions. Data in previous years have shown that the Duncan River flow regime affects black cottonwood establishment and survival. Study Year 8 is a summary reporting year with comparisons of 2015, 2016, and 2017 seedling data. Data from study Year 8 will add to the collective data sets for statistical testing of the three Hypotheses in 2018, to assess the effect of Alt S73.

2 METHODS

2.1 Study Area

The lower Duncan River is located in the Columbia Mountains region in southeastern British Columbia. It flows south out of the 45 km-long Duncan Reservoir (includes the former Duncan Lake which was 15 km long), which was impounded by the Duncan Dam in 1967. Approximately 300 m downstream from the Dam, the lower Duncan River is joined by the free-flowing Lardeau River, and the combined rivers continue south for approximately 11 km to Kootenay Lake where a broad delta is formed (Figure 2-1). Midway along, in Segment 4, the lower Duncan River channel is joined by three free-flowing tributaries: Meadow, Hamill and Cooper creeks. Meadow Creek includes an artificial channel producing a low gradient stream, contributing only small amounts of sediment and woody debris during spring high water. At their confluence, the Duncan River flows into Meadow Creek creating a back-water effect during high water. This backup of water into the Meadow Creek channel has been documented to occur past the second meander point bar upstream of the confluence since 2009, and earlier by Miles (2002). In contrast to Meadow Creek, Hamill and Cooper Creeks are high gradient streams that contribute substantial sediment and large woody debris to the lower Duncan River.

The Lardeau River was selected as the reference reach because of its proximity to the lower Duncan River and similar channel reaches compared to the Duncan River (Polzin et al. 2010 and 2015 have further information about the similarities and differences between the lower Duncan River and the Lardeau River reference reach). The Lardeau River flows out of a nearly parallel watershed with a higher gradient and lower discharge volume compared to the Duncan River. The Lardeau River study reach starts approximately 3 km upstream of the confluence with the lower Duncan River and extends upstream for approximately 11 km (Figure 2-2).

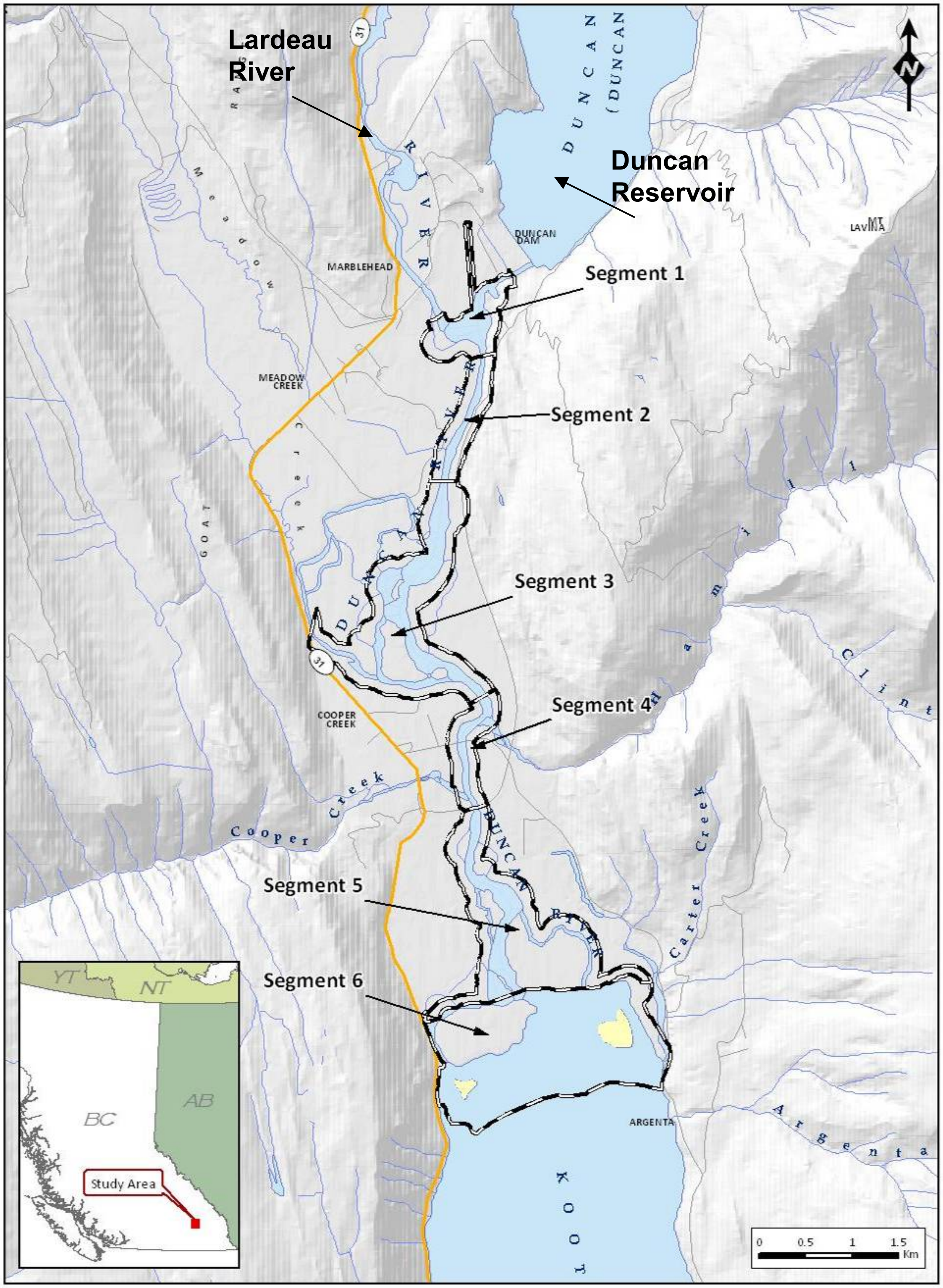


Figure 2-1: **Study area for the lower Duncan River with stratification of the river study segments.**

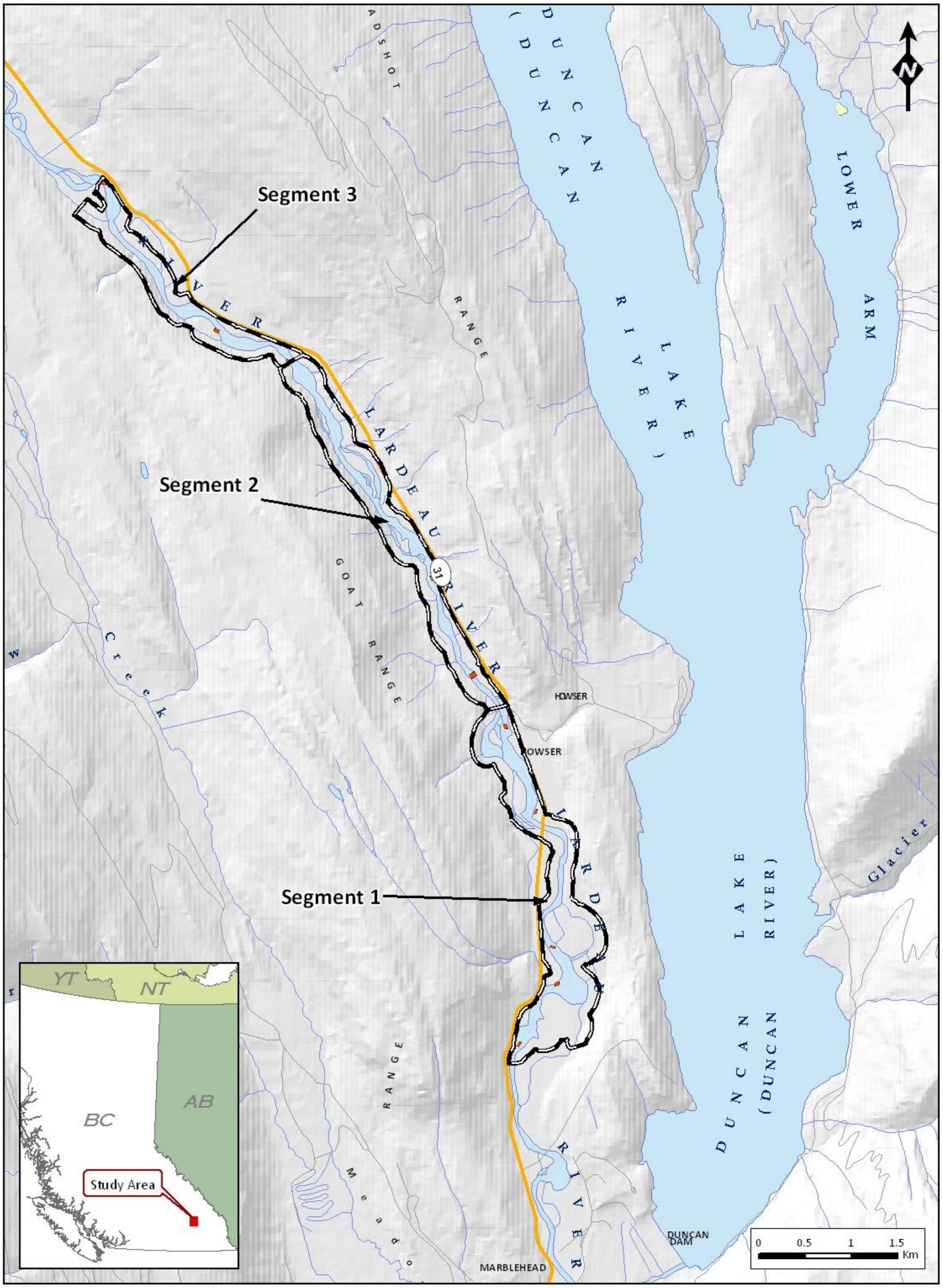


Figure 2-2: **Study area for the Lardeau River with stratification of the river study segments.**

2.2 Sampling Design

Study Year 8 (2017) of this project utilized the study design from Year 1 (2009) (see Polzin et al. 2010) with modifications implemented in study Year 3 (2012), (Polzin and Rood 2013). In brief, the sampling design included the following tasks and collection of the following data for 2017:

- Collect seedling information from 2017 black cottonwood germinants and previously measured seedlings from 2015 and 2016;
- Collect transect-specific stages at locations with gradually sloping point bars;
- Download hydrometric records from Water Survey of Canada stations 08NH118 and 08NH007 for hydrometric analyses;
- Download precipitation and temperature records (Duncan Lake Dam station at Meadow Creek station 1142574) for weather analyses; and
- Describe black cottonwood phenology and the timing of development.

The Duncan Reach was stratified into six segments and the Lardeau Reach into three, based on channel morphology (Polzin et al. 2010). Each segment was sampled using randomly selected transect lines for the Duncan Reach (Figure 2-4) and Lardeau Reach (Figure 2-5; see Polzin et al. 2010 for details). All potential recruitment meander point bars and mid-channel bars in each segment had transect lines laid out perpendicular to the river, every 10 m (the length of a tree quadrat) and numbered sequentially using GIS. Then using a random number generator, (“random between” where 1 is the bottom, and the number of transect lines for the segment is the top number, example 30), a random number(s) were generated per segment. The number associated with each selected transect line had GPS coordinates and were used to locate the position in the field. The resulting transect lines had tag numbers attached to a tree for the point-of-commencement (POC) and the bearing for the line recorded. The established POC’s and end-of-transect (EOT’s) had their locations recorded based on a Trimble precision GPS used in the field (see Polzin et al. 2010 for a detailed description). The UTM coordinates are located in Appendix 4.

The Duncan Reach segments have the following number of permanent transect lines established.

- Duncan Segment 1 (D1) has three transect lines – one transect line in the splash zone of the dam and two transect lines on the meander lobe back channel – influenced by Duncan River similar to delta zone.
- D2 has a moderately entrenched straight channel pattern (Leopold and Wolman 1957, Schumm 1981) with very limited opportunities for black cottonwood recruitment. This segment is monitored through periodic float trips to observe any recruitment sites that might develop during the study period. It was floated in 2009, 2013, 2015, 2016, and 2017 with no new development of potential recruitment sites. It is also monitored with the orthophoto analysis that is completed every three years.
- D3 has ten transect lines on a wide floodplain with a meandering channel pattern (Leopold and Wolman 1957, Schumm 1981).
- D4 has three transect lines along an entrenched, relatively straight channel pattern, and is influenced by Hamill and Cooper creeks.
- D5 has six transect lines and is more constrained than D3 with a meandering channel pattern (lower sinuosity) (Leopold and Wolman 1957, Schumm 1981).

- D6 has four transect lines in the delta zone that are influenced by Kootenay Lake and the Duncan River outflow.

The Lardeau Reach segments have the following number of permanent transect lines established.

- Lardeau Segment 1 (L1) has four transect lines. This involves the widest floodplain with a meandering channel.
- L2 has three transect lines along a very constrained to slightly meandering channel.
- L3 has three transect lines along a river reach that is intermediate between L1 and L2 for the extent of constraint versus meandering.

The sampling designed (set up in 2009) incorporated the basic concept of a hydrogeomorphic framework, where the relationships between riparian vegetation, elevation and substrate conditions, as well as river flow, stage patterns and groundwater patterns can be analyzed and modeled. We implemented a composite study design within this framework, which included both temporal and spatial comparisons, as employed by Braatne et al. (2008). The use of a surveyed (elevational profile) belt transect lines allowed for the collection of riparian plant occurrence along three spatial dimensions (Cartesian coordinated x, y, z) (Figure 2-3). The x-axis represents the longitudinal axis, the position along the upstream-to-downstream corridor of a river. The y-axis represents the distance away from the river edge. The banks rise up from the river and this elevational rise provides the third spatial dimension, the z-axis. Long-term monitoring to analyze responses to human alterations, such as changes in river flow regime requires a study system that facilitates repetitive observations relative to the three spatial dimensions which adds the fourth dimension, temporal (time) comparisons.

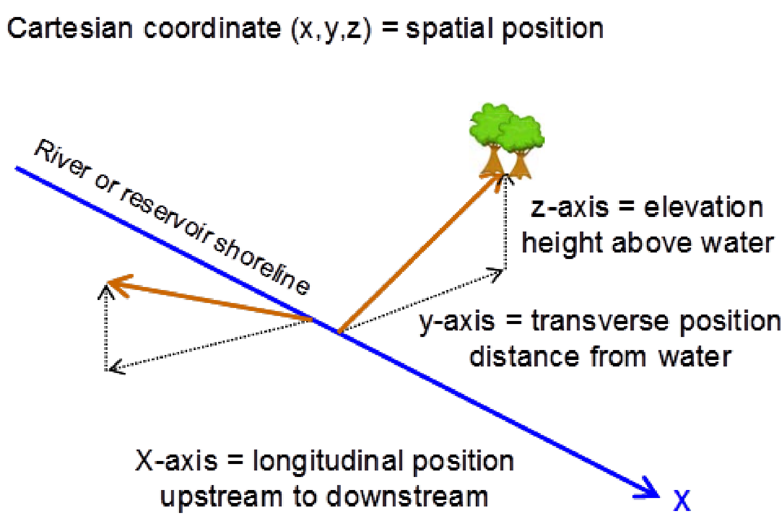


Figure 2-3: Riparian plant occurrence along three spatial dimensions.

The 2017 black cottonwood germinants densities, heights, and positions along the transect line (for elevation) were recorded when they occurred along the transect line. Seedling data were recorded within 1 m^2 quadrats along the downstream side of the transect lines. The seedlings from 2015 to 2017 were tracked for survival densities and heights, resulting in three age classes being recorded each year. Quadrats that had seedlings recorded in the previous two years were revisited and any new locations where germinates occurred were also inventoried.

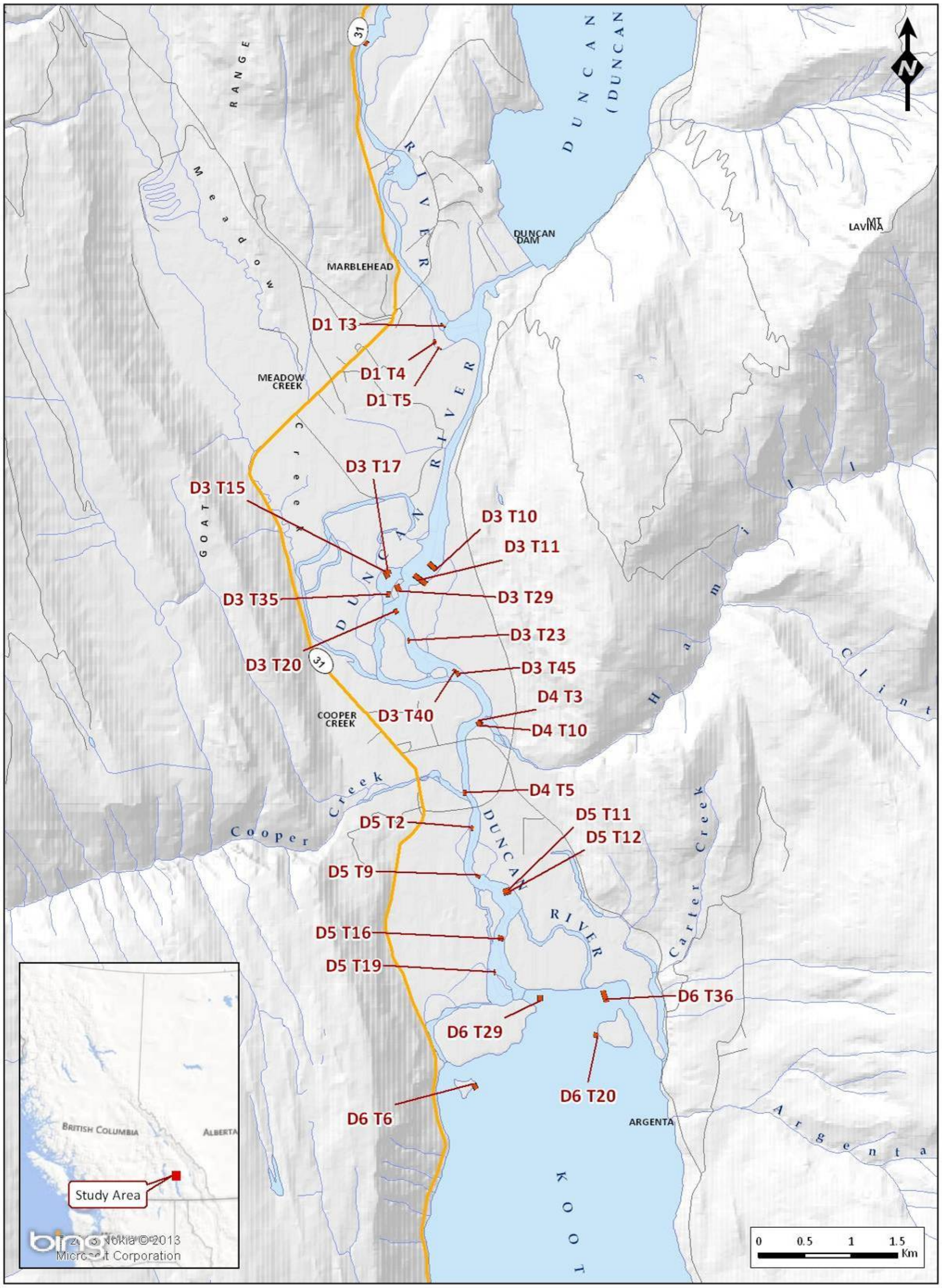


Figure 2-4: **Lower Duncan River study transects in 2017. Segments are indicated by the number following D (Duncan), and transect numbers are indicated after the T (transect).**

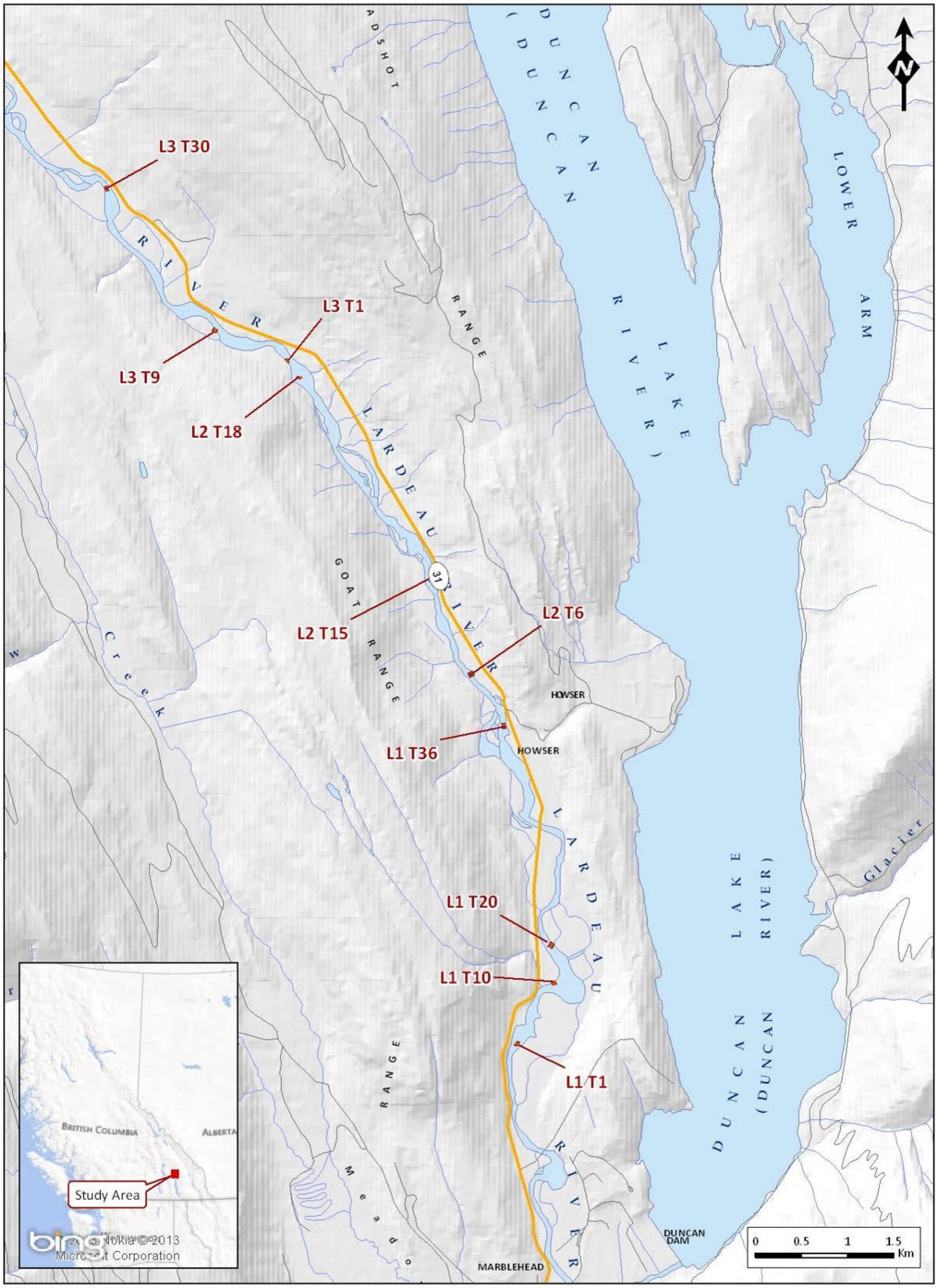


Figure 2-5: Lardeau River study transects in 2017. Segments are indicated by the number following L (Lardeau), and transect numbers are indicated after the T (transect).

All transect lines were surveyed in 2009 and resurveyed in April/May of 2013. New transect lines were established to replace transect lines that no longer met requirements or were removed following the extended flood of 2012. Duncan River Segment 4 (D4) transect lines are located along the Duncan River but are also influenced by the Hamill Creek (two transect lines) and Cooper Creek (one transect line) outflows. Both of these creeks experienced large flash flood events triggered by an extreme rain event resulting in considerable erosion and deposition. Therefore, the three transect lines were resurveyed in spring of 2014 to record the extent of change that occurred from the high water event (Polzin et al. 2015).

2.3 Seasonal Weather

For this study, the weather is part of the analysis as both the Lardeau and the Duncan study reaches have the same weather. This allows us to separate establishment, growth, and survival of black cottonwood and riparian vegetation influenced by the seasonal weather from a possible impact from river stage and other fluvial geomorphic processes. Daily precipitation and temperature data were downloaded from Environment Canada's website for the Duncan Lake Dam station at Meadow Creek, climate ID: 1142574. The website address was changed in 2016[1].

Precipitation and temperature data were provided for years 2015, 2016 and 2017, from January to December, thus allowing the tracking of changes over a three year period. At the time of analyses and report writing, weather data from weather station 1142574 for 2017 ended Nov 28th as of Feb 26, 2018. Historical averages for precipitation were also downloaded. The Canadian Climate Averages were updated from the Environment Canada website with their calculation set for the three-decade interval from 1981 to 2010.

Snow survey data were obtained from BC Ministry of Forests, Lands and Natural Resources River Forecast Centre from the Snow Survey and Water Supply Bulletins – 2017.The average included for "Normal" Snow Water Equivalent (SWE) used the time period from 1981 to 2000.

The Snow Water Equivalent (SWE measured in mm) for 2015, 2016, and 2017 were obtained from the Duncan Lake watershed station 2D07A (archive manual snow survey data), which is at 662 m elevation, the same location as the Marble Head Weather station. The high elevation snow survey data were from the East Creek station 2D08P which is at 2,004 m elevation

2.4 Hydrology

Riparian cottonwood seed dispersal typically coincides with declining river flows following springtime snowmelt and stormflows on natural systems. This increases the probability of seeds landing in favorable microsites along the river channel. Seed viability is very short, generally lasting only 1-2 weeks under natural conditions (Braatne et al. 1996). Once seeds become wet, viability will be lost in 2-3 days if a favorable microsite is not encountered.

[1] http://climate.weather.gc.ca/climate_data/daily_data_e.html?timeframe=2&hlyRange=%7C&dlyRange=1963-03-01%7C2016-07-20&mlyRange=1963-01-01%7C2007-02-01&StationID=1115&Prov=BC&urlExtension=_e.html&searchType=stnProv&optLimit=yearRange&StartYear=1840&EndYear=2016&selRowPerPage=25&Line=439&lstProvince=BC&Day=18&Year=2016&Month=8

Cottonwood seedlings and saplings are intolerant of drought but they are tolerant of inundation and siltation (Smit 1988, Rood and Mahoney 1990, Mahoney and Rood 1992). While seedlings are tolerant of inundation, springtime flooding also eliminates many seedlings adjacent to the main channel by physical scouring (Bradley and Smith 1986, Rood and Mahoney 1990). There is a complex interaction between fluvial processes and seedling recruitment. As such hydrology analysis plays an important part in addressing the hypotheses and management questions for this study.

Major differences in river channel morphology may also influence spatial and temporal patterns of seedling recruitment, as the distribution of suitable microsites changes in relation to the dominant fluvial processes (Braatne et al. 1996). As such, the study reaches were delineated by channel morphology.

The 2017 river discharge (*Q*) and stage data were downloaded from Environment Canada's Water Survey website[2] for the lower Duncan and the Lardeau rivers hydrometric stations. Hydrometric data were collected from the following stations:

1) Station 08NH118: located on the lower Duncan River, below the dam and below the confluence of Lardeau River (downstream (d/s) station), the 2017 data are provisional; and
2) Station 08NH007: located on the Lardeau River at Marblehead, approximately 700 m upstream of the confluence with the lower Duncan River, the 2017 data are provisional.

Base stages were identified in 2009 for the Duncan and Lardeau rivers (Polzin et al. 2010). The Duncan River base stage of 1.52 m was selected as it was the typical stage for late September into early October before the Duncan Dam was constructed. The Lardeau River base stage of 0.843 m was used as the typical stage for the same time period.

2.5 Black Cottonwood Phenology

The seasonal timing of developmental and reproductive events was documented for black cottonwood phenology, consistent with previous years' data collections. Close-up observations of representative trees were used to track dates of catkin and leaf emergence. Visual observations from fixed vantage points overlooking the lower Duncan-Lardeau River floodplain were used to rate seed release events as Low, Medium, or High based on the airborne seed densities and the length of the apparent release duration. Observation sites and geographic coverage were similar to previous years. No differences in timing and apparent quantity of seed release were noted between the two reaches in 2017, and therefore only one data set is reported, representing both reaches.

2.6 Field Visits

Two field visit intervals occurred in 2017: July 31 to August 2; and October 2 to October 5. The August visit and first black cottonwood recruitment monitoring for 2017 occurred when discharges for the Duncan River were between 221 m^3/s to 240 m^3/s (August 1 to 2). The Lardeau River discharges were 59.0 m^3/s to 63.0 m^3/s (July 31 to August 2).

The October field visit occurred during low flows to assess the establishment and survival of the seedlings during the 2017 growing season, and the condition of seedlings from the two prior years. The discharge was between 93.1 m^3/s and 94.5 m^3/s for the October 2 to October 5 field monitoring interval along the Duncan River, and 15.0 m^3/s for the Lardeau River for the October 5 and 6, 2017 monitoring period.

[2] http://wateroffice.ec.gc.ca/my_station_list/index_e.html

2.7 Seedling Establishment and Recruitment

Belt transects were previously randomly located within pre-stratified river reach segments and pre-identified recruitment areas. These transects allowed for tracking of the 2015 and 2016 seedlings, and for the assessments anywhere along the transect line where new 2017 seedlings germinated (germinants) (as described in the Study Design Section 2.2). Black cottonwood seedling densities, heights (averages from 10 seedling heights within a 1 m^2 quadrat), and positions along the transect line were collected for 2015, 2016 and 2017 seedlings.

Data for black cottonwood establishment for 2017 germinants, and for continuing 2016 and 2015 seedling survival and recruitment, were collected during the August and October 2017 field visits. The field data collected were tied to distances along the surveyed transect lines. This provided surveyed elevation points from 2013 for the Lardeau and most of the Duncan reaches and from 2014 elevational data for transects in D4. The link to transect distances will facilitate comparisons over time, by enabling assessment of sediment deposition and erosion, as well as revealing changes in vegetation patterns, including black cottonwood colonization and survival.

The 2017 seedling sampling methods followed the methods described in Polzin et al. (2014). By following seedlings for a three-year period, we are able to assess initial establishment levels, survival through three growing seasons, and subsequently seedling recruitment levels for each year of establishment (1^{st}, 2^{nd}, and 3^{rd}-year survival). We use the term ‘recruitment’ to represent the successful establishment and survival through the vulnerable first three seasons and these subsequent saplings would be more likely to contribute to the floodplain forest population (Rood et al. 2007). Recruitment is the result of two sequential but somewhat independent processes of establishment (or colonization) and survival:

Recruitment = Establishment (colonization) + Survival

The seedlings established in 2015 (that survived to the October 2017 field sampling) were considered successful recruits. Therefore, the 2015 seedlings will shift to be part of the vegetation monitoring design, utilizing cover by species to assess growth and cover expansion during 2018 riparian vegetation monitoring.

Photos taken during the 2017 field season are documented in Appendix 1, and contact sheets of photos are located in Appendix 2. Original digital images are supplied on a video disc (DVD) with the final report.

2.8 Transect-Specific Stage/Discharge Relationships

The position of the water’s edge along each transect was determined at each visit to permit site-specific stage-discharge rating curves. This information will be utilized in the advancement of the conceptual models as well as for determining stages at transect lines during a specific discharge of interest during analyses of years, as needed. Transect and quadrat positions are subsequently expressed relative to the transect elevation of the river at a base flow of 57.8 m^3/s (1.52 m stage at Duncan station 08NH118) for the Duncan River as described in Polzin et al. (2010). The Lardeau River base flow of 11.1 m^3/s (0.843 m at Lardeau station 08NH007) was used for transect elevation for the Lardeau River.

2.9 Data Analyses

Data analyses focused on addressing the second key management question that relates to the relationship between river flow pattern and black cottonwood seedling establishment and recruitment. These analyses involved comparisons between the seedling establishment and recruitment across 2015, 2016, and 2017 data sets. Within and between comparisons were completed for representative reaches along the lower Duncan River and the free-flowing Lardeau River (reference reach details in Polzin et al. 2010 and 2015).

Hypotheses testing will be further developed in 2018 with full analyses of the river and vegetation observations over the nine years of monitoring (2011 was cancelled). For this annual report, data analyses are limited to data summaries without deliberate hypothesis testing.

Statistical analyses were conducted using SigmaPlot 12.5 (Systat Software. Inc. San Jose California USA) and all tests were interpreted with an alpha criterion of 0.05. Descriptive statistics were used for general data distribution. Data transformations were unable to provide normal distributions for seedling density data for comparisons with patterns from previous years and between reaches. Consequently, non-parametric tests were used when required. Tests included: Kruskal-Wallis One Way Analysis of Variance on Ranks (Kruskal-Wallis) and Friedman repeated measures analysis of variance on ranks. Signed rank test for paired t-test was used but when normality testing failed the Wilcoxon Signed Rank Test was applied. The Mann-Whitney Rank Sum Test was applied when normality tests failed for comparisons among 1st, 2nd, and 3rd-year survival rates for the lower Duncan River versus the Lardeau reach. One-Sample Signed Rank Tests were used for numbers of germinates between years. One-Sample t-tests were used for germinate comparisons when normality was observed. Statistical outputs related to results are provided in Appendix 3.

Pairwise multiple comparison procedures using Tukey's tests were used to isolate the group or groups that differed from the others. The Tukey's test was selected as it is a more conservative test than the Student-Newman-Keuls test. When the treatment group sizes were unequal the Dunn's test was used. Uneven sample sizes occurred when comparing the Duncan reach (27 transects) to the Lardeau reach (10 transects).

Paired data were used for comparing the same transect lines between years. When quadrats had seedlings one year but were bare in the previous or subsequent year, 0 was entered in the spreadsheet. If no seedlings occurred at a meter mark in any of the three years the cell was left blank. This gave the 0 meaning and it was included in analyses for paired data between years.

Raw data were presented using box plots. These data included seedling densities that occurred along transects with no zero's, to indicate where seedlings occurred in other years of sampling. Paired data were used for statistical analysis when comparing between years and also presented using box plots to accurately compare between years for seedling establishment and spatial distribution of first-year seedlings (germinants).

The 2009 (first year of the study) occurred a week too early for being able to distinguish cottonwood germinants (2009 seedlings) from willow germinants. This resulted in a skewed number for 2009. Past reports used this total with a comment that the number of willows in the count was unknown. The raw data from 2009 establishment counts were reviewed. When possible, later in the sampling timeframe, comments were made about the number of willows but since the sampling started off with counting all germinates the sampling stayed consistent for the Duncan reach.

For transect lines with willow densities noted, the number of willows was removed from the sampling total. Transect line sampling during the first five days of monitoring when willow could not be distinguished from cottonwoods had estimates generated using the autumn counts when cottonwoods were distinguished, and densities were multiplied by 1.5 based on a 50% survival rate. This was higher than the calculated survival rate of 23.1 per cent, to allow for variations and that the initial survival rate was based on counts that included willow. This revised count for the Duncan reach in 2009 was 47,786 germinates, down from 123,956 in the original report. The new estimate was used in the comparative analysis when assessing the full study period.

Inventory along the Lardeau reach was completed six days after the Duncan reach in 2009 when cottonwoods were able to be distinguished from willow. Therefore, no correction or estimation was required for the 2009 Lardeau germinants.

3 RESULTS

Cottonwoods are ecological specialists that require particular environmental conditions for successful seedling recruitment (Braatne et al. 1996; Karrenberg et al. 2002). The seeds are very small and with correspondingly limited stored resources, their interval of viability is quite short, typically a few weeks. For successful seedling establishment the seeds must reach locations that are barren from established vegetation, since they are shade intolerant, and require a saturated substrate for water imbibition. The suitable conditions are provided on newly formed or scoured gravel bars such as at meander lobes or along islands. With river stage (level) recession, those positions are saturated, providing moisture for imbibition and to support early seedling survival, but rain provides an alternate water source. Consequently, the river flow and stage patterns and weather events including rain are essential to understand cottonwood colonization.

3.1 Weather

The mean temperatures for January and February were colder in 2017 compared to 2015 and 2016. March through July temperatures were similar to 2015 and/or 2016. The April mean temperature in 2017 was similar to 2015 and the historical average of 7.2 °C for the station (1142574) (Figure 3-1) (Government of Canada[3]).

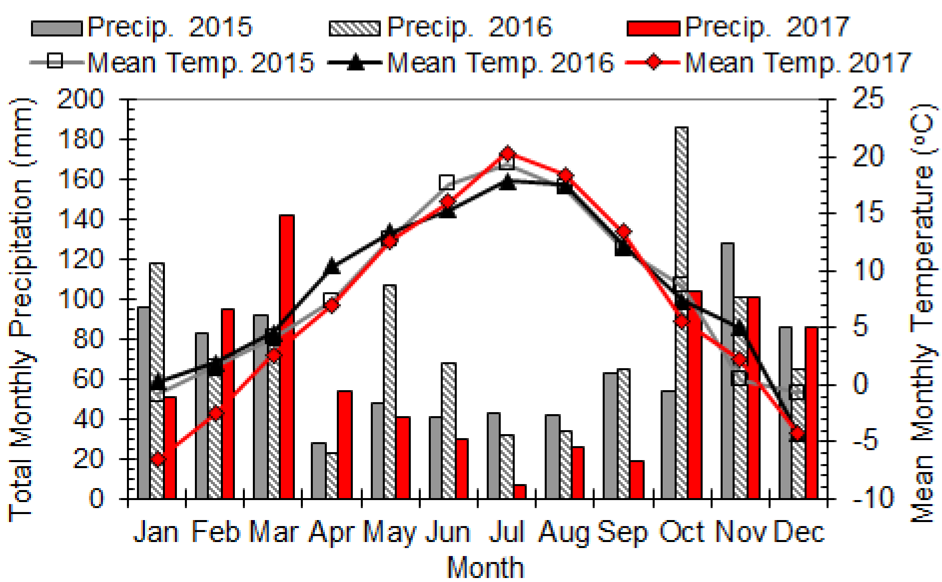


Figure 3-1: Duncan Lake Dam weather station at Meadow Creek monthly mean temperature and monthly total precipitation for 2015, 2016, and 2017.

Total precipitation for May through August (growing season) was the lowest since Alt S73 was first initiated in 2008 (Table 3-1). The precipitation in July 2017 of only 7.2 mm was extremely low compared to previous years of the study and the historical mean precipitation for July of 55.9 mm (1981 to 2010 mean, Canadian Climate Normals for station 1142574). The 2017 growing season total precipitation was well below 2016 levels and around one-half of the typical total over the past decade (Table 3-1)

[3] http://climate.weather.gc.ca/climate_normals/index_e.html

Table 3-1: Average temperatures and total precipitation for the summer months of June, July, and August from 2008 to 2017.

	2008	2009	2010	2012	2013	2014	2015	2016	2017
Average Temperature (°C)	16.5	17.3	16.2	17.0	17.5	17.8	18.1	16.9	18.3
Total Precipitation	197.8	134.9	124.7	223.1	204.4	99.3	126.3	133.6	62.7

The monthly precipitation for 2017 and 2016 displayed variability and differences (Figure 3-2). A notable difference was 142.0 mm for March 2017, which was 86.5 mm above the historical average. The next extreme was for July which was 48.7 mm below the historical average for that month.

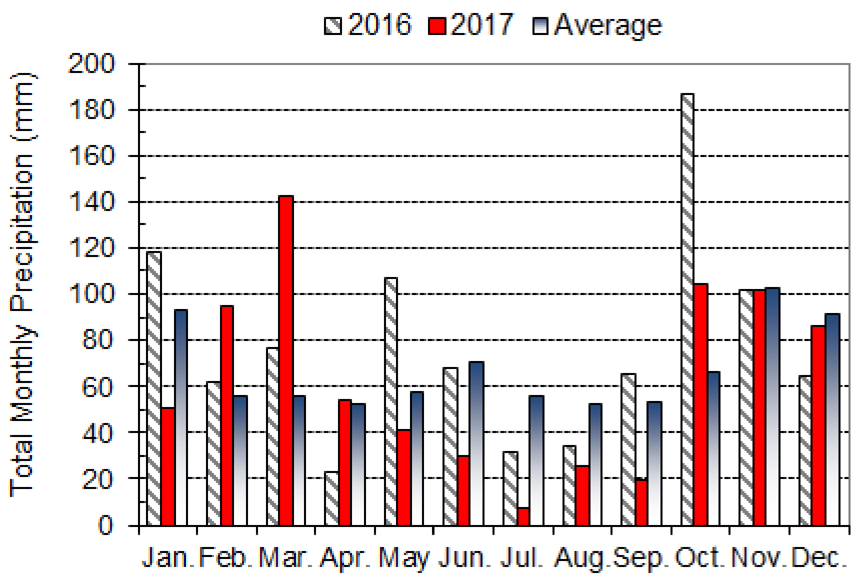


Figure 3-2: Monthly precipitation (mm) for 2016 and 2017 recorded at the Duncan Lake Dam weather station. The maximum and minimum monthly precipitation in 2017 occurred in March and July, with 142.0 mm and 7.2 mm respectively.

3.1.1 Snow Survey

The Duncan and Lardeau rivers are nival, or snow-melt dominated systems. As such, seasonal snow pack levels play a role in the extent of freshet flooding and in subsequent flows through the plant growth season. However, variations in weather determine snow melt rates and influence flood probabilities.

When 2017 was compared to 2015, 2016, and the Normal (this is an average and 'Normal' is listed on the website; 1981 to 2010 from 2D07A station), SWE was below normal for February and below 2015 levels and above 2016 levels. The snowpack was above normal by 131 per cent by March 1, 2017, and well above 2015 and 2016 levels. The snowpack had melted at this location in April, in 2015 and 2016 but it was at 217 per cent above normal snow pack by April 1, 2017 (180 mm) (Figure 3-3). The Duncan Lake watershed station was not monitoring after April 1 but it is likely that the snow at this elevation had melted by May 2017.

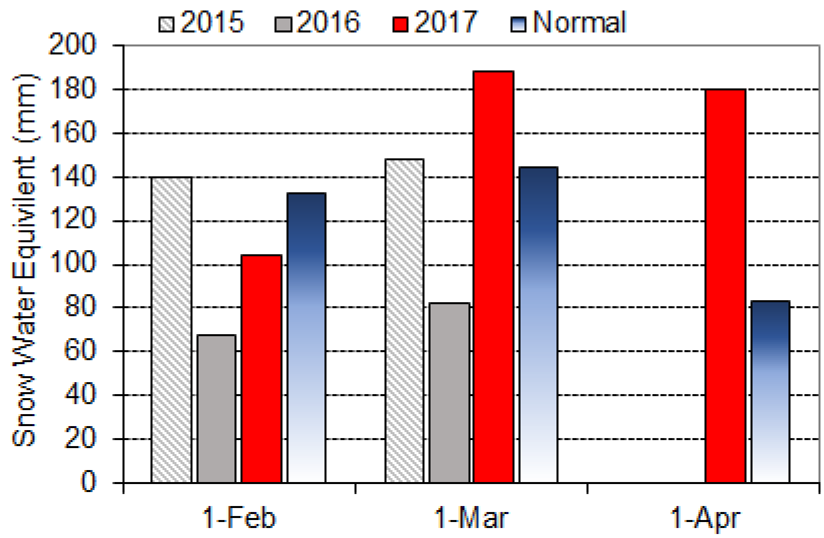


Figure 3-3: Snow water equivalent totals for the months February to April at the station 2D07A Duncan Lake No. 2 for 2015 to 2017.

The snow pack at higher elevations influence the extent of freshet flooding more than the valley bottom snow pack. For the Duncan Lake drainage, East Creek is the established station and is actively monitored. East Creek station 2D08P is at 2,004 m elevation and had snow pack levels similar to the Normal levels for the area to March 1, 2017. The snow pack remained above Normal (>120 per cent above normal, range 121 mm to 129 mm) for April 1 through to June 15, 2017 (Figure 3-4).

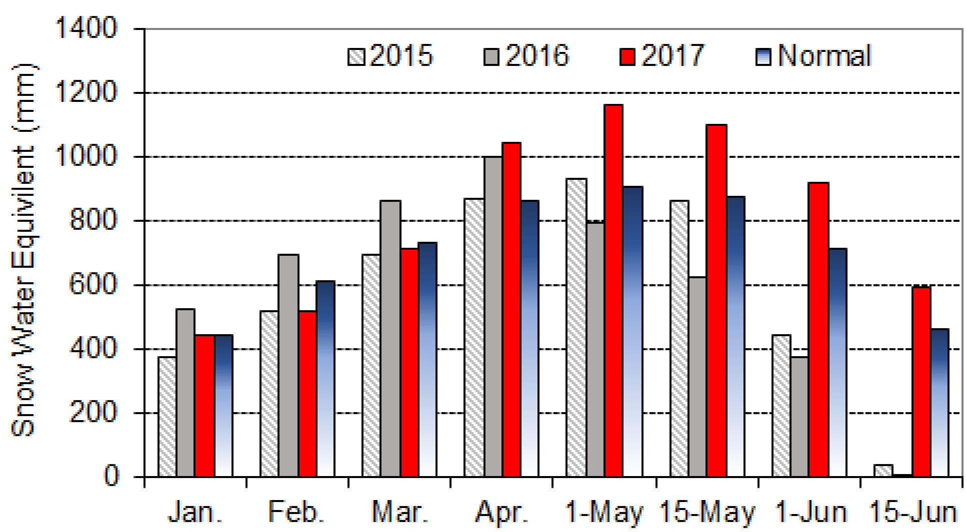


Figure 3-4: Snow water equivalent (mm) data for East Creek station 2D08P, elevation 2004 m, for 2015, 2016, 2017, and the Normal levels (1981 – 2010) for the station.

In general, there were two key weather factors driving seasonal snowpack development in 2017 for this region of BC (MFLNR 2017).

1. An extremely warm November resulted in a delay in early season snow accumulations, with some areas experiencing melting of snow that accumulated in

October. Melting snow and moderate to heavy rainfall led to extremely high seasonal flow for most river systems.

2. Arctic air dominated through December resulting in dry conditions particularly in northern BC, with cold conditions across the province. Colder than normal temperatures in south-west BC resulted in greater snow accumulation at low elevations while the impact on higher elevation snow packs was moderate. Snow at low elevation was higher than normal through December for most of southern BC with many areas receiving twice as much snow as normal or more.

The increase in snow pack at the lower elevations is illustrated in the data from 2D07A Duncan Lake No. 2 at Marble Head. The East Creek Station 2D08P at 2004 m elevation is typical of the elevation of automated stations. The "Normal SWE" for the West Kootenay area averaged the stations within the boundary for the time period 1981 to 2000. Table 3-2 compares the East Creek snow pack with the regional West Kootenay area snow pack.

Table 3-2: The West Kootenay area snow water equivalent (SWE) levels as a percentage of the "Normal" levels and the East Creek 2D08P station SWE levels as a percentage of the "Normal" levels for that station for 2017.

	Per Cent of Normal SWE (1981 to 2000)							
	Jan 1	**Feb 1**	**Mar. 1**	**Apr. 1**	**May 1**	**May 15**	**Jun. 1**	**Jun. 15**
West Kootenay	80	73	91	119	134	156	117	136
East Creek	100	84	98	121	128	126	129	128

3.2 Hydrology

3.2.1 Duncan River

Mean monthly discharges from 2009 to 2017 are shown in Figure 3-5 (2009 and 2010 were combined, and 2013 and 2014 were combined, since these provided similar patterns as assessed in Polzin et al. 2014). The sampling year of 2012 was an exception as the regular Alt S73 flow regime was pre-empted by high snowmelt and rainfall in the Duncan Basin (see Polzin and Rood 2013).

The 2017 sampling year had similar flows for January through April as compared to the previous years of the study, except 2016. May had the highest flow since the study began with a mean monthly discharge of 263 m^3/s (provisional data). June (241 m^3/s) was the highest for regular year flows but lower than 2012 flood year. The average discharge for June from 2009 to 2017 was 200 m^3/s with June 2017 being above average. (Figure 3-5). Discharges for August through December were similar to those of prior years of the study except 2015 for November and 2015 and 2016 for the month of December. It should be noted that the 2017 discharges are provisional, prior to verification by the Water Survey of Canada.

The daily mean flow data show the day-to-day variation which is smoothed out by monthly means. The 2017 hydrograph displayed two flow peaks (Figure 3-6). The larger peak occurred June 1 (348 m^3/s) with a slightly smaller peak about a week later, on June 9 (329 m^3/s). The flow declined through June with July and August showing greater variation in daily mean flows compared to previous years as well as being higher during the summer months, as compared to 2009, 2010, 2015, and 2016.

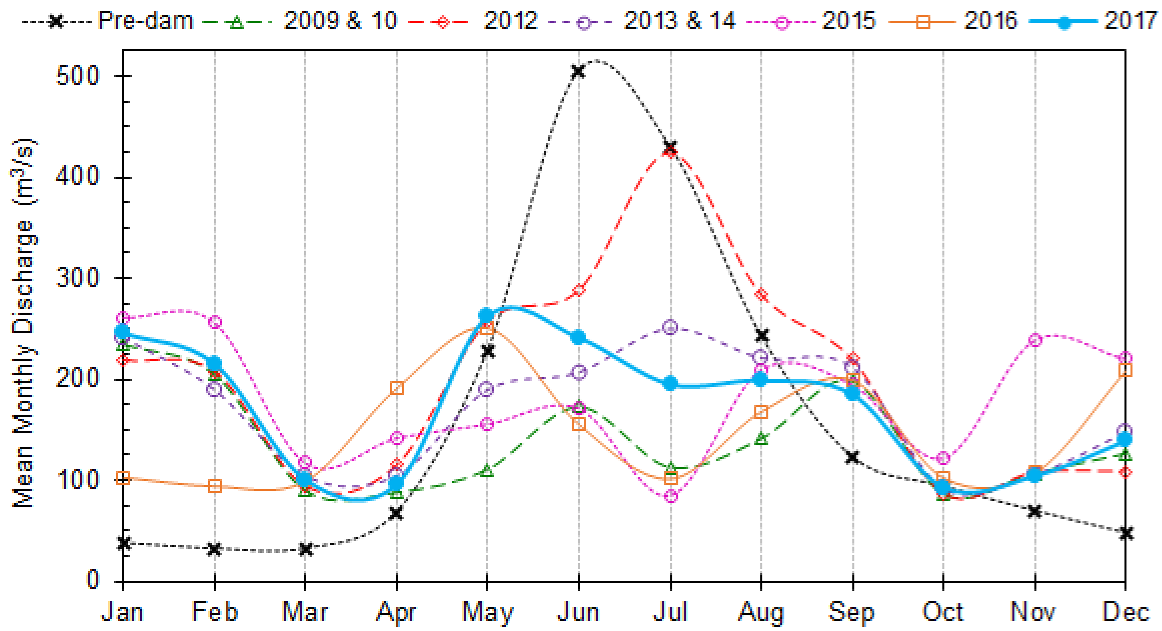


Figure 3-5: **Mean monthly hydrographs for the lower Duncan River for sampling years 2009 and 2010 averaged, 2012, 2013 and 2014 averaged, 2015, 2016, and 2017 (provisional) and pre-dam (3 years of data) discharges plotted with smoothed lines.**

Autumn flows through to November were similar to previous years, except for 2015.

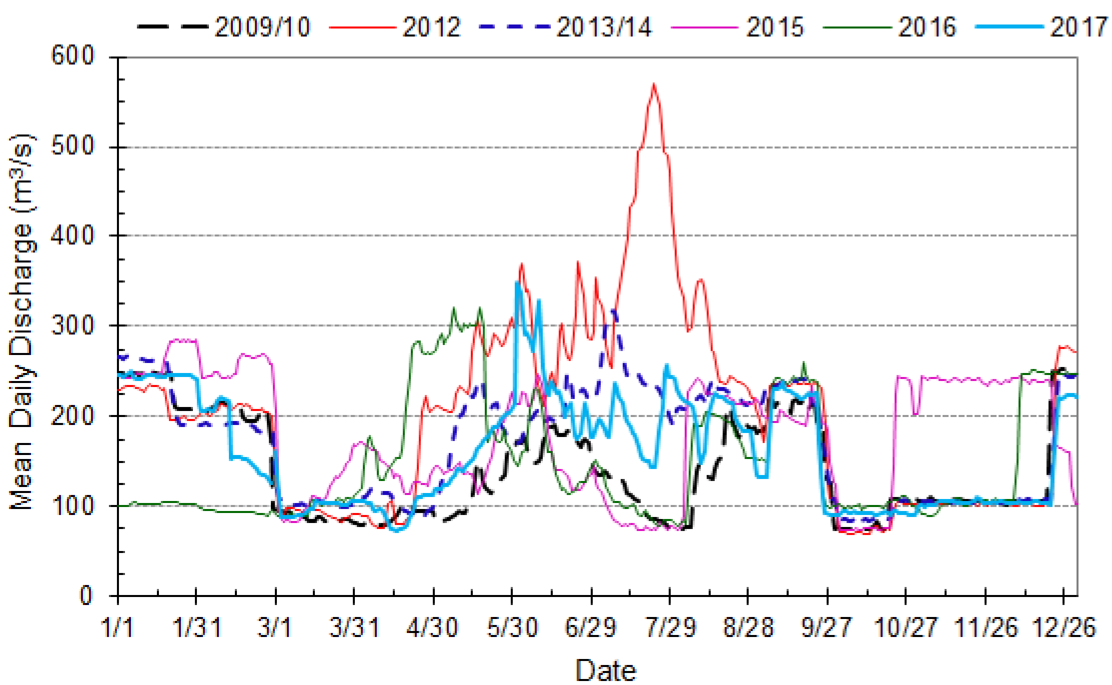


Figure 3-6: **Mean daily discharge (m^3/s) for 2009 and 2010 (averaged), 2012, 2013 and 2014 (averaged), 2015, 2016, and 2017 (provisional) for the lower Duncan River at Station 08NH118.**

3.2.2 Lardeau River

In 2017, the Lardeau River experienced a similar monthly mean discharge of 230 m^3/s for June, as compared to 2011 and 2012 (Figure 3-7). However, the duration of high discharge in 2011 and 2012 continued into July while the 2017 July discharge dropped to the mid-range for the study interval. September and October 2017 mean discharges (24.2 m^3/s and 16.4 m^3/s respectively) were the lowest since the start of the project in 2009, with flows remaining low for November. (The 2017 discharge record is provisional, prior to Water Survey of Canada verification).

There are 70 years of flow records for the Lardeau River starting in 1917, with an interval missing from 1920 to 1945. Flow records from two hydrometric sites were coordinated by regression analysis for the period of overlap for the missing years of 1997 through 2002 (Q_{max} at 08NH007 = Q_{max} at 08NH118 x 0.37, R^2 = 0.96, linear regression forced through the origin). Recurrence analysis indicated that the 2017 spring freshet along the Lardeau River was above the 1-in-5 year flood event (Q_{max2}) see Polzin and Rood (2013) for detailed log Pearson Type III analysis.

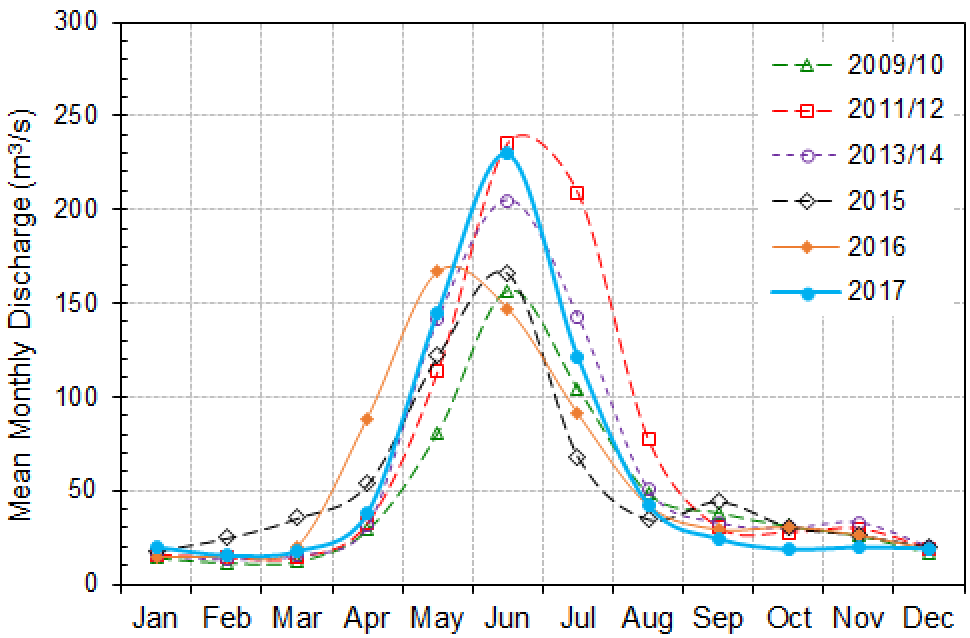


Figure 3-7: Mean monthly discharge (m^3/s) for the Lardeau River for 2017, and averages for years 2009/2010, 2011/2012, 2013/2014 (very similar flows for the paired years see Appendix 3), 2015, 2016, and 2017 (provisional).

The 2017 peak flow occurred on June 1 (324 m^3/s) which is typical timing for the Lardeau River. Historically, 73.1 per cent of annual peaks have occurred within June and seven have occurred in June during the nine years of monitoring (Table 3-3). Since the Duncan Project monitoring started in 2009, the peak discharge in 2017 was the second highest, with a 5-year return interval ($Q_{max 5}$) (Table 3-3).

Table 3-3: Peak spring freshet discharge for the Lardeau River from 2009 to 2017 with log Pearson Type III flood return periods and predicted discharge levels.

				Log Pearson Type III		
Year	Month and Day	Peak Discharge		Return Period	Prediction (m^3/s)	Std. Dev.
2009	June 17	201 m^3/s		**100**	430.5	28.4
2010	June 29	183 m^3/s		**50**	407.7	22.4
2011	June 23	297 m^3/s	Q_{max3}	**25**	383.7	17.3
2012	**July 1**	**354 m^3/s**	Q_{max10}	**10**	349.2	12.1
2013	June 20	269 m^3/s	Q_{max2}	**5**	319.5	9.5
2014	June 25	243 m^3/s		**3**	293.9	8.2
2015	June 9	245 m^3/s		**2**	269.2	7.4
2016	**May 8**	**206 m^3/s**				
2017	**June 1**	**324 m^3/s**	Q_{max5}			

Daily variability was graphed to compare the monthly means. The low discharge for September and October were the lowest during the study period. It also shows daily fluctuations which influence where seedling establishment and recruitment occurs. Peak discharge occurred June 1 and June 9 which was the same as the peak discharge dates for the Duncan River.

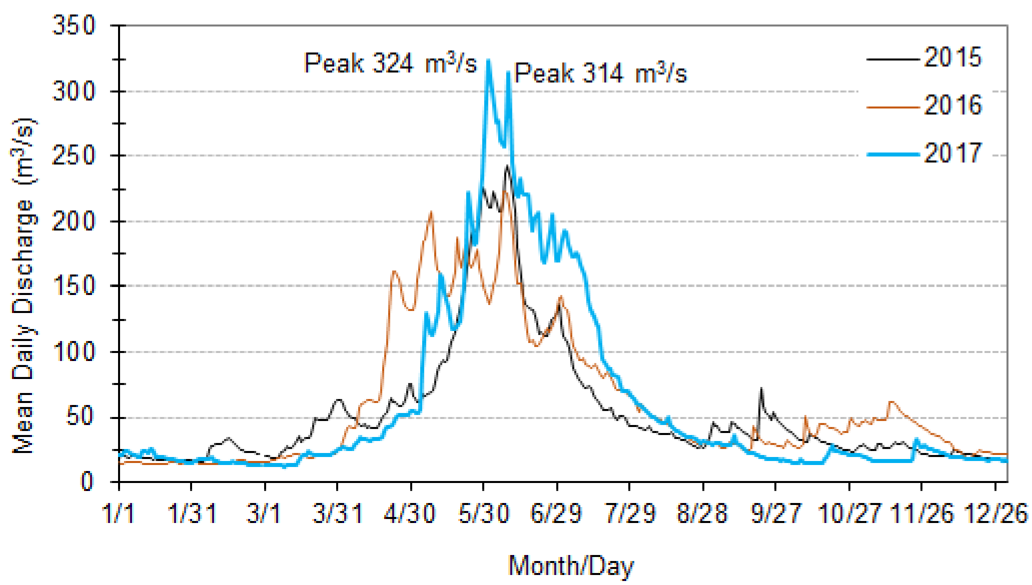


Figure 3-8: Mean daily discharge for the Lardeau River, 2015 to 2017.

3.3 Black Cottonwood Phenology

Consistent with the prior sampling, we recorded dates of catkin and flower emergence, leaf emergence, seed development, senescence, and seed release events through the growth season of 2017. Most of the developmental stages occurred later in 2017 than in 2016, which was an unusually early spring (Table 3-4 and Figure 3-1). The start of the 2017 spring phenology was average relative to the study period that commenced in 2009.

Table 3-4: Black cottonwood phenology for 2017 with 2016 and 2015 phenology for comparison, along the Duncan and Lardeau rivers.

Occurrence / Stage	2015	2016	2017
The gradual emergence of male (1st) and female (2nd) inflorescences.	Rapid growth Apr. 1+	Mar. 20 to 30 male, Mar. 25 – Apr. 8 female	Mar 28 – Apr 10 male Apr 2 – 15 female
Flowers developed, pollination	April 12 – 19	April 8 – 15	Apr 14 – 22
Abscission of male catkins	April 20 – 30	April 10 – 15	Apr 24 – May 8
Leaf emergence	April 10 – 30	April 1 – 20	Apr 20 – 30
Seed pods developing	Green by May 25	Green by May 1	Green by May 20
Seed release	June 7 to July 16	May 30 to Jun 20	May 28 – Jul 21
Leaf senescence	Late Sep. through Oct.	Early Sep. through Sep.	Late Sep. through Oct.

The first seed release event in 2017 was on May 28 and the last was observed on July 21. Most releases noted in 2017 were limited, but these were frequent relative for the study interval. Between July 2 and July 7 there were intermittent light seed releases daily. July seed releases did not occur in 2013 or 2016. No August seed releases were observed in 2017, or for monitoring years 2013 to 2016 (Table 3-5).

The seed release events commonly occurred with warming temperature, sometimes after rain events. The most extensive seed release occurred over three days from July 19 through 21, 2017.

Table 3-5: Black cottonwood seed dispersal events in 2017 for the lower Duncan and lower Lardeau floodplains of southeastern British Columbia. Event T_{max} = average max temperature for the event and time period.

Event	Date	Seed Abundance	T_{max} (°C)	Rain (mm)	Event T_{max}	Prior and Post Rain Events Time Periods
1	May 28	Low	29.0	0.0	**29.0**	Rained May 24 & 25 total 2.6 mm. Rained May 30 to Jun. 4, total 13.2 mm. T_{max} for rain period – 16.8 °C.
2	Jun. 17	Low	20.5	2.0	**20.5**	Rained 14.4 mm, June 11 to 17. No rain on June 12.
3	Jun. 19 Jun. 20 Jun. 21	Moderate Moderate Low	21.5 27.0 22.0	0 0 0	**27.0**	No rain for at least 8 days prior to these events.
4	Jun 29	Low	27.5	0	**27.5**	Rained 0.4 mm on June 26.
5	Jul 2 Jul 3 Jul 4 Jul 5 Jul 6 Jul 7	Low Low Low Low Low Low	31.5 31.0 31.0 32.5 33.5 32.5	0 0 0 0 0 0	**33.5**	Rained 5.4 mm on July 10th.
6	Jul 17	Low	26.0	0	**26.0**	Rained 1.4 mm on July 20 and 0.4 mm on July 23, no rain in-between these dates.
7	Jul 21	Low	23.0	0	**23.0**	Rained 1.4 mm on July 20 and 0.4 mm on July 23rd no rain in-between these dates.

3.4 Black Cottonwood Establishment and Recruitment along the Lower Duncan and Lardeau Rivers

3.4.1 Seedling Abundance

Duncan River

Following the 2017 field inventories, a total of 264 sampling quadrats along the lower Duncan River had black cottonwood seedlings (3 age classes) that had established in 2015 to 2017 (2017 seedlings are germinants) (Table 3-6). There was a significant difference (P = <0.001, Appendix 3) among the total number of quadrats with seedlings compared to monitoring years, 2009 to 2017.

The total number of 2017 germinants (# Germ) were the lowest establishment density since monitoring started in 2009, except for the very high flow year of 2012, when colonization sites were inundated through the interval of seed release.

Table 3-6: Comparisons of 2014, 2015, 2016, and 2017 numbers of quadrats with seedlings and the total density per transect of germinants for the corresponding year, along the Duncan River (Dun. Seg. = Duncan Segment, Tran = Transect, Quad = Quadrats, # Germ = total density of germinants (current year seedlings) per transect).

Dun. Seg.	Tran #	2014		2015		2016		2017	
		# Quad	# Germ	# Quad	# Germ	# Quad	# Germ	# Quad	# Germ
D1	T3	9	2,786	13	8,026	20	1,315	8	45
	T4	0	0	0	0	2	7	0	0
	T5	0	0	0	0	0	0	0	0
D3	T10	1	2	0	0	0	0	0	0
	T11	67	4,604	9	2	25	2,871	13	225
	T15	41	1,639	21	507	36	1,251	32	2,240
	T17*	26	651	24	660	23	569	34	2,380
	T29*	35	1,551	7	38	19	242	11	596
	T35*	21	982	14	201	31	1,147	30	1,912
	T20	12	400	12	160	0	0	0	0
	T23	0	0	0	0	0	0	0	0
	T40*	8	250	12	183	21	476	7	271
	T45*	20	465	27	4,347	38	934	26	178
D4	T3	62	3.273	51	951	39	260	34	220
	T10*	42	1,027	45	493	47	227	28	456
	T5	0	0	0	0	0	0	0	0
D5	T2	9	88	7	59	9	113	0	0
	T9	13	156	9	184	14	329	5	18
	T11	21	740	18	5,893	17	139	9	55
	T12	31	1,395	38	4,006	39	995	21	140
	T16	18	574	4	170	0	0	0	0
	T19	7	268	6	76	3	61	2	36
D6	T6	5	696	0	0	1	4	0	0
	T20*	13	83	0	0	3	13	0	0
	T29	19	231	20	1,092	28	1,210	22	807
	T36	60	758	65	979	58	639	20	495
Totals		**540**	**22,619**	**402**	**28,027**	**473**	**12,802**	**302**	**10,073**

Note: * indicates new transect lines established in 2013.

The total number of germinants (10,073) was lower than previous sampling years (2009 to 2016), except 2012, and lower than the average (21,181) number of germinants for 2009 to 2016 including 2012. The total number of germinants for 2009 to 2013 were:

- 2009 – 123,956 (includes willow seedlings), 47,786 estimated cottonwood;
- 2010 – 22,830;
- 2011 – unknown, study was suspended for the year;
- 2012 – 122; and
- 2013 – 14,078.

There is a significant difference between total numbers of 2017 germinates versus 2009 to 2016 total number of germinates (P = <0.001). There is a significant difference comparing 2017 to 2016 and 2015 (P = 0.002 and P = 0.004, respectively, utilizing One-Sample Signed Rank Test and the median for 2017 used to test 2016 and 2015 data, Appendix 3). The average number of germinates is 24,690 using the 2009 estimated total and excluding 2012 (almost zero establishment due to extremely high water levels during seed release and the growing season). The total number of germinants in 2017 was the lowest recorded during the study period with the exception of the flood year 2012.

There is an apparent downward trend in the number of established germinants for the Duncan reach from 2009 to 2012. Following the flood of 2012, there was an apparent upward trend with increasing number of germinants to 2015. After 2015, there appears to be a downward trend to 2017 (Figure 3-9).

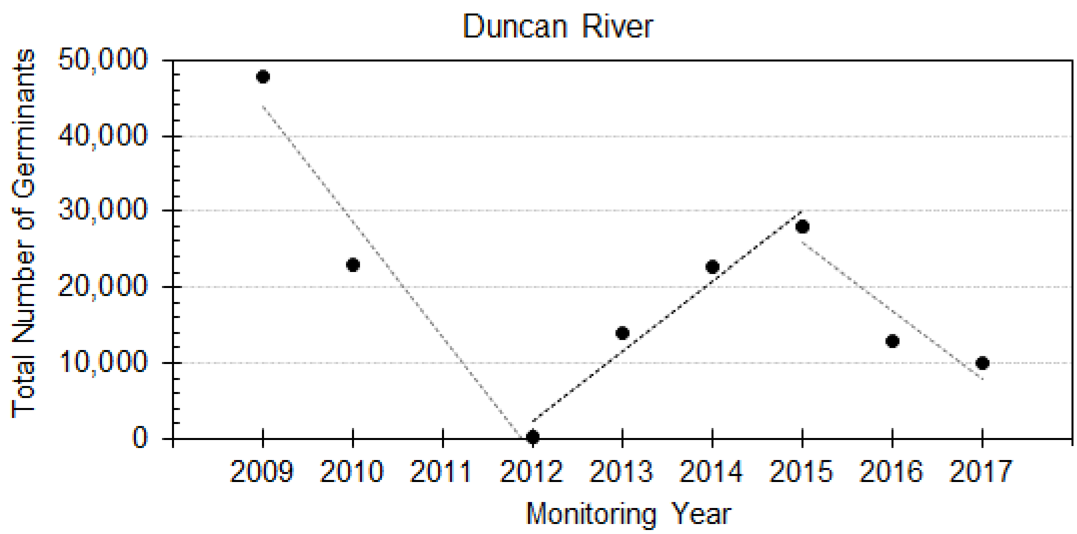


Figure 3-9: Total number of germinants along the Duncan River for each field study year.

Lardeau River

There is a decrease in the total number of quadrats along the Lardeau Reach with seedlings in 2017 (72), as compared to all previous years during the study period except 2012 which had 42 quadrats (Table 3-7). There is a significant difference (P = <0.001) between 2017 total number of quadrats and the mean total number of quadrats from 2009 to 2016. However, there was no significant difference between 2017 and 2016 or 2015 (P = 0.13 and P = 0.65, respectively).

A total of 1,127 germinants (2017 seedlings) occurred along transect lines in 2017 (Table 3-7). This is a significant decrease (P = 0.002) compared to 2009 to 2016. The average number of germinants (2009 to 2016) for the Lardeau Reach was 4,119. Comparing 2017 total number of germinants to 2016 and 2015 totals, there is no significant difference between the previous two years (P = 0.48 and P = 0.95 respectively) (Figure 3-10).

Table 3-7: Comparisons of 2014, 2015, 2016, and 2017 numbers of quadrats with seedlings and the total density per transect line of germinants for the corresponding year, along the Lardeau River (Lard. Seg. = Leadeau Segment, Tran = Transect, Quad = Quadrats, # Germ = total density of germinants (current year seedlings) per transect line).

Lard. Seg.	Tran #	2014		2015		2016		2017	
		# Quad	# Germ	# Quad	# Germ	# Quad	# Germ	# Quad	# Germ
L1	T1	8	238	12	95	14	124	3	10
	T10	20	575	21	292	23	249	11	340
	T20	43	1,823	36	339	42	918	16	373
	T36	14	670	10	61	9	50	23	320
L2	T6	11	312	7	313	16	143	1	8
	T15	4	173	1	0	0	0	0	0
	T18*	19	648	0	0	8	24	13	53
L3	T1	5	200	0	0	8	35	0	0
	T9	6	179	0	0	2	5	1	1
	T30*	0	0	0	0	9	59	4	22
Totals		**130**	**4,818**	**87**	**1,100**	**131**	**1,607**	**72**	**1,127**

Note: * indicates new transect lines established in 2013.

There has been a downward trend since the start of the study (2009) with a possible increase following the flood of 2012 in 2013, and then continuing decline to 2017 (Figure 3-10).

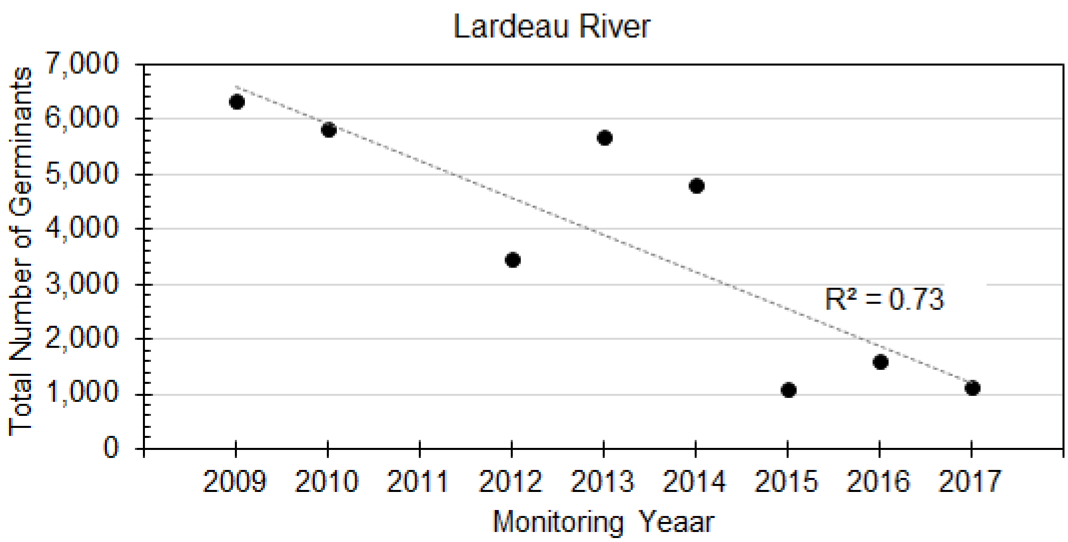


Figure 3-10: Total number of germinants along the Lardeau River for each field year of the study period.

3.4.2 Seedling Densities and Survival

Duncan River

Seedling densities occur with high variabilities. Box plot comparisons between densities for 2015, 2016, and 2017 illustrate the magnitude of differences for the Duncan Reach across years (Figure 3-11)[4]. A significant difference occurred between years (P = <0.001 Appendix 3 using paired data). Multiple comparison procedures isolated the differences occurred between 2017 and 2016 and 2015, but not between 2016 and 2015 (Appendix 3).

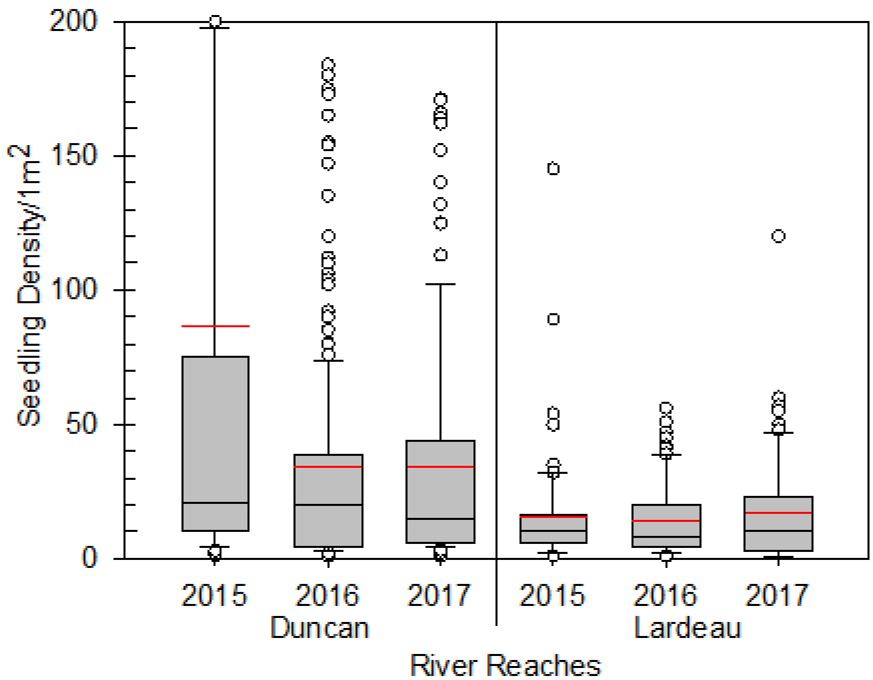


Figure 3-11: 2015, 2016, and 2017 black cottonwood germinant densities. Extreme outliers removed (see Appendix 3).

The 2017 seedling densities for the Duncan reach were significantly higher compared to the Lardeau reach seedling densities in 2017 (P = 0.003, Figure 3-11). This is consistent with prior years' results (except for 2012 flood year).

Comparisons between years for each segment along the Duncan reach also showed high variability. Figure 3-12 shows the raw data with the y-axis scaled down to show more detail between years with low densities compared to D1 and D5 in 2015. Differences for germinant densities occurred within segments for the three years. See Appendix 3 for the graph with no scaling.

Duncan Segment 1 (D1) had a significant difference (P = <0.001) between years with 2017 germinant densities extremely low compared to 2015 and lower than 2016. Duncan Segment 3 (D3) did not have significant differences in median values between 2017 and 2016 but there was a significant difference between 2017 and 2015 (P = 0.81 and P = 0.03 respectively). D4 segment had no significant difference between 2017 and 2016 and 2015 with 2017 densities lower than both previous years (P = 0.09 and P = 0.37 respectively). The D5 segment has significantly lower densities compared to 2016 and 2015 densities (P = <0.001). D6 segment has 2017 densities significantly lower than densities in 2015 and 2015 (P = 0.04) but not significantly different compared to 2016 (P = 0.11).

[4] For box plots, the lower boundary of the box indicates the 25th percentile, the black line within the box marks the median, the red line marks the mean and the upper boundary indicates the 75th percentile. Whiskers above and below the box indicate the 90th and 10th percentiles. Outliers are indicated with an open circle.

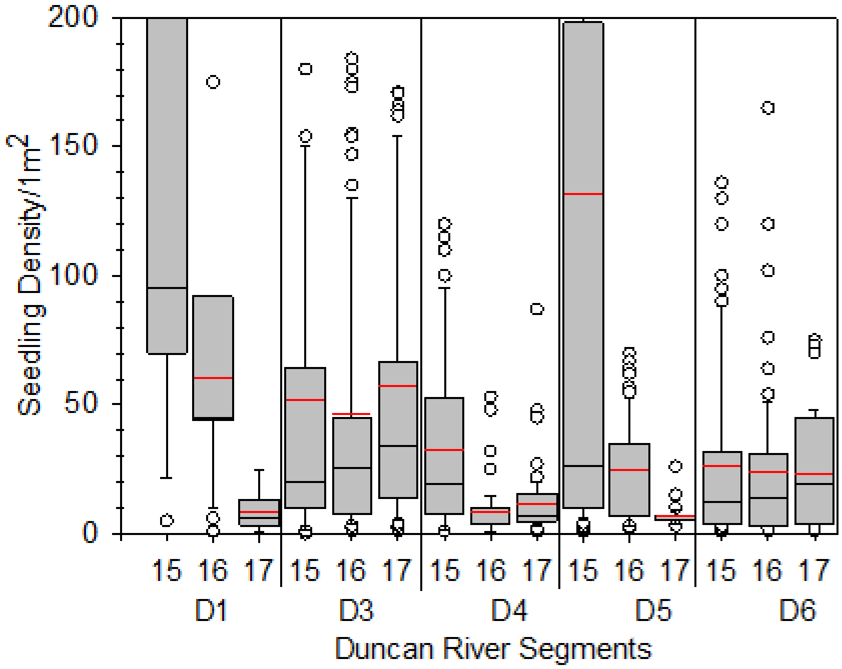


Figure 3-12: Germinant densities for 2015, 2016, and 2017 for each segment along the lower Duncan (D) River. Extreme outliers removed (see Appendix 3 for outliers).

Figure 3-13 shows the difference between raw and paired data. It has also been scaled to show detail between years within segments when 2015 densities in a few quadrats where considerably higher but the medium values were considerably lower.

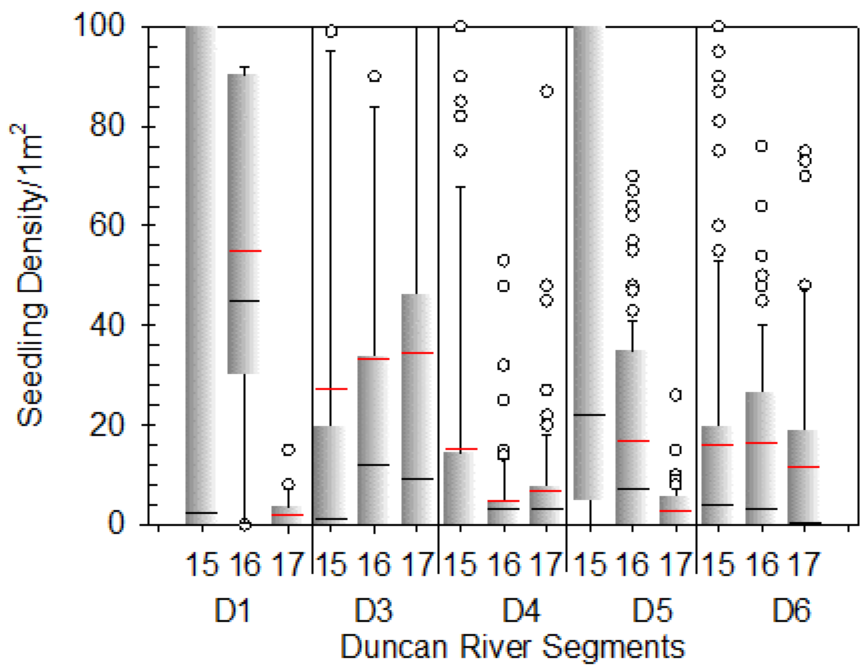


Figure 3-13: Paired data for Duncan River segments scaled down to show 2017 values.

Lardeau River

The Lardeau River also has significantly different median values for germinant densities in 2017, compared to 2016 (P = <0.001) but not significant compared to 2015 (P = 81) for paired data along transect lines measured within quadrats (Figure 3-14, see Appendix 3 for Lardeau Reach outliers beyond 60 germinants). Comparison of raw data counts shows that 2015 was a very low establishment year for the natural Lardeau River during the study period. Raw data without scaling for the Lardeau River is presented in Figure 3-11.

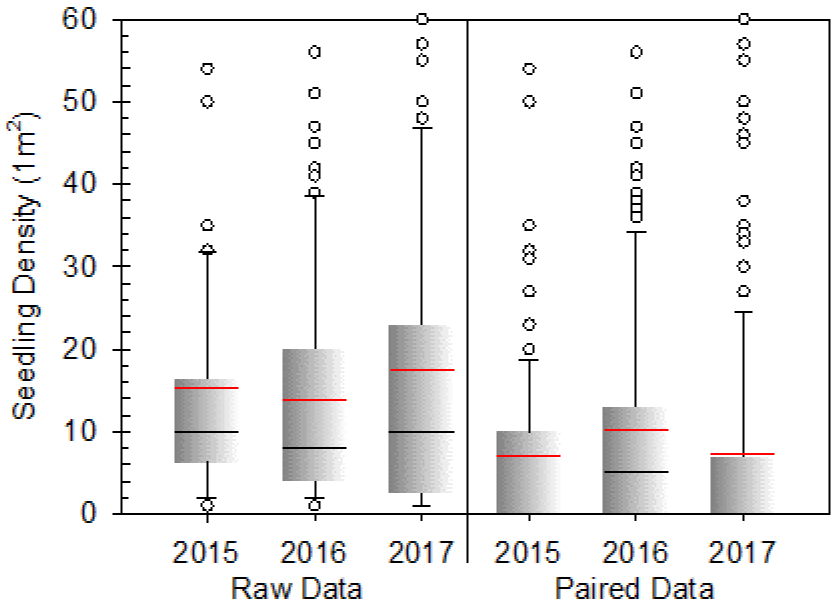


Figure 3-14: 2015, 2016, and 2017 black cottonwood germinant densities along the Lardeau Reach with the Y-axis scaled for raw and paired data.

Figure 3-15 shows the paired data for seedling densities when they occurred along transects. Graphs with no scaling are located in Appendix 3.

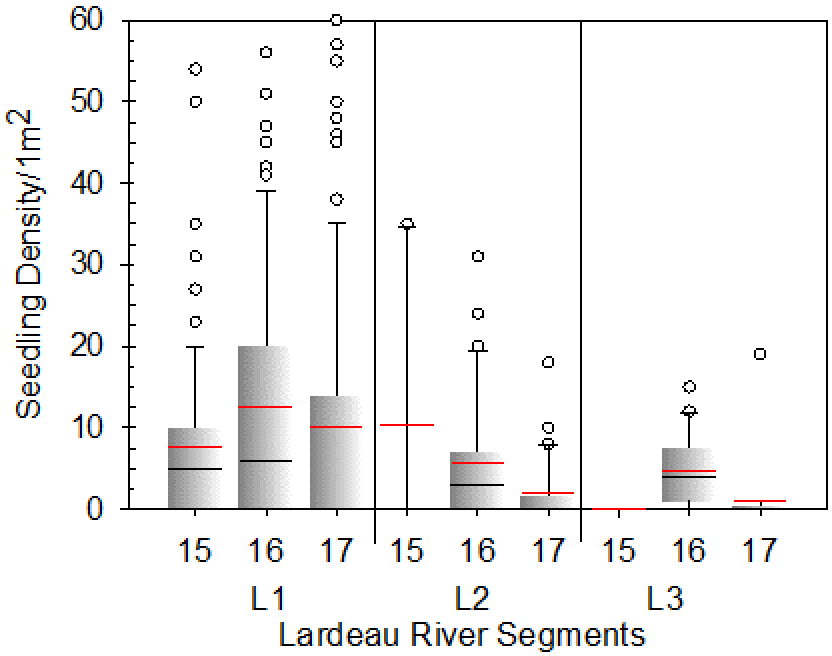


Figure 3-15: Germinants densities for 2015, 2016, and 2017 for each segment along the Lardeau (L) River using paired data (scaled).

Comparisons between segments show that Lardeau Segment 1 (L1) has significantly lower density median values for 2017 compared to 2016 (P = <0.02) and no significant difference between 2017 and 2015 (P = 0.73) (Figure 3-15). L2 has significantly lower densities compared to 2016 (P = 0.04) but not to 2015 (P = 0.72). L3 had significantly lower densities in 2017 compared to 2016 (P = 0.002) Densities are slightly higher for 2017 compared to 2015 but not significantly (P = 0.06). There was zero establishment in 2015 for segment L3 and 2017 had a zero median with 75 per cent was 0.5 seedling density.

3.4.3 Establishment to Recruitment of 2015 to 2017 Seedlings

In 2017, seedlings established in 2015, 2016, and 2017 were monitored. Substantial decreases in seedling density by the end of the first growing season are typical for black cottonwood survival through the first season (Bradley and Smith 1986, Polzin 1998, Rood et al. 2007). The average survival rates for seedlings in their third growing season are usually the highest (Polzin and Rood 2013). The surviving seedlings established in 2015 are considered recruited by the fall of 2017.

Survival pattern was not similar to the typical pattern with the highest survival rates in the third year and the lowest in the first year (Figure 3-16). The first year survival rates for the Duncan 2017 seedlings (germinants) is significantly higher (P = <0.001, Appendix 3), (38.2 per cent) than the average first-year survival (2008-2016) for the study period (Figure 3-16). It is similar to 2016 1st year survival rate of 39.9 per cent. The second-year survival rate for 2017 (16.8) is significantly (P = <0.001) lower compared to the average second-year survival rate of 31.8 per cent (2008-2016) for the study period. The third year is lower (26.9 per cent) than the average (42.5 per cent) for the study period with a significant difference (P = <0.001).

The free-flowing reference reach, the Lardeau River has a complete reversal of the typical pattern of survival rates (Figure 3-16). The first year survival rate for 2017 seedlings (germinants) was similar to the average for the study period with a slight increase in survival (P = 0.41). The second and third-year rates for 2017 are significantly reduced (P = <0.001) compared to the average rates for the study period.

The survival rates for the 2017 seedlings monitored (2015, 3rd year, 2016, 2nd year, and 2017, 1st year) are higher for the Duncan compared to the Lardeau reaches (Figure 3-16). There is significant differences for the 1st, 2nd, and 3rd, year survival rates (P = <0.001, P = 0.002, and P = <0.001 respectively).

Comparison between the Duncan and the Lardeau reaches for the average first, second, and third-year survival rates (2008 to 2016) resulted in the Duncan reach being significantly higher (P = <0.001) compared to the Lardeau reach for first-year survival rates. The Duncan reach is significantly lower for the average second year (P = <0.001) and third year (P = 0.004) survival rates compared to the Lardeau reach.

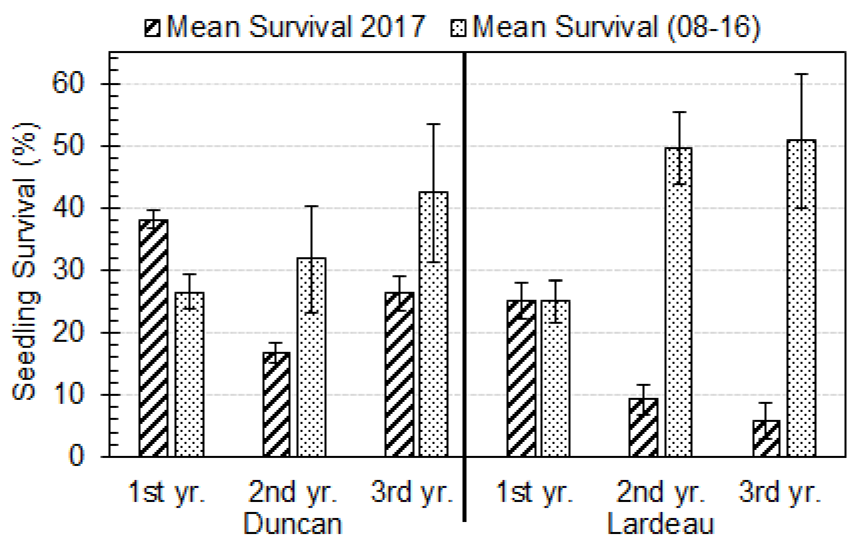


Figure 3-16: Mean (± s.e.) survival percentages for 2015 (3rd-year survival), 2016 (2nd-year survival), and 2017 (1st-year survival), seedlings monitored in 2017. Mean (± s.e.) seedling survival for 1st, 2nd, and 3rd year means for 2008 to 2016.

4 DISCUSSION

Naturally, flowing rivers are dynamic, with seasonal flow patterns and internal variations, including flood events that provide physical disturbances of the river bed, banks, and adjacent floodplains. River flooding provides essential occasional disturbance that underlies the episodic rejuvenation of riparian woodland resulting in arcuate bands of single age cohorts (Hughes 1990, Stromberg et al. 1991, Friedman et al. 1996, Friedman and Lee 2002). Prior study results consistently reveal that section *Aigeiros* cottonwoods *Populus deltoids* Marsh, *P. fremontii* Watson and *P. nigra* L. require floods for population replenishment through seedling colonization. (Rood and Mahoney 1995, Scott et al. 1996, Cordes et al. 1997, Shafroth et al. 1998, Cooper et al. 1999, Guilloy-Froget et al. 2002). Episodic rejuvenation occurs when suitable conditions (flood events large enough to create new recruitment zones) are created on intervals of five to ten years or longer (Bradley and Smith 1986, Baker 1990, Stromberg et al. 1991, and 1993, Hughes 1994, Johnson 1994).

Conversely, the role of flood events for reproduction of section *Tacamahaca* cottonwoods is less well understood (Baker 1990, Polzin and Rood 2000, Fierke and Kauffman 2005). This taxonomic group of 'balsam poplars' includes narrowleaf cottonwood, *P. angustifolia* James, balsam poplar, *P. balsamifera* L., and black cottonwood, *P. trichocarpa* Torr. & Gray, species that have a greater reliance on clonal reproduction and other ecophysiological differences from the section *Aigeiros* cottonwoods (Farrar 1995, Gom and Rood 1999, Rood et al. 2003).

The Elk River is located in the East Kootenay within the Elk Valley and occurs within a humid reach. Patch recruitment was documented along the Elk River for black cottonwood within this humid reach (Polzin and Rood 2006). Patch recruitment consists of patches of relatively even-aged cottonwood (1 to 5 year-aged cottonwood, Polzin 1998 and 2006) in contrast to arcuate banding of single age cohorts that occurs in semi-arid and arid reaches. The free-flowing Elk River research showed that river water levels were less limiting and geomorphic disturbance was the more vital component of the flood event for successful recruitment. Similarly, the Duncan and Lardeau rivers occur within humid reaches where patch recruitment of black cottonwood also occurs.

This study is focussed on the long-term investigation of the riparian vegetation and black cottonwood recruitment trends in response to Alt S73. This report summarizes the 2017 results and compares these observations with previous year patterns.

4.1 Black Cottonwood Monitoring Summary 2017

The seasonal water pattern plays a role in cottonwood recruitment. It is the pattern of dam operation and not the presence or absence of a dam *per se*, which largely determines the impacts on seedling colonization by cottonwoods and other riparian species. However, river damming also interrupts the flow of suspended sediments and this provides a further impact from river damming. The Lower Duncan River is very unusual in that prior to damming, the natural Duncan Lake sequence would have similarly trapped alluvial sediments and that system was consequently somewhat naturally sediment-depleted.

For both the natural, pre-dam situation and the post-dam condition, the Lardeau River delivers an extensive load of suspended sediment, and it also provides woody debris. In contrast to other regulated rivers, there is consequently a net accumulation of alluvial sediments, and woody debris, along the Lower Duncan River since the Lardeau continues to provide this inputs but with flood flow attenuation from the upstream reach of the Duncan River. The combined peak flow from the Upper Duncan and Lardeau rivers is diminished relative to the pre-dam situation. This attenuation of the peak flow pulse has reduced capacity to transport the alluvial sediments and woody debris and consequently these have increased after damming. Thus, while some aspects related to floodplain processes are common across the Duncan and other regulated rivers, there are also some important differences. These differences must be considered to fully analyze and understand the patterns of cottonwood colonization and the succession of the riparian woodlands

The black cottonwood phenological developmental stages occurred at an average time interval consistent with previous study years except 2016 which was earlier than average. The pattern of seed release following rain events was not consistent in 2017 (Polzin et al. 2015). Most of June and July seed releases did not follow rain events. Rain events may promote seed release from black cottonwood in this humid, temperate-climate mountain ecoregion and increase the seed release time period to include an August seed release. However, during hot dry periods, seed release timing is similar to dryer ecoregions with no August seed release. The main seed release events occurred during June and July, both months had below average total precipitation and July had the lowest level recorded since the start of the study in 2009.

Germinant densities were the lowest since the start of the study excluding 2012 flood year, for the Duncan reach and lowest since the start of the study including 2012 for the Lardeau reach. However, this does not mean that seed release levels were lower than in previous years. Monitoring occurred the first week in August which was found to be the best time for seedling monitoring for distinguishing between cottonwood and willow germinants for the later seed release bursts. With the record low precipitation in July, a high proportion of the germinants had already died from drought stress before sampling began along both reaches. The last three years have experienced dryer summers compared to the historical average. A combination of increased drought mortality early in the growing season and the natural succession of the loss of recruitment zone areas as they become vegetated probably contributed to the low densities observed this year for both the Duncan and the Lardeau reaches. Cottonwood recruitment sites are moist, barren sites with full sunlight exposure (Bradley 1982, Scott et al. 1996, Braatne et al. 1996). The moisture level of sites appeared to be the limiting factor.

In a long-term study, it is not surprising that some of the former high establishment levels measured along transects experienced reduced establishment levels as the recruitment zone becomes colonized by cottonwood, willow, grasses, and forb species. The same zones increased in elevation with deposition from periodic flooding of the recruitment zones. The flood of 2012 created and eroded away recruitment areas creating new recruitment zones for the flow attenuated Duncan reach and the free-flowing Lardeau River. This resulted in a steady increase in establishment levels to and including 2015 for the Duncan. The following two years have experienced decreasing levels of establishment which may be more a factor of weather than the decrease in establishment area from colonization of vegetation.

The Lardeau River also experienced similar fluctuations in establishment levels but without the extreme low in 2012. While the flood of 2012 created new recruitment zones most were downstream of established transect lines. The subsequent decrease in establishment levels along the natural flow Lardeau reach for 2016 and 2017 suggest that the dryer, hotter weather for the growing season may be the driving factor for the decline of establishment levels for the last two years for both reaches.

An example of a new recruitment zone following the 10-year return interval flood event along the Lardeau River is shown in Figure 4-1. The area was created downstream of the established transect line L1T10. Figure A shows the seedlings during May 2013. Seedlings established along two bands on either side of the top of the newly form recruitment bar. Figure B shows the same area in 2017. Recruitment is mainly willow but there is cottonwood scattered throughout.

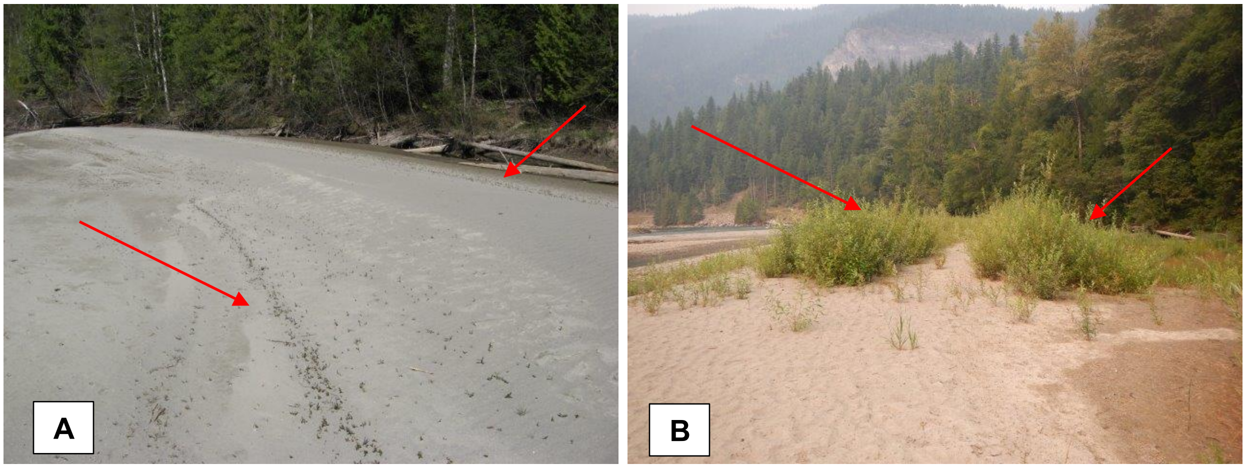


Figure 4-1: Lardeau River segment 1 (L1) Transect 10 (T10) May 2013 (A) and August 2017 (B). Arrows point to cottonwood and willow seedlings on a sand bar in 2013. Same bar and seedlings in 2017, mainly willow seedlings survived with a few cottonwoods by 2017 with arrows pointing to same seedling bands.

Survival of germinants through the first growing season along the Duncan reach was 38 per cent, well above the average of 26.5 per cent. This was attributed to the high mortality of germinants before sampling began, and increased survival of the remaining seedlings. The Lardeau reach had a similar decrease in establishment levels but had a similar survival rate for the first year seedlings. Some of the increase in survival for the Duncan reach may be attributed to the regulated flows of the Duncan reach. There was an increase in river stage along the Duncan reach for the last week in July and all of August while the Lardeau River discharge and stage continued to decrease. The increased river stage along the Duncan would raise the alluvial ground water level, increasing seedlings access.

Both the Duncan and the Lardeau reaches had second and third-year survival rates significantly lower than average survival rates in prior years. The summer of 2017 precipitation during the growing season considerably lower compared to 2015 and 2016. Similar decreases in survival rates compared to the average survival rates suggest that the primary impact to the survival of the second and third-year seedlings was due to weather.

The first year average survival rates were similar between reaches, showing the ability of black cottonwood seedlings to establish wherever moisture levels are sufficient and the area is bare or relatively bare. However, the ability to survive to the end of the third growing season requires a broader range of more specific requirements (Polzin and Rood 2006. These factors were identified in Polzin et al. (2010) and data has been collected for these factors since 2009 (study Year 1) monitoring started. This data will be used in the 2018 hypothesis testing and analysis. The increase in the 2017 first year survival rate compared to the average and the Lardeau reach suggests that the altered flow regime may increase first-year survival during drought conditions. This theory will be tested in 2018.

5 CONCLUSIONS

The data collection for DDMMON#8-1 study Year 8 data extended from August to October 2017. The purpose of study Year 8 was to investigate the effects of the implementation of the Alt S73 flow regime on black cottonwood establishment and recruitment with respect to the following attributes:

- The extent of black cottonwood seedling establishment; and
- The level of black cottonwood seedling survival and recruitment.

The results in this report document black cottonwood establishment and recruitment since 2015 along the lower Duncan River and along the reference reach, the Lardeau River.

Establishment densities for 2017 germinants were below average for the Duncan and the Lardeau reaches. Survival rates were reversed from the average survival rates for both reaches. Recruitment survival through the third growing season was well below average for both reaches, with the Duncan 2017 third year survival higher than the Lardeau 2017 third year survival.

The relationship between abiotic influences and the biological responses by black cottonwood seedlings supported key factors identified in previous years. Black cottonwood establishment and survival along the lower Duncan River during this monitoring period were influenced by:

1. Lower August stage allowing seedling establishment at lower elevations. Most of the lower elevation areas were close to or within the active channel.
2. Seedling establishment elevation is a factor that determines the extent affected by inundation. Additionally, for seedlings established on lower recruitment zones, the probability of burial by deposition or scour is increased which is correlated with river stage patterns.
3. Water availability for seedlings is very important during the summer months. In previous years an artificially high river stage resulting in high groundwater level during the growing season along the Duncan reach moderated the influence from drought. In 2017, the extreme low precipitation in July reduced establishment and survival of seedling along both reaches. The Duncan reach had increased first-year seedling survival compared to the average and the Lardeau reach had similar survival for first-year survival compared to the average. Second and third-year survival rates were greatly reduced compared to the averages for both reaches. The reduced water availability from precipitation greatly reduced survival rates that the flow attenuation along the Duncan reach could not offset.

The lower Duncan River peak discharge occurred June 1, with the lowest discharge during March, October, and November. The spring peak was approximately 100 m^3/s higher than the January high water level. Usually, the peak discharge occurs in January for the flow attenuated Duncan River.

The Lardeau River experienced a Q_{max5} (a 1-in-5 year peak) peak flow that occurred June 1st. This is the second highest for the study period with 2012 receiving a Q_{max10}. The dry hot summer resulted in the lowest discharge rates for September through November.

Results from comparative analyses for 2015, 2016, and 2017 indicated that sediment deposition and erosion, inundation duration and timing, discharge, and establishment elevation are key factors for assessing the performance of Alt S73 on black cottonwood along the lower Duncan River. The findings in 2017 support the previous results of key factors and drivers affecting black cottonwood recruitment. Emerging evidence from recent years of monitoring suggests that climate change may change the average weather conditions which changes the hydrology for the drainage. Continued monitoring of annual black cottonwood recruitment and the 2018 monitoring of riparian vegetation and communities next year will be important to complete the decade interval analyses in 2018. The results of the 2018 analyses will then be used to assess the three hypotheses, and subsequently to address the objectives and the two key management questions outlined in Section 1 (taken from the BC Hydro TOR 2009).

In conclusion, the study Year 8 results largely extended and confirmed the patterns observed in previous years. The consistency of black cottonwood seedling recruitment distributions supports a deterministic pattern, whereby establishment and survival depend on particular physical conditions and seasonal timing.

6 RECOMMENDATIONS

6.1 Air Photo Acquisition

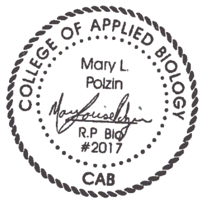
We recommend that the flight-time for the 2018 air photo acquisition be switched from autumn back to spring. Mid-May is recommended as the foliage is on the deciduous trees and shrubs (or an appropriate spring date relative 2018 spring weather). This will allow for photos to be available for the August field monitoring for navigating the rivers to avoid new log jams. It will also provide additional time for air photo analysis and reporting.

7 CLOSURE

VAST Resource Solutions Inc., trusts that this report satisfies your present requirements. Should you have any comments, please contact us at your convenience.

Vast Resource Solutions Inc.,

Prepared by:



March 13 2018

Mary Louise Polzin, PhD, RPBio
Senior Biologist/Riparian Specialist

Stewart Rood, PhD
Research Professor

Reviewed by:

Leigh Anne Isaac, PhD., RPBio.
Senior Wildlife Biologist

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Appendix 1: Lower Duncan and Lardeau Rivers Photo Documentation

Date: August 2017			**Environmental Crew:** MLP, AS, CC
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
1-Aug	DSCN5305	9:13	**D1T3** at EOT looking upstream
1-Aug	DSCN5306	9:14	At EOT looking downstream
1-Aug	DSCN5307	9:14	At 25-26 m plot
1-Aug	DSCN5308	9:18	At 12 m looking at POC
1-Aug	DSCN5309	9:18	At 10 m looking upstream
1-Aug	DSCN5310	9:18	At 10 m looking downstream
1-Aug	IMG_0430	8:49	**D3T11** at EOT looking upstream
1-Aug	IMG_0431	8:49	At EOT looking downstream
1-Aug	IMG_0432	8:49	At EOT looking across the river
1-Aug	IMG_0433	8:49	At EOT looking at POC
1-Aug	IMG_0434	8:51	At 86 m looking upstream
1-Aug	IMG_0435	8:52	At 86 m looking downstream
1-Aug	IMG_0436	8:52	At 86 m looking across stream
1-Aug	IMG_0437	8:52	At 86 m looking at POC
1-Aug	IMG_0438	8:53	At POC looking upstream
1-Aug	IMG_0439	8:53	At POC looking downstream
1-Aug	IMG_0440	8:53	At POC looking at EOT
1-Aug	IMG_0441	8:54	At POC looking at POC
1-Aug	IMG_0442	9:39	At 134 m submerged cottonwoods at EOT
1-Aug	IMG_0443	10:49	**D3T15** at EOT looking upstream
1-Aug	IMG_0444	10:50	At EOT looking downstream
1-Aug	IMG_0445	10:50	At EOT looking across the river
1-Aug	IMG_0446	10:50	At EOT looking at POC
1-Aug	IMG_0447	10:51	At 55 m looking upstream
1-Aug	IMG_0448	10:51	At 55 m looking downstream
1-Aug	IMG_0449	10:51	At 55 m looking at EOT
1-Aug	IMG_0450	10:51	At 55 m looking at POC
1-Aug	IMG_0451	10:52	At 41.8 m looking upstream
1-Aug	IMG_0452	10:52	At 41.8 m looking downstream
1-Aug	IMG_0453	10:52	At 41.8 m looking at EOT
1-Aug	IMG_0454	10:52	At 41.8 m looking at piezometer at 41.8 m
1-Aug	IMG_0455	10:53	At 20 m looking upstream
1-Aug	IMG_0456	10:53	At 20 m looking downstream
1-Aug	IMG_0457	13:00	**D3T17** at EOT looking upstream
1-Aug	IMG_0458	13:01	At EOT looking downstream
1-Aug	IMG_0459	13:01	At EOT looking across the river
1-Aug	IMG_0460	13:01	At EOT looking at POC
1-Aug	IMG_0461	13:02	At 23 m looking upstream
1-Aug	IMG_0462	13:02	At 23 m looking downstream
1-Aug	IMG_0463	13:02	At 23 m looking at EOT
1-Aug	IMG_0464	13:02	At 23 m looking at POC (pink ribbon)
1-Aug	IMG_0465	13:03	At POC looking upstream
1-Aug	IMG_0466	13:03	At POC looking downstream
1-Aug	IMG_0467	13:03	At POC looking at EOT
1-Aug	IMG_0468	13:03	Near POC looking at POC
1-Aug	IMG_0469	14:49	**D3T29** at EOT looking upstream
1-Aug	IMG_0470	14:49	At EOT looking downstream
1-Aug	IMG_0471	14:49	At EOT looking across stream
1-Aug	IMG_0472	14:50	At EOT looking at POC
1-Aug	IMG_0473	14:51	At 25 m looking upstream

Date	Image #	Time	Description
1-Aug	IMG_0474	14:51	**D3T29 (Cont.)** At 25 m looking downstream
1-Aug	IMG_0475	14:52	At 25 m looking at EOT
1-Aug	IMG_0476	14:52	At 25 m looking at POC
1-Aug	IMG_0477	14:52	At POC looking upstream
1-Aug	IMG_0478	14:52	At POC looking downstream
1-Aug	IMG_0479	14:52	At POC looking at EOT
1-Aug	IMG_0480	14:53	Near POC looking at POC (rebar and pink ribbon marks the location)
1-Aug	IMG_0481	15:43	**D3T35** at EOT looking upstream
1-Aug	IMG_0482	15:43	At EOT looking downstream
1-Aug	IMG_0483	15:43	At EOT looking across stream
1-Aug	IMG_0484	15:43	At EOT looking at POC
1-Aug	IMG_0485	15:44	At 28 m looking upstream
1-Aug	IMG_0486	15:44	At 28 m looking downstream
1-Aug	IMG_0487	15:45	At 28 m looking at EOT
1-Aug	IMG_0488	15:45	At 28 m looking at POC
1-Aug	IMG_0489	15:45	At POC looking upstream
1-Aug	IMG_0490	15:45	At POC looking downstream
1-Aug	IMG_0491	15:45	At POC looking at EOT
1-Aug	IMG_0492	15:45	At 6 m looking at POC
1-Aug	IMG_0493	17:18	**D3T45** at EOT looking upstream
1-Aug	IMG_0494	17:18	At EOT looking downstream
1-Aug	IMG_0495	17:19	At EOT looking across stream
1-Aug	IMG_0496	17:19	At EOT looking at POC
1-Aug	IMG_0497	17:19	At 22 m looking upstream
1-Aug	IMG_0498	17:19	At 22 m looking downstream
1-Aug	IMG_0499	17:20	At 22 m looking at EOT
1-Aug	IMG_0500	17:20	At 22 m looking at POC
1-Aug	IMG_0501	17:20	At 8 m looking upstream
1-Aug	IMG_0502	17:20	At 8 m looking downstream
1-Aug	IMG_0503	17:20	At 8 m looking at EOT
1-Aug	IMG_0504	17:21	At 8 m looking at POC
1-Aug	IMG_0505	18:15	**D3T40** at EOT looking upstream
1-Aug	IMG_0506	18:15	At 6 m looking downstream
1-Aug	IMG_0507	18:15	At 6 m looking at POC
1-Aug	IMG_0508	18:16	At 6 m looking upstream
1-Aug	IMG_0509	18:16	At 6 m looking towards D3T45 along back-channel
1-Aug	IMG_0510	18:17	**D3T40 (continued)** at 6 m looking at EOT
1-Aug	IMG_0511	18:17	Near POC looking at POC (rebar in willow near edge of bank)
1-Aug	DSCN5311	12:43	**D4T3** at EOT looking upstream
1-Aug	DSCN5312	12:44	At EOT looking downstream
1-Aug	DSCN5313	12:44	At EOT looking at POC
1-Aug	DSCN5314	12:49	At 41 m looking at EOT
1-Aug	DSCN5315	12:49	At 41 m looking at POC
1-Aug	DSCN5316	12:49	At 41 m looking upstream
1-Aug	DSCN5317	12:50	At 41 m looking downstream
1-Aug	DSCN5318	12:51	At 30 m seedling plot
1-Aug	DSCN5319	12:43	**D4T10** at EOT looking upstream
1-Aug	DSCN5320	12:44	At EOT looking downstream
1-Aug	DSCN5321	12:44	At EOT looking at POC
1-Aug	DSCN5322	12:49	At 33 m looking at POC
1-Aug	DSCN5323	12:49	At 33 m looking at EOT
1-Aug	DSCN5324	12:49	At 33 m looking upstream
1-Aug	DSCN5325	12:50	At 33 m looking downstream
1-Aug	DSCN5326	12:51	At 31 m seedling plot

Date	Image #	Time	Description
1-Aug	DSCN5333	16:19	**D5T2** at EOT looking upstream
1-Aug	DSCN5334	16:20	At EOT looking downstream
1-Aug	DSCN5335	16:20	At EOT looking at POC
1-Aug	DSCN5336	16:23	At 11 m looking at POC
1-Aug	DSCN5337	16:23	At 11 m looking upstream
1-Aug	DSCN5338	16:24	At 12.5 m looking downstream
1-Aug	DSCN5327	15:04	**D5T9** at EOT looking upstream
1-Aug	DSCN5328	15:04	At EOT looking downstream
1-Aug	DSCN5329	15:04	At EOT looking at POC
1-Aug	DSCN5330	15:06	At 19 m looking upstream
1-Aug	DSCN5331	15:06	At 19 m looking downstream
1-Aug	DSCN5332	15:06	At 19 m looking at POC
2-Aug	IMG_0512	8:19	**D5T11** at EOT looking upstream
2-Aug	IMG_0513	8:19	At EOT looking downstream
2-Aug	IMG_0514	8:19	At EOT looking across stream
2-Aug	IMG_0515	8:19	At EOT looking at POC
2-Aug	IMG_0516	8:21	At 45 m looking upstream
2-Aug	IMG_0517	8:21	At 45 m middle of T looking downstream
2-Aug	IMG_0518	8:21	At 45 m looking at EOT
2-Aug	IMG_0519	8:22	At 45 m looking at POC
2-Aug	IMG_0520	8:22	At rebar 36 m mark looking downstream
2-Aug	IMG_0521	8:22	At rebar 36 m mark looking upstream
2-Aug	IMG_0522	8:23	At rebar 36 m mark looking at EOT
2-Aug	IMG_0523	8:23	At rebar 36 m mark looking direction of POC (pink flag on rebar POC in trees behind shrubs)
2-Aug	IMG_0524	8:42	**D5T12** at EOT looking upstream
2-Aug	IMG_0525	8:43	At EOT looking downstream
2-Aug	IMG_0526	8:43	At EOT looking across stream
2-Aug	IMG_0527	8:43	At EOT looking at POC
2-Aug	IMG_0528	9:47	At 48 m looking at start of tape measure as back channel too large to cross to measure from POC
2-Aug	IMG_0529	9:47	At 48 looking upstream
2-Aug	IMG_0530	9:48	At 48 m looking at EOT
2-Aug	IMG_0531	9:48	At 48 m looking at POC
2-Aug	IMG_0532	10:28	**D5T19** at EOT looking upstream
2-Aug	IMG_0533	10:29	At EOT looking downstream
2-Aug	IMG_0534	10:29	At EOT looking across river
2-Aug	IMG_0535	10:29	At EOT looking at rebar at the 8.4 m mark
2-Aug	IMG_0536	11:19	**D6T29** at EOT looking upstream
2-Aug	IMG_0537	11:19	At EOT looking downstream
2-Aug	IMG_0538	11:19	At EOT looking across the river
2-Aug	IMG_0539	11:19	At 48 m looking at POC (across back channel in trees)
2-Aug	IMG_0540	11:20	Looking upstream at start of tape (39 m from POC)
2-Aug	IMG_0541	11:21	Looking downstream at start of tape
2-Aug	IMG_0542	11:21	At 39 m looking at EOT
2-Aug	IMG_0543	11:21	Looking at POC with start of tape (39 m in foreground)
2-Aug	IMG_0544	12:50	**D6T36** at EOT looking upstream
2-Aug	IMG_0545	12:50	At EOT looking downstream
2-Aug	IMG_0546	12:50	At EOT looking across the river

Date	Image #	Time	Description
2-Aug	IMG_0547	12:50	**D6T36 (Cont.)** At EOT looking at POC
2-Aug	IMG_0548	12:53	At 33 m looking upstream
2-Aug	IMG_0549	12:53	At 33 m looking downstream
2-Aug	IMG_0550	12:53	At 33 m looking at EOT
2-Aug	IMG_0551	12:53	At 33 m looking at POC
2-Aug	IMG_0552	12:55	At 18 m looking upstream
2-Aug	IMG_0553	12:55	At 18 m looking downstream
2-Aug	IMG_0554	12:55	At 18 m looking at EOT
2-Aug	IMG_0555	12:55	At 18 m looking at POC
2-Aug	IMG_0556	14:32	**D6T20** at EOT looking upstream
2-Aug	IMG_0557	14:32	At EOT looking downstream
2-Aug	IMG_0558	14:32	At EOT looking across the channel (not main channel)
2-Aug	IMG_0559	14:32	At EOT looking at POC
2-Aug	IMG_0560	14:32	Retake of Photo 556 with shutter open completely
2-Aug	IMG_0561	14:32	Retake of Photo 557 with shutter open completely

Date: October 2017			**Environmental Crew:** MLP, AS
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
2-Oct	DSCN5485	17:28	**D1T3** at EOT looking upstream
2-Oct	DSCN5486	17:28	At EOT looking downstream
2-Oct	DSCN5487	17:28	At EOT looking at POC
3-Oct	DSCN5488	8:55	**D3T11** at 57m looking at POC
3-Oct	DSCN5489	8:55	At 57.3 m looking at EOT
3-Oct	DSCN5490	8:56	At 57.3 m looking upstream
3-Oct	DSCN5491	8:56	At 57.3 m looking downstream
3-Oct	DSCN5492	9:27	At EOT looking upstream
3-Oct	DSCN5493	9:27	At EOT looking downstream
3-Oct	DSCN5494	9:27	At EOT looking at POC
3-Oct	DSCN5495	9:29	At 97m (+57) looking at POC
3-Oct	DSCN5496	9:30	At 97m (+57) looking upstream
3-Oct	DSCN5497	9:30	At 97m (+57) looking downstream
3-Oct	DSCN5498	10:59	**D3T15** at EOT looking upstream
3-Oct	DSCN5499	10:59	at EOT looking downstream
3-Oct	DSCN5500	11:00	at EOT looking at POC
3-Oct	DSCN5501	11:01	At 60 m looking upstream
3-Oct	DSCN5502	11:02	At 60 m looking downstream
3-Oct	DSCN5503	11:02	At 60 m looking at EOT
3-Oct	DSCN5504	11:02	At 60 m looking at POC
3-Oct	DSCN5505	11:10	**D3T17** at EOT looking upstream
3-Oct	DSCN5506	11:11	At EOT looking downstream
3-Oct	DSCN5507	11:11	At EOT looking at POC
3-Oct	DSCN5508	11:13	At 30 m looking upstream
3-Oct	DSCN5509	11:13	At 30 m looking downstream
3-Oct	DSCN5510	11:13	At 30 m looking at EOT
3-Oct	DSCN5511	11:13	At 30 m looking at POC
3-Oct	DSCN5512	12:11	**D3T29** at EOT looking at upstream
3-Oct	DSCN5513	12:11	At EOT looking downstream
3-Oct	DSCN5514	12:11	At EOT looking at POC
3-Oct	DSCN5515	12:13	At 37 m looking upstream
3-Oct	DSCN5516	12:13	At 37 m looking downstream
3-Oct	DSCN5517	13:38	**D3T35** at EOT looking upstream
3-Oct	DSCN5518	13:38	at EOT looking downstream
3-Oct	DSCN5519	13:38	at EOT looking at POC
3-Oct	DSCN5520	13:43	At 28 m looking upstream
3-Oct	DSCN5521	13:43	At 28 m looking downstream
3-Oct	DSCN5522	13:43	At 28 m looking at EOT
3-Oct	DSCN5523	13:43	At 28 m looking at POC
3-Oct	DSCN5524	15:21	**D3T45** at EOT looking upstream
3-Oct	DSCN5525	15:22	At EOT looking downstream
3-Oct	DSCN5526	15:22	At EOT looking at POC
3-Oct	DSCN5527	15:24	At 31 m looking upstream
3-Oct	DSCN5528	15:24	At 31 m looking downstream
3-Oct	DSCN5529	15:24	At 31 m looking at POC
3-Oct	DSCN5530	15:26	At 31 m looking at EOT
3-Oct	DSCN5531	15:26	At 19 m looking upstream
3-Oct	DSCN5532	15:26	At 19 m looking downstream
3-Oct	DSCN5533	15:26	At 19 m looking at POC

Date	Image #	Time	Description
3-Oct	DSCN5534	15:35	**D3T40** at EOT looking upstream
3-Oct	DSCN5535	15:36	At EOT looking downstream
3-Oct	DSCN5536	15:36	At EOT looking at POC
3-Oct	DSCN5537	15:38	At 14 m looking upstream
3-Oct	DSCN5538	15:39	At 14 m looking downstream
3-Oct	DSCN5539	15:39	At 14 m looking at POC
3-Oct	DSCN5540	15:39	At 14 m looking at EOT
2-Oct	DSCN5467	14:17	**D4T3** At EOT looking upstream
2-Oct	DSCN5468	14:17	At EOT looking downstream
2-Oct	DSCN5469	14:18	At EOT looking at POC
2-Oct	DSCN5470	14:19	At 64 m looking upstream
2-Oct	DSCN5471	14:19	At 64 m looking downstream
2-Oct	DSCN5472	15:28	**D4T10** At EOT looking upstream
2-Oct	DSCN5473	15:29	At EOT looking downstream
2-Oct	DSCN5474	15:29	At EOT looking at POC
2-Oct	DSCN5475	15:29	At 50 m looking upstream
2-Oct	DSCN5476	15:29	At 50 m looking downstream
2-Oct	DSCN5477	15:29	At 50 m looking at EOT
2-Oct	DSCN5478	15:30	At 50 m looking at POC
4-Oct	DSCN5541	9:24	**D5T12** At EOT looking upstream
4-Oct	DSCN5542	9:24	At EOT looking downstream
4-Oct	DSCN5543	9:24	At EOT looking at POC
4-Oct	DSCN5544	9:27	At 50 m looking at POC
4-Oct	DSCN5545	9:27	At 50 m looking at EOT
4-Oct	DSCN5546	9:27	At 50 m looking upstream
4-Oct	DSCN5547	9:27	At 50 m looking downstream
4-Oct	DSCN5548	9:49	**D5T19** at EOT looking upstream
4-Oct	DSCN5549	9:49	At EOT looking downstream
4-Oct	DSCN5550	9:50	At EOT looking at POC
4-Oct	DSCN5551	10:31	**D6T29** at 39 m looking at seedling plot
4-Oct	DSCN5552	10:31	At 39 m close up of seedlings
4-Oct	DSCN5553	11:09	At EOT looking upstream
4-Oct	DSCN5554	11:10	At EOT looking downstream
4-Oct	DSCN5555	11:10	At EOT looking at POC
4-Oct	DSCN5556	11:12	At 49 m looking at POC
4-Oct	DSCN5557	11:12	At 49 m looking at EOT
4-Oct	DSCN5558	11:12	At 49 m looking upstream
4-Oct	DSCN5559	11:12	At 49 m looking downstream
4-Oct	DSCN5560	12:07	**D6T36** at EOT looking upstream
4-Oct	DSCN5561	12:08	At EOT looking downstream
4-Oct	DSCN5562	12:08	At EOT looking at POC
4-Oct	DSCN5563	12:15	At 34 m looking at POC
4-Oct	DSCN5564	12:16	At 34 m looking at EOT
4-Oct	DSCN5565	12:16	At 34 m looking upstream
4-Oct	DSCN5566	12:16	At 34 m looking downstream

Date: July/Aug. t 2017			**Environmental Crew:** MLP, AS, & CC
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
2-Aug	DSCN5355	12:32	**L1T1** at EOT looking upstream
2-Aug	DSCN5356	12:32	At EOT looking downstream
2-Aug	DSCN5357	12:32	At EOT looking at POC
2-Aug	DSCN5358	12:35	At 19 m looking upstream
2-Aug	DSCN5359	12:35	At 19 m looking downstream
2-Aug	DSCN5360	12:35	At 19 m looking at EOT
2-Aug	DSCN5361	12:35	At 19 m looking at POC
2-Aug	DSCN5345	11:04	**L1T10** at 44 m seedling plot (dead seedlings from drought)
2-Aug	DSCN5346	11:06	At EOT looking upstream
2-Aug	DSCN5347	11:06	At EOT looking downstream
2-Aug	DSCN5348	11:06	At EOT looking at POC
2-Aug	DSCN5349	11:07	Downstream of L1T10 new sandbar (2013 establishment)
2-Aug	DSCN5350	11:07	Looking downstream at sandbar
2-Aug	DSCN5351	11:09	Middle of sandbar looking upstream
2-Aug	DSCN5352	11:09	Middle of sandbar looking downstream
2-Aug	DSCN5353	11:11	Downstream end looking upstream riverside
2-Aug	DSCN5354	11:11	Downstream end looking upstream forest side
2-Aug	DSCN5339	8:19	**L1T20** at EOT looking upstream
2-Aug	DSCN5340	8:19	At EOT looking downstream
2-Aug	DSCN5341	8:19	At EOT looking at POC
2-Aug	DSCN5342	9:02	At 22 m looking at EOT
2-Aug	DSCN5343	9:02	At 22 m looking upstream (tadpoles in standing water)
2-Aug	DSCN5344	9:02	At 22 m looking downstream
2-Aug	DSCN5339	8:19	**L1T20** at EOT looking upstream
2-Aug	DSCN5340	8:19	At EOT looking downstream
2-Aug	DSCN5341	8:19	At EOT looking at POC
2-Aug	DSCN5342	9:02	At 22 m looking at EOT
2-Aug	DSCN5343	9:02	At 22 m looking upstream (tadpoles in standing water)
2-Aug	DSCN5344	9:02	At 22 m looking downstream
31-Jul	IMG_0421	16:36	**L1T36** at 5 m looking at EOT
31-Jul	IMG_0422	16:36	At EOT looking up line at POC
31-Jul	IMG_0423	16:37	At EOT looking downstream
31-Jul	IMG_0424	16:37	At EOT looking upstream
31-Jul	IMG_0425	16:37	At EOT looking across stream
31-Jul	IMG_0426	16:38	At 15 m looking downstream
31-Jul	IMG_0427	16:38	At 15 m looking upstream (note: spotted knapweed)
31-Jul	IMG_0428	16:38	At 15 m looking at EOT
31-Jul	IMG_0429	16:39	At 15 m looking at POC
31-Jul	DSCN5292	10:31	**L2T6** at EOT looking upstream
31-Jul	DSCN5293	10:31	At EOT looking downstream
31-Jul	DSCN5294	10:31	At EOT looking at POC
31-Jul	DSCN5295	10:31	At 26 m looking upstream
31-Jul	DSCN5296	10:33	At 26 m looking downstream
31-Jul	DSCN5297	10:33	At 26 m looking at POC
31-Jul	DSCN5298	10:33	At 33 m looking at POC
31-Jul	DSCN5299	10:34	At 33 m looking at EOT
31-Jul	DSCN5288	14:22	**L2T15** at EOT looking upstream
31-Jul	DSCN5289	14:22	At EOT looking downstream
31-Jul	DSCN5290	14:22	At 33 m looking towards POC (rebar at 29 m with pink flagging)
31-Jul	DSCN5291	14:23	At 33 m looking at ground at EOT (no cottonwood seedlings)
31-Jul	DSCN5282	13:09	**L2T18** at EOT looking upstream
31-Jul	DSCN5283	13:09	At EOT looking downstream
31-Jul	DSCN5284	13:10	At 16 m looking at POC
31-Jul	DSCN5285	13:10	At 16 m looking at EOT
31-Jul	DSCN5286	13:10	At 16 m looking upstream
31-Jul	DSCN5287	13:10	At 16 m looking downstream

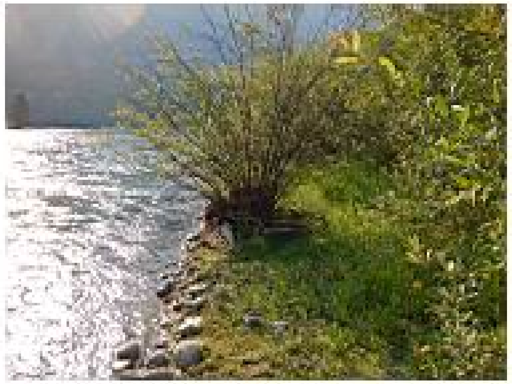
Date	Image #	Time	Description
31-Jul	IMG_0412	14:25	**L3T1** at 8.6 m looking at EOT
31-Jul	IMG_0413	14:25	At EOT looking at POC
31-Jul	IMG_0414	14:26	At EOT looking downstream
31-Jul	IMG_0415	14:26	At EOT looking upstream
31-Jul	IMG_0416	14:26	At EOT looking across stream
31-Jul	IMG_0417	14:26	At 21 m looking upstream
31-Jul	IMG_0418	14:27	At 21 m looking downstream
31-Jul	IMG_0419	14:27	At 21 m looking at EOT
31-Jul	IMG_0420	14:27	At 21 m looking at POC
31-Jul	IMG_0403	13:35	**L3T9** at 35 m looking at EOT
31-Jul	IMG_0404	13:35	At EOT looking at POC
31-Jul	IMG_0405	13:36	At EOT looking downstream
31-Jul	IMG_0406	13:36	At EOT looking upstream
31-Jul	IMG_0407	13:36	At EOT looking across stream
31-Jul	IMG_0408	13:36	At 40 m looking downstream
31-Jul	IMG_0409	13:36	At 40 m looking upstream
31-Jul	IMG_0410	13:37	At 40 m looking at EOT
31-Jul	IMG_0411	13:37	At 40 m looking at POC
31-Jul	IMG_0394	12:21	**L3T30** at 10.8 m looking down line at EOT
31-Jul	IMG_0395	12:23	At EOT looking up line at POC
31-Jul	IMG_0396	12:23	At EOT looking downstream
31-Jul	IMG_0397	12:24	At EOT looking upstream
31-Jul	IMG_0398	12:24	At EOT looking across stream
31-Jul	IMG_0399	12:24	At 17.5 m looking upstream
31-Jul	IMG_0400	12:25	At 17.5 m looking downstream
31-Jul	IMG_0401	12:25	At 17.5 m looking at EOT
31-Jul	IMG_0402	12:25	At 17.5 m looking at POC

Date: October 2017			**Environmental Crew:** MLP, AS
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
5-Oct	DSCN5621	16:14	**L1T20** At EOT looking upstream
5-Oct	DSCN5622	16:14	At EOT looking downstream
5-Oct	DSCN5623	16:14	At EOT looking at POC
5-Oct	DSCN5624	16:18	At 38 m looking at POC
5-Oct	DSCN5625	16:18	At 38 m looking at EOT
5-Oct	DSCN5626	16:18	At 38 m looking upstream
5-Oct	DSCN5627	16:18	At 38 m looking downstream
5-Oct	DSCN5609	14:15	**L1T36** at EOT looking upstream
5-Oct	DSCN5610	14:15	At EOT looking downstream
5-Oct	DSCN5611	14:16	At EOT looking at POC
5-Oct	DSCN5612	14:16	At EOT looking across river
5-Oct	DSCN5613	14:21	Seedling dug up for root growth, the sapling was 10mm above ground.
5-Oct	DSCN5614	14:24	At 34 m upstream of line
5-Oct	DSCN5615	14:24	At 34 m seedling band online
5-Oct	DSCN5616	14:24	At 34 m seedling band downstream online
5-Oct	DSCN5617	14:29	At 13 m looking at POC
5-Oct	DSCN5618	14:29	At 13 m looking at EOT
5-Oct	DSCN5619	14:29	At 13 m looking upstream
5-Oct	DSCN5620	14:29	At 13 m looking downstream
5-Oct	DSCN5602	13:30	**L2T6** at EOT looking upstream
5-Oct	DSCN5603	13:31	At EOT looking downstream
5-Oct	DSCN5604	13:31	At EOT looking at POC
5-Oct	DSCN5605	13:35	At 18 m looking at POC
5-Oct	DSCN5606	13:35	At 18 m looking at EOT
5-Oct	DSCN5607	13:35	At 18 m looking upstream
5-Oct	DSCN5608	13:35	At 18 m looking downstream
5-Oct	DSCN5595	11:22	**L2T18** at EOT looking upstream
5-Oct	DSCN5596	11:23	At EOT looking downstream
5-Oct	DSCN5597	11:23	At EOT looking at POC
5-Oct	DSCN5598	11:28	At 17 m looking at EOT
5-Oct	DSCN5599	11:29	At 17 m looking at POC
5-Oct	DSCN5600	11:29	At 17 m looking upstream
5-Oct	DSCN5601	11:29	At 17 m looking downstream
5-Oct	DSCN5601	11:29	At 17 m looking downstream
5-Oct	DSCN5598	11:28	At 17 m looking at EOT
5-Oct	DSCN5599	11:29	At 17 m looking at POC
5-Oct	DSCN5600	11:29	At 17 m looking upstream
5-Oct	DSCN5601	11:29	At 17 m looking downstream
5-Oct	DSCN5588	10:42	**L3T1** at EOT looking upstream
5-Oct	DSCN5589	10:42	At EOT looking downstream
5-Oct	DSCN5590	10:42	At EOT looking at POC
5-Oct	DSCN5591	10:44	At 25 m looking at POC
5-Oct	DSCN5592	10:44	At 25 m looking at EOT
5-Oct	DSCN5593	10:44	At 25 m looking upstream
5-Oct	DSCN5594	10:45	At 25 m looking downstream
5-Oct	DSCN5581	9:58	**L3T9** at EOT looking upstream
5-Oct	DSCN5582	9:58	At EOT looking downstream
5-Oct	DSCN5583	9:59	At EOT looking at POC
5-Oct	DSCN5584	10:01	At 41 m looking at POC
5-Oct	DSCN5585	10:02	At 41 m looking at EOT
5-Oct	DSCN5586	10:02	At 41 m looking upstream
5-Oct	DSCN5587	10:02	At 41 m looking downstream

Appendix 2: Duncan and Lardeau rivers contact sheets

Duncan River, August 1&2, 2017, Seg1 T3, Seg 6 T20.


DSCN5305_D1T3


DSCN5306_D1T3


DSCN5307_D1T3


DSCN5308_D1T3


DSCN5309_D1T3


DSCN5310_D1T3


IMG_0556_D6T20


IMG_0557_D6T20


IMG_0558_D6T20


IMG_0559_D6T20


IMG_0560_D6T20


IMG_0561_D6T20

Duncan River August 1, 2017, Segment 3, Transect 11.

IMG_0430

IMG_0431

IMG_0433

IMG_0434

IMG_0435

IMG_0436

IMG_0437

IMG_0438

IMG_0439

IMG_0440

IMG_0441

IMG_0442

Duncan River August 1, 2017, Segment 3, Transect 15.

IMG_0443

IMG_0444

IMG_0445

IMG_0446

IMG_0447

IMG_0448

IMG_0449

IMG_0450

IMG_0451

IMG_0452

IMG_0453

IMG_0454

Duncan River August 1, 2017, Segment 3, Transect 17.

IMG_0457

IMG_0458

IMG_0459

IMG_0460

IMG_0461

IMG_0462

IMG_0463

IMG_0464

IMG_0465

IMG_0466

IMG_0467

IMG_0468

Duncan River August 1, 2017, Segment 3, Transect 29.

IMG_0469

IMG_0470

IMG_0471

IMG_0472

IMG_0473

IMG_0474

IMG_0475

IMG_0476

IMG_0477

IMG_0478

IMG_0479

IMG_0480

Duncan River August 1, 2017, Segment 3, Transect 35.

IMG_0481

IMG_0482

IMG_0483

IMG_0484

IMG_0485

IMG_0486

IMG_0487

IMG_0488

IMG_0489

IMG_0490

IMG_0491

IMG_0492

Duncan River, August 1, 2017, Seg.3T40 & Seg.6T29


IMG_0505_D3T40


IMG_0506_D3T40


IMG_0507_D3T40


IMG_0508_D3T40


IMG_0509_D3T40


IMG_0510_D3T40


IMG_0511_D3T40


IMG_0536_D6T29


IMG_0537_D6T29


IMG_0538_D6T29


IMG_0539_D6T29


IMG_0540_D6T29


IMG_0541_D6T29


IMG_0542_D6T29


IMG_0543_D6T29

Duncan River August 1, 2017, Segment 3, Transect 45.

IMG_0493

IMG_0494

IMG_0495

IMG_0496

IMG_0497

IMG_0498

IMG_0499

IMG_0500

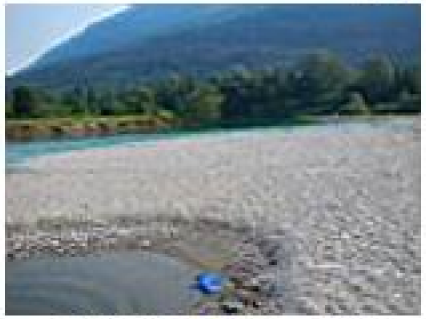
IMG_0501

IMG_0502

IMG_0503

IMG_0504

Duncan River, August 1, 2017, Seg.4, T3 & T10


DSCN5311_T3


DSCN5312_T3


DSCN5313_T3


DSCN5314_T3


DSCN5315_T3

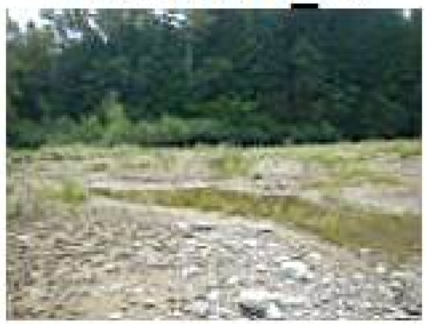

DSCN5316_T3


DSCN5317_T3


DSCN5318_T3


DSCN5319_T10


DSCN5320_T10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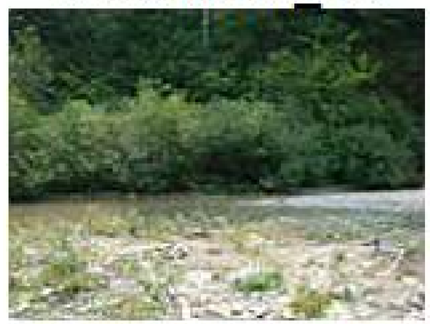
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DSCN5323_T10


DSCN5324_T10


DSCN5325_T10


DSCN5326_T10

Duncan River August 2, 2017, Segment 5, Transect 2 & 9.


DSCN5333_T2


DSCN5334_T2


DSCN5335_T2


DSCN5336_T2


DSCN5337_T2


DSCN5338_T2


DSCN5327_T9


DSCN5328_T9


DSCN5329_T9


DSCN5330_T9


DSCN5331_T9


DSCN5332_T9

Duncan River August 2, 2017, Segment 5, Transect 11.

IMG_0512

IMG_0513

IMG_0514

IMG_0515

IMG_0516

IMG_0517

IMG_0518

IMG_0519

IMG_0520

IMG_0521

IMG_0522

IMG_0523

Duncan River, August 2, 2017, Segment 5, Tran 12 & 19.


IMG_0524_T12


IMG_0525_T12


IMG_0526_T12


IMG_0527_T12


IMG_0528_T12


IMG_0529_T12


IMG_0530_T12


IMG_0531_T12


IMG_0532_T19


IMG_0533_T19


IMG_0534_T19


IMG_0535_T19

Duncan River, August 2, 2017, Segment 6, Transect 36.


IMG_0544


IMG_0545


IMG_0546


IMG_0547


IMG_0548


IMG_0549


IMG_0550


IMG_0551


IMG_0552

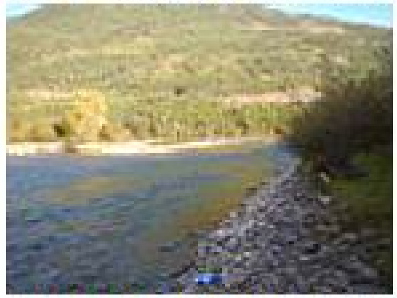

IMG_0553


IMG_0554


IMG_0555

Duncan River, October 2&3, 2017, D1T3, D3T29, & T35


DSCN5485_D1T3


DSCN5486_D1T3


DSCN5487_D1T3


DSCN5512_D3T29


DSCN5513_D3T29


DSCN5514_D3T29


DSCN5515_D3T29


DSCN5516_D3T29


DSCN5517_D3T35


DSCN5518_D3T35


DSCN5519_D3T35


DSCN5520_D3T35


DSCN5521_D3T35


DSCN5522_D3T35


DSCN5523_D3T35

Duncan River, October 3, 2017, D3T11 & T17


DSCN5498_T15


DSCN5499_T15


DSCN5500_T15


DSCN5501_T15


DSCN5502_T15

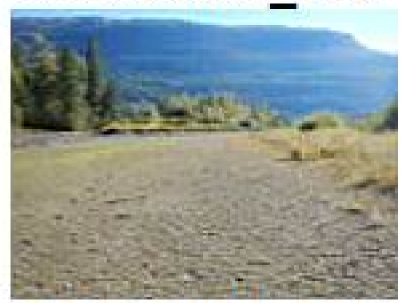

DSCN5503_T15


DSCN5504_T15


DSCN5505_T17


DSCN5506_T17


DSCN5507_T17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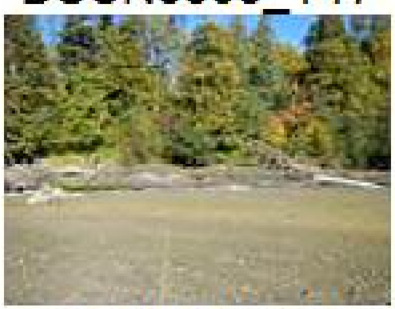
DSCN5509_T17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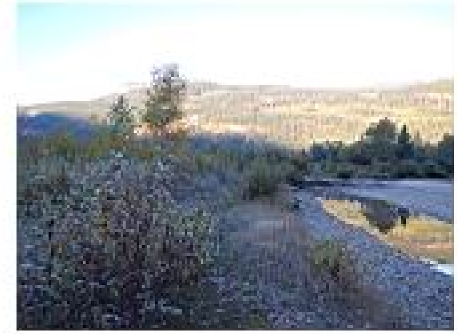
DSCN5511_T17

Duncan River, October 3, 2017, Seg. 3 Tran. 11 (D3T11)

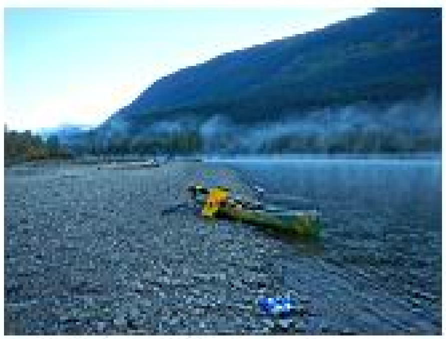
DSCN5488

DSCN5489

DSCN5490



DSCN5491



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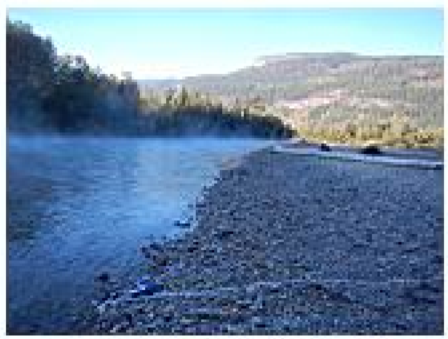
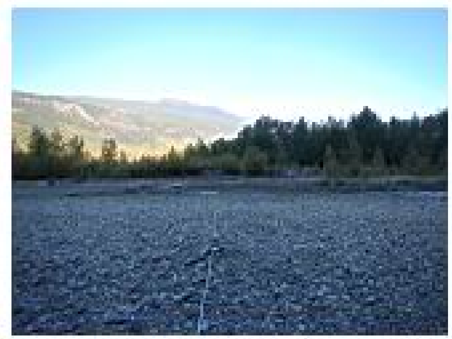
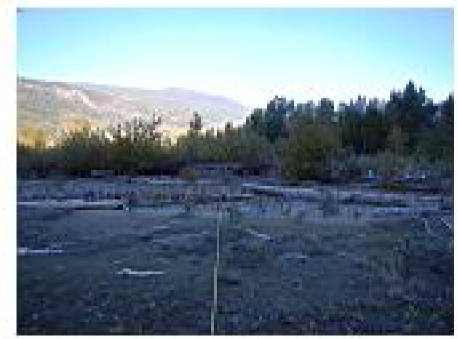


DSCN5493



DSCN5494



DSCN5495

DSCN5496

DSCN5497

Duncan River, October 2 & 3, 2017, D3T40 & D4T3

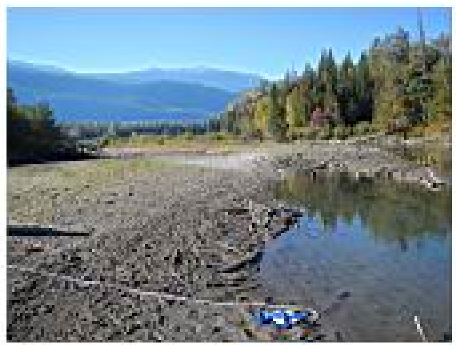

DSCN5467_D4T3


DSCN5468_D4T3


DSCN5469_D4T3


DSCN5470_D4T3


DSCN5471_D4T3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DSCN5535_D3T40


DSCN5536_D3T40


DSCN5537_D3T40


DSCN5538_D3T40


DSCN5539_D3T40

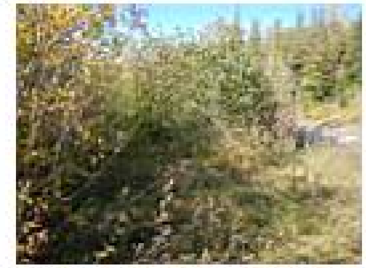

DSCN5540_D3T40

Duncan River, October 3 & 4, 2017, D3T45 & D6T36


DSCN5524_D3T45


DSCN5525_D3T45


DSCN5526_D3T45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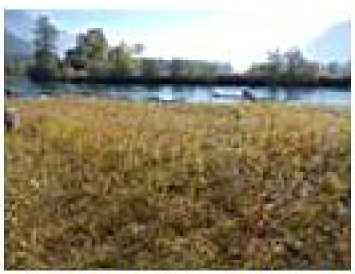
DSCN5528_D3T45


DSCN5529_D3T45


DSCN5530_D3T45


DSCN5531_D3T45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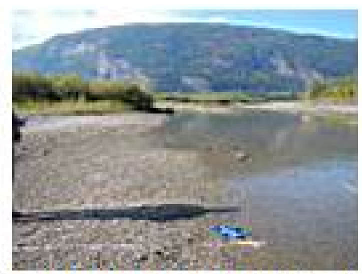
DSCN5533_D3T45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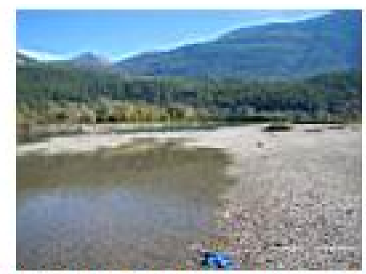
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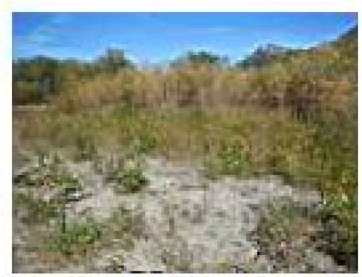
DSCN5562_D6T36


DSCN5563_D6T36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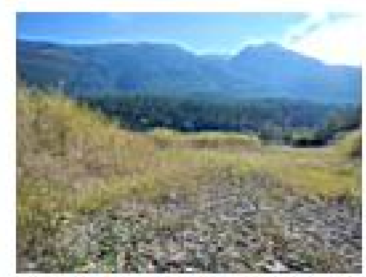
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Duncan River, October 2 & 4, 2017, D4T10 & D5T12


DSCN5472_D4T10

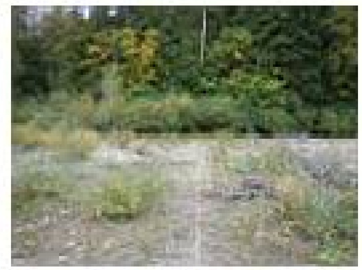

DSCN5473_D4T10


DSCN5474_D4T10


DSCN5475_D4T10


DSCN5476_D4T10


DSCN5477_D4T10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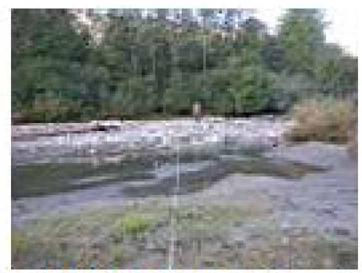
DSCN5541_D5T12


DSCN5542_D5T12


DSCN5543_D5T12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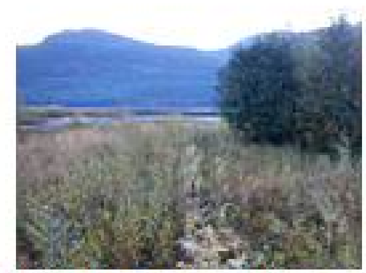

DSCN5545_D5T12


DSCN5546_D5T12


DSCN5547_D5T12

Duncan River, October 4, 2017, D5T19 & D6T29

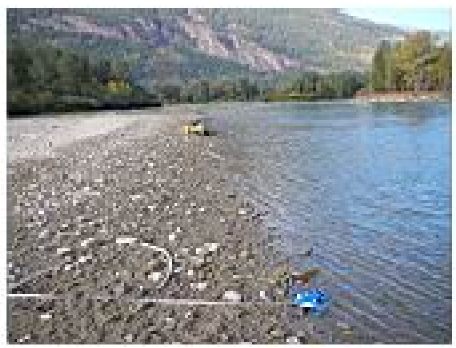
DSCN5548_D5T19

DSCN5549_D5T19

DSCN5550_D5T19

DSCN5551_D6T29

DSCN5552_D6T29



DSCN5553_D6T29

DSCN5554_D6T29

DSCN5555_D6T29

DSCN5556_D6T29

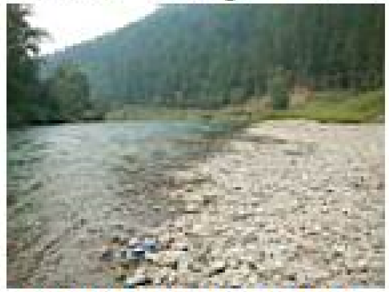
DSCN5557_D6T29

DSCN5558_D6T29

DSCN5559_D6T29

Lardeau River, July 31 & August 2, 2017, L1T1 & T36


DSCN5355_L1T1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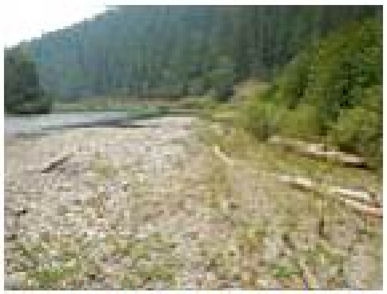
DSCN5357_L1T1


DSCN5358_L1T1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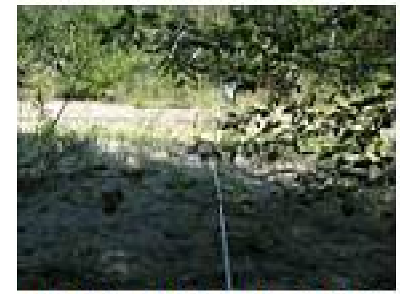
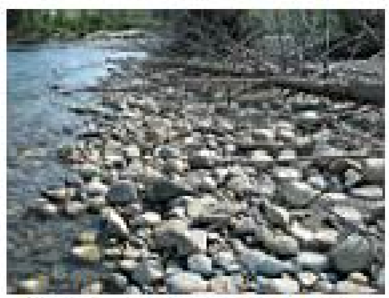
DSCN5360_L1T1


DSCN5361_L1T1


IMG_0421_L1T36


IMG_0422_L1T36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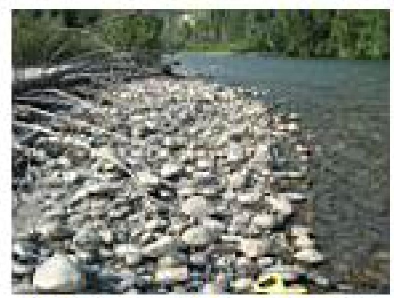
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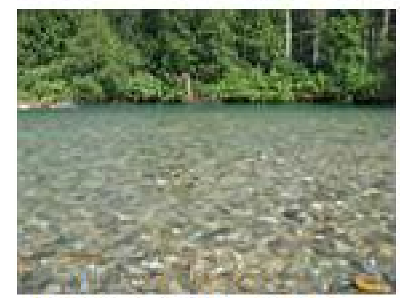

IMG_0425_L1T36


IMG_0426_L1T36


IMG_0427_L1T36


IMG_0428_L1T36


IMG_0429_L1T36

Lardeau River, July 31 & August 2, 2017, L1T10 & L3T1


DSCN5345_L1T10

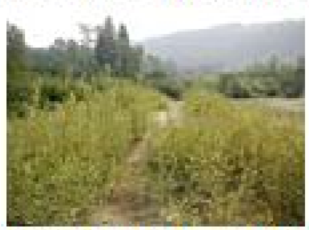

DSCN5346_L1T10


DSCN5347_L1T10


DSCN5348_L1T10


DSCN5349_L1T10


DSCN5350_L1T10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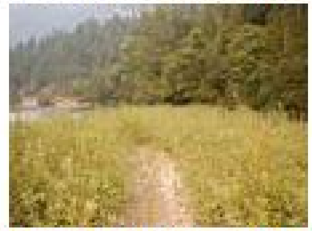
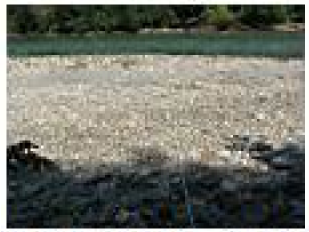
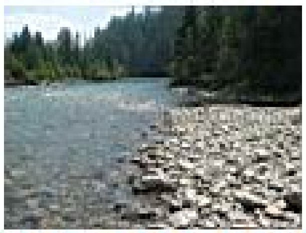

DSCN5352_L1T10


DSCN5353_L1T10


DSCN5354_L1T10


IMG_0412_L3T1


IMG_0413_L3T1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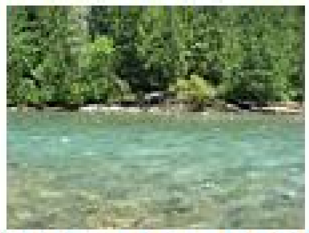
IMG_0415_L3T1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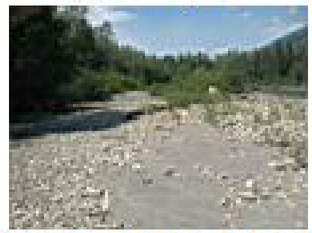
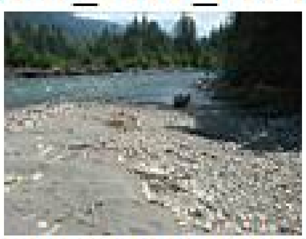

IMG_0417_L3T1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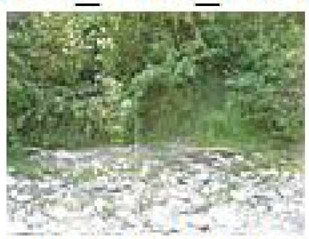
IMG_0419_L3T1


IMG_0420_L3T1

Lardeau River, July 31 & August 2, 2017, L1T20 & L2T18


DSCN5339_L1T20


DSCN5340_L1T20


DSCN5341_L1T20


DSCN5342_L1T20


DSCN5343_L1T20


DSCN5344_L1T20


DSCN5282_L2T18


DSCN5283_L2T18


DSCN5284_L2T18


DSCN5285_L2T18


DSCN5286_L2T18


DSCN5287_L2T18

Lardeau River, July 31 & August 2, 2017, L2T6 & T15

DSCN5292_L2T6

DSCN5293_L2T6

DSCN5294_L2T6

DSCN5295_L2T6

DSCN5296_L2T6

DSCN5297_L2T6

DSCN5298_L2T6

DSCN5299_L2T6

DSCN5288_L2T15

DSCN5289_L2T15

DSCN5290_L2T15

DSCN5291_L2T15

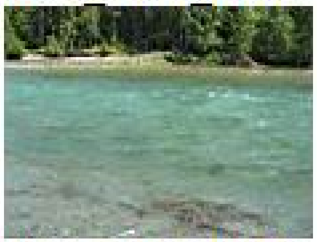
Lardeau River, July 31, 2017, L3T9 & T30


IMG_0403_L3T9


IMG_0404_L3T9


IMG_0405_L3T9


IMG_0406_L3T9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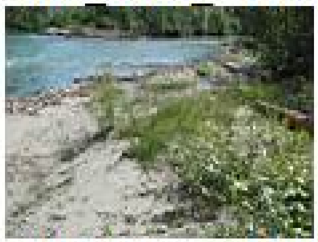
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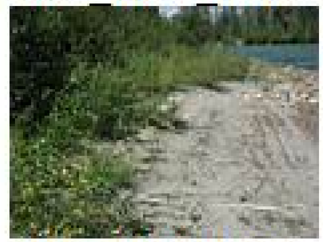
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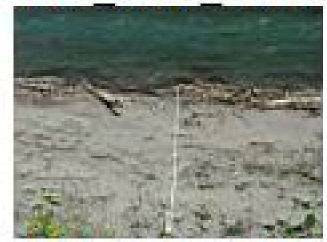
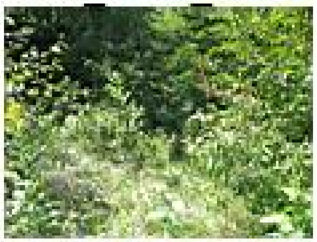

IMG_0410_L3T9

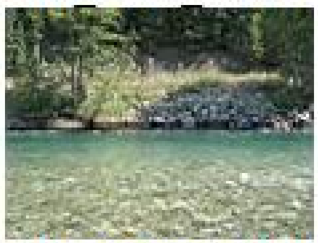

IMG_0411_L3T9


IMG_0394_L3T30


IMG_0395_L3T30


IMG_0396_L3T30


IMG_0397_L3T30


IMG_0398_L3T30

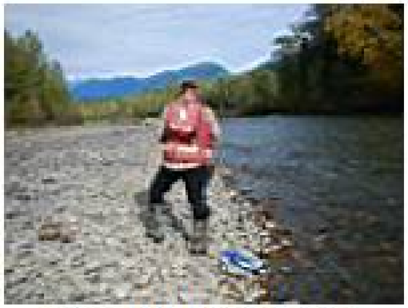

IMG_0399_L3T30


IMG_0400_L3T30


IMG_0401_L3T30


IMG_0402_L3T30

Lardeau River, October 4, 2017, L1T1 & T10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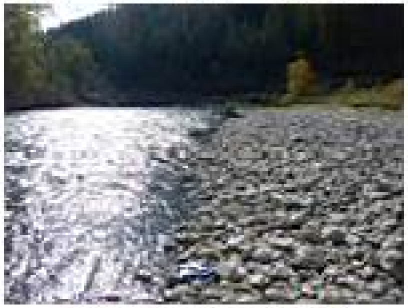
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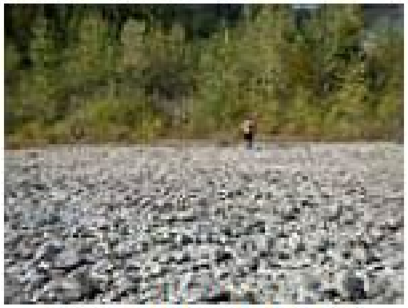
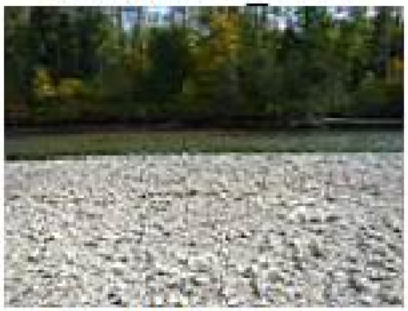

DSCN5569_L1T1

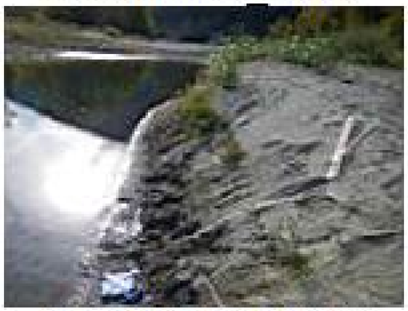

DSCN5570_L1T1


DSCN5571_L1T1


DSCN5572_L1T1

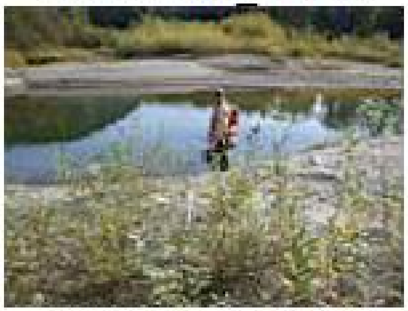

DSCN5573_L1T1


DSCN5574_L1T10


DSCN5575_L1T10


DSCN5576_L1T10


DSCN5577_L1T10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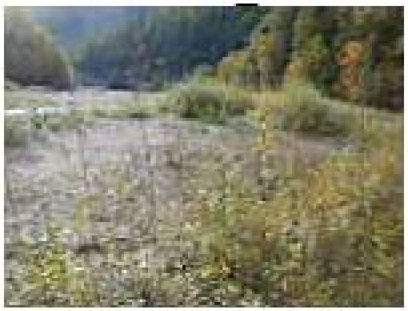
DSCN5579_L1T10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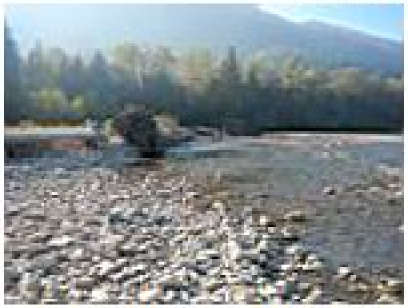
Lardeau River, October 5, 2017, L1T20 & L2T6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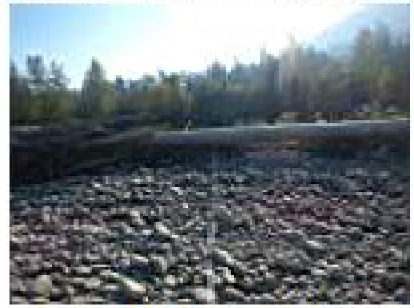
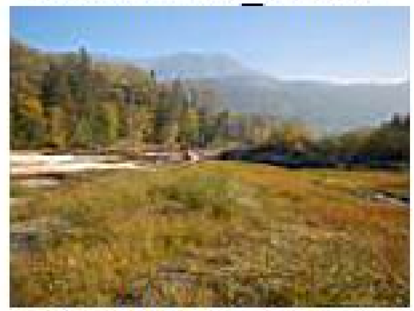
DSCN5622_L1T20


DSCN5623_L1T20


DSCN5624_L1T20


DSCN5625_L1T20


DSCN5626_L1T20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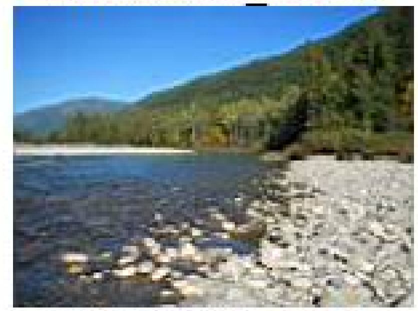
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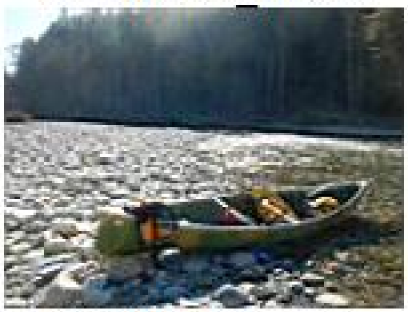
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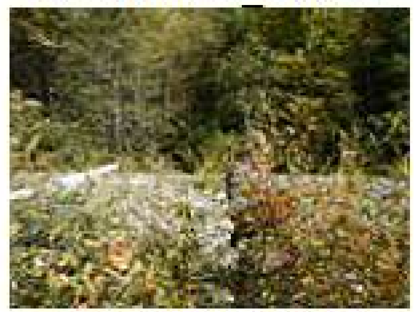
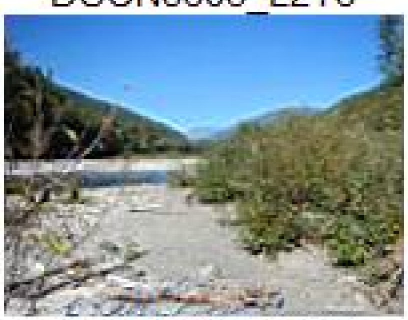
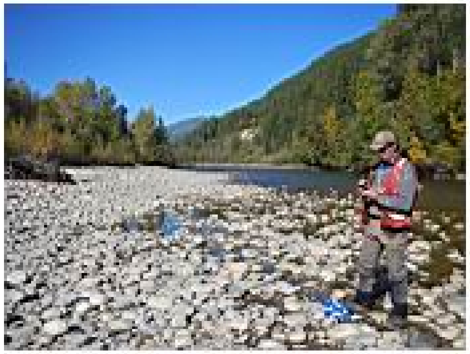

DSCN5605_L2T6


DSCN5606_L2T6


DSCN5607_L2T6

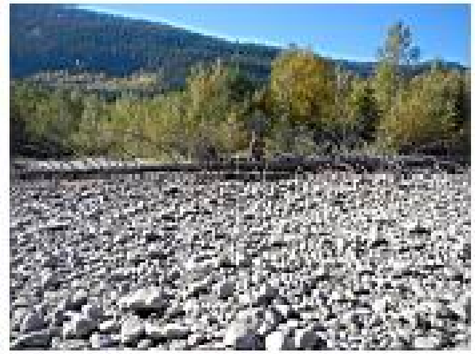

DSCN5608_L2T6

Lardeau River, October 5, 2017, L1T36



DSCN5609

DSCN5610



DSCN5611

DSCN5612

DSCN5613

DSCN5614

DSCN5615

DSCN5616

DSCN5617

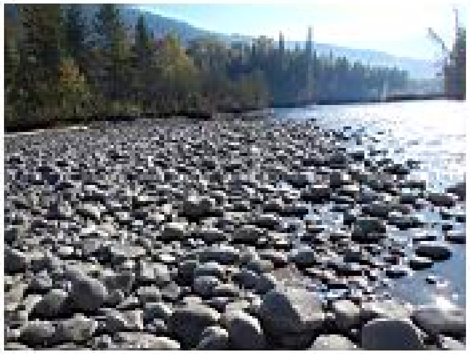
DSCN5618

DSCN5619

DSCN5620

Lardeau River, October 5, 2017, L2T18

DSCN5595



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DSCN5597

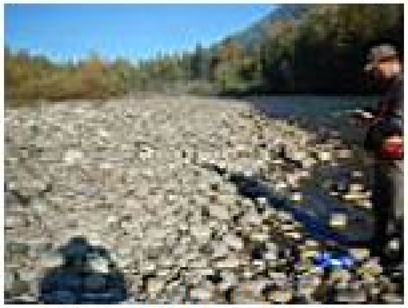
DSCN5598

DSCN5599

DSCN5600

DSCN5601

Lardeau River, October 5, 2017, L3T1 & T9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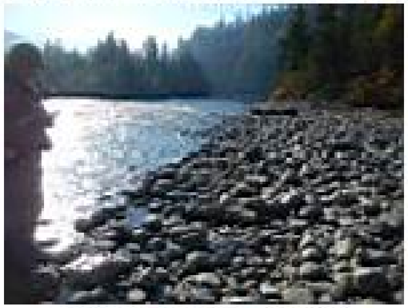

DSCN5589_L3T1


DSCN5590_L3T1

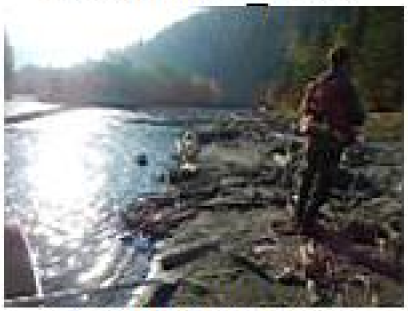

DSCN5591_L3T1


DSCN5592_L3T1


DSCN5593_L3T1


DSCN5594_L3T1


DSCN5581_L3T9


DSCN5582_L3T9


DSCN5583_L3T9

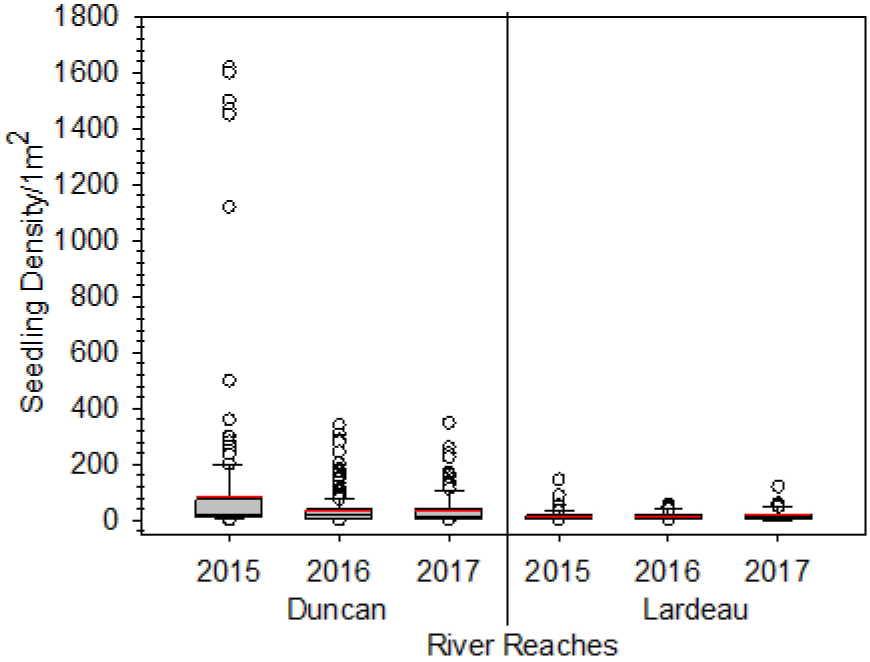

DSCN5584_L3T9


DSCN5585_L3T9

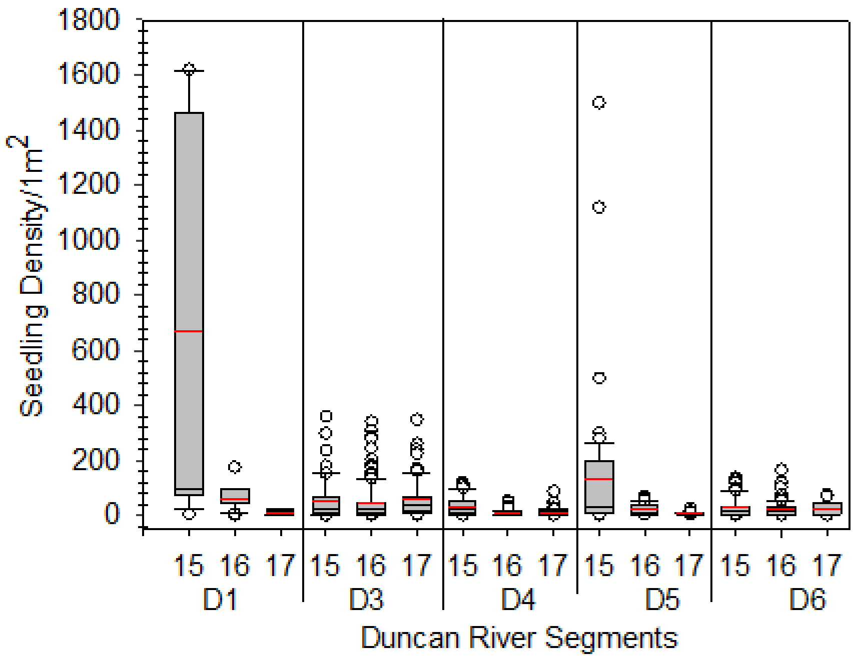

DSCN5586_L3T9


DSCN5587_L3T9

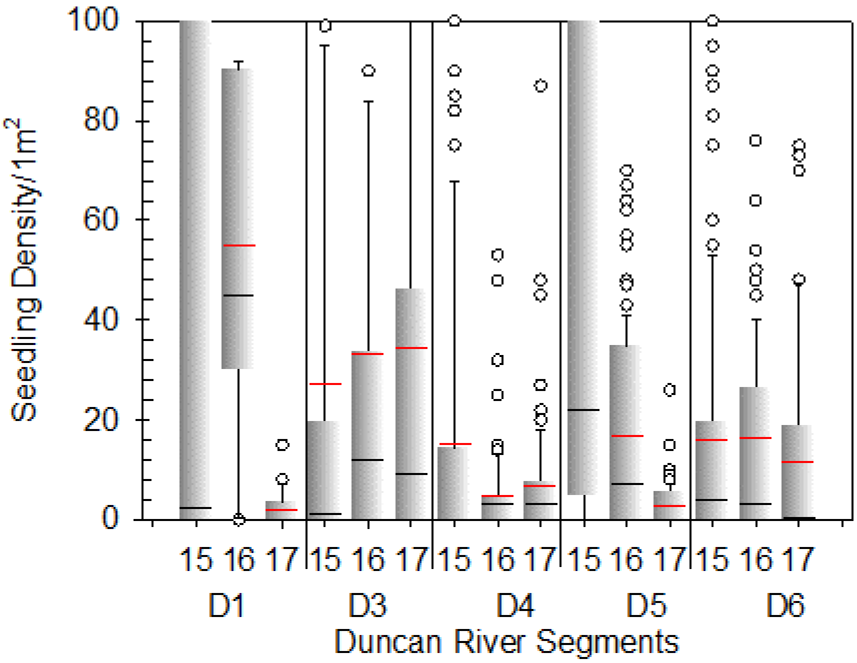
Appendix 3: Statistical Analysis Details and Additional Graphs



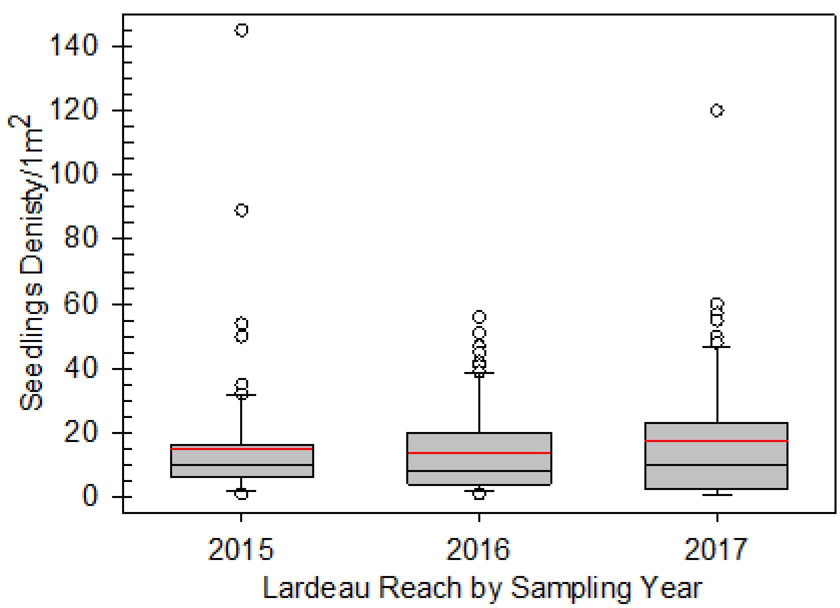
The 2015, 2016, and 2017 black cottonwood germinant densities for the Duncan reach, no scaling.



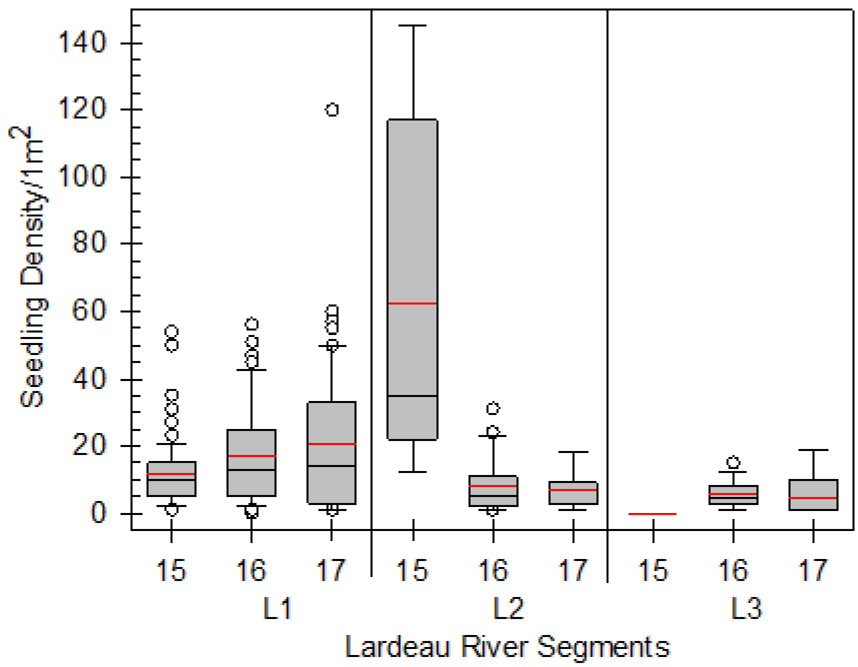
All data for Duncan segments, no scaling.



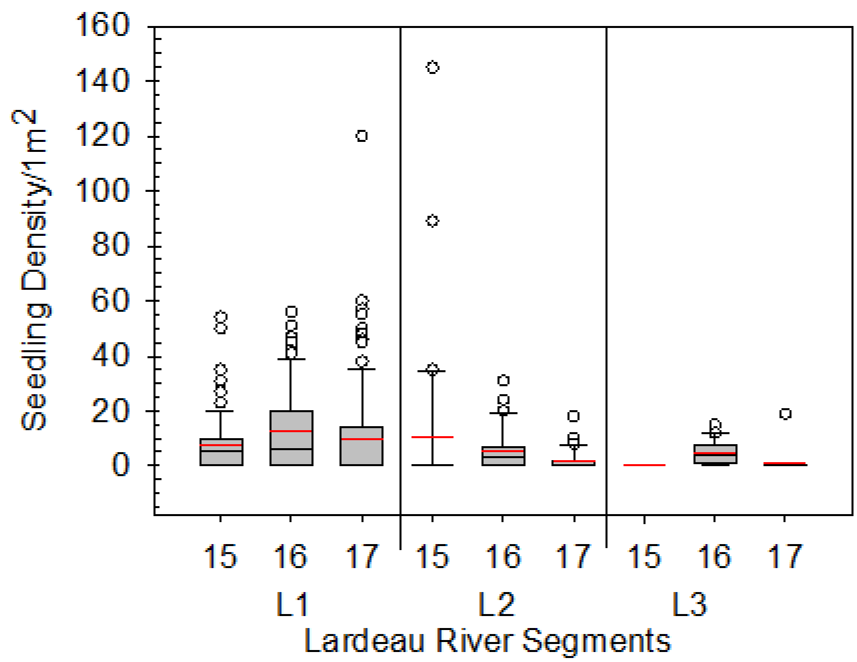
Paired data for Duncan segments and scaled down.



Lardeau Reach with no scaling for raw data.



Lardeau River raw data for segments with no scaling.



Lardeau River paired data for segments, no scaling.

Descriptive Statistics

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
D_3rd_08-16	7	1	42.517	27.176	11.094	28.519
D_2nd_08-16	7	0	31.743	22.708	8.583	21.001
D_1st_08-16	7	0	26.486	7.149	2.702	6.612
L_3rd_08-16	7	1	50.833	26.171	10.684	27.465
L_2nd_08-16	7	0	49.529	15.356	5.804	14.202
L_1st_08-16	7	0	25.043	9.042	3.418	8.362
Column	Range	Max	Min	Median	25%	75%
D_3rd_08-16	72.1	72.1	0	42.7	21.375	69.85
D_2nd_08-16	75.2	75.2	0	27.2	23.9	40
D_1st_08-16	21.2	39.9	18.7	23.1	22	30.5
L_3rd_08-16	67.5	72.3	4.8	61.85	27.45	69.975
L_2nd_08-16	42.2	69.5	27.3	46.5	35.4	63.9
L_1st_08-16	28.6	36.6	8	26.1	21	30.3
Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	SWilk W	SWilk Prob
D_3rd_08-16	-0.521	-0.375	0.169	0.691	0.944	0.692
D_2nd_08-16	0.991	2.661	0.227	0.316	0.894	0.297
D_1st_08-16	1.17	1.223	0.254	0.188	0.899	0.325
L_3rd_08-16	-1.377	1.09	0.292	0.114	0.835	0.118
L_2nd_08-16	-0.139	-1.255	0.158	0.712	0.961	0.823
L_1st_08-16	-1.023	1.836	0.185	0.573	0.937	0.615
Column	Sum	Sum of Squares				
D_3rd_08-16	255.1	14538.63				
D_2nd_08-16	222.2	10147.1				
D_1st_08-16	185.4	5217.1				
L_3rd_08-16	305	18928.86				
L_2nd_08-16	346.7	18586.41				
L_1st_08-16	175.3	4880.55				

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
Dun_17_3_yr	170	0	26.296	34.252	2.627	5.186
Dun_17_2_yr	352	0	16.849	29.348	1.564	3.076
Dun_17_1_yr	293	0	38.178	26.8	1.566	3.081
Lar_17_3_yr	49	0	5.796	20.621	2.946	5.923
Lar_17_2_yr	96	0	9.279	24.259	2.476	4.915
Lar_17_1_yr	64	0	25.254	23.467	2.933	5.862
Column	Range	Max	Min	Median	25%	75%
Dun_17_3_yr	100	100	0	0	0	48.275
Dun_17_2_yr	100	100	0	0	0	22.863
Dun_17_1_yr	100	100	0	38.7	15.2	56.981
Lar_17_3_yr	100	100	0	0	0	0
Lar_17_2_yr	100	100	0	0	0	0
Lar_17_1_yr	100	100	0	20.8	0.5	34.3
Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	SWilk W	SWilk Prob
Dun_17_3_yr	0.961	-0.468	0.302	<0.001	0.753	<0.001
Dun_17_2_yr	1.656	1.399	0.359	<0.001	0.632	<0.001
Dun_17_1_yr	0.383	-0.56	0.0849	<0.001	0.953	<0.001
Lar_17_3_yr	3.662	12.974	0.529	<0.001	0.312	<0.001
Lar_17_2_yr	2.822	7.226	0.472	<0.001	0.438	<0.001
Lar_17_1_yr	1.211	1.762	0.168	<0.001	0.877	<0.001

Column	Sum	Sum of Squares			
Dun_17_3_yr	4470.402	315823.2			
Dun_17_2_yr	5930.838	402242.5			
Dun_17_1_yr	11186.28	636799.9			
Lar_17_3_yr	284	22056			
Lar_17_2_yr	890.788	64174.16			
Lar_17_1_yr	1616.271	75512.64			

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
D_#Germ08-16	7	0	21180.57	14852.74	5613.806	13736.49
D_#Quad08-16	7	0	342.429	170.446	64.423	157.637
Column	Range	Max	Min	Median	25%	75%
D_#Germ08-16	47664	47786	122	22619	12802	28027
D_#Quad08-16	528	540	12	364	272	473
Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	SWilk W	SWilk Prob
D_#Germ08-16	0.632	1.383	0.18	0.602	0.955	0.772
D_#Quad08-16	-1.238	2.215	0.197	0.498	0.916	0.436
Column	Sum	Sum of Squares				
D_#Germ08-16	148264	4.46E+09				
D_#Quad08-16	2397	995113				

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
L_2009_Q#	10	0	7.3	7.761	2.454	5.552
L_2009_Ger#	10	0	632.9	926.864	293.1	663.039
L_2010_Q#	10	0	14.5	12.43	3.931	8.892
L_2010_Ger#	10	0	582.3	1006.871	318.401	720.272
L_2012_Q#	10	0	4.2	6.07	1.919	4.342
L_2012_Ger#	10	0	347.4	760.469	240.481	544.007
L_2013_Q#	10	0	7.2	8.053	2.546	5.76
L_2013_Ger#	10	0	112.7	161.098	50.944	115.243
L_2014_Q#	10	0	13	12.374	3.913	8.852
L_2014_Ger#	10	0	481.8	522.537	165.241	373.8
L_2015_Q#	10	0	8.7	11.898	3.763	8.511
L_2015_Ger#	10	0	110	145.258	45.935	103.912
L_2016_Q#	10	0	13.1	12.124	3.834	8.673
L_2016_Ger#	10	0	160.7	276.91	87.567	198.089
L_2017_Q#	10	0	7.2	8.053	2.546	5.76
L_2017_Ger#	10	0	112.7	161.098	50.944	115.243
L_#Quad/year	8	0	97.75	35.648	12.604	29.803
L_#Germ/year	8	0	3175.625	2232.914	789.454	1866.763
L_#Quad/08-16	7	0	101.429	36.828	13.92	34.06
L_#Germ/08-16	7	0	3468.286	2239.974	846.631	2071.631
L_#Q_15,16,17	3	0	96.667	30.665	17.704	76.176
L_#Germ_15,16,17	3	0	1278	285.242	164.685	708.58
Column	Range	Max	Min	Median	25%	75%
L_2009_Q#	20	20	0	5.5	0	15.25
L_2009_Ger#	2820	2820	0	144.5	0	1152.5
L_2010_Q#	39	39	0	13	4	23.5
L_2010_Ger#	3215	3215	0	140.5	18.25	891.5
L_2012_Q#	18	18	0	1.5	0	8
L_2012_Ger#	2258	2258	0	8	0	317.75
L_2013_Q#	23	23	0	3.5	0.75	13.75
L_2013_Ger#	373	373	0	16	0.75	325

L_2014_Q#	43	43	0	9.5	4.75	19.25
L_2014_Ger#	1823	1823	0	275	177.5	653.5
L_2015_Q#	36	36	0	4	0	14.25
L_2015_Ger#	339	339	0	30.5	0	297.25
L_2016_Q#	42	42	0	9	6.5	17.75
L_2016_Ger#	918	918	0	54.5	19.25	169.5
L_2017_Q#	23	23	0	3.5	0.75	13.75
L_2017_Ger#	373	373	0	16	0.75	325
L_#Quad/year	103	145	42	94.5	72.25	130.75
L_#Germ/year	5229	6329	1100	2540.5	1127	5571.75
L_#Quad/08-16	103	145	42	102	73	131
L_#Germ/08-16	5229	6329	1100	3474	1127	5823
L_#Q_15,16,17	59	131	72	87	72	131
L_#Germ_15,16,17	507	1607	1100	1127	1100	1607
Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	SWilk W	SWilk Prob
L_2009_Q#	0.469	-1.503	0.227	0.153	0.853	0.063
L_2009_Ger#	1.699	2.798	0.253	0.07	0.755	0.004
L_2010_Q#	0.781	0.0997	0.127	0.78	0.943	0.586
L_2010_Ger#	2.394	5.998	0.341	0.002	0.643	<0.001
L_2012_Q#	1.629	2.066	0.278	0.027	0.758	0.004
L_2012_Ger#	2.264	4.69	0.456	<0.001	0.544	<0.001
L_2013_Q#	0.943	-0.27	0.254	0.066	0.852	0.061
L_2013_Ger#	1.025	-1.132	0.345	0.001	0.686	<0.001
L_2014_Q#	1.733	3.63	0.186	0.392	0.841	0.045
L_2014_Ger#	2.155	5.38	0.259	0.055	0.751	0.004
L_2015_Q#	1.579	2.248	0.241	0.1	0.784	0.009
L_2015_Ger#	0.889	-1.259	0.276	0.03	0.737	0.002
L_2016_Q#	1.646	3.275	0.232	0.13	0.846	0.052
L_2016_Ger#	2.748	7.95	0.325	0.004	0.6	<0.001
L_2017_Q#	0.943	-0.27	0.254	0.066	0.852	0.061
L_2017_Ger#	1.025	-1.132	0.345	0.001	0.686	<0.001
L_#Quad/year	-0.13	-1.126	0.192	0.465	0.948	0.687
L_#Germ/year	0.417	-1.933	0.259	0.118	0.836	0.068
L_#Quad/08-16	-0.486	-0.782	0.21	0.419	0.948	0.71
L_#Germ/08-16	0.132	-2.165	0.226	0.325	0.876	0.208
L_#Q_15,16,17	1.278	--	0.29	0.351	0.925	0.472
L_#Germ_15,16,17	1.715	--	0.368	0.12	0.79	0.09
Column	Sum	Sum of Squares				
L_2009_Q#	73	1075				
L_2009_Ger#	6329	11737321				
L_2010_Q#	145	3493				
L_2010_Ger#	5823	12514837				
L_2012_Q#	42	508				
L_2012_Ger#	3474	6411682				
L_2013_Q#	72	1102				
L_2013_Ger#	1127	360587				
L_2014_Q#	130	3068				
L_2014_Ger#	4818	4778716				
L_2015_Q#	87	2031				
L_2015_Ger#	1100	310900				
L_2016_Q#	131	3039				
L_2016_Ger#	1607	948357				
L_2017_Q#	72	1102				

L_2017_Ger#	1127	360587				
L_#Quad/year	782	85336				
L_#Germ/year	25405	115578077				
L_#Quad/08-16	710	80152				
L_#Germ/08-16	24278	114307948				
L_#Q_15,16,17	290	29914				
L_#Germ_15,16,17	3834	5062578				

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
L_#Quad/08-16	7	0	101.429	36.828	13.92	34.06
L_#Germ/08-16	7	0	3468.286	2239.974	846.631	2071.631
Column	Range	Max	Min	Median	25%	75%
L_#Quad/08-16	103	145	42	102	73	131
L_#Germ/08-16	5229	6329	1100	3474	1127	5823
Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	SWilk W	SWilk Prob
L_#Quad/08-16	-0.486	-0.782	0.21	0.419	0.948	0.71
L_#Germ/08-16	0.132	-2.165	0.226	0.325	0.876	0.208
Column	Sum	Sum of Squares				
L_#Quad/08-16	710	80152				
L_#Germ/08-16	24278	1.14E+08				

Duncan Germinants

Kruskal-Wallis One Way Analysis of Variance on Ranks					
Group	N	Missing	Median	25%	75%
D_2009_Ger#	23	0	40	0	970
D_2010_Ger#	23	0	142	46	784
D_2012_Germ#	23	0	0	0	0
D_2013_Ger#	26	0	233	0	852.5
D_2014_Ger#	26	0	519.5	86.75	1119
D_2015_Ger#	26	0	176.5	0	958
D_2016_Ger#	26	0	234.5	3	949.25
D_2017_Ger#	26	0	50	0	465.75
H = 33.519 with 7 degrees of freedom. (P = <0.001)					
The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)					

Kruskal-Wallis One Way Analysis of Variance on Ranks							
Group	N	Missing	Median	25%	75%		
D_2009_Q#	23	0	3	0	17		
D_2010_Q#	23	0	12	3	30		
D_2012_Q#	23	0	0	0	0		
D_2013_Q#	26	0	8	0	18		
D_2014_Q#	26	0	15.5	6.5	32		
D_2015_Q#	26	0	10.5	0	21.75		
D_2016_Q#	26	0	18	0.75	32.25		
D_2017_Q#	26	0	7.5	0	23		
H = 35.833 with 7 degrees of freedom. (P = <0.001)							
The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)							

One-Sample Signed Rank Test (Normality Test (Shapiro-Wilk) Failed (P <0.05.)

Group	N	Missing	Median	25%	75%	
D_2017_Ger#	26	0	50	0	465.75	
Hypothesized population median			22,619	08-16 median		
W= -351.000 T+ = 0.000 T-= 351.000						
Z-Statistic (based on positive ranks) = -4.487					(P = <0.001)	
Yates correction for continuity was used in calculating this test.						
95 percent confidence interval for the population median: 0.000 to 225.000						
There is a statistically significant difference between the median of the group and the hypothesized population median (P = <0.001).						

One-Sample Signed Rank Test (Normality Test (Shapiro-Wilk) Failed (P <0.05.)

Group	N	Missing	Median	25%	75%	
D_2017_Q#	26	0	7.5	0	23	
Hypothesized population median			364	08-16 median		
W= -351.000 T+ = 0.000 T-= 351.000						
Z-Statistic (based on positive ranks) = -4.487						
(P = <0.001)						
Yates correction for continuity was used in calculating this test.						
95 percent confidence interval for the population median: 0.000 to 20.000						
There is a statistically significant difference between the median of the group and the hypothesized population median (P = <0.001).						

One-Sample Signed Rank Test (Normality Test (Shapiro-Wilk) Failed (P < 0.050))

Group	N	Missing	Median	25%	75%
D_2016_Ger#	26	0	234.5	3	949.25

Hypothesized population median 50 (Median for 2017)

W= 243.000 T+ = 297.000 T-= 54.000
Z-Statistic (based on positive ranks) = 3.090 (P = 0.002)

Yates correction for continuity was used in calculating this test.

95 percent confidence interval for the population median: 13.000 to 569.000

There is a statistically significant difference between the median of the group and the hypothesized population median (P = 0.002).

One-Sample Signed Rank Test (Normality Test (Shapiro-Wilk) Failed (P < 0.050))

Group	N	Missing	Median	25%	75%
D_2015_Ger#	26	0	176.5	0	958

Hypothesized population median 50 (Median for 2017)

W= 227.000 T+ = 289.000 T-= 62.000
Z-Statistic (based on positive ranks) = 2.889 (P = 0.004)

Yates correction for continuity was used in calculating this test.
95 percent confidence interval for the population median: 38.000 to 507.000

There is a statistically significant difference between the median of the group and the hypothesized population median (P = 0.004).

Lardeau River Germinants

One-Sample t-test					
Normality Test (Shapiro-Wilk)			Passed	(P = 0.061)	
Group Name	N	Missing	Mean	Std Dev	SEM
L_2017_Q#	10	0	7.2	8.053	2.546
Hypothesized population mean			101.43	Mean 08-16	
t = -37.004 with 9 degrees of freedom.					
95 percent two-tailed confidence interval for the population mean: 1.440 to 12.960					
Two-tailed P-value = 3.810E-011					
There is a statistically significant difference between the mean of the sampled population and the hypothesized population mean (P = <0.001).					
One-tailed P-value = 1.905E-011					
The hypothesized mean exceeds the sample mean of the group by an amount that is greater than would be expected by chance, rejecting the hypothesis that the true mean of group is greater than or equal to the hypothesized mean. (P = <0.001).					
Power of performed two-tailed test with alpha = 0.050: 1.000					
Power of performed one-tailed test with alpha = 0.050: 1.000					

Paired t-test:							
Normality Test (Shapiro-Wilk)			Passed	(P = 0.998)			
Treatment Name	N	Missing	Mean	Std Dev	SEM		
L_2017_Q#	10	0	7.2	8.053	2.546		
L_2016_Q#	10	0	13.1	12.124	3.834		
Difference	10	0	-5.9	11.2	3.542		
t = -1.666 with 9 degrees of freedom.							
95 percent two-tailed confidence interval for difference of means: -13.912 to 2.112							
Two-tailed P-value = 0.130							
The change that occurred with the treatment is not great enough to exclude the possibility that the difference is due to chance (P = 0.130)							
One-tailed P-value = 0.0650							
The sample mean of treatment L_2016_Q# does not exceed the sample mean of the treatment L_2017_Q# by an amount great enough to exclude the possibility that the difference is due to random sampling variability. The hypothesis that the population mean of treatment L_2017_Q# is greater than or equal to the population mean of treatment L_2016_Q# cannot be rejected. (P = 0.130)							
Power of performed two-tailed test with alpha = 0.050: 0.320							
The power of the performed test (0.320) is below the desired power of 0.800.							
Less than desired power indicates you are less likely to detect a difference when one actually exists.							
Negative results should be interpreted cautiously.							
Power of performed one-tailed test with alpha = 0.050: 0.458							
The power of the performed test (0.458) is below the desired power of 0.800.							
Less than desired power indicates you are less likely to detect a difference when one actually exists.							
Negative results should be interpreted cautiously.							

Paired t-test:					
Normality Test (Shapiro-Wilk)			Passed	(P = 0.770)	
Treatment Name	N	Missing	Mean	Std Dev	SEM
L_2017_Q#	10	0	7.2	8.053	2.546
L_2015_Q#	10	0	8.7	11.898	3.763
Difference	10	0	-1.5	10.277	3.25
t = -0.462 with 9 degrees of freedom.					
95 percent two-tailed confidence interval for difference of means: -8.852 to 5.852					
Two-tailed P-value = 0.655					
The change that occurred with the treatment is not great enough to exclude the possibility that the difference is due to chance (P = 0.655)					
One-tailed P-value = 0.328					
The sample mean of treatment L_2015_Q# does not exceed the sample mean of the treatment L_2017_Q# by an amount great enough to exclude the possibility that the difference is due to random sampling variability. The hypothesis that the population mean of treatment L_2017_Q# is greater than or equal to the population mean of treatment L_2015_Q# cannot be rejected. (P = 0.655)					
Power of performed two-tailed test with alpha = 0.050: 0.070					
The power of the performed test (0.070) is below the desired power of 0.800.					
Less than desired power indicates you are less likely to detect a difference when one actually exists.					
Negative results should be interpreted cautiously.					
Power of performed one-tailed test with alpha = 0.050: 0.112					
The power of the performed test (0.112) is below the desired power of 0.800.					
Less than desired power indicates you are less likely to detect a difference when one actually exists.					
Negative results should be interpreted cautiously.					

Paired t-test:		Normality Test (Shapiro-Wilk)				Passed	(P = 0.072)
Treatment Name	N	Missing	Mean	Std Dev	SEM		
L_2017_Ger#	10	0	112.7	161.098	50.944		
L_2016_Ger#	10	0	160.7	276.91	87.567		
Difference	10	0	-48	208.123	65.814		
t = -0.729 with 9 degrees of freedom.							
95 percent two-tailed confidence interval for difference of means: -196.882 to 100.882							
Two-tailed P-value = 0.484							
The change that occurred with the treatment is not great enough to exclude the possibility that the difference is due to chance (P = 0.484)							
One-tailed P-value = 0.242							
The sample mean of treatment L_2016_Ger# does not exceed the sample mean of the treatment L_2017_Ger# by an amount great enough to exclude the possibility that the difference is due to random sampling variability. The hypothesis that the population mean of treatment L_2017_Ger# is greater than or equal to the population mean of treatment L_2016_Ger# cannot be rejected. (P = 0.484)							
Power of performed two-tailed test with alpha = 0.050: 0.100							

Paired t-test:		Normality Test (Shapiro-Wilk)				Passed	(P = 0.072)
Treatment Name	N	Missing	Mean	Std Dev	SEM		
L_2017_Ger#	10	0	112.7	161.098	50.944		
L_2016_Ger#	10	0	160.7	276.91	87.567		
Difference	10	0	-48	208.123	65.814		
t = -0.729 with 9 degrees of freedom.							

95 percent two-tailed confidence interval for difference of means: -196.882 to 100.882	
Two-tailed P-value = 0.484	
The change that occurred with the treatment is not great enough to exclude the possibility that the difference is due to chance (P = 0.484)	
One-tailed P-value = 0.242	
The sample mean of treatment L_2016_Ger# does not exceed the sample mean of the treatment L_2017_Ger# by an amount great enough to exclude the possibility that the difference is due to random sampling variability. The hypothesis that the population mean of treatment L_2017_Ger# is greater than or equal to the population mean of treatment L_2016_Ger# cannot be rejected. (P = 0.484)	

Duncan and Lardeau Seedling Densities

One Way Repeated Measures Analysis of Variance					
Normality Test (Shapiro-Wilk)			Failed	(P < 0.050)	
Test execution ended by user request, RM ANOVA on Ranks begun					
Friedman Repeated Measures Analysis of Variance on Ranks					
Group	N	Missing	Median	25%	75%
D_Seed_17_P	550	0	2	0	18
D_Seed_16_P	550	0	5	0	31
D_Seed_15_P	550	0	4.5	0	25
Chi-square= 25.955 with 2 degrees of freedom. (P = <0.001)					
The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)					
To isolate the group or groups that differ from the others use a multiple comparison procedure.					
All Pairwise Multiple Comparison Procedures (Tukey Test):					
Comparison			Diff of Ranks	q	P<0.05
D_Seed_15_P vs D_Seed_17_P			148	6.311	Yes
D_Seed_15_P vs D_Seed_16_P			21.5	0.917	No
D_Seed_16_P vs D_Seed_17_P			126.5	5.394	Yes
Note: The multiple comparisons on ranks do not include an adjustment for ties.					

Rank Sum Test					
Normality Test (Shapiro-Wilk)			Failed	(P < 0.050)	
Mann-Whitney Rank Sum Test					
Group	N	Missing	Median	25%	75%
D_Seed_17_P	550	0	2	0	18
L_Seed_17_P	155	0	0	0	7
Mann-Whitney U Statistic= 35639.000					
T = 47729.000 n(small)= 155 n(big)= 550 (P = <0.001)					
The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)					

Mann-Whitney Rank Sum Test					
Group	N	Missing	Median	25%	75%
D_2017_Raw	294	0	15	6	44.25
L_2017_Raw	65	0	10	2.5	23
Mann-Whitney U Statistic= 7280.000					
T = 9425.000 n(small)= 65 n(big)= 294 (P = 0.003)					
The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.003)					

One Way Analysis of Variance						
Normality Test (Shapiro-Wilk)			Failed	(P < 0.050)		
Test execution ended by user request, **ANOVA on Ranks** begun						
Kruskal-Wallis One Way Analysis of Variance on Ranks						
Group	N	Missing	Median	25%	75%	
D1_2017	24	0	0	0	3.75	
D1_2016	24	0	45	30.25	90.25	
D1_2015	24	0	2.5	0	107.5	
H = 21.153 with 2 degrees of freedom. (P = <0.001)						
The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)						
To isolate the group or groups that differ from the others use a multiple comparison procedure.						
All Pairwise Multiple Comparison Procedures (Tukey Test):						
Comparison	Diff of Ranks	q	P<0.05			
D1_2016 vs D1_2017	638	6.223	Yes			
D1_2016 vs D1_2015	259	2.526	No	P=0.889	Z-Stat = -0.243	
D1_2015 vs D1_2017	379	3.697	Yes			
Note: The multiple comparisons on ranks do not include an adjustment for ties.						

Paired t-test:						
Normality Test (Shapiro-Wilk)			Failed	(P < 0.050)		
Wilcoxon Signed Rank Test						
Group	N	Missing	Median	25%	75%	
D3_2017	225	0	9	0	46.5	
D3_2015	225	0	1	0	20	
W= -3397.000 T+ = 7469.500 T-= -10866.500						
Z-Statistic (based on positive ranks) = -2.220					(P = 0.026)	
The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = 0.026).						

Wilcoxon Signed Rank Test						
Group	N	Missing	Median	25%	75%	
D4_2017	96	0	3	0	8	
D4_2016	96	0	3	0	5	
W= -752.000 T+ = 1367.000 T-= -2119.000						
Z-Statistic (based on positive ranks) = -1.708					(P = 0.088)	
The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.088).						

Wilcoxon Signed Rank Test					
Group	N	Missing	Median	25%	75%
D4_2017	96	0	3	0	8
D4_2015	96	0	0	0	14.5
W= 367.000 T+ = 1763.500 T-= -1396.500					
Z-Statistic (based on positive ranks) = 0.897				(P = 0.371)	
The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.371).					

Wilcoxon Signed Rank Test					
Group	N	Missing	Median	25%	75%
D5_2017	93	0	0	0	6
D5_2016	93	0	7	0	35
W= 2056.000 T+ = 2133.500 T-= -77.500					
Z-Statistic (based on positive ranks) = 6.573				(P = <0.001)	
The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).					

Wilcoxon Signed Rank Test					
Group	N	Missing	Median	25%	75%
D5_2017	93	0	0	0	6
D5_2015	93	0	22	5	191.5
W= 3376.000 T+ = 3473.000 T-= -97.000					
Z-Statistic (based on positive ranks) = 7.532				(P = <0.001)	
The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).					

Wilcoxon Signed Rank Test					
Group	N	Missing	Median	25%	75%
D6_2017	112	0	0.5	0	19
D6_2016	112	0	3	0	26.75
W= 953.000 T+ = 3052.000 T-= -2099.000					
Z-Statistic (based on positive ranks) = 1.617				(P = 0.106)	
The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.106).					

Wilcoxon Signed Rank Test					
Group	N	Missing	Median	25%	75%
D6_2017	112	0	0.5	0	19
D6_2015	112	0	4	0	20
W= 1162.000 T+ = 3106.000 T-= -1944.000					
Z-Statistic (based on positive ranks) = 2.005				(P = 0.045)	
The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = 0.045).					

Lardeau Reach

One Way Repeated Measures Analysis of Variance							
Normality Test (Shapiro-Wilk)			Failed	(P < 0.050)			
Test execution ended by user request, RM ANOVA on Ranks begun							
Friedman Repeated Measures Analysis of Variance on Ranks							
Group	N	Missing	Median	25%	75%		
L_Seed_2017	155	0	0	0	7		
L_Seed_2016	155	0	5	0	13		
L_Seed_15	155	0	0	0	10		
Chi-square= 32.164 with 2 degrees of freedom. (P = <0.001)							
The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)							
To isolate the group or groups that differ from the others use a multiple comparison procedure.							
All Pairwise Multiple Comparison Procedures (Tukey Test):							
Comparison		Diff of Ranks	q	P<0.05			
L_Seed_16 vs 15		81.5	6.546	Yes			
L_Seed_16 vs 17		77.5	6.225	Yes			
L_Seed_17 vs 15		4	0.321	No			
Note: The multiple comparisons on ranks do not include an adjustment for ties.							

Wilcoxon Signed Rank Test					
Group	N	Missing	Median	25%	75%
L_Seed_2017	155	0	0	0	7
L_Seed_2015	155	0	0	0	10
W= -141.000 T+ = 2505.000 T-= -2646.000 Z-Statistic (based on positive ranks) = -0.239					
The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.812).					

Wilcoxon Signed Rank Test					
Normality Test (Shapiro-Wilk)			Failed	(P < 0.050)	
Group	N	Missing	Median	25%	75%
L_Seed_2017	155	0	0	0	7
L_Seed_2016	155	0	5	0	13
W= 3373.000 T+ = 6344.500 T-= -2971.500					
Z-Statistic (based on positive ranks) = 3.665				(P = <0.001)	
The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).					

Paired t-test:					
Normality Test (Shapiro-Wilk)			Failed	(P < 0.050)	
Test execution ended by user request, Signed Rank Test begun					
Wilcoxon Signed Rank Test					
Group	N	Missing	Median	25%	75%
L1_2017	104	0	0	0	14
L1_2016	104	0	6	0	20
W= 1154.000 T+ = 2670.000 T-= -1516.000					

Z-Statistic (based on positive ranks) = 2.285		(P = 0.022)
The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = 0.022).		

Wilcoxon Signed Rank Test						
Group	N	Missing	Median	25%	75%	
L1_2017	104	0	0	0	14	
L1_2015	104	0	5	0	10	
W= -151.000 T+ = 1626.000 T-= -1777.000						
Z-Statistic (based on positive ranks) = -0.349						(P = 0.729)
The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.729).						

Wilcoxon Signed Rank Test						
Group	N	Missing	Median	25%	75%	
L2_2017	30	0	0	0	1.75	
L2_2016	30	0	3	0	7	
W= 141.000 T+ = 220.500 T-= -79.500						
Z-Statistic (based on positive ranks) = 2.016						(P = 0.045)
The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = 0.045).						

Wilcoxon Signed Rank Test						
Group	N	Missing	Median	25%	75%	
L2_2017	30	0	0	0	1.75	
L2_2015	30	0	0	0	0	
W= 13.000 T+ = 59.000 T-= -46.000				Z-Statistic (based on positive ranks) = 0.408		
P(est.)= 0.706 P(exact)= 0.715						
The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.715).						

Wilcoxon Signed Rank Test						
Group	N	Missing	Median	25%	75%	
L3_2017	21	0	0	0	0.5	
L3_2016	21	0	4	1	7.5	
W= 177.000 T+ = 204.000 T-= -27.000						
Z-Statistic (based on positive ranks) = 3.083						(P = 0.002)
The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = 0.002).						

Wilcoxon Signed Rank Test							
Group	N	Missing	Median	25%	75%		
L3_2017	21	0	0	0	0.5		
L3_2015	21	0	0	0	0		
W= -15.000 T+ = 0.000 T-= -15.000							
Z-Statistic (based on positive ranks) = -2.121					P(est.)= 0.048 P(exact)= 0.063		
The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.063).							

Duncan Reach Survival

t-test						
Normality Test (Shapiro-Wilk)			Failed	(P < 0.050)		
Test execution ended by user request, Rank Sum Test begun						
Mann-Whitney Rank Sum Test						
Group	N	Missing	Median	25%	75%	
Dun_17_1_yr	293	0	38.7	15.2	56.981	
Lar_17_1_yr	64	0	20.8	0.5	34.3	
Mann-Whitney U Statistic= 6608.500						
T = 8688.500 n(small)= 64 n(big)= 293 (P = <0.001)						
The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)						

Mann-Whitney Rank Sum Test							
Group	N	Missing	Median	25%	75%		
Dun_17_2_yr	352	0	0	0	22.863		
Lar_17_2_yr	96	0	0	0	0		
Mann-Whitney U Statistic= 13960.500							
T = 18616.500 n(small)= 96 n(big)= 352 (P = 0.002)							
The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.002)							

Mann-Whitney Rank Sum Test						
Group	N	Missing	Median	25%	75%	
Dun_17_3_yr	170	0	0	0	48.275	
Lar_17_3_yr	49	0	0	0	0	
Mann-Whitney U Statistic= 2575.000				T = 3800.000 n(small)= 49 n(big)= 170 (P = <0.001)		
The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)						

t-test						
Normality Test (Shapiro-Wilk)			Failed	(P < 0.050)		
Test execution ended by user request, Rank Sum Test begun						
Mann-Whitney Rank Sum Test						
Group	N	Missing	Median	25%	75%	
Dun_08-16 1_yr	2179	0	20.909	0	50	
Lar_08-16 1_yr	629	0	14.286	0	39.231	
Mann-Whitney U Statistic= 622261.000						
T = 820396.000 n(small)= 629 n(big)= 2179 (P = <0.001)						
The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)						

Mann-Whitney Rank Sum Test						
Group	N	Missing	Median	25%	75%	
Dun_08-16 2_yr	1387	0	0	0	71.429	
Lar_08-16 2_yr	432	0	50	0	99.107	
Mann-Whitney U Statistic= 246684.500						
T = 446027.500 n(small)= 432 n(big)= 1387 (P = <0.001)						
The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)						

Mann-Whitney Rank Sum Test						
Group	N	Missing	Median	25%	75%	
Dun_08-16 3_yr	718	0	0	0	77.692	
Lar_08-16 3_yr	301	0	0	0	100	
Mann-Whitney U Statistic= 97267.000						
T = 164302.000 n(small)= 301 n(big)= 718 (P = 0.004)						
The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.004)						

Appendix 4: POC UTM Coordinates for the Duncan and Lardeau reaches

OBJECTID	TRANSECT_ID	TYPE	UTM_ZONE	UTM_N	UTM_E	LOCATION	GNSS_Heigh	Vert_Prec	Horz_Prec	Std_Dev
1	D3 T10	P.O.C.	11	5,563,098	502,915	D3T10 POC	544.1	1.0	1.3	0.14
2	D3 T11	P.O.C.	11	5,562,967	502,761	d3t11 poc	543.1	1.0	1.2	0.15
3	D3 T15	P.O.C.	11	5,562,941	502,483	d3t15 poc	543.1	0.8	1.0	0.11
4	D3 T17	P.O.C.	11	5,562,976	502,492	d3t17 poc shr cot	540.9	0.8	1.1	0.05
5	D1 T3	P.O.C.	11	5,565,650	503,065	d1t3 poc	549.5	0.9	1.1	0.73
6	D1 T4	P.O.C.	11	5,565,490	502,999	d1t4 poc cottenwood	548.0	0.9	1.2	0.22
7	D1 T5	P.O.C.	11	5,565,423	503,032	d1t5 poc alder	546.9	1.0	1.2	0.05
8	D3 T29	P.O.C.	11	5,562,795	502,596	d3t29 poc spruce	542.2	0.8	1.1	0.02
9	D3 T35	P.O.C.	11	5,562,758	502,506	d3t35 poc Willow	541.2	0.8	1.1	0.06
10	D3 T20	P.O.C.	11	5,562,587	502,582	d3t20 poc alder	542.4	1.8	2.3	0.49
11	D3 T23	P.O.C.	11	5,562,253	502,686	d3t23 poc downtree	541.1	0.9	1.1	0.06
12	D3 T45	P.O.C.	11	5,561,894	503,209	d3t45 poc Willow	539.4	0.9	1.1	0.04
13	D3 T40	P.O.C.	11	5,561,926	503,195	d3t40 poc flat top 31	540.4	0.9	1.1	0.10
14	D5 T11	P.O.C.	11	5,559,550	503,718	d5t11 poc birch	534.7	1.1	1.2	0.07
15	D5 T12	P.O.C.	11	5,559,531	503,726	d5t12 poc	536.4	1.0	1.1	0.22
16	D5 T16	P.O.C.	11	5,559,040	503,726	d5t16 poc	533.9	1.2	1.2	0.73
17	D5 T19	P.O.C.	11	5,558,679	503,638	d5t19 poc cot down beaver	535.9	1.0	1.2	0.09
18	D6 T29	P.O.C.	11	5,558,373	504,120	d6t29 poc alder	534.9	1.1	1.3	0.31
19	D6 T36	P.O.C.	11	5,558,360	504,841	d6t36 poc Willow	534.0	0.8	1.0	0.02
20	D6 T20	P.O.C.	11	5,557,994	504,746	d6t20 new poc	533.2	0.9	1.1	0.07
21	D6 T6	P.O.C.	11	5,557,477	503,399	d6t6 poc alder	533.7	0.8	1.1	0.09
23	L1 T20	P.O.C.	11	5,569,740	502,598	L1T20 poc birch	557.2	1.1	1.2	0.07
24	L1 T10	P.O.C.	11	5,569,377	502,644	L1T10 poc cot	559.3	1.5	2.1	2.09
25	L1 T1	P.O.C.	11	5,568,715	502,230	L1T1 poc alder	554.3	1.5	1.2	0.37
26	D4 T3	P.O.C.	11	5,561,351	503,484	D4T3 poc 6 m bearing 330	542.4	1.3	1.6	2.44
27	D4 T10	P.O.C.	11	5,561,344	503,470	D4T10 poc cot 1 m infront	541.4	1.6	2.0	2.97
28	D4 T5	P.O.C.	11	5,560,622	503,286	D4T5 poc alder	540.7	1.0	1.2	0.29
29	D5 T2	P.O.C.	11	5,560,236	503,370	D5T2 poc cot	541.0	1.0	1.2	0.12
30	D5 T9	P.O.C.	11	5,559,732	503,460	D5T9 poc aspen	539.0	1.0	1.2	0.76
32	L3 T30	P.O.C.	11	5,577,918	497,775	l3t30 poc	579.0	4.5	2.3	1.05
33	L3 T9	P.O.C.	11	5,576,381	498,953	L3t9 poc cot	584.6	1.1	1.3	0.41
35	L3 T1	P.O.C.	11	5,576,065	499,739	L3T1 poc 2m u/str of cot	581.5	1.3	1.6	0.39
36	L2 T18	P.O.C.	11	5,575,906	499,883	L2T18 poc fir tr	579.7	1.0	1.2	0.15
37	L2 T15	P.O.C.	11	5,573,724	501,317	L2T15 poc cottenwood	573.4	1.1	1.1	0.61
38	L2 T6	P.O.C.	11	5,572,702	501,774	L2T6 poc cot	568.4	1.1	1.3	0.37
39	L1 T36	P.O.C.	11	5,572,128	502,074	L1T36 poc fir	567.7	1.0	1.2	0.23
40	D3 T10	E.O.T.	11	5,563,023	502,994	D3T10 EOT 110.8 m	540.4	0.9	1.1	0.03

OBJECTID	TRANSECT_ID	TYPE	UTM_ZONE	UTM_N	UTM_E	LOCATION	GNSS_Heigh	Vert_Prec	Horz_Prec	Std_Dev
41	D3 T11	E.O.T.	11	5,562,870	502,890	d3t11 eot river edge	541.2	1.3	1.7	0.08
42	D3 T15	E.O.T.	11	5,563,006	502,444	d3t15 eot 77.35mBackChEdg	540.0	0.8	1.0	0.04
43	D3 T17	E.O.T.	11	5,563,023	502,471	d3t17 eot backCh riveredg	539.4	0.8	1.1	0.20
44	D1 T3	E.O.T.	11	5,565,670	503,082	d1t3 eot river edge	545.2	0.8	1.1	0.21
45	D1 T4	E.O.T.	11	5,565,479	502,963	d1t4 eot 37.9m backchan	545.6	1.0	1.2	0.09
46	D1 T5	E.O.T.	11	5,565,406	503,025	d1t5 eot 20.2m backch	547.6	1.9	1.3	0.23
47	D3 T29	E.O.T.	11	5,562,869	502,565	d3t29 eot 80.7m R edge	540.8	0.8	1.1	0.10
48	D3 T35	E.O.T.	11	5,562,762	502,455	d3t35 eot 53.3 m	540.0	0.8	1.1	0.28
49	D3 T20	E.O.T.	11	5,562,568	502,545	d3t20 eot 42.9m	540.3	0.8	1.0	0.22
50	D3 T23	E.O.T.	11	5,562,263	502,707	d3t23 eot 25 m	540.9	0.8	1.1	0.13
51	D3 T45	E.O.T.	11	5,561,911	503,250	d3t45 eot 46.5 m	538.2	0.8	1.1	0.19
52	D3 T40	E.O.T.	11	5,561,949	503,214	d3t40 eot 30.25m	538.9	0.8	1.1	0.06
53	D5 T11	E.O.T.	11	5,559,576	503,788	d5t11 eot 76 m	534.6	0.9	1.1	0.28
54	D5 T12	E.O.T.	11	5,559,559	503,803	d5t12 eot 82.4 m on log	535.3	0.8	1.1	0.05
55	D5 T16	E.O.T.	11	5,559,048	503,692	d5t16 eot 1 Wedge	532.8	0.8	1.1	0.05
56	D5 T16	E.O.T.	11	5,559,053	503,678	d5t16 eot Wedge iland 2	533.2	0.8	1.1	0.06
57	D5 T16	E.O.T.	11	5,559,057	503,659	d5t16 eot MainChan 69.5	533.5	0.9	1.2	0.07
58	D5 T19	E.O.T.	11	5,558,681	503,622	d5t19 eot 15.7 m	534.7	0.9	1.1	0.12
59	D6 T29	E.O.T.	11	5,558,435	504,119	d6t29 eot 65.6 m	533.4	0.8	1.1	0.07
60	D6 T36	E.O.T.	11	5,558,488	504,798	d6t36 eot 134 m about	533.2	0.8	1.0	0.04
61	D6 T20	E.O.T.	11	5,558,005	504,694	d6t20 eot 53.6 m	532.2	1.0	1.1	0.22
62	D6 T6	E.O.T.	11	5,557,421	503,431	d6t6 eot 66.5 lake bottom	531.7	0.8	1.0	0.07
65	L1 T20	E.O.T.	11	5,569,794	502,629	L1T20 eot 67 m	557.1	1.0	1.1	0.06
66	L1 T10	E.O.T.	11	5,569,331	502,651	L1T10 eot	555.1	0.8	1.1	0.14
67	L1 T1	E.O.T.	11	5,568,692	502,259	L1T1 eot 38.6 m	552.0	1.0	1.1	0.11
68	D4 T3	E.O.T.	11	5,561,399	503,454	D4T3 eot	539.2	0.8	1.1	0.14
69	D4 T10	E.O.T.	11	5,561,389	503,446	D4T10 eot	538.7	0.8	1.1	0.03
70	D4 T5	E.O.T.	11	5,560,619	503,328	D4T5 eot 42 m	538.5	0.8	1.0	0.12
71	D5 T2	E.O.T.	11	5,560,228	503,399	D5T2 eot	537.7	0.8	1.0	0.20
72	D5 T9	E.O.T.	11	5,559,702	503,443	D5T9 eot 35 m	536.9	0.8	1.1	0.12
73	L3 T30	E.O.T.	11	5,577,936	497,813	l3t30 eot	592.2	1.0	1.1	0.17
74	L3 T9	E.O.T.	11	5,576,418	498,982	L3t9 eot 47.5 m	582.5	0.8	1.1	0.10
75	L3 T1	E.O.T.	11	5,576,081	499,766	L3t1 eot 32.6 m	579.0	0.9	1.1	0.19
76	L2 T18	E.O.T.	11	5,575,874	499,876	L2T18 eot 33.6 m	578.3	0.9	1.0	0.16
77	L2 T15	E.O.T.	11	5,573,715	501,285	L2T15 correct eot	569.9	0.8	1.1	0.10
78	L2 T6	E.O.T.	11	5,572,672	501,722	L2T6 eot 60.7 m	567.5	0.8	1.0	0.17
80	L1 T36	E.O.T.	11	5,572,135	502,121		565.7	3.5	1.6	1.36