Duncan Dam Project Water Use Plan

Lower Duncan River
Riparian Cottonwood Monitoring

Reference: DDMMON#8-1

Year 5 Report

Study Period: April 2014 – January 2015

VAST Resource Solutions Inc.
Cranbrook, B.C.

March 2015

DDMMON#8-1 Lower Duncan River Riparian Cottonwood Monitoring Year 5 Annual Report (2014)

Final Report

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

Prepared by:
Mary Louise Polzin[1], Brenda Herbison[2] and Stewart B. Rood[3]
[1]VAST Resource Solutions Inc.,
[2]North Kootenay Consulting Services Ltd. and
[3]University of Lethbridge, Alberta

March 2015

Suggested Citation

Polzin, M.L., B. Herbison and S.B. Rood. 2015. DDMMON #8-1 Lower Duncan River Riparian Cottonwood Monitoring Program. Year 5 Report – 2014. VAST Resource Solutions and University of Lethbridge, Alberta. Unpublished report by VAST Resource Solutions, Cranbrook, B.C., for BC Hydro Generations, Water License Requirements, Castlegar, BC. 48 pp. + Apps.

Cover photo

Lower Duncan River, Segment 3, Transect line 11 on mid-channel bar, July 28, 2014. Same mid-channel bar as cover photo 2010 report. Photo © Mary Louise Polzin, VAST Resource Solutions Inc.

© 2014 BC Hydro.
No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior permission from BC Hydro, Burnaby, B.C.

EXECUTIVE SUMMARY

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

- Sufficient time between spring freshet recession and late summer/fall dam releases to allow seedlings to establish;
- Short duration periods for late summer/fall/winter high flow when they do occur (less than three weeks); and
- Lower winter dam release flows relative to spring freshet flows.

The study provides site-specific data to guide the river flow regulation and to improve the understanding of the relationships between flow regime, physical environmental conditions, and riparian vegetation. This report describes Year 5 (2014) of the monitoring project for the study area, which includes the lower Duncan River and the adjacent free-flowing lower Lardeau River that serves as a comparative reference reach. Year 5 is a black cottonwood establishment and recruitment monitoring year, with a summary analysis report.

To address management questions and associated hypotheses (table following), the floodplain zones, riparian vegetation, and black cottonwood recruitment are being assessed. The performance of Alt S73 on the lower Duncan River riparian community combines all years of the study and this 2014 report presents black cottonwood colonization data from 2009, 2010, 2012, 2013, and 2014. This fifth year of sampling investigated factors influencing the level of success or failure of black cottonwood establishment and recruitment compared to previous years for the lower Duncan River as well as comparative analysis along the reference reach, the lower Lardeau River.

Following from the field data collection and analyses and previous years' data, there is a trend which suggests that the river flow regime is the primary driver affecting black cottonwood seedling establishment and recruitment along the Duncan River. The hot, dry summer of 2014 illustrated how a low precipitation summer can affect germinant survival. The reference Lardeau River reach had significantly reduced survival rates for the 2014 germinates due to desiccation of seedling, while the lower Duncan was not as severely impacted by the weather due to the higher river level (stage) experienced in 2014 from May through September. Due to the high stage during seed release, no black cottonwood establishment occurred within the active channel, as it did in 2009 and 2010. Recruitment success among 2012 seedlings was similar for both reaches with both rates slightly above the average rates for third year survival.

The lower Duncan reach had significantly higher densities of black cottonwood seedling establishment compared to the Lardeau reach ($P < 0.001$). The Duncan River is a larger river with a broader floodplain area resulting in larger recruitment zones; recruitment has generally been higher since the start of the project. Data collected in 2014 were consistent with this pattern. Both reaches had broader dispersal (increase in the number of quadrats with germinants) but with lower densities on average within each quadrat. Preliminary seedling safe sites were calculated but the foundational assumptions will not be verified until resurveys of transect lines are completed in 2015. If resurveys are completed in 2015, there will be data for determining the average erosion and deposition rates associated with Alt S73 and seedling safe site elevations for 2012 and 2013 recruitment (3 years of survival) data to assess the Alt S73 flow regime and address whether flow regime is the primary driver of black cottonwood recruitment (H_{03}).

Testing hypotheses to assess the performance of Alt S73 was not part of the requirements for 2014. However, building on previous years' data, 2014 results support the flow regime as driving sediment deposition and erosion, which have major impacts on black cottonwood establishment and recruitment success. Colonization requirements appeared to be tied to elevational position with reference to stream stage pattern, geomorphic context, sediment substrate, longitudinal position (upstream-to-downstream), and influences of tributary inflows, lake level, and channel morphology. These factors were supported in 2014. Full vegetation monitoring and mapping in years 2015 and 2018 will provide important data for testing hypotheses to further address the management questions.

Keywords – Duncan River, black cottonwood (*Populus trichocarpa*), seedling recruitment, and flow regime

DDMMON#8-1 Status of Objectives, Management Questions and Hypotheses after monitoring Year 5. Hypotheses testing was not part of year 5 analyses.

Objectives	Management Questions	Management Hypotheses	Year 5 (2014) Status
1) To assess the performance of Alt S73 on the lower Duncan River riparian community and specifically black cottonwoods, through comparisons of field-based performance measures.	1) Will the implementation of Alt S73 result in neutral, positive, or negative changes for black cottonwoods 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.	Because of the different flow regimes implemented during Alt S73 in 2009 and 2010, compared to 2013 and 2014 and the extreme flood event in 2012, H_{01} cannot yet be resolved.
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.	Key factors appear to be water inundation, deposition and erosion, establishment elevation, and distance from river edge. All of these factors are influenced by river regulation. Other factors appear to be tributary influences, channel morphology and lake influences. The past 5 years' show a strong trend suggesting that river flow regime does affect establishment and survival along the lower Duncan River.
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.	Year 5 summary analyses along the lower Duncan River indicated that the river flow regime is a primary driver of black cottonwood establishment and survival along the lower Duncan River.

ACKNOWLEDGEMENTS

Sincere thanks go to the 2014 field data collection team: Ben Meunier, Aden Stewart, and Megan Laing. This year's July field visits were not plagued by mosquito swarms which made field work very pleasant. The experience and knowledge of Aden Stewart from the start of the project enabled efficient and time-saving sampling this season. Special thanks are extended to Aden Stewart and Ben Meunier for their expertise in the navigation and operation of the canoe and raft (respectively) that allowed sampling of transects not accessible by land, while keeping costs within the available budget. Funding for the project was provided by BC Hydro Columbia Water License Requirements and in-kind contribution of time and resources from the University of Lethbridge.

Table of Contents

List of Figures

List of Tables

List of Appendices

1 INTRODUCTION

1.1 Overview

In southeastern British Columbia, the Duncan River is the major river flowing into the north end of Kootenay Lake. This river was dammed in 1967 as the first of four major dams that followed the 1964 Columbia River Treaty between Canada and United States. These dams and reservoirs were intended to provide flood control and hydroelectric power generation. The Duncan Dam resulted in the flooding of the 25 km long Duncan Lake and adjacent wetlands and river reaches creating the 45 km long Duncan Reservoir. The Dam has no hydroelectric turbine thereby increasing its operational flexibility. Water is released downstream for storage in Kootenay Lake and subsequent reservoirs and passage through an extensive sequence of turbines along the Kootenay and Columbia Rivers.

Commencing in 2001, BC Hydro, which owns and operates Duncan Dam, commenced a Water Use Planning (WUP) process to consider alternate river regulation regimes. Following hydrologic modeling and consultations with various regional groups, the flow scenario alternative (Alt) ‘S73’ was selected for implementation. This was intended 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*), the species of black cottonwood occurring in the area, which provide the foundation for floodplain forests and associated wildlife along the lower Duncan River. This operations regime was implemented in 2008 and we have been investigating the environmental responses along the Lower Duncan River and along the adjacent and free-flowing Lardeau River as a reference for comparison since 2009. This riparian black cottonwood monitoring program was designated as DDMMON#8-1 (BC Hydro 2009).

Past research has demonstrated strong links between black cottonwood recruitment, and river flow (Mahoney and Rood 1998), especially below dams (Polzin 1998, Polzin and Rood 2000). Studies have also revealed the links between black cottonwoods, wildlife habitat and overall ecosystem function (Naiman et al. 2005). Accordingly, black cottonwood was identified by the WUP as the indicator species for monitoring the effects of Alt S73 on riparian biological diversity for the lower Duncan River. A more detailed description of the background to this project is provided in the initial Year 1 report (Polzin et al. 2010).

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 drivers of successful black cottonwood recruitment along the lower Duncan River floodplain and how are these drivers influenced by river regulation?

Declines in black cottonwood populations downstream from dams along other river systems have been documented (Rood and Mahoney 1990, Polzin and Rood 2000, Merritt and Cooper 2000). The lower Duncan River differs from most other dammed systems studied because 50 to 60 per cent of the flow below the dam comes from the free-flowing

Lardeau River, and two smaller creeks. The inputs from the Lardeau River, and Hamill and Copper creeks result in sediment and woody debris contributions below the dam. In contrast, sediment and woody debris deficiencies normally occur along other dammed systems (Williams and Wolman 1984, Dunne 1988, Debano and Schmidt 1990, Rood and Mahoney 1995, Polzin 1998).

Contrary to typical dammed systems where a ‘silt shadow’ and loss of large woody debris occurs downstream of the dam (Williams and Wolman 1984, Rood and Mahoney 1990) the lower Duncan River experiences increases in sediment deposition and large woody debris. The Duncan Dam has reduced spring peak flows since the start of operation and Alt S73 did not change this. The reduced spring peak freshet cannot move the sediment and woody debris entering the system from the free-flowing tributaries, as it did before the dam was installed. This has resulted in extensive large woody debris deposits along the lower Duncan River as well as increased sediment deposition.

A second factor which differs from many other previously-studied dammed systems is that the lower Duncan River is situated in a humid, mountainous region characteristic of high groundwater recharge. The data collected during DDMMON#8-1 monitoring project will thus characterize the hydrogeomorphic conditions for the unusual lower Duncan River and the affect it has on black cottonwood recruitment, and subsequently 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 cottonwoods 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 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 Year 5 were to:

- Resurvey elevation profiles of Duncan Segment 4 (D4) transect lines to add deposition and erosion data for transect lines surveyed in 2013 resulting in change from Hamill and Cooper Creeks spring peak flows in 2013; and
- Collect black cottonwood seedling data for 2012, 2013, and 2014 to add to the previous data sets (2009 – 2013).

The black cottonwood seedling establishment and recruitment analyses at the transect level for Year 5 were analyzed relative to the key management questions. Changes in elevation profiles will be assessed relevant to seedling establishment elevation. Data collected in 2014 will add to previous years of monitoring to address Hypothesis 1 (H_{01}). Data in previous years have shown that the Duncan River flow regime affects black cottonwood establishment and survival. This is a summary report year though comparison analyses will be completed as well. Data from Year 5 will add to the body of knowledge for testing the three Hypotheses 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, 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 is very low gradient stream, thus contributing a very small amount of sediment and woody debris during spring high water. At the confluence with the lower Duncan River, the gradient is so low that the Duncan River flows into Meadow Creek creating a back water effect when the lower Duncan River stage is higher than Meadow Creek, with flow direction upstream instead of downstream along the lower Meadow Creek. This backup of water into Meadow Creek channel has been documented to occur past the second meander point bar upstream of the confluence since 2009 and by Miles (2002). Hamill and Cooper Creeks are high gradient streams that contribute 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. The Lardeau River flows out of a nearly parallel watershed with a higher gradient and lower discharge 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).

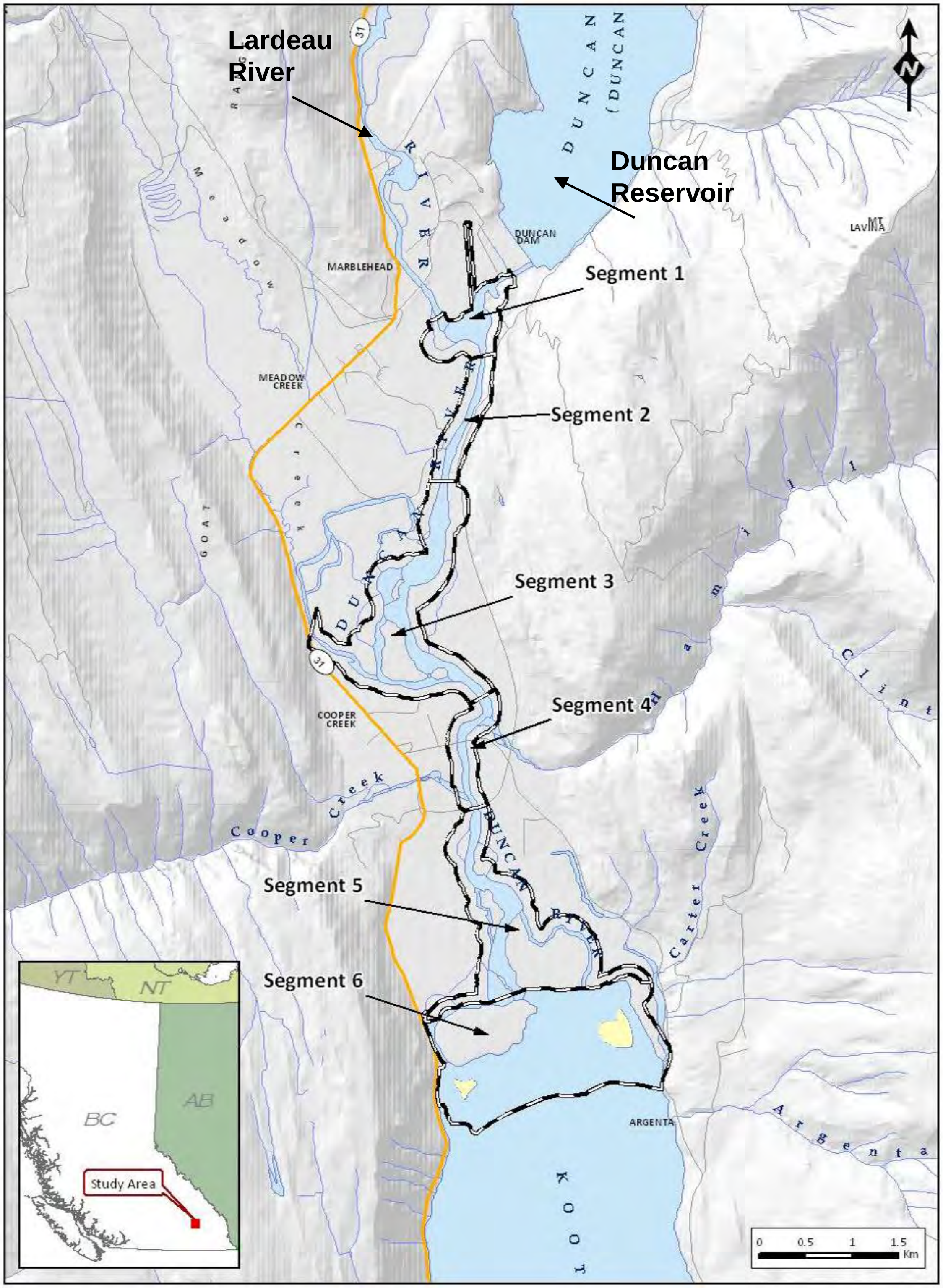


Figure 2-1: Study area for the lower Duncan River with stratification of the river study segments.

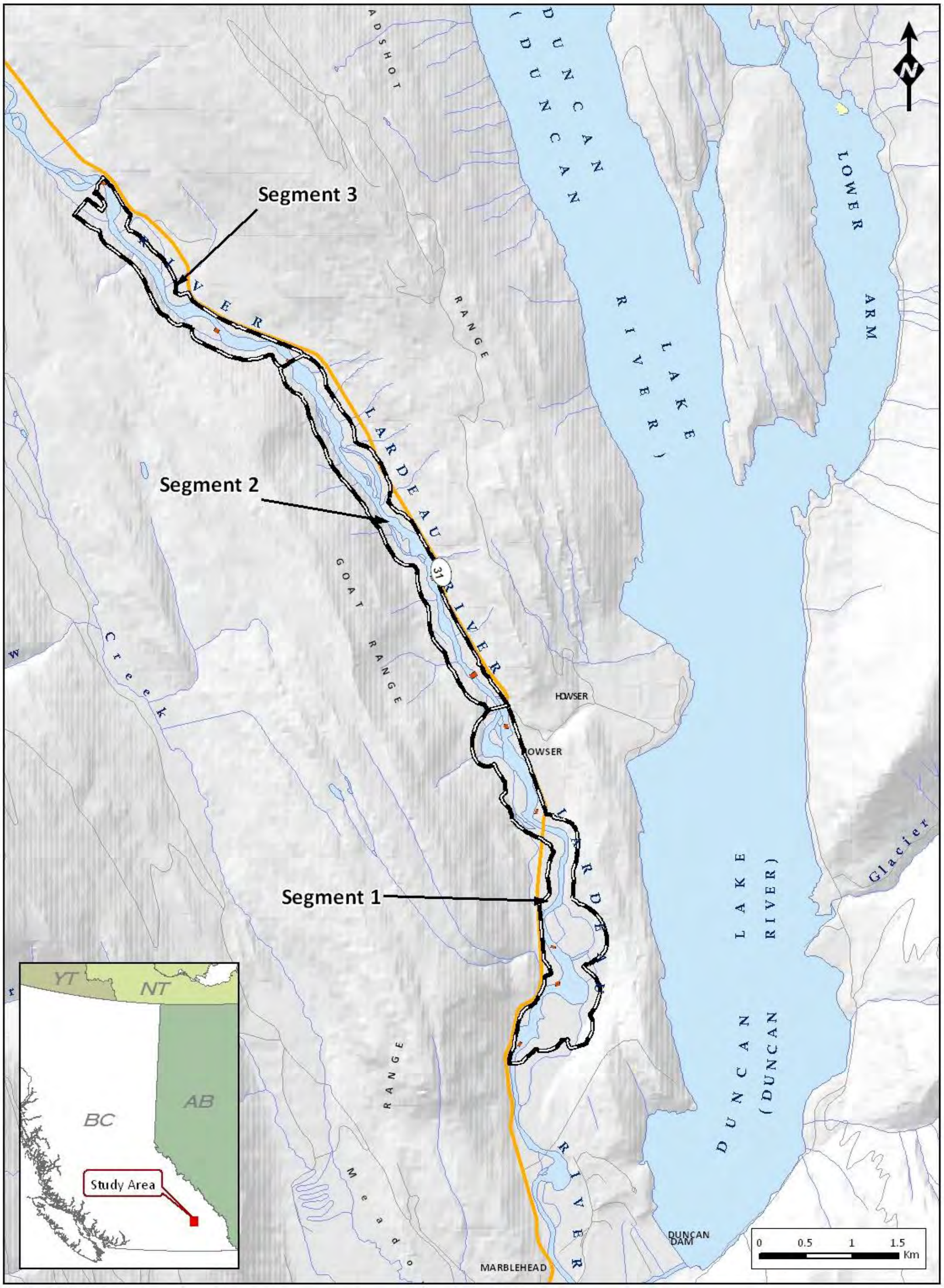


Figure 2-2: Study area for the Lardeau River with stratification of the river study segments.

2.2 Sampling Design

Year 5 (2014) of this study utilized the study design from Year 1 (see Polzin et al. 2010) with the modifications implemented in Year 3 (2012), (Polzin and Rood 2013). In brief, the sampling design included the following tasks and collection of the following data for 2014:

- Complete elevation profile surveys for Duncan Segment 4 along each of the three previously established transect lines;
- Collect seedling information from 2014 black cottonwood germinants and previously measured seedlings from 2012 and 2013;
- 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 climate analyses; and
- Describe black cottonwood phenology, 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 number sequentially using GIS. Then using a random number generator with the total number of transect lines available for each segment 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.

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

- Duncan Segment 1 (D1) has three transect lines – one transect line in the splash zone of dam and two transect lines on the meander lobe back channel – influenced by Duncan River similar to delta zone.
- D2 is moderately entrenched straight channel pattern (Leopold and Wolman 1957, Schumm 1981) with very limited to no opportunities for black cottonwood recruitment. This segment is monitored through periodic float trips to assess if any recruitment sites develop during the study period. It was floated in 2009 and 2013 with no potential recruitment sites. It is also monitored with the orthophoto analysis completed every three years.
- D3 has ten transect lines on a wide floodplain – meandering channel pattern (Leopold and Wolman 1957, Schumm 1981).
- D4 has three transect lines – entrenched relatively straight channel pattern – influenced by Hamill and Cooper creeks.
- D5 has six transect line – more constrained than D3 – meandering channel pattern (lower sinuosity) (Leopold and Wolman 1957, Schumm 1981).
- D6 has four transect lines – delta – influenced by Kootenay Lake and the Duncan River confluence with the lake.

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

- Lardeau Segment 1 (L1) has four transect lines – the widest floodplain with a meandering channel.
- L2 has three transect lines – very constrained – slightly meandering channel.
- L3 has three transect lines – half way in-between L1 and L2 for constraint and level of meandering of channel.

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 modelled. 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.

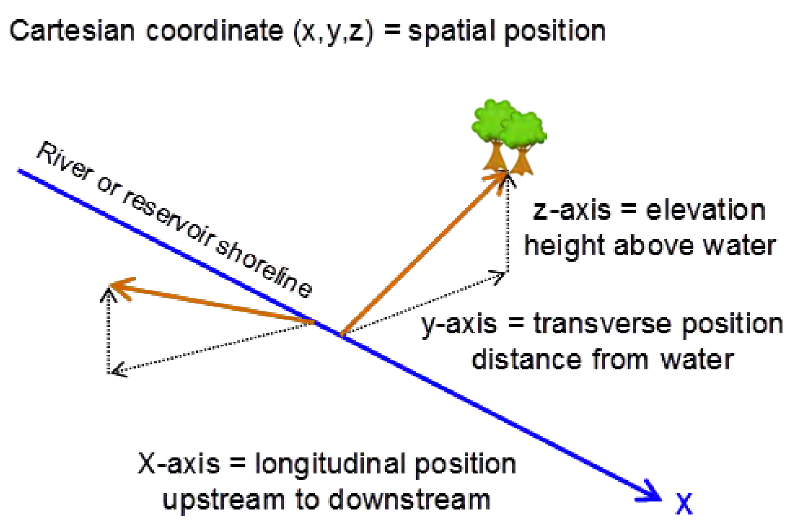


Figure 2-3. Riparian plant occurrence along three spatial dimensions.

The current year black cottonwood germinates density, height, and position along 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 previous seedlings from last year and two years ago were tracked for survival densities and heights resulting in three age classes recorded each year. Quadrats that had seedlings recorded in the previous two years were revisited and any new locations where germinates occurred.

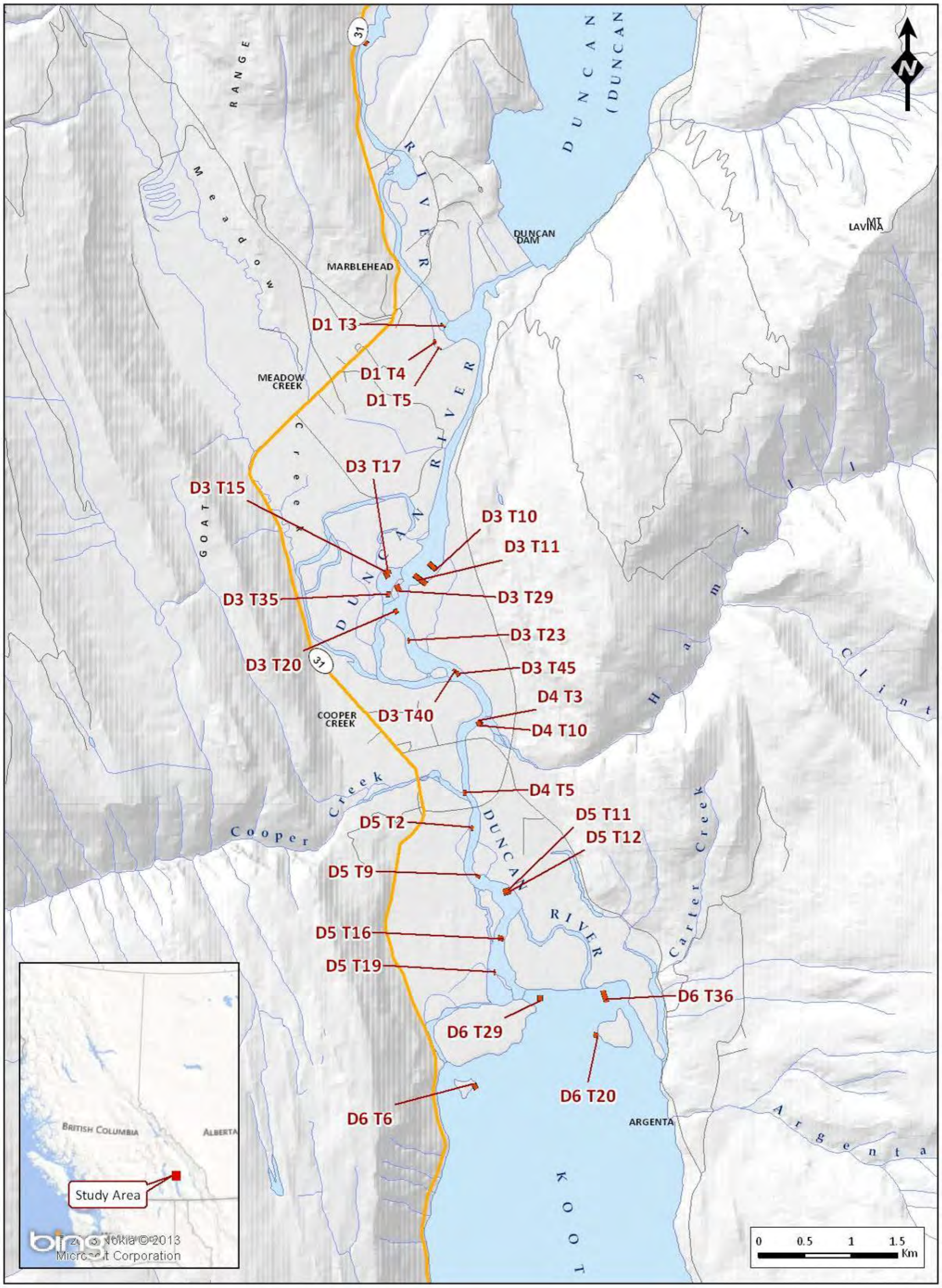


Figure 2-4: **Lower Duncan River study transects in 2013. Segments are indicated by the number following D (Duncan), and transect numbers are indicated after the T (transect).**

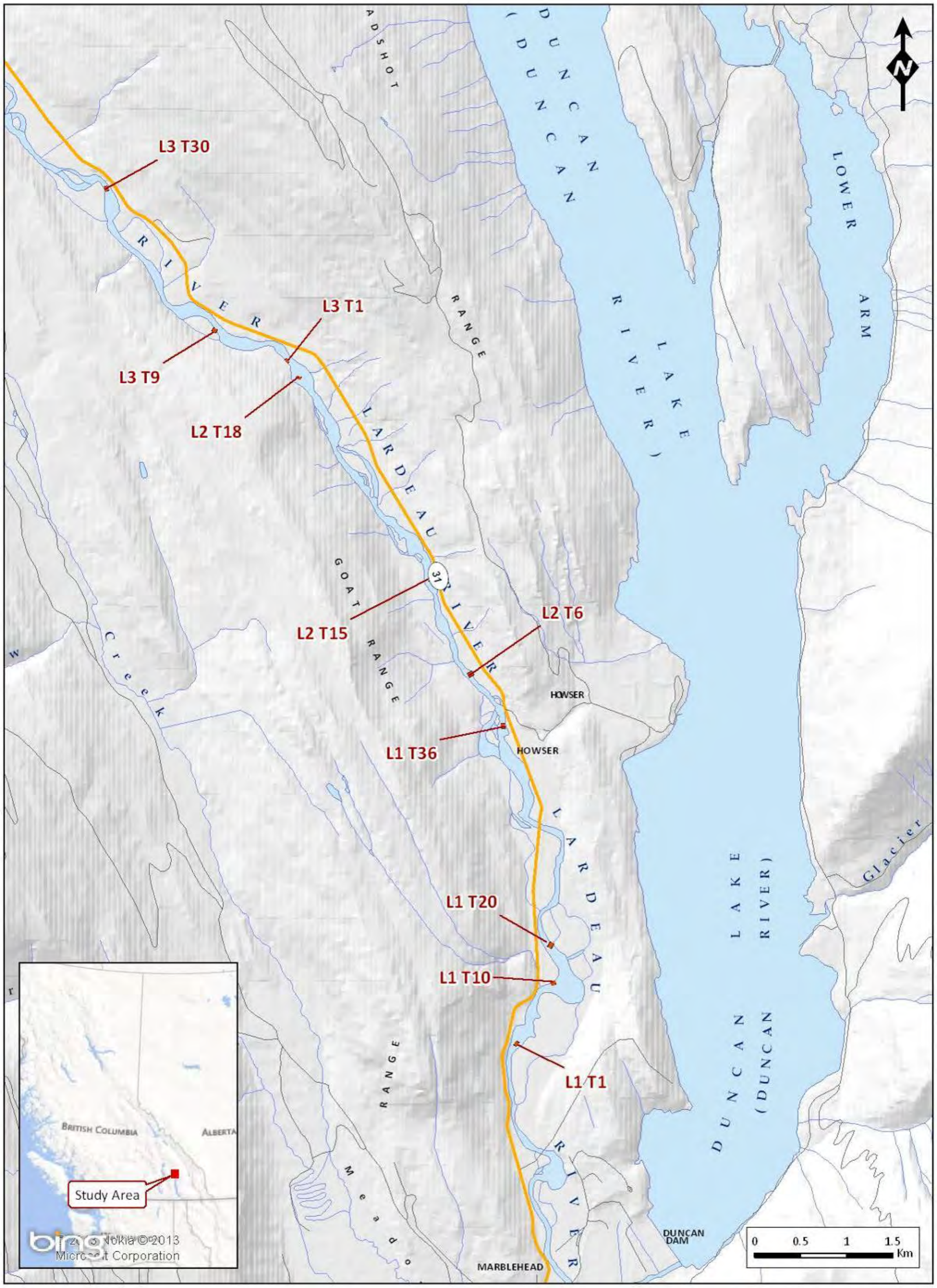


Figure 2-5: Lardeau River study transects in 2013. Segments are indicated by the number following L (Lardeau), and transect numbers are indicated after the T (transect).

All transect lines were surveyed in April/May of 2013 and new transect lines were established. Duncan River Segment 4 (D4) transect lines are located along the Duncan River but are influenced by the Hamill Creek (two transect lines) and Cooper Creek (one transect line) confluences with the Duncan River. Both of these creeks experienced large flash flood events triggered by an extreme rain event (mainly Hamill Cr.) during spring high flows, resulting in the adjacent floodplain being altered considerably from erosion and deposition. The changes in the transect line profiles were major and would impact the interpretation of elevation profiles for seedling recruitment and specific stage measurements for D4. Therefore, the three transect lines were resurveyed in spring of 2014 to record the extent of change that occurred from the high water event. A total station was used and bench marks were resurveyed as well as points from last year and new deposition and scour patches. D4 is an important segment as it allows us to assess the influence of creek confluences with the Duncan River on black cottonwood recruitment and riparian vegetation.

2.3 Seasonal Weather

Daily precipitation and temperature data were downloaded from Environment Canada's website for the Duncan Lake Dam station at Meadow Creek, climate ID: 1142574:

http://climate.weather.gc.ca/climateData/dailydata_e.html?timeframe=2&Prov=&StationID=1115

Precipitation and temperature data were provided for years 2012, 2013 and 2014, from January to December (only tracking changes over a three year period). Historical averages for precipitation were also downloaded. The Canadian Climate Averages were updated from the above web site. The original data set was calculated utilizing 1971 to 2000 data. The new data set was calculated utilizing 1981 to 2010 data. This change resulted in slight differences in the average precipitation for each month compared to the record used in previous reports.

2.4 Hydrology

The 2014 river discharge (*Q*) and stage data were downloaded from Environment Canada's Water Survey website[1] for the lower Duncan hydrometric station. The Lardeau River provisional discharge data were provided by special request from Environment Canada's water office. Hydrometric data were 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 2013 data are provisional; and
2) Station 08NH007: located on the Lardeau River at Marblehead located approximately 700 m upstream of the confluence with the lower Duncan River, the 2013 data are provisional.

The Lardeau River record was only available to Sep 25, 2014 when requested February 25, 2015.

[1] http://climate.weather.gc.ca/climateData/dailydata_e.html?timeframe=2&Prov=&StationID=1115&Year=2014&Month=1&cmdB1=Go

2.5 Black cottonwood Phenology

We documented black cottonwood phenology (the seasonal timing of developmental and reproductive events) through visual observations from fixed vantage points that provided a good overview of the lower Duncan floodplain and the lower Lardeau River. There were more observation sites and a generally broader geographic coverage than in previous years. Dispersing black cottonwood seed release dates were recorded as well as the apparent quantity of the dispersal (i.e., low, medium, and high). Similar to 2009 methods, visits to the Duncan and Lardeau reaches recorded catkin and leaf emergence and abscission dates, as well as the seed dispersal.

2.6 Elevation Profile Survey

Elevations along the length of each transect for Duncan Segment 4 were re-surveyed using a Topcon total station model GTS-225 in 2014 along the Duncan River (detailed methods in Polzin et al. 2010 for transect line location selection methods). The start of the transect line is referred to as the Point of Commencement (POC), the end of the transect (EOT) is at the river's edge. Re-surveys of Duncan Segment 4 (D4) transect lines were required to update the elevation profiles that underwent major changes due to erosion and deposition during spring high water from Hamill and Cooper creeks. Using the Topcan total station, benchmarks set up in 2013 were utilized as well as second benchmarks that were established for the D4 transect lines. These survey data were used to update D4 elevation profiles, D4-specific stage versus discharge rating curves, characterize hydrogeomorphic requirements for *seedling safe site* development (see Polzin et al. 2010 and Polzin and Rood 2006), and for early analysis of seedling elevation establishment for 2013 along these three lines. D4 transect line profiles showing 2009, 2013, and 2014 profiles are located in Appendix 1.

2.7 Field Visits

Three field visits occurred in 2014: April 30 to May 1; July 28 to August 1; and September 29 to October 3. The first 2014 field visit occurred before spring high water, allowing surveying profiles of the recruitment zones and the higher elevations of the floodplain to the POC for D4. Leaves were just starting to emerge so clear sight lines were possible when shooting into the vegetated parts of the floodplain. Water level during the field work was above the base stage by 0.245 m to 0.249 m. Base stage was identified in 2009 (Polzin et al. 2010), it was the typical stage for late September into early October, before the Duncan Dam was constructed.

The second visit and first black cottonwood recruitment monitoring for 2014, occurred when discharges for the Duncan River were between 174.5 m^3/s to 175.5 m^3/s. The previous week had a peak discharge of 222.2 m^3/s on July 21 with a gradual decrease to the July 28 discharge of 174.5 m^3/s. This resulted in some of the recruitment areas just recently emerging from higher flows. The Lardeau River discharge was 89.3 m^3/s for the July 31 sampling day. The third and final field visit occurred during low flows to assess the establishment and survival of the seedlings during the 2014 growing season, and the condition of seedlings from prior years. The discharge was between 119.7 m^3/s to 87.51 m^3/s for the September 29 to October 1 field monitoring interval along the Duncan River and 26.9 m^3/s and 26.5 m^3/s for the Lardeau River for October 1 and 2 (respectively) monitoring period.

2.8 Seedling Establishment and Recruitment

Belt transects were randomly located within pre-stratified river reach segments and pre-identified recruitment areas. These allowed for tracking 2012 and 2013 seedlings and for the assessments anywhere along the transect line where new 2014 seedlings germinated, as described in the Study Design Section 2.2. Black cottonwood seedling densities, heights (averages from 10 seedling heights recorded when greater than 10 seedlings occurred within a 1 m^2 quadrat), and positions along the transect line (and subsequently elevations of the seedling positions) were collected for 2012, 2013 and 2014 seedlings.

D4 transect lines were resurveyed from the POC to river's edge in early spring. This procedure allowed us to quantify the amount of erosion and deposition along the transect lines after the 2013 spring freshet of the two major creeks (Hamill and Cooper creeks), thus updating the elevation profiles. The amount of deposition was calculated above the prior surveyed surface at the time of the 2014 survey (end of April). If the point bar extended beyond the river's edge in early 2013 a theoretical channel slope was used for graphing purposes only. Actual deposition calculations were based on deposition above base flow. The theoretical channel slope was based on the slope above the river's edge particularly for the Hamill Creek area to illustrate the potential deposition that may have occurred in this zone. Accurate survey profiles allow for accurate elevation analyses for seedling locations along these three transect lines to determine where that successful recruitment occurs and the site-specific river stage.

Data for black cottonwood establishment for 2014 germinants and for continuing 2013 and 2012 seedling survival and recruitment (2012) were collected during the July and September field visits. The field data collected were tied to distances along the surveyed transect lines, which provided surveyed elevation points from 2013 for the Lardeau and most of the Duncan reaches and from 2014 for transect 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 2014 seedling sampling methods followed the methods described in Polzin and Rood (2014). By following seedlings for a three year period we are able to assess establishment levels, survival through three growing seasons, and recruitment levels achieved for each year of establishment. We use the term 'recruitment' to represent the successful contribution 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 2012 that survived to the October 2014 field sampling were considered successful recruits and we thus shift from tracking by seedling monitoring to vegetation monitoring utilizing cover by species to assess growth and cover expansion during the years that riparian vegetation is monitored.

Preliminary analyses of 'seedling safe sites' were completed for 2008 to 2013 seedlings along the Duncan and Lardeau reaches. These assessments characterize survivable positions relative to sediment deposition and erosive scour. Data for seedlings considered recruited after 3 years were not tracked into their fifth year (2008) so it is unknown if they survived the level of deposition or scour that occurred after their third year. Seedling elevation position in their third year was plotted but some seedlings would actually be four or five years old in 2013. Survival information after the third year will be gathered in 2015 during the riparian vegetation monitoring, and relevant information will be added at that time for analysis of impact due to these factors (scour, deposition, inundation, and duration). Data from 2012 survival to 2015 will be presented in 2015 with survival data for 2012 and 2013 added to extend the data base.

Photos taken during the 2014 field season are documented in Appendix 2 and contact sheets of photos are located in Appendix 3. Original digital images are supplied on a video disc (DVD) with the final report.

2.9 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.

2.10 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 seedling establishment and recruitment across the 2012, 2013, and 2014 data sets. With-in and between comparisons were completed for representative reaches along the lower Duncan River and the free-flowing Lardeau River.

Analyses of erosion and deposition had deposition occurring along D4T3 and D4T10 lines beyond Duncan River's edge during 2013 survey. Calculation of deposition beyond the river's edge of the 2013 survey set 0 m as the comparison elevation for 2013. However, graphing utilized the calculated slope to river's edge in 2013 with a continued slope below the water. This dispersed the points on the graph but these –estimated values were not used in the calculation of deposition since it was not known what the actual submerged profile was in 2013. The deposition could have been higher as the slope of the stream bed would probably have been greater than zero, 20 to 30 m into the main channel. Therefore, the deposition calculations are somewhat conservative along the transect lines adjacent to Hamill Creek confluence with the Duncan River.

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 transformation was unable to provide normal distributions for seedling density data (for germinants) when comparing previous years and between reaches therefore non-parametric tests were used when needed. Tests included; Kruskal-Wallis One Way Analysis of Variance of Variance on Ranks for the Duncan River seedling densities between 2014, 2013, and 2012. A pair-wise, multiple comparison procedure (Dunn's Method) was used to isolate the group or groups that differed from the others. The Mann-Whitney Rank Sum test was used to test for differences between the Duncan and Lardeau reaches for seedling abundance in 2014. It was also used for differences between years 2014 to 2013 and to 2012 seedling densities for both reaches and for differences between years for each segment within each reach. A One Way Repeated Measures Analysis of Variance with pair-wise multiple comparison procedures using Holm-Sidak method was used for 2014 and 2013 survival comparisons, for the Lardeau reach.

Variables

There were a number of independent variables identified at the start of project. It is important to recognize that suitable cottonwood recruitment zones are barren, open, and occur most often within newly deposited sediments of fine to moderate texture at 'seedling safe' elevations (Mahoney and Rood 1998, Scott et al. 1997, Karrenberg et al. 2002, Polzin and Rood 2006). These are the variables that we investigated relative to prospective influence on the dependent variables involving seedling black cottonwood recruitment, as detected along other river systems and some tested in 2009 and will test all in 2018 (Rood & Mahoney 1995, Mahoney & Rood 1998, Polzin 1998, Polzin & Rood 2000, and Polzin & Rood 2006). A list of dependent and independent variables is provided in Table 2-1.

Table 2-1: Summary of dependent and independent variables for the study.

Independent Variables	Dependent Variables
Channel morphology	Black cottonwood juvenile & mature cover %
Elevation position	Tree ages
Deposition	Annual growth increments
Erosion	Black cottonwood establishment density
Stage	Seedling recruitment
Stage duration (time at a constant level)	Willow cover %
Peak discharge	Riparian species & cover %
Peak discharge duration	Upland species & cover %
Substrate sediment textures	Species diversity
Groundwater levels	Species richness
Longitudinal position	
Time (over the 10 years of the study)	
Time (pre-S73 vs. post-S73)	

<u>Confounding variables</u>

A confounding variable is an independent variable of interest in this study that is difficult to control or assess but still may further affect the dependent variables. The Lardeau River was selected as a reference to control for confounding variables such as the variability in weather across seasons, (hot dry summers compared to cool wet summers) and insect infestations. This could influence the seasonal variation in seed release levels from year-to-year and possible correspondence with the variability in river discharges in a free-flowing system. By comparing the lower Duncan River riparian vegetation and black cottonwood seedling establishment and recruitment to the Lardeau River data, variability due to weather, biological variation in seed production, possible infestations of insect pests such as defoliators, sucking insects, woody tissue feeders etc., and spring peak flows timing are somewhat controlled. As the study has advanced we believe that the reference comparison using the Lardeau River is appropriate since we've observed similar seed release densities along both systems as well as apparently similar weather and insect pest patterns, both are cobble based rivers with similar riparian soils and surface substrate texture. However the Lardeau River is a higher gradient system.

3 RESULTS

3.1 Weather

The past sampling year (2014) experienced generally similar mean temperatures through the growing season but a colder February compared to 2012 and 2013 (Figure 3-1). The mean daily temperature for the growing season (May to end of September) was similar to previous years; 2012 (15.0 ºC), 2013 (16.0 ºC), and 2014 (16.1 ºC) with the 2014 season slightly warmer (monthly mean) than the past sampling years.

The month of June, 2014, did not experience any heavy precipitation event and the total precipitation for June (52.4 mm) was less than in one day of the extreme event of the prior year when 57 mm was recorded June 19, 2013 (Figure 3-2). There was slight difference between total precipitation for 2012, 2013, and 2014 (Figure 3-3;). However, the weather for the summer months, June, July, and August 2014 experienced slightly warmer conditions than previous sampling years, and with reduced precipitation (Figure 3-4 and Table 3-1). The total precipitation for each month was not the lowest recorded for each month over the study interval but the combination was a reduced precipitation pattern, coupled with the higher mean temperature for each month. June, 2009 had the lowest precipitation for the month but it was followed by higher precipitation for July and August. July, 2013 had the lowest precipitation for the month but it had higher June and August precipitation levels. August, 2013 had the lowest precipitation for the month but it was preceded by the highest June precipitation level and higher July precipitation than 2014 during the same period (Figure 3-4). The lowest mean monthly precipitation and slightly higher temperature for this period of time occurred in 2014 (Table 3-1) resulting in a warm dry summer for 2014 compared to previous sampling years.

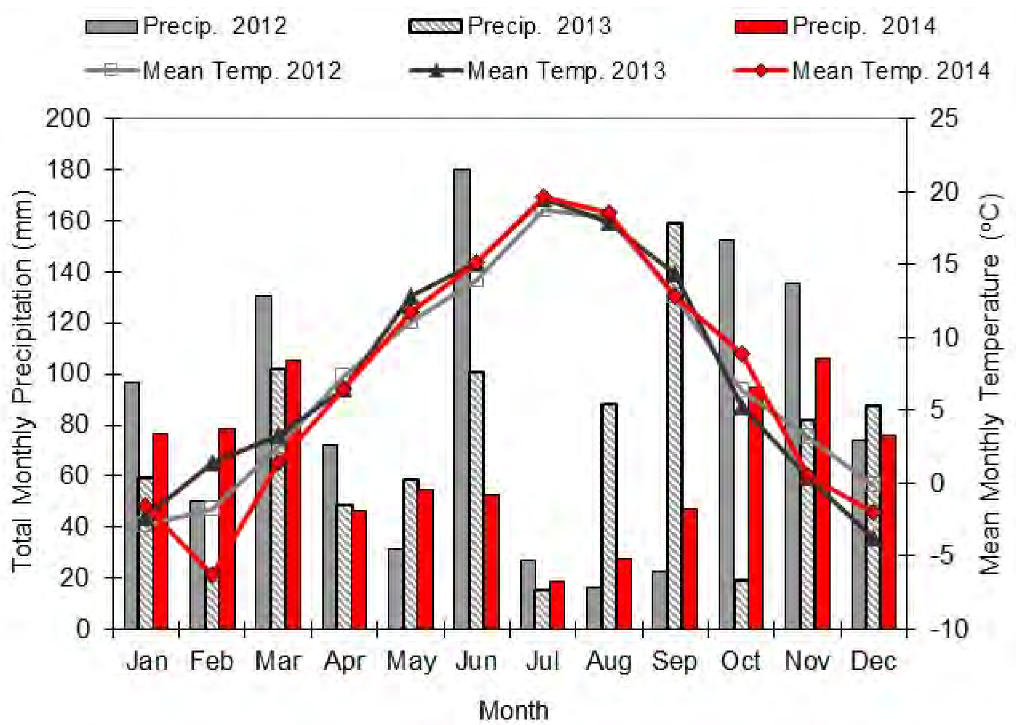


Figure 3-1: Duncan Lake Dam weather station at Meadow Creek monthly mean temperature and monthly total precipitation for 2012, 2013, and 2014.

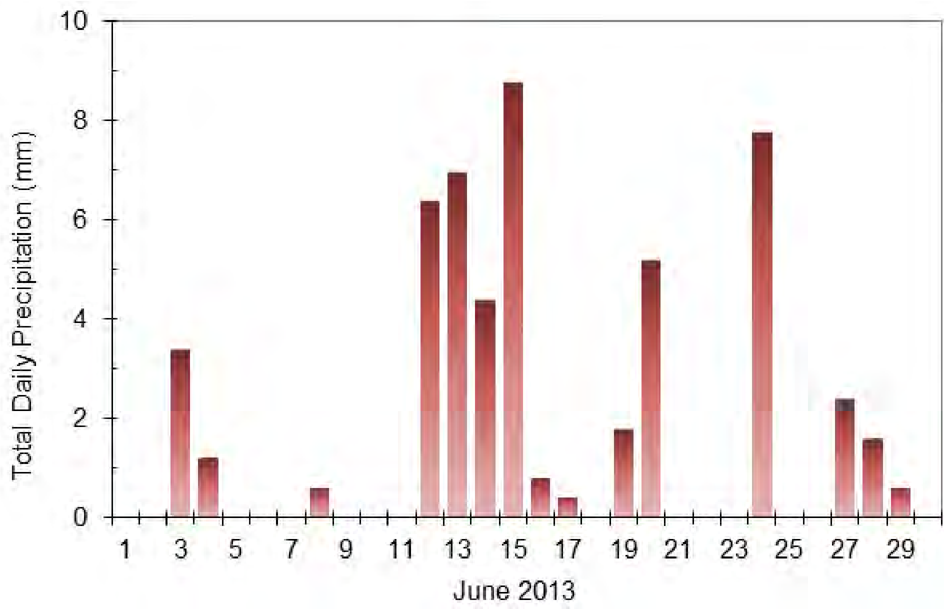


Figure 3-2: Precipitation (mm) for the month of June 2014 at Duncan Lake Dam weather station. Total precipitation for the month of June was 52.4 mm.

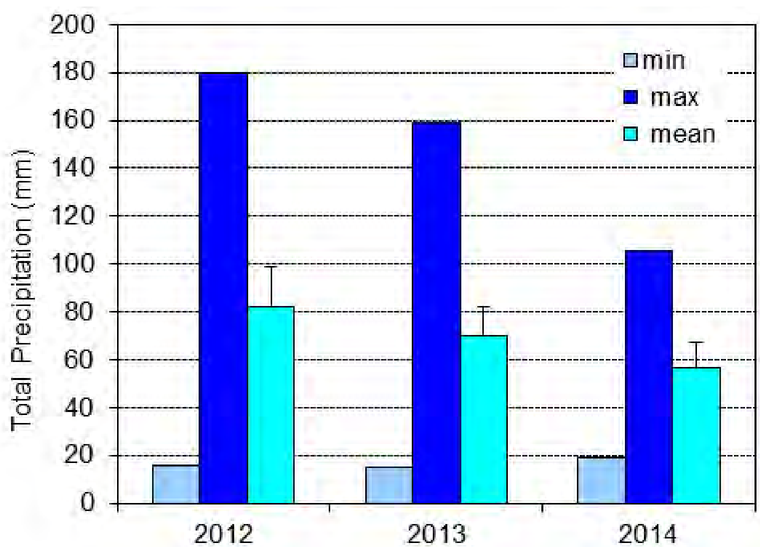


Figure 3-3: The minimum, maximum and mean total precipitation for 2012, 2013, and 2014. Standard error bars are marked for the mean total precipitation.

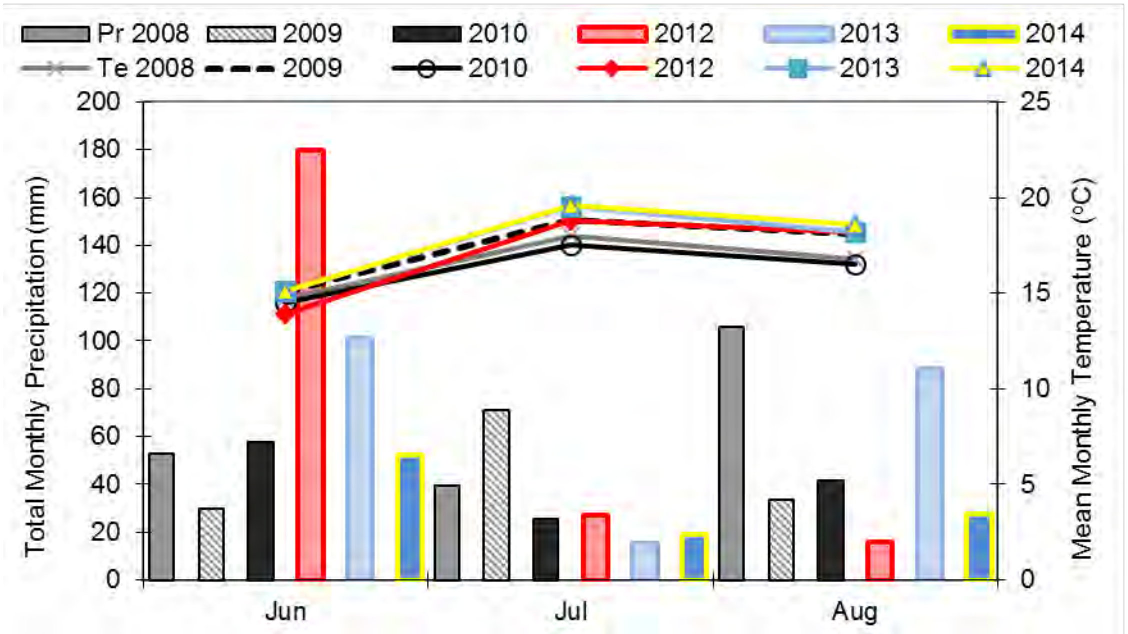


Figure 3-4: Comparison of total precipitation and average temperatures for the summer months; June, July, and August during the study period (Pr = precipitation and Te = temperature).

Table 3-1: Average precipitation and temperatures and total precipitation for the summer months of June, July, and August from 2008 to 2014.

Average	2008	2009	2010	2012	2013	2014
Precipitation (mm)	65.9	45.0	41.6	74.4	68.1	30.9
Total Precipitation	197.8	134.9	124.7	223.1	204.4	92.8
Temperature (ºC)	16.5	17.3	16.2	17.0	17.6	17.9

Both the Duncan and Lardeau rivers are snowmelt-dominated systems. As such, seasonal snow pack levels play a role in the extent of freshet flooding. However, weather determines the rate of snow melt and subsequently contributes to whether or not flood conditions occur. The Snow Water Equivalent (SWE) for 2012, 2013, and 2014 were obtained the from Duncan Lake watershed station 2D07A (archive manual snow survey data), which is at 662 m elevation at the Marble Head Weather station. This shows that 2014 was similar to 2012 and did not have the low snow pack levels of 2013, at least at this low elevation site (Figure 3-5).

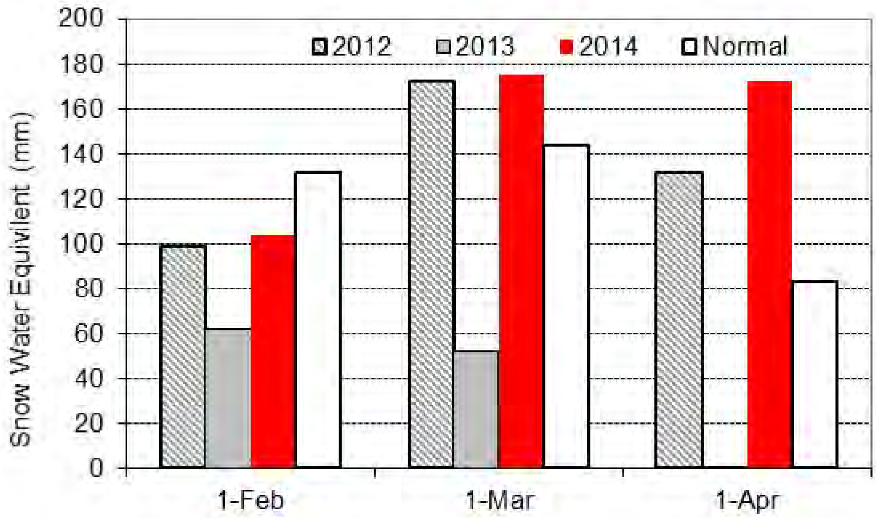


Figure 3-5: **Snow water equivalent totals for the months February, March, and April at the station 2D07A Duncan Lake No. 2 at 662 m elevation at Marble Head weather station for 2012, 2013, and 2014. Normal values for each month are illustrated as well taken from 2D07A Duncan Lake No. 2 station.**

3.2 Hydrology

3.2.1 Duncan River

Mean monthly discharges for 2009 to 2014 (2009 and 2010 were combined as these provided similar patterns as demonstrated in Polzin and Rood 2014), are shown in Figure 3-6. The sampling year of 2012 was an exception with the regular Alt S73 flow regime pre-empted by high snowmelt and rainfall in the Duncan Basin (see Polzin and Rood 2013). The past sampling year, 2014, had similar flows during the start of the growing season compared to 2013. However, 2014 did not have a similar peak in July and this is important to the study since this is when the major seed establishment primarily commences. The flow regimes for 2013 and 2014 were dissimilar to those of 2009 and 2010. There was a gradual increase in the mean discharge rate from May (195 m^3/s) to August, 2014 (228 m^3/s) with September flows being only slightly lower, around 222 m^3/s, which was slightly higher than all previous years of the study.

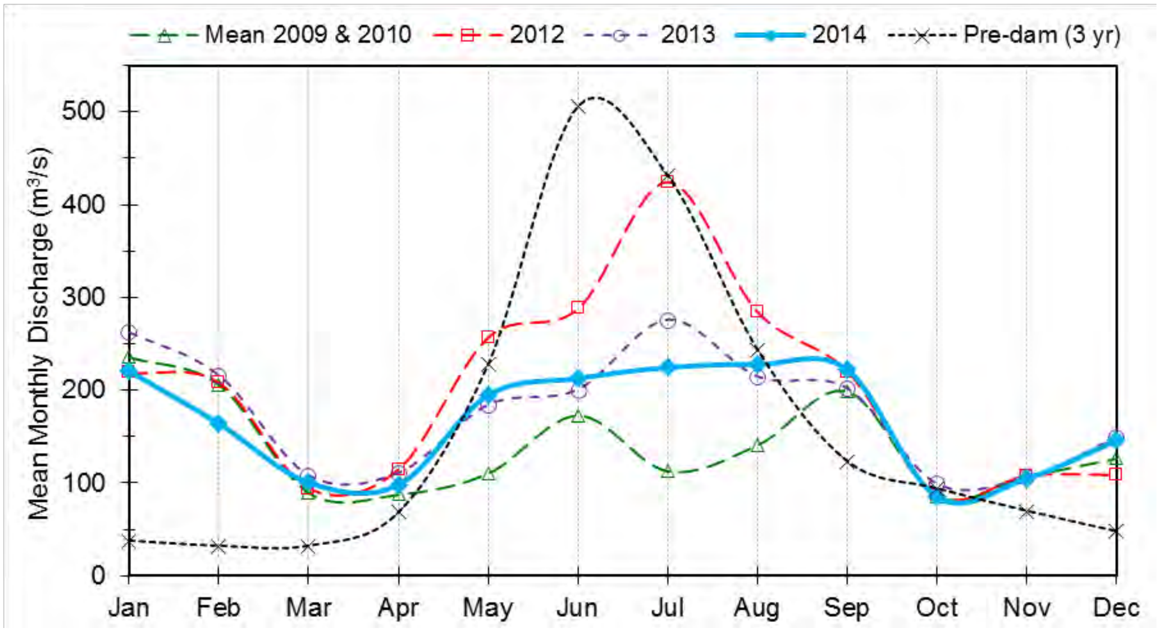


Figure 3-6: Mean monthly hydrographs for the lower Duncan River for sampling years 2009 and 2010 combined, 2012, 2013, 2014, and pre-dam (3 years of data) discharges plotted with smoothed lines.

The daily mean data shows the variation that occurs during the month (Figure 3-7) which is smoothed out by monthly means. The sampling years 2009 and 2010 both had two extended periods of peak flows, one during June and a second during August and September. The discharges in May were slightly higher in 2014 compared to 2013 and from June to September 5, 2014 discharge was lower than 2013 with some variation. The peak occurring July 6, 2014 (271 m^3/s) and was smaller than that of July 8, 2013 (369 m^3/s). Discharges were similar for September for 2013 and 2014 with flows slightly higher for 2014 (Figure 3-7). From May 1 to the end of September 2014, daily flows were higher than 2009 and 2010.

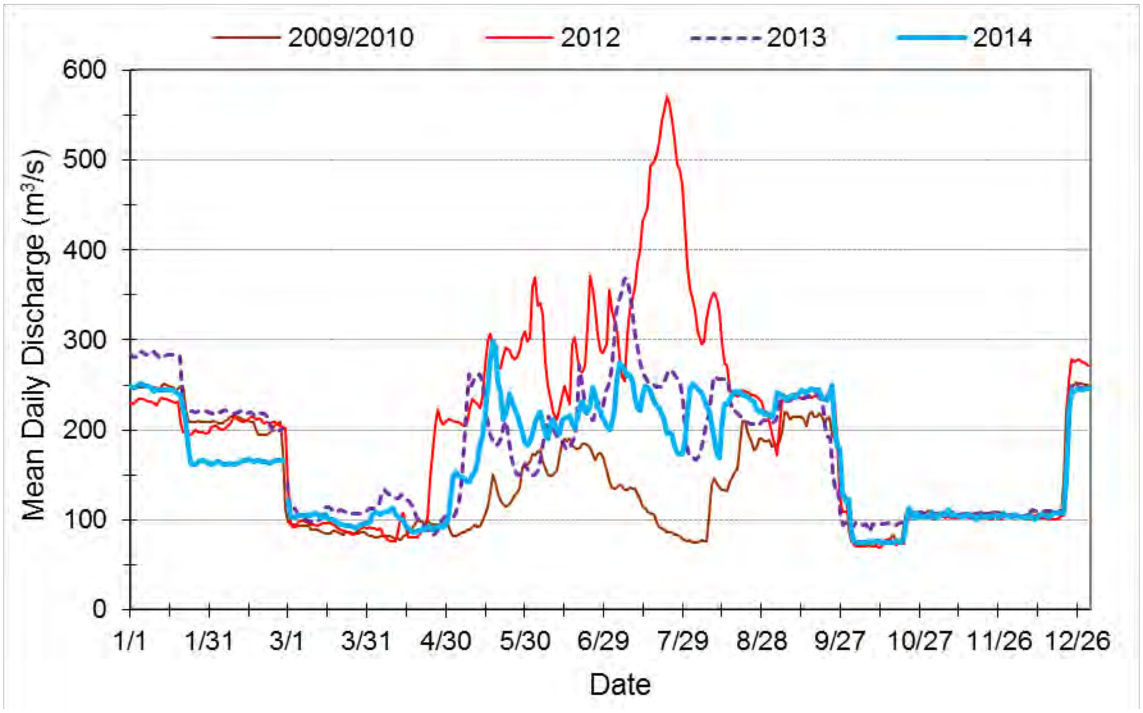


Figure 3-7: **Mean daily discharge (m^3/s) for 2009 and 2010 (combined), 2012, 2013, and 2014 (provisional) for the lower Duncan River at Station 08NH118.**

3.2.2 Lardeau River

In 2014, the Lardeau River (reference reach for the study) experienced an average spring freshet with a peak discharge of 243 m^3/s that was slightly below the 2 year recurrence peak (Q_{max2} = 269.2 m^3/s) in 2014. The mean monthly discharges for 2014 were very similar to 2013 (Figure 3-8). There was a slight drop in the average discharge for August in 2014 compared to previous year flows. Flow records for the Lardeau River consisted of 70 years of records starting in 1917, with a period of missing records from 1920 through 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 origin). Recurrence analysis indicated that the 2014 spring freshet along the Lardeau River was below the 1-in-2 year flood event (Q_{max2}) see Polzin and Rood (2013) for detailed log Pearson Type III analysis.

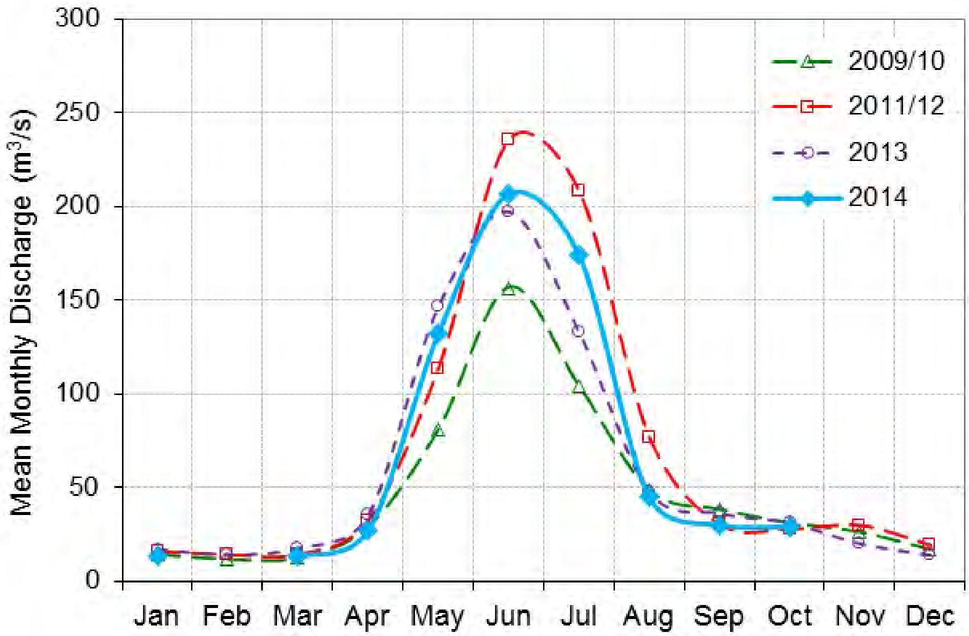


Figure 3-8: Mean monthly discharge (m^3/s) for the Lardeau River for 2014, 2013 and the average for years 2009 and 2010 and the average of 2011 and 2012 (because very similar flows for the paired years (Polzin and Rood 2013).

The 2014 peak flow occurred on June 25, which was typical timing for the Lardeau River. Historically, 71 per cent of annual peaks have occurred within June. During the research years of this project, spring freshet occurred mid to late June (Table 3-2). The discharge gradually declined from June 20 to September as it approached base flow with the slight dip in August compared to previous years. There was a decline in the mean monthly discharge for August and September with Figure 3-9 showing the daily discharge pattern with discharge higher in 2014 at the start of August, similar during mid-to the end-August, and a drop in discharge in September compared to the 2013 discharge.

Table 3-2: Peak spring freshet discharge for the Lardeau River from 2009 to 2014 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		**10**	349	12
2010	June 29	183 m^3/s		**5**	319	9
2011	June 23	297 m^3/s		**3**	294	8
2012	July 1	314 m^3/s	Q_{max5}	**2**	269	7
2013	June 20	269 m^3/s	Q_{max2}			
2014	June 25	243 m^3/s				

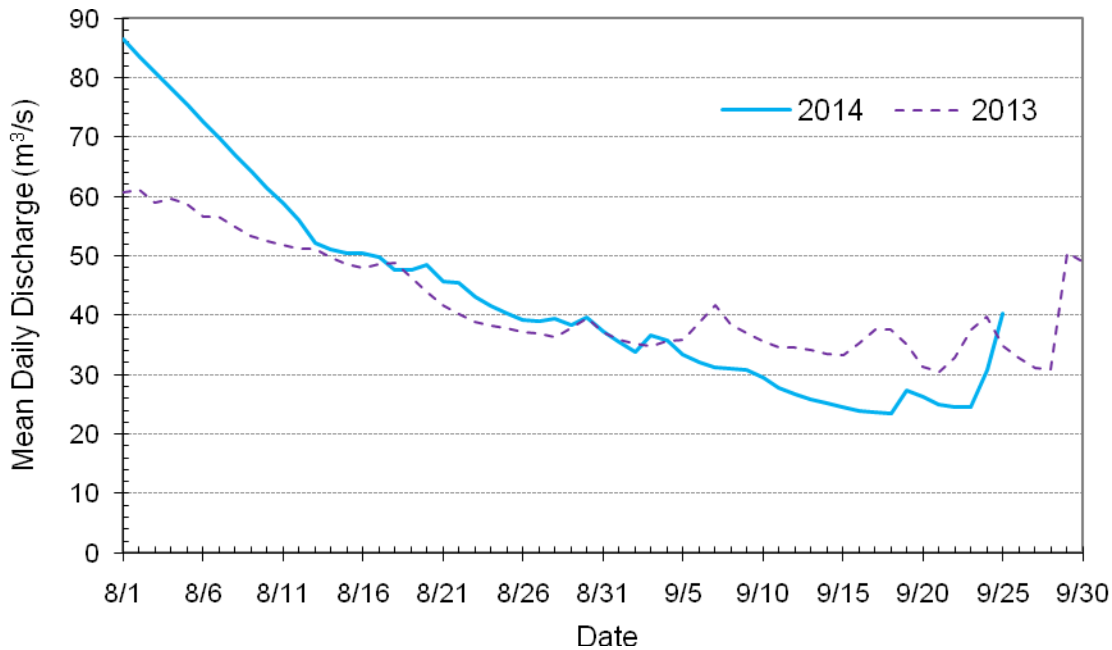


Figure 3-9: Mean daily discharge (m^3/s) for 2013 and 2014 (provisional) for the lower Lardeau River at Station 08NH007 for August and September.

3.3 Black cottonwood Phenology

In 2014 we recorded dates of catkin and flower emergence, leaf emergence, seed development, and senescence, in addition to seed release events, consistent with the 2009 sampling (Table 3-3). Developmental timing was generally similar to 2009 with a slightly shorter period for seed release in 2009.

Seed release events were rated from ‘Low to High’ relative to the observed airborne seed densities. There was no ‘High’ seed release observed in 2014, and all releases were rated as ‘Low’ to ‘Moderately Low’. The first release (Moderately Low) was June 19-21, and it was widespread, including north along the Lardeau River to Gerrard and south to Nelson. (By comparison, a seed release on June 19, in and near Nelson was ‘High’). The next release pulses were on June 25 (Low) and June 29, (Low), along both the Lardeau and Duncan Rivers. Throughout July many small and apparently more site-specific seed release events were observed, all were rated as 'Low' events, along both rivers. In late July we found numerous 1/3 full seed pods on the ground downed by wind and/or rain events. There were no seed releases observed in August in 2014.

Table 3-3: Black cottonwood phenology for 2014 with 2009 phenology for comparison, along the Duncan and Lardeau rivers (same times for both rivers.

Occurrence / Stage	2009	2014
Gradual emergence of male (1st) and female inflorescences.	April 4 to April 30	April 1 – April 30
Flowers fully developed Pollination	Not recorded	End of April, approximately
Abscission of male catkins	May 2 – May 7	Early May
Leaf emergence	May 1 to mid-May	End of April (28th) to mid-May
Seed pods developing	May to mid-June	May to mid-June
Seed release begins	June 20-21 first event – late June to mid-July	June 19-20 first event - from late June through July
Leaf senescence	Late Sep. through Oct.	Late Sep. through October

Table 3-4: Black cottonwood seed dispersal event details for the lower Duncan and lower Lardeau region of British Columbia.

Event	Date	Seed Abundance	T_{max} (°C)	Rain (mm)	Event T_{max}	Prior and Post Rain Events
1	Jun 19 Jun 20	Mod. Low Mod. Low	21.0 20.5	1.8 5.2	**20.8**	8.8 mm rain June 15th 0.0 mm rain June 21 to 23rd
2	Jun 25	Low	24.0	0	**24.0**	7.8 mm June 24, 0.0 mm June 26
3	Jun 29	Low	21.0	0.6	**21.0**	2.4 mm & 1.6 mm June 27 & 28th 0.0 mm June 30th
4	Jul 3 Jul 4 Jul 5	Low Low Low	29.0 29.5 28.5	0.0 0.0 0.6	**29.0**	0.0 mm of rain from Jun 30 to Jul 4th 0.0 mm of rain July 6th
5	Jul 7 Jul 8	Low Low	31.0 33.0	0.0 0.0	**32.0**	0.0 mm of rain July 6th 0.0 mm of rain July 9 to July 13th
6	Jul 15	Low	31.0	0.0	**31.0**	0.6 mm Jul 14, 0 mm Jul 16 to Jul 22nd
7	Jul 23	Low	29.0	10.8	**29.0**	0.0 mm of rain July 22nd 6.2 mm of rain July 24th

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

3.4.1 Seedling Abundance

Following the 2014 field inventories, a total of 540 sampling quadrats along the lower Duncan River had black cottonwood seedlings, and these had originated in 2012 to 2014 but mainly in 2014. This was the highest number of quadrats with seedling compared to all previous sampling years (Table 3-5) with 265 quadrats in 2009. The total number of germinates were only slightly lower than in 2010 and higher than in 2012 and 2013 (Table 3-5) with 2009 number of germinants the highest for the study period (138,032).

We had an increase in the number of quadrats along the Lardeau River with seedlings in 2014 (130) as compared to 2013, 2012, and 2009 (73) but less than in 2010 (Table 3-6). The total germinant counts were lower in 2014 (4,818) compared to 2013, 2010, and 2009 (6,325) but higher than 2012 sampling years. L2 and L3 had significant increases ($P<0.001$ for both) in the number of germinants in 2014 since the Q_{max5} spring peak in 2012.

Table 3-5: Comparisons of 2010, 2012, 2013 and 2014 numbers of quadrats with seedlings and the total density per transect line of germinants for the corresponding year, along the Duncan River (Tran = Transect, Quad = Quadrats, # Germ = total density of Germinants per transect line).

Duncan Segments	Tran #	2010		2012		2013		2014	
		# Quad	# Germ	# Quad	# Germ	# Quad	# Germ	# Quad	# Germ
D1	T3	15	3,197	8	52	21	857	9	2,786
	T4	0		0		0		0	
	T5	0		0		0		0	
D3	T10	5	139	0		0		1	2
	T11	4	142	0		54	2,084	67	4,604
	T15	61	7,372	1	1	17	1,075	41	1,639
	T17*					14	851	26	651
	T29*					28	1,267	35	1,551
	T35*					11	1,221	21	982
	T20	13	784	0		13	609	12	400
	T23	3	64	0		0		0	
	T40*					2	6	8	250
	T45*					17	370	20	465
D4	T3	31	48	1	65	64	3,003	62	3,273
	T10*					35	813	42	1,027
	T5	32	249	0		0		0	
D5	T2	12	296	0		11	90	9	88
	T9	20	2,276	0		5	571	13	156
	T11	5	20	0		22	787	21	740
	T12	34	5,260	0		4	8	31	1,395
	T16	12	5	0		13	260	18	574
	T19	8	614	0		3	206	7	268
D6	T6	0		0		0		5	696
	T20*					0		13	83
	T29	30	1,400	0		0		19	231
	T36	41	217	0		0		60	758
Totals		**364**	**22,830**	**12**	**122**	**334**	**14,078**	**540**	**22,619**

Note: * indicates new transect lines established 2013.

Table 3-6: Comparisons of 2010, 2012, 2013, and 2014 numbers of quadrats with seedlings and the total density per transect line of germinants for the corresponding year, along the Lardeau River (Tran = Transect, Quad = Quadrats, # Germ = total density of Germinants per transect line).

Lardeau Segments	Tran #	2010		2012		2013		2014	
		# Quad	# Germ	# Quad	# Germ	# Quad	# Germ	# Quad	# Germ
L1	T1	17	143	7	2,258	13	523	8	238
	T10	28	3,215	18	1,145	20	3,895	20	575
	T20	22	785	11	42	19	415	43	1,823
	T36	12	138	2	13	17	687	14	670
L2	T6	39	1,211	1	4	15	31	11	312
	T15	5	220	3	12	1	1	4	173
	T18*					13	122	19	648
L3	T1	14	86	0	0	1	1	5	200
	T9	7	24	0	0	3	7	6	179
	T30*					0	0	0	
Totals		**145**	**5,823**	**42**	**3,474**	**102**	**5,682**	**130**	**4,818**

Note: * indicates new transect lines established 2013.

3.4.2 Seedling densities and survival

In 2014, black cottonwood seedling densities (‘densities’ will be used to refer to the germinant densities and does not include 2013 and/or 2012 seedling densities in 2014) along the lower Duncan River were significantly higher than in 2012 with higher densities in 2014 (P<0.001) and tended to be different from 2013 densities (P = 0.096) (See Appendix 4 for statistical results). The difference in the median value comparisons for 2014 to 2012 densities indicated that seedling densities were greater than would be expected by chance. Seedling density comparison between the Duncan and the Lardeau reaches for 2014 were also significantly different in the median values (P=<0.001, see Appendix 4). Box plot comparisons between densities for 2012, 2013, and 2014 illustrate the magnitude of differences for the Duncan Reach across years and between the Lardeau and Duncan Reaches (Figure 3-10) as well as across the Duncan River segments (Figure 3-11).

The Lardeau River also had significant difference in the median values for seedling densities in 2014 compared to 2013 (P = 0.002) and 2012 (P = 0.045 Appendix 4). However, unlike the Duncan reach, the seedling densities were highest in 2012 (Figure 3-10). Comparisons between segments show that Segment 1 (L1) had a reduction of seedling establishment in 2014 compared to 2013 and 2012 but not great enough to exclude the possibility that the difference was due to random sampling variability. There were significant increases in seedling densities for L2 and L3 in 2014 compared to 2012 and 2013 densities (P = <0.001 for L2 and L3 Appendix 4) (Figure 3-12).

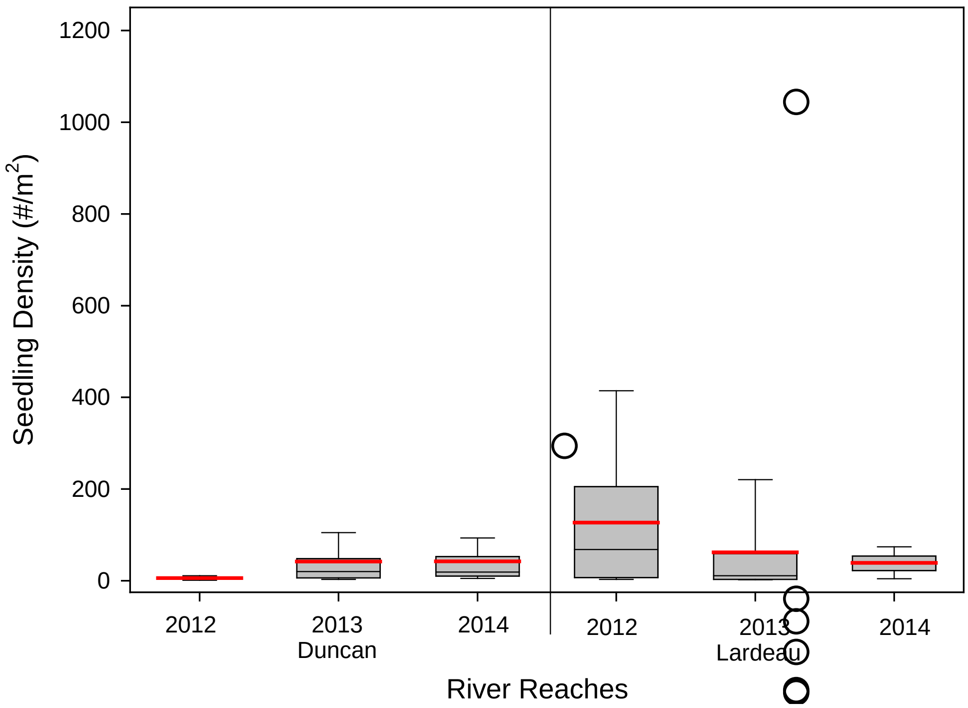


Figure 3-10: The 2012, 2013, and 2014 black cottonwood germinant densities for the Duncan and Lardeau study reaches.

[*For box plots, the lower boundary of the box indicates the 25th percentile, the black line within the box marks the median, the wider 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.]

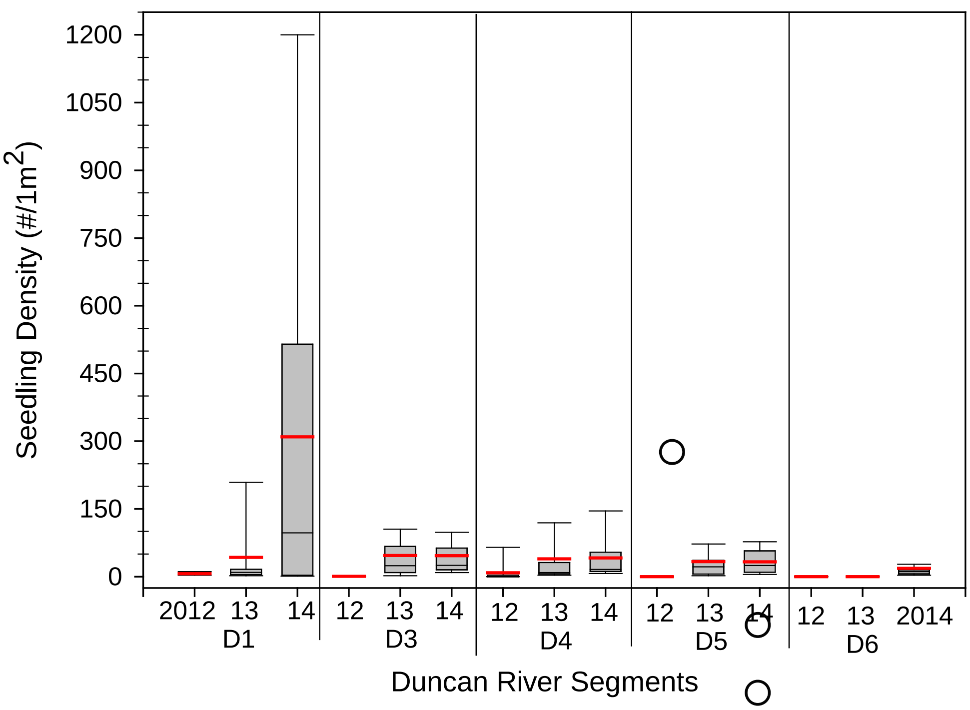


Figure 3-11: Germinant densities for 2012, 2013, and 2014 for each segment along the lower Duncan (D) River.

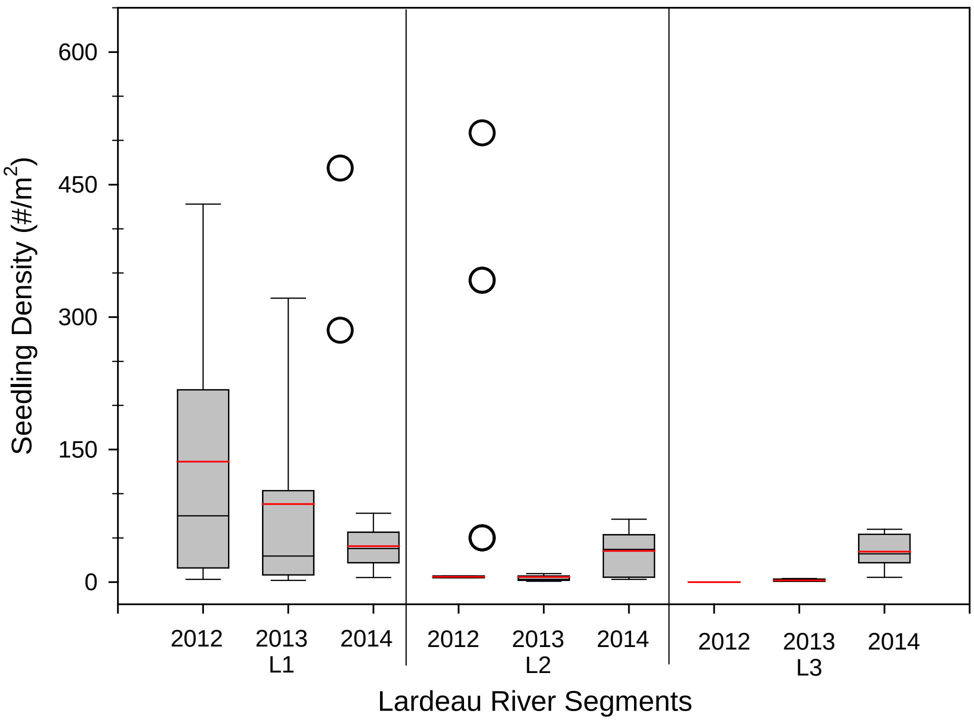


Figure 3-12: Seedling establishment densities (germinants) for 2012, 2013, and 2014 for each segment along the Lardeau (L) River.

Survival and Recruitment

Both the Duncan and Lardeau reaches had reduced survival rates for the initial growth season for the 2014 seedlings compared to the first season survival in 2013 (Figure 3-13). The 2014 mean survival along the Duncan reach was lower than 2013 mean (30.9, Std Dev 29.43 and 39.9, Std Dev 31.8, respectively). However, the average first summer survival was 25.0 percent from 2009 to 2013. The average calculation included the very low survival rate of 13.0 percent in 2012. Therefore the 2014 survival rate was slightly above average for the first summer.

Along the Lardeau reach the 2014 survival of germinants through the summer was significantly reduced compared to 2013 (7.0, Std Dev 15.0 and 20.8, Std Dev 28.0 respectively) with $P = <0.001$, $F = 13.0$ (Appendix 4). The average first season survival rate was 23.6 percent (2009 to 2013). This includes the reduced survival rate of 19.0 percent for 2012 (2009 and 2010 had an average survival rate of 31.0 percent).

Recruitment of 2012 seedlings was above average for both reaches. The Duncan reach had 82.4 percent survival for their third summer but initial establishment was very low and the survival rate involved only seven quadrats with 2012 seedlings. The average for the Duncan recruitment was 75.0 percent. The Lardeau reach had 86.1 percent survival for the third summer. Initial establishment abundance was above average in 2012. The Lardeau reach averaged 75.9 percent for recruitment (3rd year) with 21 quadrats in 2014 which had 2012 seedlings. Survival rates for the third year were consistent with previous monitoring years with the Lardeau reach consistently having slightly higher rates (Polzin and Rood 2013).

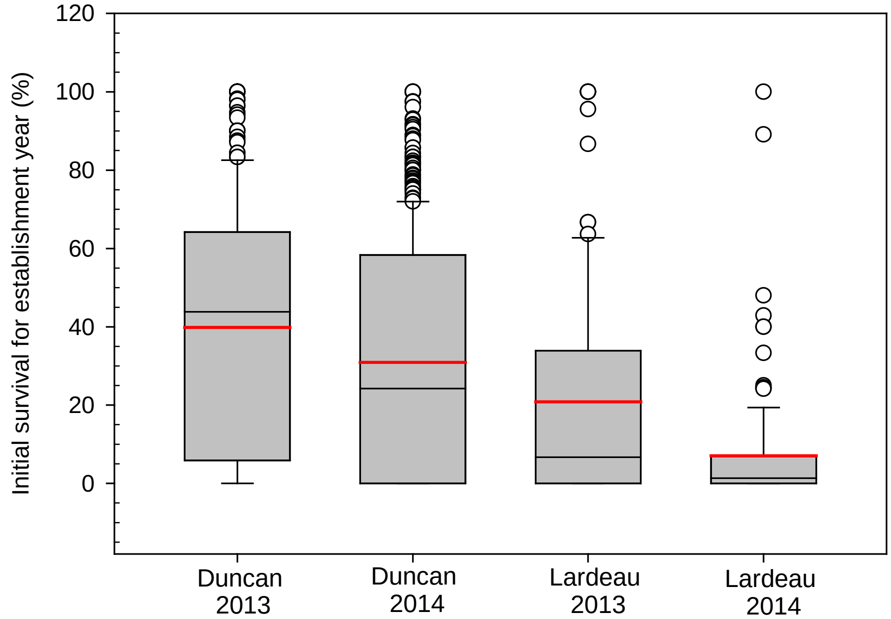


Figure 3-13: Survival percentages (for each quadrat) for 2013 and 2014 germinants for the Duncan and Lardeau reaches.

3.4.3 Duncan Segment 4, Erosion and deposition

Following the high waters of the late spring 2013 flood of Hamill and Cooper Creeks, extensive deposition and erosion was noted along the three transect lines for Duncan Segment 4. This segment monitors the effects of the tributaries on the adjacent Duncan River floodplain and was correlated to black cottonwood recruitment and riparian vegetation establishment.

Duncan Segment 4 (D4) transects 3, 5 and 10 (T3, T5 and T10 respectively) experienced erosion and deposition especially in the extension of the transect lines adjacent to Hamill Creek (T3 and T10). This effect is revealed with comparison to the spring 2013 profiles (Figure 3-14 and Appendix 1). Base stage levels at the time of the surveys were similar for both years (2013 – 0.32 m and 2014 – 0.25 m above base stage). Because of the influence of Hamill Creek, D4T3 and T10 had changes in elevation profiles due to 54.2 per cent erosion and 45.8 per cent from deposition. D4T5 was also influenced by Cooper Creek and experienced more change due to deposition (87.2 per cent) with limited erosion (12.8 per cent). D4T5 had greater amount of deposition near the POC compared to D4T3 and T10 (Figure 3-14) and less expansion of the point bar (2 m compared to 23 m for D4T10 and 32 m for D4T3) due to deposition beyond rivers edge.

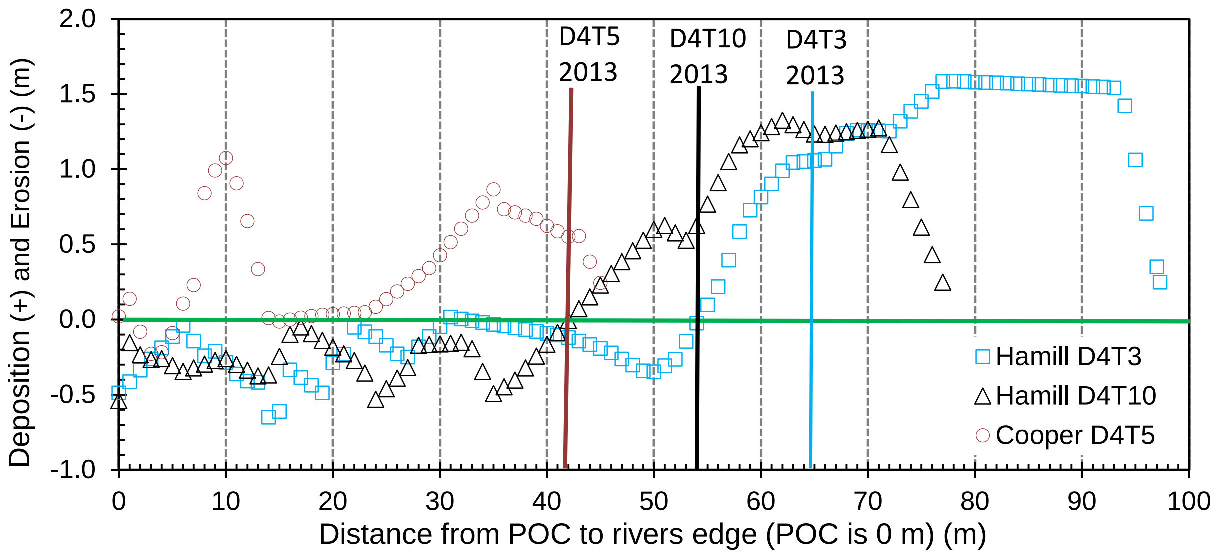


Figure 3-14: **Erosion and deposition along D4. The POC is at 0 m and vertical lines indicate rivers' edge when surveyed May 1, 2013.**

The theoretical slope was used in Figure 3-15 so the points would not be superimposed at the zero elevation and to illustrate the apparent deposition that may have occurred in this zone due to the extension of the point bar beyond the river's edge in the early spring of 2013. The Duncan River's edge level above base stage is marked for each transect line in Figure 3-15 at the time of the survey.

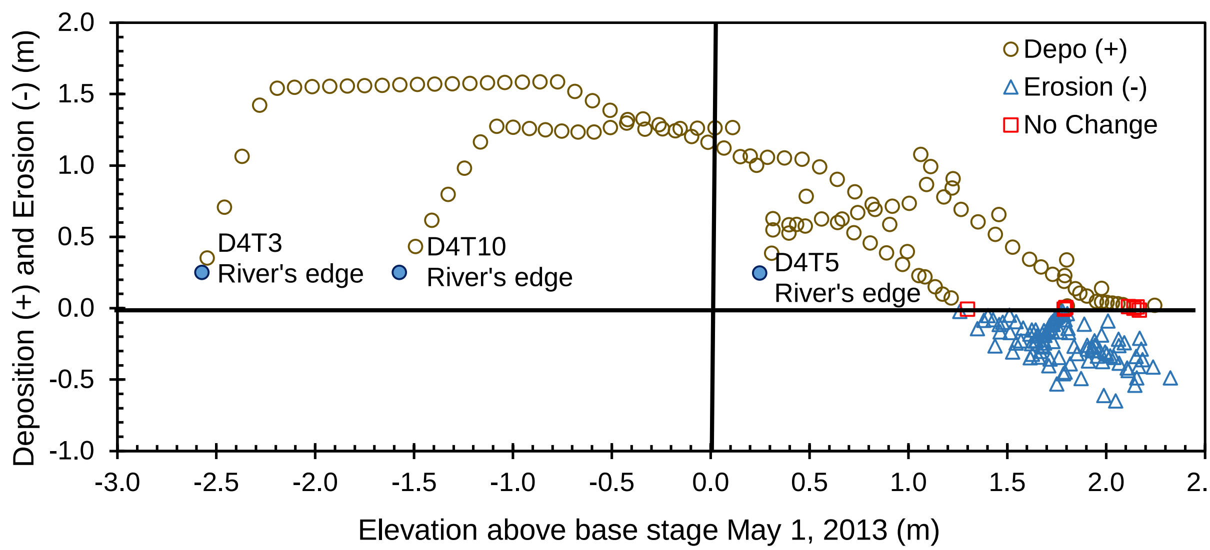


Figure 3-15: **Erosion and deposition along D 4 following spring freshet of Hamill and Cooper creeks. The red squares indicate 'no change'. The 0 m on X axis is rivers' edge April 2013.**

3.4.5 Seedling safe sites

Preliminary results show similar seedling safe zones for both rivers when all data for all segments were analyzed (Figure 3-16 and Figure 3-17). Lethal drought and/or drought stress did not occur along the Duncan reach but did to a small degree along the Lardeau reach for data up to 2013. The Duncan reach has only six year-olds (established in 2008) and no seedlings from 2010 or 2011 survived the inundation duration, scour, and deposition that occurred in 2012. There was no re-surveys of transect lines in 2010 to quantify what level of scour or deposition that the 2008 seedlings actually survived. However, riparian vegetation monitoring in 2012 confirmed the loss of some of the 2008 seedlings. The older black cottonwoods were not excavated to determine age, so the presence of young black cottonwoods in the same location might have included pre-2008 germinants during 2012 riparian monitoring surveys. These data show the elevation of the 2008 seedlings in 2009 but not the extent of erosion or deposition that they may have survived to be classified as recruited seedlings in 2010. Instead, the analyses represent only the amount of scour and deposition that occurred at those positions in 2012. Most of the 2008 seedlings counted and measured for height had some level of deposition since growth scars were observed below the ground surface level when some seedlings were excavated in 2009 and in subsequent years. Additionally, measuring scour and deposition that occurred at rebar stakes (measuring height of rebar from ground surface level) along transect lines and the embedded piezometer pipes (2013 and 2014) indicates that localized scour and deposition is occurring annually but at a reduced rate compared to 2012. Rebar measurements along the Duncan reach had 53 percent no change (<1 cm) and a range from 1 to 16.5 cm deposition and 1 to 5.1 cm erosion. The Lardeau had 45 percent no change with 1 to 6 cm deposition and 1 to 13.5 cm erosion. This suggests that slight deposition or scour had occurred from 2008 to 2010 similar to 2013 and 2014 results. We will derive more accurate analyses of the seedling safe zones if re-surveys occur in 2015 and 2017.

The Lardeau had seedlings survive from 2010 through to 2013 so there is a slightly more accurate picture of three year old seedlings surviving the levels of scour and deposition following the 2012 flood (< Q_{max10}) event. However, with only 2009 and 2012 elevation profiles it is not known at what elevations the 2008, 2010, and 2011 seedlings actually established or the amount of erosion and deposition they survived. The primary recruitment (colonization) safe zone for three year-olds is reduced in area if the older seedlings are removed from the data set (Figure 3-17). This reduces the area from 0.4 to 2.25 m for initial elevation to 0.9 to 1.75 m with the survival of 0.3 m deposition for three year-olds to 0.8 m of deposition survival by older seedlings.

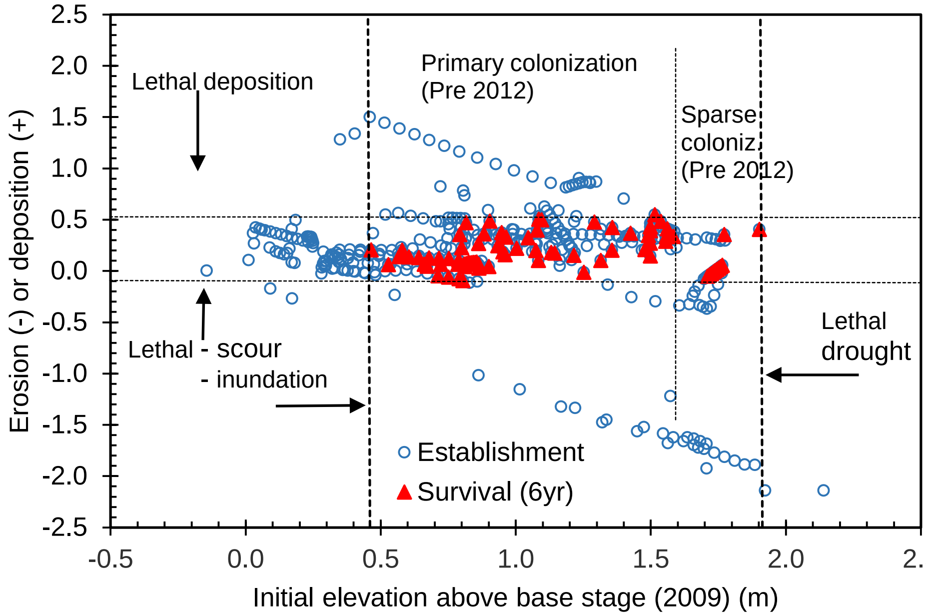


Figure 3-16: Seedling safe sites for the Duncan reach for seedling data from 2008 to 2013. Change in elevation (erosion and deposition) is for 2012.

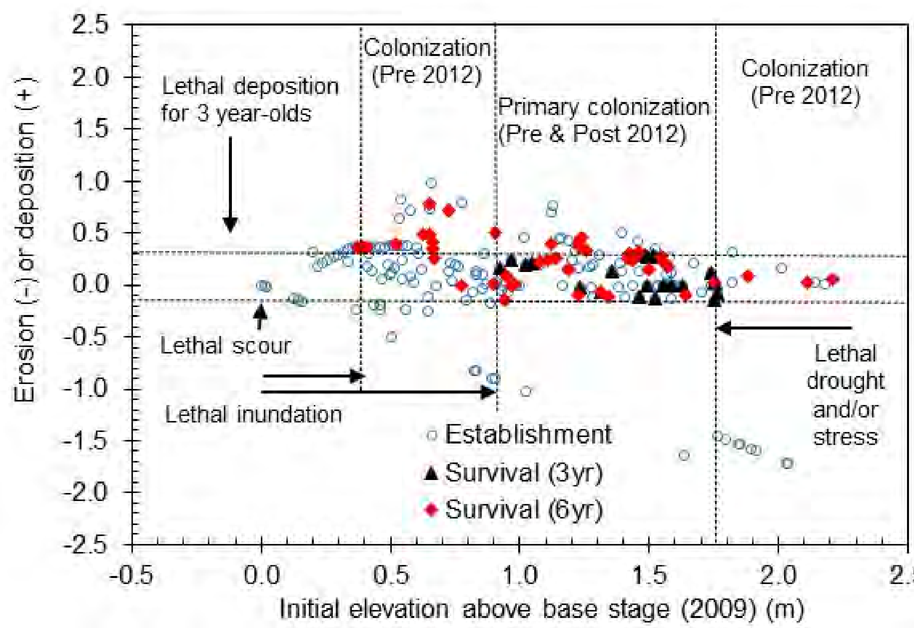


Figure 3-17: Seedling safe sites for the Lardeau reach for seedling data from 2008 to 2013. Change in elevation (erosion and deposition) is for 2012.

4 DISCUSSION

4.1 Black cottonwood Monitoring Summary 2014

This study is focussed on the long-term investigation of black cottonwood recruitment trends in response to Alt S73, and this report summarizes the 2014 results and compares these with previous year's patterns. A hydrogeomorphic approach was applied for the study design, and these results analyzed from 2014 field analyses show how black cottonwood recruitment is affected by water availability (rain and river stage), elevation, and sediment scour and deposition that occurs within recruitment zones. Seed release abundance and initial establishment densities can affect the abundance level of seedling recruitment as well.

Widespread and readily observable seed dispersal events in 2014 occurred from mid-June through July. The level of seed abundance was 'Low' with the first event slightly higher, with 'Moderately Low' abundance. Despite the low levels, 2014 had more quadrats with germinants as compared to the other study years (for the Duncan and only 2010 had more quadrats for the Lardeau) but with lower densities within quadrats at many locations. Through 2014, there was a wider seed dispersal pattern along the Duncan and the Lardeau reaches. This may have been due to the low precipitation during the 2014 growing season allowing black cottonwood seed to disperse more readily in the dryer conditions. An additional factor, mainly for the Duncan but also for the Lardeau and especially for Lardeau Segments 2 and 3 (L2, L3), was the extended flooding period along the Duncan in 2012 and the >Q_{max5} peak flow along the Lardeau. The higher discharges resulted in an increase in deposition (2012) which contributed to the increased area of suitable recruitment zones than were available in 2010. The 2012 freshet also deposited fine substrates on top of existing recruitment zones and helped to build-up areas that were too low for recruitment in the past. The higher depositional levels (elevations) at some bars previously considered marginal resulted in increased recruitment rates in 2013 and 2014 within segments for the Duncan reach (Figure 3-11) and within Segments 2 and 3 along the Lardeau reach (Figure 3-12). Suitable black cottonwood recruitment zones are barren, open, and often associated with newly deposited sediments of fine to moderate texture at 'seedling safe' elevations (Mahoney and Rood 1998, Scott et al. 1997, Karrenberg et al. 2002, Polzin and Rood 2006).

In previous years, we speculated that the first warm days following rainy periods were the most likely days for seed dispersal events to occur. However, some of the results in 2013 did not fully support this hypothesis and during 2014 there was less correlation to large rain events of the previous days. These results may indicate that precipitation and high humidity influence seed dispersal during most years and may be contributing factors for August seed releases in the past. Conversely, during a dry, warm summer weather, seed release may not follow this pattern and no August seed release occurred. The results of the black cottonwood phenology observed in 2014 are more similar to seed phenology events in 2009 and possibly, other years since 2002 (B. Herbison unpubl. data).

The dry summer of 2014 also indicated the level of seedling survival of the first growing season success may be substantially influenced by precipitation as observed along the free-flowing Lardeau River. It was also a factor on the flow-controlled Duncan River but the low precipitation level was apparently offset by the artificially higher river stage during the summer. Discharge for the Duncan reach was near or above 200 m^3/s for May through September, which was higher than previous study years and without the higher peak in July that occurred in 2013. This resulted in only higher elevation recruitment zones available for colonization. Groundwater levels are equivalent to the river stage levels along point and mid-channel bars and high terraces adjacent to the river (Polzin et al. 2010 and 2011 and Polzin and Rood 2014). The Duncan River stage was sufficient to support a higher survival rate for the 2014 seedlings along the Duncan reach (30.9 percent) compared to the Lardeau study reach (7.0 percent). The higher stage of flow along the Duncan reach since May also restricted establishment of germinants within the active channel zone as recorded in 2009 and 2010. There was a drop in survival for Duncan germinates in 2014 (30.9 percent) compared to 2013 (39.9 percent) probably due to the reduced precipitation; however, differences were not as large as those recorded along the Lardeau reach. The average first season survival rates (2009 to 2013) for Duncan reach was 25.0 percent.

The Lardeau River did not experience a Q_{max2} or greater flood event in 2014. The peak occurred June 25, 2014 (243 m^3/s max instantaneous discharge) with a steady decline in discharge towards base flow to August when the mean monthly discharge fell below previous sampling years. The river stage was not high enough to offset the decrease in precipitation during the growing season in 2014 resulting in a significantly ($P<0.001$) lower survival rate of 2014 seedlings. The average first season survival for the Lardeau River was 23.6 percent from 2009 to 2013 whereas the average survival for 2014 was 7.0 percent.

Observations during monitoring surveys noted that along the Lardeau reach, more 2014 seedlings were already orange or red or had already dropped their leaves during July 31 field visit compared to seedlings along the Duncan reach. The fall field monitoring also showed signs of lethal drought as well as drought stress with some seedlings surviving but only slightly increasing in height since the summer sampling along both reaches. The higher mortality noted during the late July monitoring contributed to the reduced germinant densities along the Lardeau River.

For 2014, the Duncan had the highest number of quadrats with seedlings, with 540. Seedling densities were lower than 2009 and 2010 but higher than 2012 and 2013. The largest contrast occurred when comparing 2014 to 2009, which had only 73 quadrats but had the highest seedling density for the study period of ~ 138,000 (2014 – ~ 22,600). The 2014 densities were generally consistent with other past years, considering the substantial natural variation and excluding 2009 which appeared to be unusually high and 2012, when seedling colonization was greatly reduced (12 quadrats with a total of 122 seedlings along the Duncan reach) because of the extreme flood event (Figure 3-10 for 2012 to 2014 comparison). The increase in the number of quadrats may have been due to the increased recruitment area for black cottonwood establishment following the 2012 flood that created barren recruitment areas at higher elevations than were available in 2009 and 2010. An additional factor was that the stage was lower in 2009 and 2010 during seed release and the growing season, which resulted in large numbers of seedlings establishing within the active channel where they were scoured or inundated.

4.2 Black cottonwood Recruitment

Similar to other cottonwoods, black cottonwoods are prolific seed producers, but seed viability declines sharply over a few weeks (Karrenberg et al. 2002). Previous project observations of the abundant seedling establishment were consistent with this. The 2014 season was no exception, with high initial establishment of germinants. Recruitment by the older 2012 germinants was consistent with previous monitoring although the 2014 results revealed slightly higher survival of the remaining 2012 seedlings, along both river reaches. Because of the extended flooding period in 2012, the only available recruitment zones in that summer were at the higher elevations, especially along the Duncan reach. The few that survived to the spring of 2014 were in these higher 'seedling safe zones' and because of the higher summer river and groundwater levels experienced along the Duncan reach in 2013 and 2014 there was 82.4 percent survival into the third growing season. The Lardeau reach recruitment was also above-average with 86.1 percent survival in the third growing season. The older 2012 seedlings would have had deeper and more extensive root systems by the third year and this would help to reduce the effect of the dry summer that desiccated so many of the 2014 germinants. The descending limb of the Lardeau River hydrograph for the mean monthly discharge shows that discharge was higher for June and July and leveled off to 2013 level by August 11 before dipping to lower discharge rates (Figure 3-8 and 3-9). This meant that there was available groundwater levels for the deeper rooted 2012 seedlings which helped to reduce the desiccation of the older seedlings, resulting in an average survival rate for the 2012-originated seedlings even during the dry, 2014 summer.

Some 2008 cottonwood recruits survived the 2012 extreme flood event and contribute to the recruitment on the seedling safe site graph for the Duncan River (Figure 3-16). Other 2008 successful recruits did not survive the extreme deposition that occurred along sections of some of the transect lines and were absent in 2014, even though they were classified as recruited in 2010. They apparently did not survive the amount of scour or deposition that occurred at their positions. One example was D6T36 where the mean deposition was 0.48 m with a range of 0.41 to 0.53 m. This occurred in 2012 along the section of the transect line where willows and black cottonwoods can be seen in the 2009 photo (Figure 4-1 A and B). Figure 4-1 D is taken in the same direction (looking up line) as B with field workers providing height reference for the willows. This section of the transect line had successful 2008 recruitment as well as 2009 and 2010 seedlings in 2010. In 2012 no black cottonwoods were recorded along the transect line but sometimes older buried stems, branches, and roots will send up clonal suckers in a year or two following the flood. Along the Yellowstone River, shoots from buried material emerged two years after two back-to-back Q_{max100} events occurred (Polzin 2006). However, this was not observed along transect D6T36. Willow was more abundant in 2009 at this location and it survived and increased in height substantially after the 2012 flood event, with an average height of 1.8 m in 2014 (Figure 4-1 C and D). Willow competition may have contributed to the loss of the black cottonwood recruitment and even if seedlings had survived the deposition, the shading from the willows would have hindered their growth (Braatne et al. 1996). There were 2013 and 2014 seedlings (low densities) within the willow patch in the photo.

To quantify the hydrogeomorphic conditions that define the seedling safe sites and the successful elevation zone for black cottonwood recruitment along the Duncan, elevation surveys should be completed at least every 3 years. This will reveal the extent of deposition and scour that young seedlings are able to survive. This will also allow for average scour and deposition rates to be calculated for the Alt S73 new flow regime since the extreme 2012 flood event effectively reset the riparian recruitment zones along the lower Duncan River. The next survey in 2015 will thus contribute important information for the seedling recruitment modeling.

Figure 4-1: Photographs showing a section along D6T36 in 2009 (A) and (B). The same section in 2014 (C) and (D).

5 CONCLUSIONS

Year 5 data collection for the 10-year monitoring program, DDMMON#8-1, occurred from April to October, 2014. The purpose of the Year 5 study is to investigate the effects of the implementation of Alt S73 flow regime on black cottonwood establishment and recruitment with respect to the following attributes:

- the extent of black cottonwood seedling establishment;
- the extent of black cottonwood seedling survival and recruitment; and
- to resurvey D4 transect lines following 2013 flood events of Hamill and Cooper creeks to record initial elevation profiles for the 2013 seedling establishment and recruitment elevation since 2012 (early 2013 spring surveys).

The results in this report document black cottonwood establishment and recruitment since 2012 along the lower Duncan River and along the reference reach, the Lardeau River.

Establishment densities for 2014 seedlings were average along the Duncan and slightly below average for the Lardeau reaches. First season survival was average for the Duncan and significantly lower along the Lardeau reach. Recruitment survival of the third growing season was slightly above average for both reaches.

The relationship between abiotic influences and the biological responses by black cottonwood seedling indicated some key factors that affect black cottonwood establishment and survival along the lower Duncan River during this monitoring period.

1. Long inundation periods prevented seedling establishment at lower elevations. This focused establishment to higher elevation.
2. Seedling establishment elevation is a factor that determines the extent affected by inundation. Additionally, for seedlings established on higher recruitment zones, the probability of burial by deposition is reduced and this is also coordinated with river stage patterns.
3. Water availability for seedlings was probably very important during the dry summer of 2014 – this was somewhat unusual for a normally humid reach. High mortality especially occurred along the reference reach suggesting that the artificially high river stage and groundwater level during the growing season along the Duncan reach probably moderated the influence from the drought.
4. This year the tributary influences on the adjacent floodplains did not impact seedling establishment or 2013 seedlings. Recruitment survival for the Duncan segment 4 was impacted by the erosion and deposition that occurred in 2013 which buried the 2012 seedlings resulting in zero recruitment of 2012 seedlings in D4 in 2014.

The Year 5 study components were otherwise consistent with the patterns observed in previous monitoring years. This consistency of early black cottonwood seedling establishment and recruitment distributions supports a deterministic pattern, whereby establishment and survival follow from particular physical conditions and timing.

6 RECOMMENDATIONS

6.1 Transect Line Resurveying

We recommend resurveys of all transect lines in 2015 to assess the changes to transect profiles through sediment deposition and erosion that has occurred since 2012. Resurveys of the recruitment zone is needed as this is the zone of interest for calculating seedling safe zones and the amount of deposition/erosion occurring in the recruitment zone affecting survival. This will update partial information on the transect line elevations and will contribute stage/discharge specific data for these lines as well as the profiles for seedling establishment elevations, thus contributing further to the foundational data needed for the longer term study objectives. It will also be required to derive relationships in the conceptual models for predicting the long-term response of black cottonwood recruitment to a variety of flow regimes.

7 CLOSURE

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

Vast Resource Solutions Inc.,

Prepared by:

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

Stewart Rood, PhD
Professor and Board of Governors’ Research Chair in Environmental Science,

Brenda Herbison, MSc, RPBio

Reviewed by:

Ian Adams, MSc, RPBio
Senior Wildlife Biologist

8 REFERENCES

British Columbia Hydro and Power Authority. (TOR) 2009. Contract Number Q9-9070, Advertisement for Request for Proposals for projects DDMMON#8-1 and 8-2, Duncan Watershed Riparian Monitoring Program. pp. 94.

Braatne J.H., S.B. Rood, and P.E. Heilman. 1996. Life history, ecology and conservation of riparian cottonwoods in North America, Biology of *Populus* and its implications for management and conservation, R.F Stettler, H.D. Bradshaw, Jr., P.E. Heilman, and T.M. Hinckley (eds). NRC Research Press, National Research Council of Canada, Ottawa, On, Canada. Pp. 57-85.

Braatne, J.H., S.B. Rood, L.A. Goater, and C.L. Blair. 2008. Analyzing the impacts of dams on riparian ecosystems: a review of research strategies and their relevance to the Snake River through Hells Canyon. *Environmental Management* **41**: 267-281.

Debano, L.F. and L.J. Schmidt. 1990. Potential for enhancing riparian habitat in the southwestern United States with watershed practices, *Forest Ecology and Management*, **33**: 385-403.

Dunne, T. 1988. Geomorphological contributions to flood-control planning, *Flood Geomorphology*, V.R. Baler, R.C. Kochel, and P.C. Patton, (eds). John Wiley & Sons, New York. Pp. 421-437.

Government of Canada, Environment Canada, Pacific and Yukon Region, Environment Canada, Hydrometric Archive for British Columbia and Yukon, 2010. Vancouver, British Columbia, Canada Government of Canada, Environment Canada. Data set accessed 2012- multiple times during the year at http://www.wateroffice.ec.gc.ca/index_e.html.

Karrenberg, S., P.J. Edwards, and J. Kollman. 2002. The life history of *Salicaceae* living in the active zone of floodplains. *Freshwater Biology* **47**: 733-748.

Leopold L. B., and M. G. Wolman. 1957. River channel patterns: Braided, meandering, and straight. *US Geological Survey Professional Paper* **282-B**: 39-85.

Mahoney, J.M. and S.B. Rood. 1998. Stream flow requirements for cottonwood seedling recruitment – an integrative model. *Wetlands* **18**: 634-645.

Merritt, D.M. and D.J. Cooper. 2000. Riparian vegetation and channel change in response to river regulation: a comparative study of regulated and unregulated streams in the Green River Basin, USA. *Regulated Rivers: Research and Management* **16**: 543-564.

Miles, M. and Associates. 2002. Channel stability assessment, Lower Duncan River. Report for project 0207 prepared for BC Hydro and Power Authority, Castlegar

Naiman R.J., H. Decamps, and M.E. McClain. 2005. *Riparia: Ecology, Conservation and Management of Streamside Communities.* Elsevier Academic Press: San Diego. pp. 430.

Polzin, M.L. 1998. *River and Riparian Dynamics and Black Cottonwoods in the Kootenay River Basin, British Columbia and Montana.* M.Sc. thesis, University of Lethbridge, Alberta, pp. 224.

Polzin M.L. and S.B. Rood. 2000. Effects of damming and flow stabilization on riparian processes and black cottonwoods along the Kootenay River. *Rivers* **7**:221-232.

Polzin M.L. and S.B. Rood. 2006. Effective disturbance: seedling safe sites and patch recruitment of riparian cottonwoods after a major flood of a mountain river. *Wetlands* **26**:4:965-980.

Polzin, M.L. 2006. *Temporal and spatial patterns of Populus angustifolia along the upper Yellowstone River and clonal recruitment: Extent and requirements.* Ph.D. thesis, University of Montana. pp. 125.

Polzin, M.L., B. Herbison, K.M, Gill[2], and S.B. Rood[2]. 2010. DDMMON #8-1 Lower Duncan River Riparian Cottonwood Monitoring Program. Year 1 Annual Report – 2009, Interior Reforestation Co. Ltd., and [2]University of Lethbridge, Alberta, Unpublished report by Interior Reforestation Co. Ltd., Cranbrook, B.C., for BC Hydro Generations, Water License Requirements, Castlegar, B.C. 110 pp + appendices.

Polzin, M.L., S.B. Rood[2], and B. Herbison. 2011. DDMMON #8-1 Lower Duncan River Riparian Cottonwood Monitoring Program. Year 2 Annual Report – 2010, Interior Reforestation Co. Ltd., and [2]University of Lethbridge, Alberta, Report by Interior Reforestation Co. Ltd., Cranbrook, B.C., for BC Hydro Generations, Water License Requirements, Castlegar, B.C. 74 pp + appendices.

Polzin, M.L., and S.B. Rood. 2013. DDMMON #8-1 Lower Duncan River Riparian Cottonwood Monitoring Program. Year 3 Annual Report – 2012. Vast Resource Solutions and University of Lethbridge, Alberta. Unpublished report by Vast Resource Solutions, Cranbrook, B.C., for BC Hydro Generations, Water License Requirements, Castlegar, B.C. 76 pp. + appendices.

Polzin, M.L., and S.B. Rood. 2014. DDMMON #8-1 Lower Duncan River Riparian Cottonwood Monitoring Program. Year 4 Annual Report – 2013. Vast Resource Solutions and University of Lethbridge, Alberta. Unpublished report by Vast Resource Solutions, Cranbrook, B.C., for BC Hydro Generations, Water License Requirements, Castlegar, B.C. 53 pp. + appendices.

Rood, S.B. and J.M. Mahoney. 1990. Collapse of riparian poplar forests downstream from dams in western prairies: probable causes and prospects for mitigation. *Environmental Management* **14**: 451-464.

Rood, S.B., and J.M. Mahoney, 1995. Collapse of riparian poplar forests downstream from dams in western prairies: Probable causes and prospects for mitigation, *Environmental Management*, **14:** 451-464.

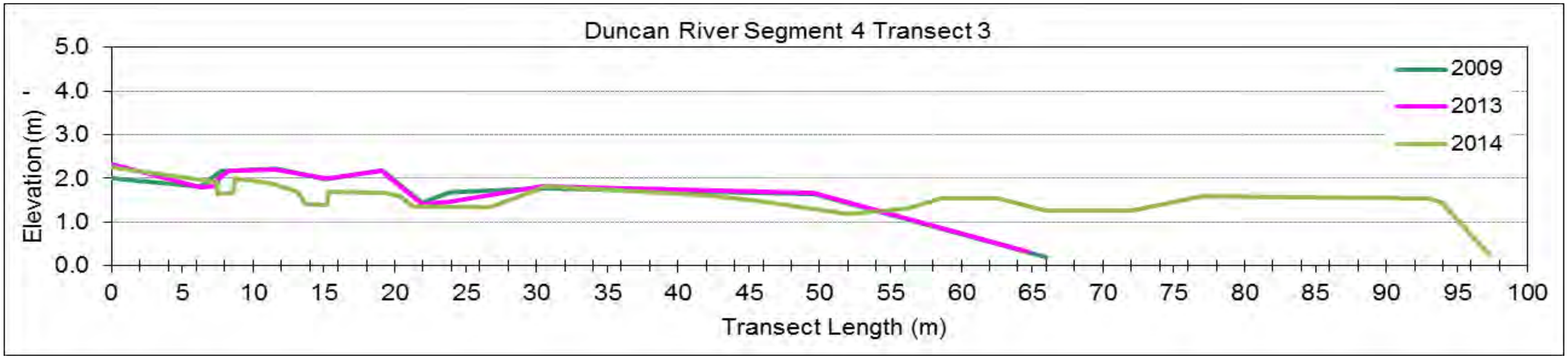
Rood S.B., K.J. Berg, and D.W. Pearce. 2007. Localized temperature adaptation of cottonwoods from elevational ecoregions in the Rocky Mountains. *Trees* **21**: 171-180.

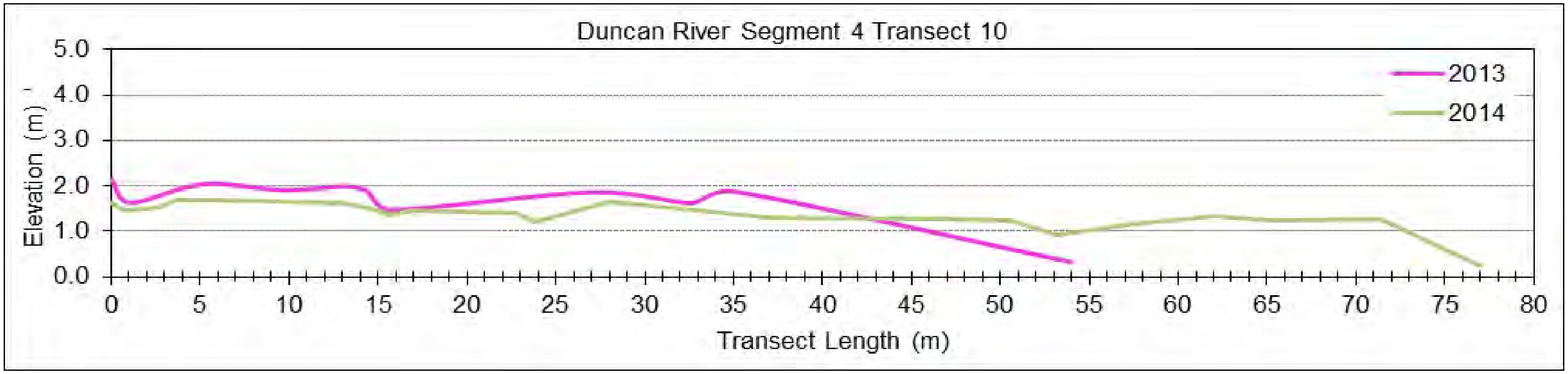
Scott M.L., G.T. Auble, and J.M. Freidman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. *Ecological Applications* **7**: 677-690.

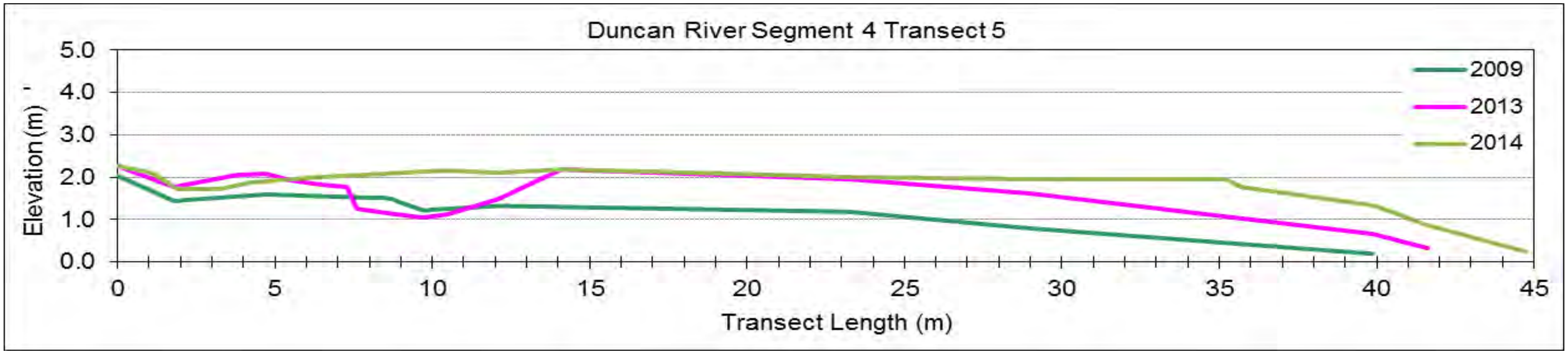
Schulmm, Stanley. 1981. Evolution and response of the fluvial system, sedimentologic implications. *The Society of Economic Paleontologists and Mineralogists Special Publication* **31**: 19-29.

Williams G.P., and M.G. Wolman. 1984. Downstream effects of dams on alluvial rivers, Geological Survey Professional Paper 1286, United States Government Printing Office, Washington, PP-83

Appendix 1: Transect profiles for the Lower Duncan Reach 4 2009, 2013, and 2014


Duncan River Segment 4 Transect 3
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Transect Length (m)
2009
2013
2014


Duncan River Segment 4 Transect 10
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Transect Length (m)
2013
2014


Duncan River Segment 4 Transect 5
Elevation (m)
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
45
Transect Length (m)
2009
2013
2014

Appendix 2:Lower Duncan and Lardeau Rivers Photo Documentation

Date: April, 2014			**Environmental Crew:** Mary Louise and Aden Stewart
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
28-Apr	DSCN0558	13:29	**D4T3** at 30 m looking at POC
28-Apr	DSCN0559	13:33	at 30 m looking at EOT
28-Apr	DSCN0560	13:33	at 46 m looking at POC
28-Apr	DSCN0561	13:33	at 46 m looking at EOT
28-Apr	DSCN0562	14:28	at EOT looking at POC
28-Apr	DSCN0563	14:28	at 94 m (top of bank) looking at EOT
28-Apr	DSCN0564	15:20	**D4T10** at EOT looking at POC
28-Apr	DSCN0565	15:20	at 74 m looking at EOT
28-Apr	DSCN0566	15:21	at 50 m looking at POC
28-Apr	DSCN0567	15:22	at 50 m looking at EOT
28-Apr	DSCN0568	15:22	at 29 m looking at POC
28-Apr	DSCN0569	15:23	at 29 m looking at EOT
28-Apr	DSCN0570	15:30	Upstream of **D4T3** looking at scour channel across meander lobe. perpendicular to both Transect lines.
28-Apr	DSCN0571	19:27	Trees taken down by beavers ~ 60 to 90 m upstream of **D3T11** and ~ 30 to 50 m to side channel (dry at this time of the year) but parallels Duncan R.
28-Apr	DSCN0572	19:27	
28-Apr	DSCN0573	19:28	
28-Apr	DSCN0574	19:28	
29-Apr	DSCN0575	9:27	**D4T5** at EOT looking at POC
29-Apr	DSCN0576	9:28	at 40 m looking at EOT
29-Apr	DSCN0577	9:31	at 20.3 m looking at POC (at rebar)
29-Apr	DSCN0578	9:31	at 20.3 m looking at EOT (at rebar)
29-Apr	DSCN0579	9:34	at 6 m looking at POC
29-Apr	DSCN0580	9:34	at 6 m looking at EOT
29-Apr	DSCN0581	9:34	at 6 m looking downstream towards Cooper Creek
29-Apr	DSCN0582	9:35	at 6 m looking upstream
29-Apr	DSCN0583	9:38	Downstream of D4T5 looking at Cooper Creek
29-Apr	DSCN0584	9:38	Same spot looking upstream at D4T5
29-Apr	DSCN0585	9:48	Large cottonwood (114.5 cm DBH) upstream of D4T5 and downstream of 2nd benchmark.
29-Apr	DSCN0586	9:48	Same as above - Tree is ~ 3 m from top of bank - bank is ~ 2.1 m high

Date: July, 2014			**Environmental Crew:** Mary Louise, Aden, Ben, Brenda
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
28-Jul	DSCN1209	14:16	**D3T10** at EOT looking across river
28-Jul	DSCN1210	14:17	at EOT looking up line (POC)
28-Jul	DSCN1211	14:20	at 51 m (rebar) looking down line
28-Jul	DSCN1212	14:20	at 51 m (rebar) looking up line
28-Jul	DSCN1213	14:21	at 51 m (rebar) looking upstream
28-Jul	DSCN1214	14:21	at 51 m (rebar) looking downstream
28-Jul	DSCN1215	14:23	at 25 m looking down line
28-Jul	DSCN1216	14:28	at 25 m looking up line
28-Jul	DSCN1217	14:29	at POC looking down line (EOT)
28-Jul	DSCN1218	14:53	**D3T11** at POC looking down line
28-Jul	DSCN1219	14:55	looking up line with dry back channel in foreground
28-Jul	DSCN1220	15:35	flood trained cottonwoods established before 2008 on mid-channel bar
28-Jul	DSCN1221	15:35	at 57 m (rebar) looking down line (mid-channel bar plant heights)
28-Jul	DSCN1222	15:23	at 57 m (rebar) looking up line at back channel between POC and mid-channel bar
28-Jul	DSCN1223	15:43	at 69 m looking down line on mid-channel bar
28-Jul	DSCN1224	15:44	at 77 m looking down line on mid-channel bar
28-Jul	DSCN1225	15:44	at 77 m looking up line on mid-channel bar
28-Jul	DSCN1226	15:44	at 91 m (rebar) looking down line on mid-channel bar
28-Jul	DSCN1227	15:44	at 91 m (rebar) looking up line on mid-channel bar
29-Jul	DSCN1229	8:28	at 74 m looking down line showing tree/shrub heights on mid-channel bar
29-Jul	DSCN1230	9:10	at 100 m looking down line
29-Jul	DSCN1231	9:16	at 120 m looking down line at EOT and across Duncan River
29-Jul	DSCN1232	9:31	at 141 m looking down line
29-Jul	DSCN1233	9:19	at 141 m looking up line
29-Jul	DSCN1234	9:20	at 141 m looking upstream
29-Jul	DSCN1235	9:34	at 141 m looking downstream
29-Jul	DSCN1236	10:07	**D3T29** at 13 m (rebar) looking down line
29-Jul	DSCN1237	10:08	at 13 m looking up line at POC
29-Jul	DSCN1238	10:09	at 13 m looking upstream
29-Jul	DSCN1239	10:09	at 13 m looking downstream
29-Jul	DSCN1240	10:11	at 1 m looking upstream
29-Jul	DSCN1241	10:13	at POC looking down line
29-Jul	DSCN1242	10:16	at 26 m (rebar) looking down line
29-Jul	DSCN1243	10:17	at 26 m (rebar) looking up line
29-Jul	DSCN1244	10:17	at 26 m looking downstream
29-Jul	DSCN1245	10:18	at 26 m looking upstream
29-Jul	DSCN1246	10:20	at 57 m looking down line at EOT and side channel between islands
29-Jul	DSCN1247	10:20	at 57 m looking up line
29-Jul	DSCN1248	10:21	at 57 m looking downstream
29-Jul	DSCN1249	10:21	at 57 m looking upstream

Date	Image #	Time	Description
29-Jul	DSCN1250	10:28	**D3T35** at POC looking down line
29-Jul	DSCN1251	10:28	at POC looking up line
29-Jul	DSCN1252	10:30	at 10.5 m (rebar) looking down line
29-Jul	DSCN1253	10:30	at 10.5 m (rebar) looking up line
29-Jul	DSCN1254	10:31	at 10.5 m (rebar) looking downstream
29-Jul	DSCN1255	10:32	at 10.5 m (rebar) looking upstream
29-Jul	DSCN1256	10:34	at 44 m looking across side channel
29-Jul	DSCN1257	10:34	at 44 m looking up line
29-Jul	DSCN1258	10:35	at 44 m looking upstream
29-Jul	DSCN1259	10:35	at 44 m looking downstream
29-Jul	DSCN1260	11:05	at 8 m looking up line at POC (willows) with Ben for height reference
29-Jul	DSCN1261	11:28	**D3T29 & T35** behind POC's looking at main Duncan R. at river's edge
29-Jul	DSCN1262	11:29	close up of cottonwood & willow seedlings in photo 1261
29-Jul	DSCN1263	12:04	**D3T20** at 27 m looking up line
29-Jul	DSCN1264	12:05	at 29 m looking down line
29-Jul	DSCN1265	12:06	at 25 m looking upstream at back-channel through transect line
29-Jul	DSCN1266	12:06	at 25 m looking downstream (for main channel) at transect line
29-Jul	DSCN1267	12:08	at 37 m looking up line
29-Jul	DSCN1268	12:08	at 37 m looking down line at EOT 2nd main channel of Duncan R.
29-Jul	DSCN1269	12:08	at 37 m looking upstream
29-Jul	DSCN1270	12:08	at 37 m looking downstream - counting seedlings
29-Jul	DSCN1271	12:14	at 33.5 m (rebar) looking up line with back channel through line
29-Jul	DSCN1272	12:15	at 33.5 m looking down line - counting seedlings
29-Jul	DSCN1273	12:15	at 33.5 m looking upstream
29-Jul	DSCN1274	12:15	at 33.5 m looking downstream
29-Jul	DSCN1275	13:29	**D3T23** at 8 m looking up line towards POC
29-Jul	DSCN1276	13:29	at 8 m looking down line
29-Jul	DSCN1277	13:32	at 21 m looking down line at EOT
29-Jul	DSCN1278	13:32	at 21 m looking across river
29-Jul	DSCN1279	13:34	at 21 m looking up line
29-Jul	DSCN1280	13:34	at 21 m looking upstream
29-Jul	DSCN1281	13:34	at 21 m looking downstream
29-Jul	DSCN1282	14:00	**D3T45** at 27 m (rebar) looking down line
29-Jul	DSCN1283	14:00	at 27 m looking up line
29-Jul	DSCN1284	14:00	at 27 m looking upstream
29-Jul	DSCN1285	14:00	at 27 m looking downstream
29-Jul	DSCN1286	14:03	at EOT looking across river
29-Jul	DSCN1287	14:03	at EOT looking up line
29-Jul	DSCN1288	14:04	at EOT looking upstream
29-Jul	DSCN1289	14:04	at EOT looking downstream
29-Jul	DSCN1290	14:08	at 4 m (rebar) looking down line
29-Jul	DSCN1291	14:08	at 4 m looking up line
29-Jul	DSCN1292	14:19	**D3T40** at POC looking down line
29-Jul	DSCN1293	14:19	at POC looking up line
29-Jul	DSCN1294	14:21	at 21 m looking at EOT (dry when measured water came up) looking across river

Date	Image #	Time	Description
29-Jul	DSCN1295	14:21	**D3T40** at 21 m looking up line
29-Jul	DSCN1296	14:21	at 21 m looking upstream
29-Jul	DSCN1297	14:21	at 21 m looking downstream
29-Jul	DSCN1298	14:34	at 18 m (rebar) looking down line at EOT
29-Jul	DSCN1299	14:34	at 18 m looking up line
29-Jul	DSCN1300	14:34	at 18 m looking upstream
29-Jul	DSCN1301	14:34	at 18 m looking downstream
29-Jul	DSCN1302	15:10	**D4T3** at 7 m looking down line
29-Jul	DSCN1303	15:10	at 7 m looking up line
29-Jul	DSCN1304	15:13	at 11 m (rebar) looking down line
29-Jul	DSCN1305	15:13	at 11 m looking up line
29-Jul	DSCN1306	15:15	at 19 m (rebar) looking down line
29-Jul	DSCN1307	15:15	at 19 m looking up line
29-Jul	DSCN1308	15:18	at 31 m looking down line
29-Jul	DSCN1309	15:18	at 31 m looking up line
29-Jul	DSCN1310	15:18	at 31 m looking upstream
29-Jul	DSCN1311	15:18	at 31 m looking downstream
29-Jul	DSCN1312	15:21	at 80 m looking down line at EOT & across river
29-Jul	DSCN1313	15:21	at 80 m looking up line
29-Jul	DSCN1314	15:21	at 80 m looking upstream
29-Jul	DSCN1315	15:21	at 80 m looking downstream
29-Jul	DSCN1316	15:32	**D4T10** at 6 m (rebar) looking down line
29-Jul	DSCN1317	15:32	at 6 m looking up line
29-Jul	DSCN1318	15:34	at 13 m (rebar) looking down line
29-Jul	DSCN1319	15:34	at 13 m looking up line
29-Jul	DSCN1320	15:38	at 57 m looking down line at EOT
29-Jul	DSCN1321	15:38	at 57 m looking up line
29-Jul	DSCN1322	15:38	at 57 m looking upstream
29-Jul	DSCN1323	15:38	at 57 m looking downstream
29-Jul	DSCN1324	15:55	**D4T3 -** upstream of transect line **-** seedling patches ~ 40 m on line
29-Jul	DSCN1327	15:56	close up of seedlings
29-Jul	DSCN1328	15:57	same
29-Jul	DSCN1329	15:57	same
29-Jul	DSCN1330	15:57	a different patch of seedlings in same area
29-Jul	DSCN1331	15:58	close up of seedlings
29-Jul	DSCN1332	15:58	band of seedlings
29-Jul	DSCN1333	15:58	close up of seedlings
29-Jul	DSCN1334	15:58	close up of seedlings
29-Jul	DSCN1335	15:59	close up of seedling patch on silt/sand
29-Jul	DSCN1336	16:01	seedlings on course gravel
29-Jul	DSCN1337	16:02	close up of 2012 seedlings
29-Jul	DSCN1338	16:02	same
29-Jul	DSCN1339	16:02	same
29-Jul	DSCN1340	16:02	2013 seedlings
29-Jul	DSCN1341	16:03	2013 & 2014 seedlings
29-Jul	DSCN1342	16:03	same - close up

Date	Image #	Time	Description
29-Jul	DSCN1343	16:05	**D4T10 -** upstream of transect line **-** seedlings on meander lobe
29-Jul	DSCN1344	16:05	willow & cottonwood seedlings
29-Jul	DSCN1345	16:05	seedlings on meander lobe
29-Jul	DSCN1346	16:05	area downstream of transect line
29-Jul	DSCN1347	16:06	willow seedlings
29-Jul	DSCN1348	16:07	willow & cottonwood seedlings
29-Jul	DSCN1349	16:07	same
29-Jul	DSCN1350	16:07	same
29-Jul	DSCN1351	16:07	same
29-Jul	DSCN1352	16:07	same
29-Jul	DSCN1353	16:07	same
29-Jul	DSCN1354	16:07	same
29-Jul	DSCN1355	16:08	same
29-Jul	DSCN1356	17:11	**D4T5** downstream of line looking upstream at 10 m on line
29-Jul	DSCN1357	17:12	standing in same place as photo 1356 - rolling up tape measure
29-Jul	DSCN1358	17:12	same place - looking at edge of Cooper Cr. & Duncan R.
29-Jul	DSCN1359	17:13	same place - looking across Cooper Cr.
29-Jul	DSCN1360	17:13	same place - looking upstream of Cooper Cr.
30-Jul	DSCN1361	7:52	**D5T2** at POC looking down line
30-Jul	DSCN1362	7:54	at 4 m (rebar) looking down line
30-Jul	DSCN1363	7:54	at 4 m looking up line at POC
30-Jul	DSCN1364	7:54	at 4 m looking upstream
30-Jul	DSCN1365	7:54	at 4 m looking downstream
30-Jul	DSCN1366	7:58	at 12 m (rebar) looking down line
30-Jul	DSCN1367	7:59	at 12 m looking up line
30-Jul	DSCN1368	7:59	at 12 m looking upstream
30-Jul	DSCN1369	7:59	at 12 m looking downstream
30-Jul	DSCN1370	8:00	at EOT looking across Duncan R. (river's edge of transect line)
30-Jul	DSCN1371	8:00	at 18 m looking up line
30-Jul	DSCN1372	8:00	at 18 m looking upstream
30-Jul	DSCN1373	8:00	at 18 m looking downstream
30-Jul	DSCN1374	8:22	**D5T9** at POC looking down line
30-Jul	DSCN1375	8:24	at 7 m looking down line
30-Jul	DSCN1376	8:24	at 7 m looking up line
30-Jul	DSCN1377	8:25	at 7 m looking upstream
30-Jul	DSCN1378	8:25	at 7 m looking downstream
30-Jul	DSCN1379	8:28	at 22 m looking down line at river's edge (EOT)
30-Jul	DSCN1380	8:28	at 22 m looking up line - counting seedlings
30-Jul	DSCN1381	8:28	at 22 m looking upstream
30-Jul	DSCN1382	8:28	at 22 m looking downstream
30-Jul	DSCN1383	8:31	at 11 m looking up line
30-Jul	DSCN1384	8:32	at 11 m looking down line
30-Jul	DSCN1385	8:35	at 3 m (rebar) looking down line
30-Jul	DSCN1386	8:35	at 3 m looking up line at POC
30-Jul	DSCN1387	8:37	at 16 m (rebar) looking down line
30-Jul	DSCN1388	8:37	at 16 m looking up line

Date	Image #	Time	Description
30-Jul	DSCN1389	9:03	**D5T11** at POC looking down line
30-Jul	DSCN1390	9:04	at POC looking up line at tag tree
30-Jul	DSCN1391	9:10	at 13 m (rebar) looking down line across back channel
30-Jul	DSCN1392	9:10	at 13 m looking up line
30-Jul	DSCN1393	9:10	at 13 m looking upstream
30-Jul	DSCN1394	9:10	at 13 m looking downstream - edge of back channel
30-Jul	DSCN1395	9:14	at 36 m (rebar) looking down line
30-Jul	DSCN1396	9:14	at 36 m looking up line
30-Jul	DSCN1397	9:15	at 36 m looking upstream
30-Jul	DSCN1398	9:15	at 36 m looking downstream
30-Jul	DSCN1399	9:20	at 68 m looking at EOT - river's edge
30-Jul	DSCN1400	9:20	at 68 m looking up line
30-Jul	DSCN1401	9:20	at 68 m looking upstream
30-Jul	DSCN1402	9:20	at 68 m looking downstream
30-Jul	DSCN1403	9:27	**D5T12** at POC looking down line
30-Jul	DSCN1404	9:27	at POC looking up line at tag tree
30-Jul	DSCN1405	9:31	at 14 m (rebar) looking down line across back channels
30-Jul	DSCN1406	9:31	at 14 m looking up line
30-Jul	DSCN1407	9:31	at 14 m looking upstream
30-Jul	DSCN1408	9:31	at 14 m looking downstream
30-Jul	DSCN1409	9:35	at 72 m looking down line at EOT and across Duncan River
30-Jul	DSCN1410	9:35	at 72 m looking up line - counting cottonwood seedlings
30-Jul	DSCN1411	9:35	at 72 m looking upstream
30-Jul	DSCN1412	9:35	at 72 m looking downstream
30-Jul	DSCN1413	9:57	**D5T11** transect line with Camila standing beside willows for height (hgt)
30-Jul	DSCN1414	9:57	same
30-Jul	DSCN1415	9:59	looking at same willow band near the end of the transect line
30-Jul	DSCN1416	9:59	looking downstream from edge of raft
30-Jul	DSCN1417	10:26	**D5T16** at POC looking down line
30-Jul	DSCN1418	10:27	at POC looking up line at tag tree
30-Jul	DSCN1419	10:32	at 7 m looking down line
30-Jul	DSCN1420	10:32	at 7 m looking up line
30-Jul	DSCN1421	10:35	at 10 m looking up line
30-Jul	DSCN1422	10:36	at 11.6 m looking up line
30-Jul	DSCN1423	10:36	at 11.6 m looking down line
30-Jul	DSCN1424	10:39	at 17.6 m (rebar) looking up line
30-Jul	DSCN1425	10:39	at 17.6 m looking down line
30-Jul	DSCN1426	10:44	at 29.6 m looking down line at EOT and across Duncan River
30-Jul	DSCN1427	10:44	at 29.6 m looking up line
30-Jul	DSCN1428	10:45	at 29.6 m looking upstream
30-Jul	DSCN1429	10:45	at 29.6 m looking downstream
30-Jul	DSCN1430	10:48	at 31.5 m looking down line
30-Jul	DSCN1431	10:48	at 31.5 m looking up line
30-Jul	DSCN1432	10:48	at 31.5 m looking upstream
30-Jul	DSCN1433	10:48	at 31.5 m looking downstream
30-Jul	DSCN1434	10:53	looking downstream at approximately the middle of the line - willow hgt
30-Jul	DSCN1435	10:54	looking at willow heights down line of POC

Date	Image #	Time	Description
30-Jul	DSCN1436	11:09	**D5T19** at POC looking down line
30-Jul	DSCN1437	11:09	at POC looking up line
30-Jul	DSCN1438	11:11	at 8 m (rebar) looking down line across Duncan River
30-Jul	DSCN1439	11:11	at 8 m looking down line at EOT
30-Jul	DSCN1440	11:11	at 8 m looking up line
30-Jul	DSCN1441	11:12	at 8 m looking downstream
30-Jul	DSCN1442	11:12	at 8 m looking upstream
30-Jul	DSCN1443	11:26	willow heights along transect line
30-Jul	DSCN1444	11:26	same
30-Jul	DSCN1445	12:03	**D6T29** at 48 m (rebar) looking down line and across Duncan River
30-Jul	DSCN1446	12:03	at 48 m looking up line - line crosses back channel
30-Jul	DSCN1447	12:04	at 48 m looking upstream
30-Jul	DSCN1448	12:04	at 48 m looking downstream
30-Jul	DSCN1449	12:17	at 48 m looking up line (Aden and Ben on upstream side of line)
30-Jul	DSCN1450	12:18	same without Aden and Ben
30-Jul	DSCN1451	12:18	at EOT looking across Duncan River
30-Jul	DSCN1452	13:02	**D6T36** at 15 m (rebar) looking down line - counting seedlings
30-Jul	DSCN1453	13:03	at 31 m looking down line
30-Jul	DSCN1454	13:03	at 31 m looking up line
30-Jul	DSCN1455	13:03	at 31 m looking upstream
30-Jul	DSCN1456	13:03	at 31 m looking downstream
30-Jul	DSCN1457	13:06	at 88 m looking down line at EOT and across Duncan River
30-Jul	DSCN1458	13:06	at 88 m looking up line
30-Jul	DSCN1459	13:06	at 88 m looking downstream
30-Jul	DSCN1460	13:06	at 88 m looking upstream
30-Jul	DSCN1461	14:06	**D6T20** at POC looking down line
30-Jul	DSCN1462	14:09	at 5 m looking down line
30-Jul	DSCN1463	14:09	at 5 m looking up line - mainly down at line
30-Jul	DSCN1464	14:09	at 5 m looking up line
30-Jul	DSCN1465	14:11	at 13.5 m (rebar) looking down line
30-Jul	DSCN1466	14:11	at 13.5 m looking up line
30-Jul	DSCN1467	14:13	at 22 m (rebar) looking down line
30-Jul	DSCN1468	14:14	at 22 m looking up line
30-Jul	DSCN1469	14:14	at 22 m looking up line with ML for sandbar willow heights
30-Jul	DSCN1470	14:14	at 22 m looking upstream
30-Jul	DSCN1471	14:14	at 22 m looking downstream
30-Jul	DSCN1472	14:44	**D6T6** snake near east side of transect line
30-Jul	DSCN1473	14:44	same
30-Jul	DSCN1474	14:49	at POC looking down line
30-Jul	DSCN1475	14:49	at POC looking up line
30-Jul	DSCN1476	14:53	at 24 m looking down line
30-Jul	DSCN1477	14:53	at 24 m looking up line
30-Jul	DSCN1478	14:54	at 24 m looking upstream
30-Jul	DSCN1479	14:54	at 24 m looking downstream
30-Jul	DSCN1480	14:57	at 60 m looking down line
30-Jul	DSCN1481	14:57	at 60 m looking up line
30-Jul	DSCN1482	14:58	at 60 m looking upstream
30-Jul	DSCN1483	14:58	at 60 m looking downstream

Date	Image #	Time	Description
30-Jul	DSCN1484	17:51	**D3T15** at 6 m looking up line
30-Jul	DSCN1485	17:51	at 6 m looking down line
30-Jul	DSCN1486	17:54	at 41 m looking up line
30-Jul	DSCN1487	17:54	at 41 m looking down line
30-Jul	DSCN1488	17:55	at 67 m looking down line at EOT
30-Jul	DSCN1489	17:56	at 67 m looking up line
30-Jul	DSCN1490	17:56	at 67 m looking downstream
30-Jul	DSCN1491	17:56	at 67 m looking upstream
30-Jul	DSCN1492	17:59	Band of willow & cottonwood recruitment 2013 downstream of line
30-Jul	DSCN1493	18:36	**D3T17** at 9 m (rebar) looking up line
30-Jul	DSCN1494	18:37	at 9 m looking down line
30-Jul	DSCN1495	18:41	at 33 m looking down line at EOT
30-Jul	DSCN1496	18:41	at 33 m looking up line
30-Jul	DSCN1497	18:42	at 33 m looking downstream
30-Jul	DSCN1498	18:42	at 33 m looking upstream
30-Jul	DSCN1499	18:44	Upstream of **D3T17 -** band of mainly willow established pre-2008
30-Jul	DSCN1500	18:45	Upstream of **D3T1**7 looking towards **D3T15**
30-Jul	DSCN1501	18:46	Same place as above looking upstream of back channel towards Duncan River
30-Jul	DSCN1502	18:47	Same place as above panning to right
30-Jul	DSCN1503	18:47	Same place as above panning to right with view towards **D3T15** and **D3T17**

Date: July, 2014			**Environmental Crew:** Mary Louise, Aden, Ben, Brenda
Location: Lardeau River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
31-Jul	DSCN1504	8:04	**L3T30** at 3.5 m (rebar) looking down line
31-Jul	DSCN1505	8:04	at 3.5 m looking up line
31-Jul	DSCN1506	8:05	at 11 m (rebar) looking down line
31-Jul	DSCN1507	8:05	at 11 m looking up line
31-Jul	DSCN1508	8:06	at 37 m looking down line at EOT and across Lardeau River
31-Jul	DSCN1509	8:06	at 37 m looking up line
31-Jul	DSCN1510	8:07	at 37 m looking downstream
31-Jul	DSCN1511	8:07	at 37 m looking upstream
31-Jul	DSCN1512	8:42	**L3T9** at POC looking down line
31-Jul	DSCN1513	8:42	at POC looking up line at tag tree
31-Jul	DSCN1514	8:45	at 10 m (rebar) looking down line
31-Jul	DSCN1515	8:45	at 10 m looking up line
31-Jul	DSCN1516	8:47	at 22 m (rebar) looking down line
31-Jul	DSCN1517	8:47	at 22 m looking up line
31-Jul	DSCN1518	8:48	looking at EOT (river's edge) and across Lardeau River
31-Jul	DSCN1519	8:48	standing at same place (1519) looking up line
31-Jul	DSCN1520	8:48	looking downstream
31-Jul	DSCN1521	8:48	looking upstream
31-Jul	DSCN1522	9:16	**L3T1** at POC looking down line
31-Jul	DSCN1523	9:16	at POC looking up line at tag tree
31-Jul	DSCN1524	9:20	at 9 m (rebar) looking down line
31-Jul	DSCN1525	9:20	at 9 m looking up line
31-Jul	DSCN1526	9:21	at 25 m (rebar) looking down line at river's edge and across Lardeau R.
31-Jul	DSCN1527	9:22	at 25 m looking up line - seedling counting
31-Jul	DSCN1528	9:22	at 25 m looking upstream
31-Jul	DSCN1529	9:22	at 25 m looking downstream
31-Jul	DSCN1530	9:33	**L2T18** at POC looking down line
31-Jul	DSCN1531	9:33	at POC looking up line at tag tree
31-Jul	DSCN1532	9:33	at POC looking downstream
31-Jul	DSCN1533	9:33	at POC looking upstream
31-Jul	DSCN1534	9:35	at 7 m (rebar) looking down line - counting seedlings
31-Jul	DSCN1535	9:35	at 7 m looking up line
31-Jul	DSCN1536	9:35	at 7 m looking downstream
31-Jul	DSCN1537	9:35	at 7 m looking upstream
31-Jul	DSCN1538	9:37	at 19 m (rebar) looking down line
31-Jul	DSCN1539	9:37	at 19 m looking up line - counting seedlings
31-Jul	DSCN1540	9:37	at 19 m looking upstream
31-Jul	DSCN1541	9:37	at 19 m looking downstream
31-Jul	DSCN1542	9:38	at 26 m looking at EOT (river's edge) and across Lardeau River
31-Jul	DSCN1543	9:38	at 26 m looking up line - counting seedlings
31-Jul	DSCN1544	9:38	at 26 m looking downstream
31-Jul	DSCN1545	9:38	at 26 m looking upstream

Date	Image #	Time	Description
31-Jul	DSCN1546	10:19	**L2T15** at POC looking down line
31-Jul	DSCN1547	10:19	at POC looking up line at tag tree
31-Jul	DSCN1548	10:20	at 11 m (rebar) looking down line
31-Jul	DSCN1549	10:20	at 11 m looking up line
31-Jul	DSCN1550	10:20	at 11 m looking downstream
31-Jul	DSCN1551	10:20	at 11 m looking upstream
31-Jul	DSCN1552	10:21	at 19 m (rebar) looking down line
31-Jul	DSCN1553	10:22	at 19 m looking up line
31-Jul	DSCN1554	10:22	at 19 m looking downstream
31-Jul	DSCN1555	10:22	at 19 m looking upstream
31-Jul	DSCN1556	10:22	at 29 m (rebar) looking down line at EOT and across Lardeau River
31-Jul	DSCN1557	10:23	at 29 m looking up line
31-Jul	DSCN1558	10:23	at 29 m looking downstream
31-Jul	DSCN1559	10:23	at 29 m looking upstream
31-Jul	DSCN1560	10:50	**L2T6** at POC looking down line
31-Jul	DSCN1561	10:50	at POC looking up line at tag tree
31-Jul	DSCN1562	10:51	at POC looking downstream
31-Jul	DSCN1563	10:51	at POC looking upstream
31-Jul	DSCN1564	10:52	at 9.5 m (rebar) looking down line
31-Jul	DSCN1565	10:52	at 9.5 m looking up line
31-Jul	DSCN1566	10:53	at 9.5 m looking downstream
31-Jul	DSCN1567	10:53	at 9.5 m looking upstream
31-Jul	DSCN1568	10:55	at 18 m (rebar) looking up line - counting seedlings
31-Jul	DSCN1569	10:55	at edge of willow community looking up line
31-Jul	DSCN1570	10:55	same as above with willow branch held out of photo
31-Jul	DSCN1571	10:58	at 52 m looking at EOT and across Lardeau River
31-Jul	DSCN1572	10:59	at 52 m looking up line
31-Jul	DSCN1573	10:59	at 52 m looking downstream
31-Jul	DSCN1574	10:59	at 52 m looking upstream
31-Jul	DSCN1575	11:24	**L1T36** at POC looking down line
31-Jul	DSCN1576	11:24	at POC looking up line at tag tree
31-Jul	DSCN1577	11:25	at 3.5 m (rebar) looking down line
31-Jul	DSCN1578	11:26	at 3.5 m looking up line
31-Jul	DSCN1579	11:27	at 15 m (rebar) looking down line
31-Jul	DSCN1580	11:27	at 15 m looking up line
31-Jul	DSCN1581	11:27	at 15 m looking upstream - silt deposited by 2012 flood
31-Jul	DSCN1582	11:27	at 15 m looking downstream - silt deposited by 2012 flood
31-Jul	DSCN1583	11:30	at 41 m looking at EOT and across Lardeau River
31-Jul	DSCN1584	11:30	at 41 m looking up line
31-Jul	DSCN1585	11:30	at 15 m looking upstream
31-Jul	DSCN1586	11:30	at 15 m looking downstream
31-Jul	DSCN1587	12:49	**L1T20** at POC looking down line
31-Jul	DSCN1588	12:50	at POC looking up line at tag tree
31-Jul	DSCN1589	12:51	at 3 m (rebar) looking down line
31-Jul	DSCN1590	12:51	at 3 m looking up line
31-Jul	DSCN1591	12:51	at 3 m looking upstream
31-Jul	DSCN1592	12:51	at 3 m looking downstream
31-Jul	DSCN1593	12:53	at 10 m looking down line

Date	Image #	Time	Description
31-Jul	DSCN1594	12:53	**L1T20** at 10 m looking up line
31-Jul	DSCN1595	12:53	at 10 m looking upstream
31-Jul	DSCN1596	12:53	at 10 m looking downstream
31-Jul	DSCN1597	12:54	ML on line for height reference for willows
31-Jul	DSCN1598	12:56	at 15 m (rebar) looking down line
31-Jul	DSCN1599	12:56	at 15 m looking up line
31-Jul	DSCN1600	12:56	at 15 m looking upstream
31-Jul	DSCN1601	12:56	at 15 m looking downstream
31-Jul	DSCN1602	12:59	at 56 m looking down line at EOT and across Lardeau River
31-Jul	DSCN1603	12:59	at 56 m looking up line
31-Jul	DSCN1604	13:00	at 56 m looking downstream
31-Jul	DSCN1605	13:00	at 56 m looking upstream
31-Jul	DSCN1606	13:43	seedlings along line
31-Jul	DSCN1608	13:43	cat tracks (cougar) on meander lob and cross transect line
31-Jul	DSCN1609	13:43	same
31-Jul	DSCN1610	13:43	same
31-Jul	DSCN1611	13:43	same
31-Jul	DSCN1612	13:44	seedlings along line
31-Jul	DSCN1613	13:44	close up of seedlings
31-Jul	DSCN1614	13:44	same
31-Jul	DSCN1615	13:44	older willows - pre-2008
31-Jul	DSCN1616	13:44	line running through willow patch
31-Jul	DSCN1617	13:44	seedlings on meander lobe
31-Jul	DSCN1618	13:44	branch fragment sprouts of willow
31-Jul	DSCN1619	13:45	willow and cottonwood seedlings 2012, 2013, and 2014
31-Jul	DSCN1620	13:45	seedlings on meander lobe
31-Jul	DSCN1621	13:45	same
31-Jul	DSCN1622	13:45	2014 seedlings (very small) in bands on meander lob
31-Jul	DSCN1623	13:45	seedlings on meander lobe
31-Jul	DSCN1624	13:46	seedlings along transect line at 42 m
31-Jul	DSCN1625	13:46	same at 42.5 to 42.7 m mainly willow
31-Jul	DSCN1626	13:46	same
31-Jul	DSCN1627	13:47	same with one willow flood trained at top middle of photo
31-Jul	DSCN1628	13:47	seedlings on silt between cobble/gravel
31-Jul	DSCN1629	13:47	same
31-Jul	DSCN1630	13:47	same
31-Jul	DSCN1631	13:47	same
31-Jul	DSCN1632	13:52	same but along line at 49 m
31-Jul	DSCN1633	13:52	same at 49 m
31-Jul	DSCN1634	13:53	same at 49 m
31-Jul	DSCN1635	13:53	same at 49 m
31-Jul	DSCN1636	13:53	same at 49 m
31-Jul	DSCN1637	13:53	same at 50 m
31-Jul	DSCN1638	13:53	same at 50 m
31-Jul	DSCN1639	13:53	seedlings on meander lobe
31-Jul	DSCN1640	13:53	same
31-Jul	DSCN1641	13:55	meander lob looking downstream
31-Jul	DSCN1642	13:55	meander lob looking upstream

Date	Image #	Time	Description
31-Jul	DSCN1643	14:25	**L1T10** meander lobe in front and downstream of transect line
31-Jul	DSCN1644	14:26	same place panning right
31-Jul	DSCN1645	14:26	same place panning further right (downstream)
31-Jul	DSCN1646	14:26	standing in same place as photo 1643 - last shot panning right
31-Jul	DSCN1647	14:26	close up of seedlings in patch from photo 1646
31-Jul	DSCN1648	14:26	same
31-Jul	DSCN1649	14:27	looking at end of meander lobe and start of back channel
31-Jul	DSCN1650	14:27	looking upstream of meander lobe
31-Jul	DSCN1651	14:27	willow, cottonwood, vegetation on meander lobe
31-Jul	DSCN1652	14:27	same
31-Jul	DSCN1653	14:28	cottonwood seedlings (2012, 2013, and 2014)
31-Jul	DSCN1654	14:28	looking upstream at meander lob
31-Jul	DSCN1655	14:29	close up of meander lob at top end of photo 1654 - mainly willow juveniles
31-Jul	DSCN1656	14:38	**L1T10** at POC looking down line
31-Jul	DSCN1657	14:39	at POC looking up line at tag tree
31-Jul	DSCN1658	14:42	at 3 m looking down line
31-Jul	DSCN1659	14:42	at 3 m looking upstream
31-Jul	DSCN1660	14:43	at 37 m (rebar) looking down line - seedling counting
31-Jul	DSCN1661	14:43	at 37 m looking up line - seedling counting
31-Jul	DSCN1662	14:43	at 37 m looking downstream - back channel confluence with main
31-Jul	DSCN1663	14:43	at 37 m looking upstream
31-Jul	DSCN1664	14:48	**Seedlings and other vegetation on upstream side of line**
31-Jul	DSCN1665	14:48	same
31-Jul	DSCN1666	14:48	seedlings from 2012 (willow & cottonwood) on meander lobe downstream of transect line - back channel in front
31-Jul	DSCN1667	14:48	same place close up of willow patch
31-Jul	DSCN1668	14:48	same place
31-Jul	DSCN1669	14:48	same
31-Jul	DSCN1670	14:48	same
31-Jul	DSCN1671	14:48	same
31-Jul	DSCN1672	14:48	same
31-Jul	DSCN1673	14:48	same
31-Jul	DSCN1674	14:49	same
31-Jul	DSCN1675	14:49	same
31-Jul	DSCN1676	14:49	same
31-Jul	DSCN1677	14:49	same
31-Jul	DSCN1678	14:49	same
31-Jul	DSCN1679	14:49	same
31-Jul	DSCN1680	14:49	same
31-Jul	DSCN1681	14:49	same
31-Jul	DSCN1682	14:53	**L1T10** looking at EOT & across back channel to meander lobe in front of line
31-Jul	DSCN1683	14:53	looking up line standing in same place as photo 1682
31-Jul	DSCN1684	14:53	looking downstream standing in same place as photo 1682
31-Jul	DSCN1685	14:53	looking upstream standing in same place as photo 1682
31-Jul	DSCN1686	15:25	ML for reference for willow (mainly) & cottonwood heights

Date	Image #	Time	Description
31-Jul	DSCN1687	15:50	**L1T1** at POC looking down line
31-Jul	DSCN1688	15:50	at POC looking up line at tag tree
31-Jul	DSCN1689	15:55	at 12 m (rebar) looking down line
31-Jul	DSCN1690	15:55	at 12 m looking up line
31-Jul	DSCN1691	15:55	at 12 m looking downstream
31-Jul	DSCN1692	15:55	at 12 m looking upstream
31-Jul	DSCN1693	15:56	at 25 m looking at EOT and across Lardeau River
31-Jul	DSCN1694	15:56	at 25 m looking up line
31-Jul	DSCN1695	15:56	at 25 m looking downstream
31-Jul	DSCN1696	15:56	at 25 m looking upstream
31-Jul	DSCN1697	15:58	cottonwood & willow seedlings near **L1T**1 line
31-Jul	DSCN1698	15:58	looking at 17.5 to 18.3 m along transect line - cottonwood & willow
31-Jul	DSCN1699	15:58	same area
31-Jul	DSCN1700	15:58	cottonwood & willow seedlings along transect line
31-Jul	DSCN1701	16:00	shrub and tree heights with Aden and ML for height reference along transect line - Aden is near the 12 m rebar

Date: Sep & Oct, 2014			**Environmental Crew:** Mary Louise, Aden, Megan, Brenda
Location: Duncan River			**Project Leader:** Mary Louise Polzin
Date	**Image #**	**Time**	**Description**
29-Sep	DSCF0536	14:29	**D1T3** at POC looking down line
	DSCF0537	14:30	Looking at POC.
	DSCF0538	14:30	Looking at a nail in the tree.
	DSCF0539	14:31	Looking down from mid point.
	DSCF0540	14:32	Looking up from mid point.
	DSCF0541	14:32	Looking upstream from midpoint.
	DSCF0542	14:32	Looking downstream from midpoint.
	DSCF0543	14:33	Looking down line at the EOT.
	DSCF0544	14:33	Looking up line from EOT.
	DSCF0545	14:33	Same as above.
	DSCF0546	14:34	Looking upstream from EOT.
	DSCF0547	14:34	Looking downstream from the EOT.
	DSCF0548	14:34	Willows with Megan as a reference.
29-Sep	DSCF0512	12:36	**D1T4** Up to reference tree from rebar.
	DSCF0513	12:38	Looking down line from 20 m.
	DSCF0514	12:38	Looking down line from POC.
	DSCF0515	12:40	Looking downstream from EOT.
	DSCF0516	12:40	Looking upstream from EOT.
	DSCF0517	12:40	Looking down line across the river from EOT.
	DSCF0518	12:44	Looking upstream at mid point.
	DSCF0519	12:44	Looking downstream from mid point.
	DSCF0520	12:45	Willow height with Brenda as a reference.
	DSCF0523	12:45	Down the line from POC.
	DSCF0524	12:46	Up line from POC.
29-Sep	DSCF0525	13:03	**D1T5** at POC looking down line
	DSCF0526	13:03	Looking up line from POC.
	DSCF0527	13:04	Looking down line from the 60 m mark.
	DSCF0528	13:04	Looking up line from the 11 m mark.
	DSCF0529	13:05	Looking upstream from the rebar.
	DSCF0530	13:05	Looking downstream from the rebar.
	DSCF0531	13:05	Looking down line at the EOT.
	DSCF0532	13:05	Looking up line from the EOT.
	DSCF0533	13:06	Looking upstream from the EOT.
	DSCF0534	13:06	Looking downstream from the EOT.
	DSCF0535	13:06	Same as above.
29-Sep	DSCN1735	13:49	**D3T10** At POC looking down line.
	DSCN1736	13:51	At 40 m looking down line.
	DSCN1737	13:51	At 40 m looking up line.
	DSCN1738	13:54	At 51 m looking upstream.
	DSCN1739	13:54	At 51 m looking downstream
	DSCN1740	13:56	At the EOT looking down line across river.
	DSCN1741	13:56	At the EOT looking up line.
	DSCN1742	13:56	Plot at 61 m with two seedlings.
	DSCN1743	13:56	At the EOT looking upstream.

Date	Image #	Time	Description
29-Sep	DSCN1744	14:09	**D3T11** At the POC looking down line.
	DSCN1745	14:14	At 32.5 m looking down line.
	DSCN1746	14:17	At 57 m looking up line.
	DSCN1747	14:18	At 57 m looking down line.
	DSCN1748	17:02	At 74 m looking at a seedling plot.
	DSCN1749	17:03	At 97 m looking down line.
	DSCN1750	17:05	Seedlings upstream of line from the 74 m mark.
	DSCN1751	17:07	At the 107 m mark looking upstream.
	DSCN1752	17:08	At the EOT looking across river.
	DSCN1753	17:08	At the EOT looking up line.
	DSCN1754	17:08	At the EOT looking upstream.
	DSCN1755	17:08	At the EOT looking downstream.
29-Sep	DSCN1775	11:26	**D3T15 POC** A piezometer access tube next to the tag tree that was felled by a beaver.
	DSCN1776	11:30	At the 7 m mark looking down line.
	DSCN1777	11:41	At the 42 m mark looking up a line.
	DSCN1778	11:41	At the 42 m mark looking down line.
	DSCN1779	11:41	At the 42 m mark looking upstream.
	DSCN1780	11:42	At the 42 m mark looking downstream.
	DSCN1781	11:42	At the EOT looking up line.
	DSCN1782	12:19	The seedling plot at the 50 m mark.
	DSCN1783	12:45	Off line on upstream side mainly willow some cottonwoods ~ 51 m
29-Sep	DSCN1784	12:53	**D3T17**Looking up a line at the 3 m mark.
	DSCN1785	12:53	Looking down line at the 9 m mark.
	DSCN1786	12:54	Looking upstream at the 9 m mark.
	DSCN1787	12:54	Looking downstream at the 23 m mark.
	DSCN1788	12:55	Looking down line at the 23 m mark.
	DSCN1789	12:55	Looking up line from the EOT.
	DSCN1790	13:39	Seedling plot at the 13 m mark.
	DSCN1791	13:39	Offline upstream looking downstream at the willow band at 10 m.
30-Sep	DSCN1757	10:04	**D3T29** At EOT across backchannel.
	DSCN1758	10:04	At the EOT looking up line.
	DSCN1759	10:07	At the 55 m mark plot with seedling band.
	DSCN1760	10:08	At the 55 m mark looking upstream.
	DSCN1761	10:09	At the 40 m mark looking up line.
	DSCN1762	10:10	At the 40 m mark looking down line.
	DSCN1763	10:10	At the 20 m mark looking up line.
	DSCN1764	10:10	At the 20 m mark looking downstream.
	DSCN1765	10:10	At the 20 m mark looking downstream.
30-Sep	DSCN1766	10:21	**D3T35** at POC looking down line.
	DSCN1767	10:22	At the 17 m mark looking up line.
	DSCN1768	10:22	At the 17 m mark looking down line.
	DSCN1769	10:22	At the 17 m mark looking upstream.
	DSCN1770	10:22	At the 17 m mark looking downstream.
	DSCN1771	10:24	At the EOT looking across backchannel.
	DSCN1772	10:25	At the EOT looking up line.

Date	Image #	Time	Description
30-Sep	DSCN1773	10:53	**D3T35** (Continued) At the 8 meter seedling plot.
	DSCN1774	10:54	At 7.9 meters seedling upstream of line.
30-Sep	DSCN1792	14:34	**D3T20** Looking up line from the 26 meter mark.
	DSCN1793	14:34	Looking down line from the 26 m mark.
	DSCN1794	14:40	Looking up line from the 31 m mark.
	DSCN1795	14:40	Looking down line from the 31 m mark.
	DSCN1796	14:41	Looking downstream from the 31 m mark.
	DSCN1797	14:42	Looking up a line from EOT.
	DSCN1798	14:42	Looking upstream from the EOT.
	DSCN1799	15:10	Seedling plot on the upstream side of the 31 m mark.
	DSCN1800	15:11	Seedling plot at the 36.5 m mark.
30-Sep	DSCN1801	15:36	**D3T23** Bank erosion at the EOT.
	DSCN1802	15:36	Looking across river from the EOT.
	DSCN1803	15:38	Looking up line from EOT.
	DSCN1804	15:38	Looking downstream from the EOT.
	DSCN1805	15:39	Looking upstream from EOT.
	DSCN1806	15:40	Looking upstream from the 20 m mark.
30-Sep	DSCN1807	16:02	**D3T45** Bear tracks near T45 (hind).
	DSCN1808	16:02	Bear tracks near T45 (front).
	DSCN1809	16:11	Looking down line from the 4 m mark.
	DSCN1810	16:13	Looking up a line from the 27 m mark.
	DSCN1811	16:13	Looking down line from the 27 m mark.
	DSCN1812	16:14	Looking across the river from EOT.
	DSCN1813	16:14	Looking up line from the EOT.
	DSCN1814	16:17	Looking upstream from the EOT.
	DSCN1815	16:17	Looking downstream from EOT.
	DSCN1816	16:44	Seeding plot at the 31 m mark.
	DSCN1817	16:46	Older willow seedlings with cottonwood germinants at the 21 m mark.
30-Sep	DSCN1818	16:54	**D3T40** Looking down the line from the 4 m mark.
	DSCN1819	16:56	Looking up line from the 18 m mark.
	DSCN1820	16:56	Looking down line from 18 m mark.
	DSCN1821	16:56	Looking across the river from the EOT.
	DSCN1822	16:57	Looking up line from EOT.
	DSCN1823	16:57	Looking downstream from EOT.
	DSCN1824	16:57	Looking upstream from EOT.
	DSCN1825	17:00	Seedling band (mainly willow) upstream side of line at the 8 m mark.
	DSCN1826	17:05	Seedling plot on the line downstream side of the 7 m mark.
30-Sep	DSCF0555 (2)	14:58	**D4T3** - Looking down line from the EOT across the river.
	DSCF0556 (2)	14:58	Looking up line from the EOT.
	DSCF0557 (2)	14:58	Looking upstream from the EOT.
	DSCF0558 (2)	14:58	Looking downstream from the EOT.
	DSCF0559 (2)	15:01	Looking down line from the 50 m mark.
	DSCF0560 (2)	15:01	Looking up line from the 50 m mark.
	DSCF0561	15:05	Looking down line from the POC.
	DSCF0562	15:07	Seedlings at the 43 m mark.
	DSCF0563	15:08	Same as above.

Date	Image #	Time	Description
30-Sep	DSCF0564	16:41	**D4T10** - looking across the stream from the EOT.
	DSCF0565	16:41	Looking up line from the EOT.
	DSCF0566	16:41	Looking upstream from the EOT.
	DSCF0567	16:41	Looking downstream from the EOT.
	DSCF0568	16:42	Looking down line from the 46 m mark.
	DSCF0569	16:42	Looking up line from the 46 m mark.
	DSCF0570	16:43	Seedlings at the 46 m mark.
	DSCF0571	16:44	Seedlings at the 46 m mark.
	DSCF0572	16:45	Looking down line from the POC.
1-Oct	DSCF0573	8:12	**D4T5** Looking down line from the POC
	DSCF0574	8:14	Looking down line from the 23 m mark.
	DSCF0575	8:14	Looking up line from the 23 m mark.
	DSCF0576	8:15	Looking down line from the EOT across the river.
	DSCF0577	8:15	Looking up line from the EOT.
	DSCF0578	8:15	Looking upstream from the EOT.
	DSCF0579	8:15	Looking downstream from the EOT.
	DSCF0580	8:18	Habitat at the 15 m mark (lack of ground cover).
	DSCF0581	8:18	The habitat at the 4 m mark (ground cover).
30-Sep	DSCF0545 (2)	8:11	**D5T2** Looking down line from the POC.
	DSCF0546 (2)	8:12	Looking up line from the 12 m mark.
	DSCF0547 (2)	8:12	Looking down line from the 12 m mark.
	DSCF0548 (2)	8:12	Looking up line from the EOT.
	DSCF0549 (2)	8:13	Looking down at EOT.
	DSCF0550 (2)	8:13	Looking upstream from the EOT.
	DSCF0551 (2)	8:13	Looking downstream from the OET.
	DSCF0552 (2)	8:14	Looking down line across the river from the EOT.
	DSCF0553 (2)	8:16	Cottonwood at 13 m mark.
	DSCF0554 (2)	8:16	Looking down line from the 13 m mark.
29-Sep	DSCF0549	15:19	**D5T9** Looking down line at POC
	DSCF0550	15:20	Looking at ground cover at mid point. Looking up line.
	DSCF0551	15:20	Same as above.
	DSCF0552	15:20	Looking at ground cover at mid point. Looking down line.
	DSCF0553	15:21	Looking down at EOT.
	DSCF0554	15:21	Same as above.
	DSCF0555	15:21	Looking at substrate. Looking up from EOT.
	DSCF0556	15:22	Looking upstream from EOT.
	DSCF0557	15:22	Same as above.
	DSCF0558	15:22	Looking downstream from EOT.
	DSCF0559	15:26	Seedlings at 19 m mark.
	DSCF0560	15:26	Seedlings at 17 m mark.
1-Oct	DSCN1827	8:40	**D5T11** At 14 m looking down the line. Willow and veg behind.
	DSCN1828	8:42	Looking up a line from 35 m.
	DSCN1829	8:43	Looking up line from 43 m.
	DSCN1830	8:43	Looking down the line from 43 m.
	DSCN1831	9:12	Looking downstream from 50 m.
	DSCN1832	9:14	Looking down line from 65 m.
	DSCN1833	9:15	Looking up line from the EOT.
	DSCN1834	9:18	Upstream side of line ~ 65 m looking up line at seedlings in frame.

Date	Image #	Time	Description
1-Oct	DSCN1835	9:18	**D5T11** (Continued) Seedling band with frame in photo.
1-Oct	DSCN1836	9:30	**D5T12** Looking down line from 50 m.
	DSCN1837	9:31	Looking up line from 37 m.
	DSCN1838	9:31	Looking down line from 37 m.
	DSCN1839	9:33	Looking upstream from 37 m.
	DSCN1840	9:33	Looking downstream from 37 m.
	DSCN1841	9:52	Seedling plot at 63 m.
	DSCN1842	9:53	Seedling plot at 68 m.
	DSCN1843	9:54	Looking down line from 68 m.
	DSCN1844	9:54	Looking up line from EOT.
1-Oct	DSCN1845	10:29	**D5T16**Looking across the river from EOT at 29 m.
	DSCN1846	10:30	Looking up line from 29 m.
	DSCN1847	10:31	Looking down line from 12 m.
	DSCN1848	10:32	Looking up line from 16 m.
	DSCN1849	10:57	Looking upstream from EOT.
	DSCN1850	10:58	Looking downstream from EOT.
	DSCN1851	10:59	Seedling plot at 30 m.
	DSCN1852	11:00	Seedling plot at 28 m.
	DSCN1853	11:01	Looking upstream at a small bay no seedlings.
1-Oct	DSCN1854	11:28	**D5T19** Looking up line from 8 m.
	DSCN1855	11:28	Looking down line from 8 m.
	DSCN1856	11:28	Looking upstream from 8 m.
	DSCN1857	11:28	Looking downstream from 8 m
	DSCN1858	11:29	Looking down the line from POC.
	DSCN1859	11:36	1 m seedling plot.
	DSCN1860	11:44	Seedling plot at 7 m. Strap in picture.
	DSCN1861	11:44	Seeding plot at 7 m.
	DSCN1862	11:45	Looking upstream from EOT.
	DSCN1863	11:45	Looking downstream from EOT.
1-Oct	DSCN1864	12:08	**D6T29** Looking up line from EOT.
	DSCN1865	12:09	Looking down the line at the EOT and river from the 59 m mark.
	DSCN1866	12:09	Looking downstream from the 59 m mark.
	DSCN1867	12:09	Looking upstream from the 59 m mark.
	DSCN1868	12:11	upstream of the line looking at recruitment of willow mainly on bar.
	DSCN1869	12:15	Seedling plot at the 45 m mark.
	DSCN1870	12:28	Seeding plot with willow at the 55 m mark.
	DSCN1871	12:31	Looking up line from the 36 m mark.
	DSCN1872	12:33	Looking down line from the 13 m mark.
1-Oct	DSCN1873	12:59	**D6T36** Looking up line from the 78 m mark.
	DSCN1874	13:00	Looking down line at the EOT and across the river from 78 m.
	DSCN1875	13:02	Looking down line from the 38 m.
	DSCN1876	13:02	Looking up line from the 38 m.
	DSCN1877	13:03	Looking upstream from the 38 m mark.
	DSCN1878	13:03	Looking downstream from the 38 m mark.
	DSCN1879	14:20	Looking upstream from the 78 m mark. 2 m seedling plot.
	DSCN1880	14:21	Seedling plot at the 44 m mark.
	DSCN1881	14:22	Band of willow & horsetail ~ 10 m upstream of line at ~ 28 m on line

Date	Image #	Time	Description
1-Oct	DSCN1882	15:14	**D6T20** Looking down line from the 22.5 m mark.
	DSCN1883	15:14	Looking up line from the 22.5 m mark.
	DSCN1884	15:17	Looking upstream from the 22.5 m mark.
	DSCN1885	15:17	Looking downstream from the 22.5 m mark.
	DSCN1886	15:18	Upstream of a line looking downstream at line and willow band.
	DSCN1887	15:20	Looking up line at POC from 5 m mark.
	DSCN1888	15:21	Looking downstream from the 5 m mark.
	DSCN1889	15:25	Seed plot frame at the 20 m mark with no seedlings.
	DSCN1890	15:28	One seedling in plot frame 2014 at the 24 m mark.

Date: Sep & Oct, 2014	**Environmental Crew:** Mary Louise, Aden, Megan, Brenda
Location: Lardeau River	**Project Leader:** Mary Louise Polzin

Date	Image #	Time	Description
2-Oct	DSCN1891	9:09	**L3T30** Looking up line at the POC from the 13 m mark.
	DSCN1892	9:09	Looking down line from the 13 m mark.
	DSCN1893	9:12	Looking down line at the EOT and across the river from the 35 m mark.
	DSCN1894	9:13	Looking up line from the 35 m mark.
	DSCN1895	9:13	Looking upstream from the 35 m mark.
	DSCN1896	9:13	Looking downstream from the 35 m mark.
	DSCN1897	9:16	Upstream side of the line looking at the POC.
	DSCN1898	9:19	Looking downstream of the line at willow and cottonwood seedlings.
2-Oct	DSCN1899	9:58	**L3T9** Looking up line from the 22 m mark.
	DSCN1900	9:58	Looking down line from the 22 m mark.
	DSCN1901	10:00	Looking down line from the 36 m mark.
	DSCN1902	10:00	Looking up line from the 36 m mark.
	DSCN1903	10:02	Looking upstream from the 41 m mark.
	DSCN1904	10:02	Looking downstream from the 41 m mark.
	DSCN1905	10:02	Looking down line at the EOT and across the river from the 41 m mark.
	DSCN1906	10:11	Looking at the seed plot at 38 m. Seed plot pre 2012.
	DSCN1907	10:12	Looking at the seed plot from 41 m. Seed plot is pre 2012.
2-Oct	DSCN1908	10:43	**L3T1** At the 25 m looking down line at the EOT and across the river.
	DSCN1909	10:43	Looking up line from the 25 m mark.
	DSCN1910	10:44	Looking upstream from the 25 m mark.
	DSCN1911	10:44	Looking downstream from the 25 m mark.
	DSCN1912	10:46	Looking up line from the 15 m mark.
	DSCN1913	10:50	The plot frame at 12 m mark. 2014 clones.
	DSCN1914	10:52	Pre 2012 recruitment upstream of line.
	DSCN1915	10:53	Same as above looking at riverside of band.
	DSCN1916	10:55	Same as above. upstream side.
2-Oct	DSCF0608	8:44	**L2T18** Looking down line across the river from the EOT.
	DSCF0609	8:44	Looking up line from the EOT.
	DSCF0610	8:44	Looking upstream from the EOT.
	DSCF0611	8:44	Looking downstream from the EOT.
	DSCF0612	8:45	Looking down line from the 17 m mark.
	IMGP0344	8:11	looking up line from the 17 m mark.
	IMGP0345	8:14	Looking down line from the POC.
	IMGP0346	8:19	Ground cover and recruitment at the 9 m mark.
2-Oct	IMGP0347	8:49	**L2T15** Looking down line across the river from the EOT.
	IMGP0348	8:49	Looking up line from the EOT.
	IMGP0349	8:50	Looking upstream from the EOT.
	IMGP0350	8:50	Looking downstream from the EOT.
	IMGP0352	8:51	Looking down line from the 19 m mark.
	IMGP0353	8:51	Looking up line from the 19 m mark.
	IMGP0355	8:52	Looking down line from the POC.
	IMGP0356	9:14	2013 seedlings height reference at the 29 m mark.
	IMGP0357	9:14	Ground cover and recruitment at the 29 m mark.

Date	Image #	Time	Description
2-Oct	IMGP0358	9:48	**L2T6** at POC looking down line
	IMGP0359	9:54	Looking down line at the 29 m mark.
	IMGP0360	9:55	Looking up line at the 29 m mark.
	IMGP0361	9:56	Looking down line across the river from the EOT.
	IMGP0362	9:56	Looking up line from the EOT.
	IMGP0363	9:56	Looking upstream from the EOT.
	IMGP0364	9:57	Looking downstream from the EOT.
	IMGP0365	10:12	Seedlings in plot frame at the 25 m mark.
	IMGP0366	10:12	2013 seedlings size references at the 25 m mark.
	IMGP0367	10:12	2013 seedlings size references at the 25 m mark.
	IMGP0368	10:12	2013 seedlings size references at the 25 m mark.
	IMGP0369	10:15	2013 seedlings size references at the 25 m mark.
	IMGP0370	10:15	2013 seedlings size references at the 25 m mark.
	IMGP0371	10:31	2013 seedlings size references at the 25 m mark.
	IMGP0372	11:50	2013 seedlings size references at the 25 m mark.
	IMGP0373	11:51	2013 seedlings size references at the 25 m mark.
	IMGP0374	11:51	2013 seedlings size references at the 25 m mark.
2-Oct	DSCN1917	12:25	**L1T36** Looking down line on edge of shrubs from 5 m mark.
	DSCN1918	12:27	Looking up line from the 15 m mark.
	DSCN1919	12:27	Looking down the line from the 15 m mark.
	DSCN1920	12:27	Looking downstream from the 15 m mark.
	DSCN1921	12:27	Looking upstream from the 15 m mark.
	DSCN1922	12:29	Looking up line from the 28 m mark.
	DSCN1923	12:29	Looking down line from the 28 m mark.
	DSCN1924	12:52	The seedling plot at the 10 m mark.
	DSCN1925	12:53	Flood trained clones downstream of line.
1-Oct	DSCF0600	15:19	**L1T20** Looking down line from the POC.
	DSCF0601	15:28	Looking down line from the 16 m mark.
	DSCF0602	15:29	Looking up line from the 16 m mark.
	DSCF0603	15:33	Looking down line from the EOT. EOT ends at the bank of a back channel.
	DSCF0604	15:33	Looking up line from the EOT.
	DSCF0605	15:33	Looking upstream from the EOT.
	DSCF0606	15:33	Looking downstream from the EOT.
	DSCF0607	16:08	Ground cover and seedlings at the 10 m mark.
2-Oct	IMGP0375	12:16	Looking down line from the EOT across the river.
	IMGP0376	12:16	Looking up line from the EOT.
	IMGP0377	12:16	Looking upstream from the EOT.
	IMGP0378	12:16	Looking downstream from the EOT.
	IMGP0379	12:17	Looking down line from the 36 m mark.
	IMGP0380	12:17	Looking up line from the 36 m mark.
	IMGP0381	13:25	Looking down line from the POC.
1-Oct	DSCF0591	10:32	**L1T10** Looking down line from the EOT.
	DSCF0592	10:32	Looking up line from the EOT.
	DSCF0593	10:32	Looking upstream from the EOT.
	DSCF0594	10:32	Looking downstream from the EOT.
	DSCF0595	10:33	Looking down line from the 32 m mark.
	DSCF0596	10:33	Looking up line from the 32 m mark.
	DSCF0597	10:34	Looking down line from the POC.
	DSCF0598	13:16	Looking downstream at the sandbar from the 40 m mark.

Date	Image #	Time	Description
1-Oct	DSCF0599	14:24	**L1T10** (Continued) seedlings at the 27 m mark.
1-Oct	DSCF0582	9:18	**L1T1** Looking down line across the river from the EOT.
	DSCF0583	9:18	Looking up line from the EOT.
	DSCF0584	9:18	Looking upstream from the EOT
	DSCF0585	9:18	Looking downstream from the EOT.
	DSCF0586	9:19	Looking down line from the 23 m mark.
	DSCF0587	9:19	Looking up line from the 23 m mark.
	DSCF0588	9:23	Looking down line from the POC.
	DSCF0589	9:41	Habitat at the 15 m mark.
	DSCF0590	9:41	Close up at the 15 m mark.

Appendix 3: Duncan and Lardeau rivers contact sheets

Duncan River D4T3, April 28, 2014

DSCN0558

DSCN0559

DSCN0560

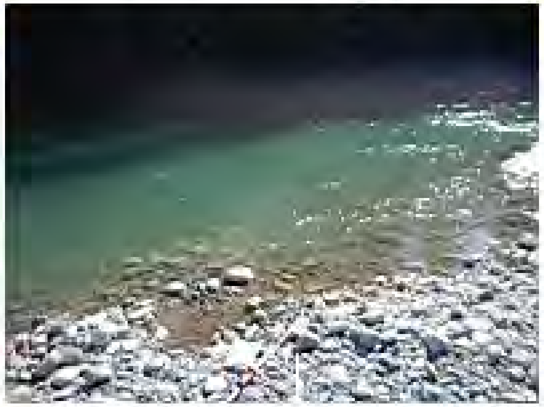
DSCN0561

DSCN0562

DSCN0563

Duncan River D4T5, April 29, 2014

DSCN0575



DSCN0576

DSCN0577

DSCN0578

DSCN0579

DSCN0580

DSCN0581

DSCN0582

DSCN0583

DSCN0584

DSCN0585

DSCN0586

Duncan River D4T10, April 28, 2014


DSCN0564


DSCN0565


DSCN0566


DSCN0567


DSCN0568


DSCN0569


DSCN0570

Duncan River Near D3T11 - Beaver Killed Cottonwood Trees - April 28, 2014


DSCN0571


DSCN0572


DSCN0573


DSCN0574

Duncan River D3T10 July 28, 2014

DSCN1209

DSCN1210

DSCN1211

DSCN1212

DSCN1213

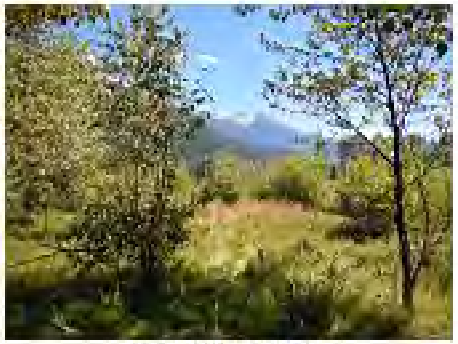
DSCN1214

DSCN1215

DSCN1216

DSCN1217

Duncan River D3T11, July 28 and July 29, 2014


DSCN1218


DSCN1219


DSCN1221


DSCN1222


DSCN1223


DSCN1224


DSCN1225


DSCN1226


DSCN1227


DSCN1229


DSCN1230


DSCN1231


DSCN1232


DSCN1233


DSCN1234


DSCN1235

Duncan River D3T15 July 30 2014


DSCN1484


DSCN1485


DSCN1486


DSCN1487


DSCN1488


DSCN1489


DSCN1490

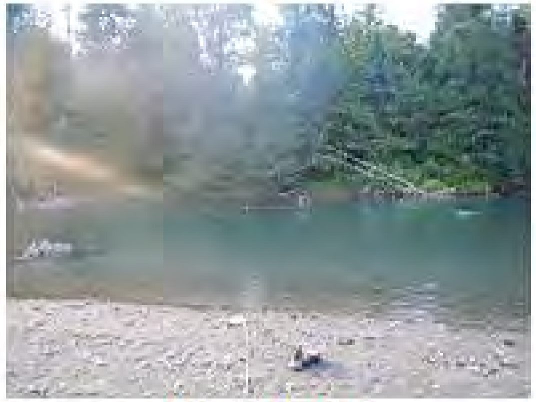

DSCN1491


DSCN1492

Duncan River D3T17 and Area Upstream of T17, July 30, 2014


DSCN1493


DSCN1494


DSCN1495


DSCN1496


DSCN1497


DSCN1498


DSCN1499


DSCN1500


DSCN1501


DSCN1502


DSCN1503

Duncan River D3T20 July 29, 2014


DSCN1263


DSCN1264


DSCN1265


DSCN1266


DSCN1267


DSCN1268


DSCN1269


DSCN1270

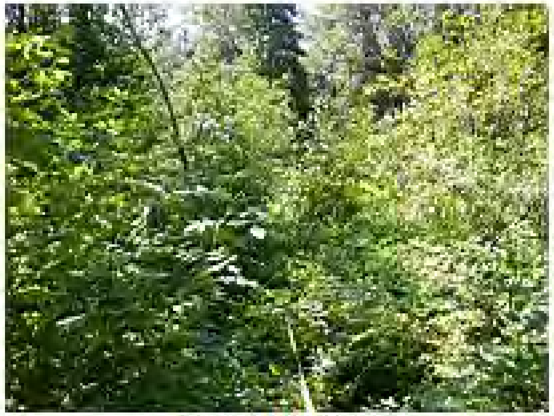

DSCN1271

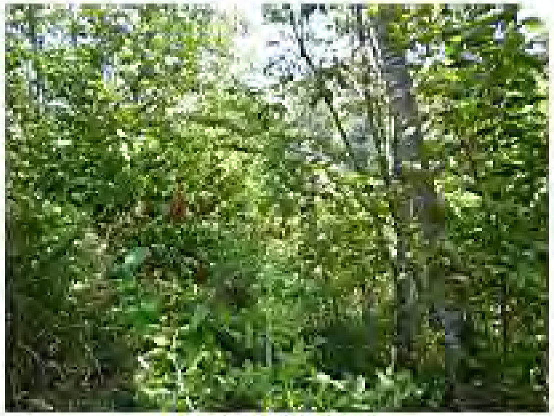

DSCN1272

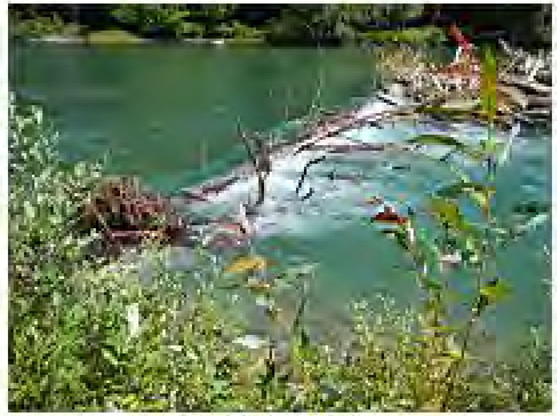

DSCN1273


DSCN1274

Duncan River D3T23 July 29, 2014


DSCN1275


DSCN1276


DSCN1277


DSCN1278


DSCN1279


DSCN1280


DSCN1281

Duncan River D3T29, July 29, 2014


DSCN1236


DSCN1237


DSCN1238


DSCN1239


DSCN1240


DSCN1241


DSCN1242


DSCN1243


DSCN1244


DSCN1245


DSCN1246


DSCN1247


DSCN1248


DSCN1249

Duncan River D3T35 July 29, 2014


DSCN1251


DSCN1252


DSCN1253


DSCN1254


DSCN1255


DSCN1256


DSCN1257


DSCN1258


DSCN1259

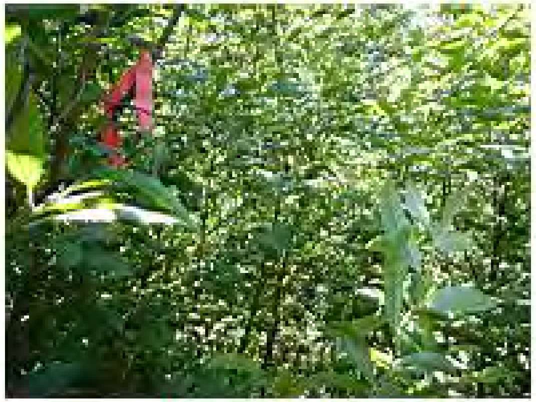

DSCN1260


DSCN1261


DSCN1262

Duncan River D3T40 July 29, 2014

DSCN1292



DSCN1293

DSCN1294

DSCN1295

DSCN1296

DSCN1297

DSCN1298

DSCN1299

DSCN1300

DSCN1301

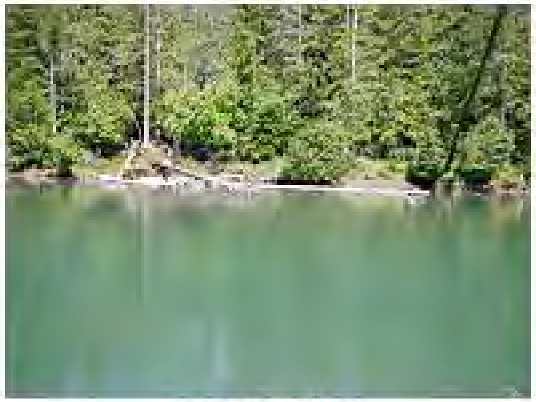
Duncan River D3T45 July 29, 2014

DSCN1282

DSCN1283

DSCN1284

DSCN1285



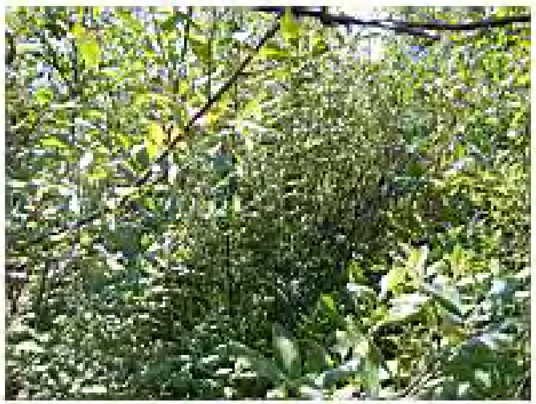
DSCN1286

DSCN1287

DSCN1288

DSCN1289

DSCN1290



DSCN1291

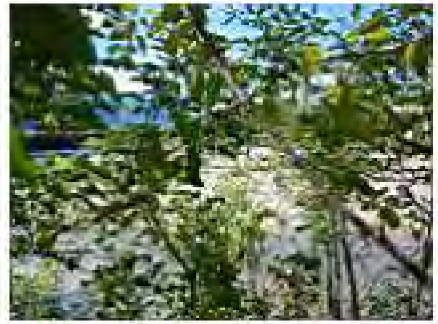
Duncan River D4T3, July 29, 2014


DSCN1302


DSCN1303

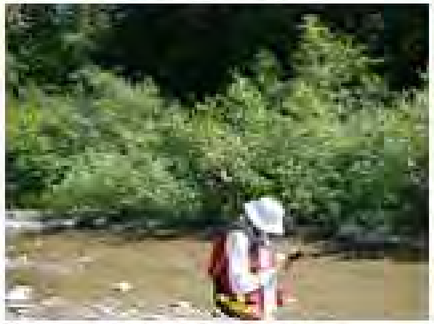

DSCN1304


DSCN1305


DSCN1306


DSCN1307


DSCN1308


DSCN1309


DSCN1310


DSCN1311


DSCN1312


DSCN1313


DSCN1314


DSCN1315


DSCN1324


DSCN1327


DSCN1328


DSCN1329


DSCN1330


DSCN1331

Duncan River D4T3, July 29, 2014

DSCN1332

DSCN1333

DSCN1334

DSCN1335

DSCN1336

DSCN1337

DSCN1338

DSCN1339

DSCN1340

DSCN1341

DSCN1342

Duncan River D4T10 and D4T5, July 29, 2014


DSCN1316


DSCN1317


DSCN1318


DSCN1319


DSCN1320


DSCN1321


DSCN1322


DSCN1323


DSCN1343

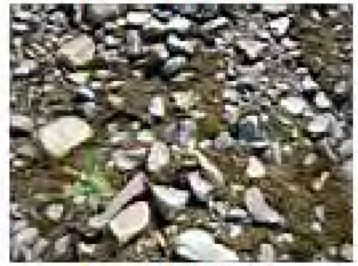

DSCN1344


DSCN1345


DSCN1346

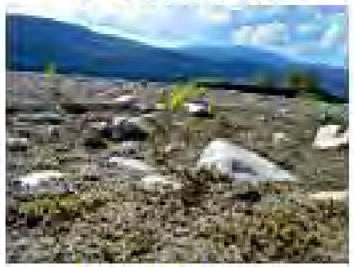

DSCN1347

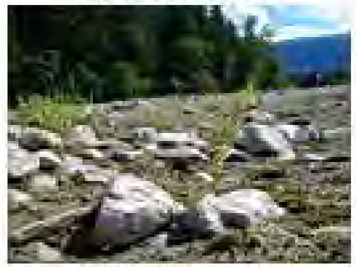

DSCN1348


DSCN1349

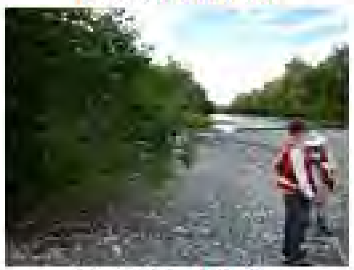

DSCN1350


DSCN1351


DSCN1352

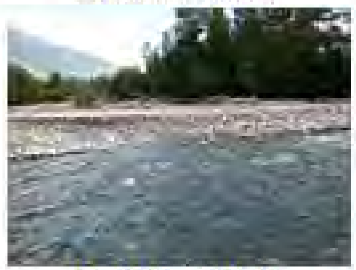

DSCN1353


DSCN1354


D4T5_1356

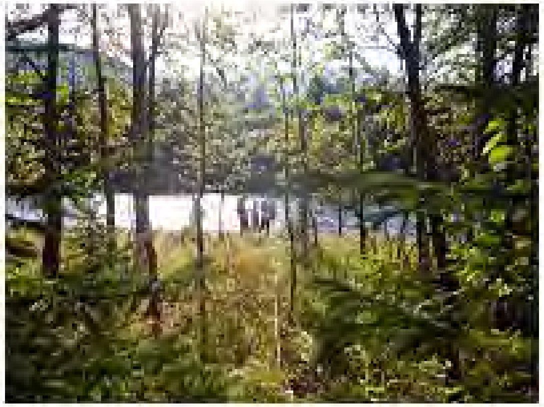

D4T5_1357


D4T5_1358

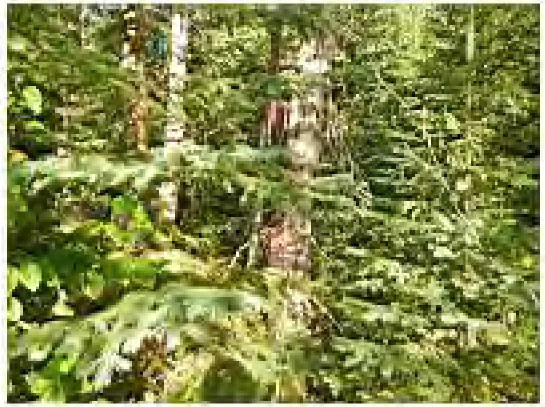

D4T5_1359


D4T5_1360

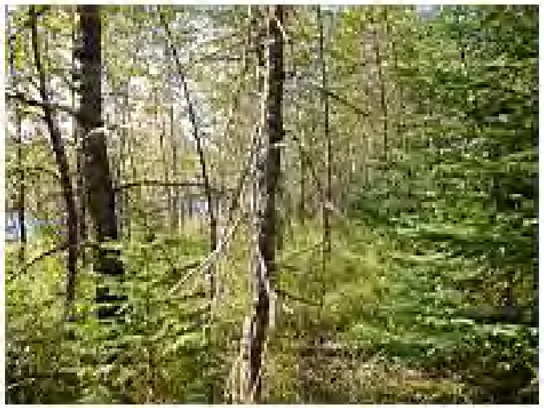
Duncan River D5T2, July 30, 2014


DSCN1361

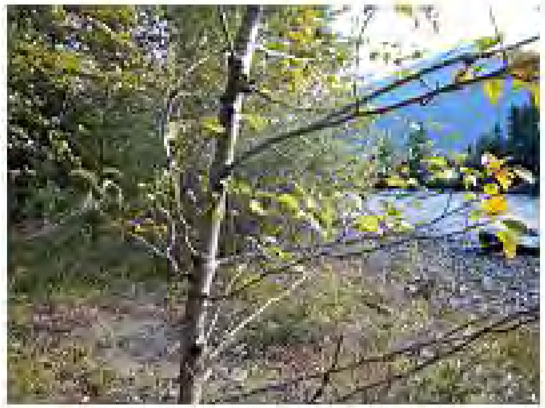

DSCN1362


DSCN1363

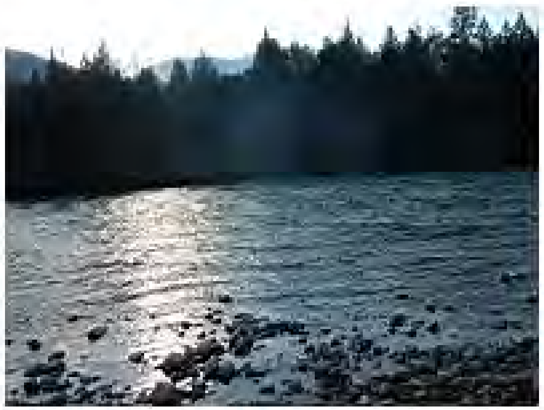

DSCN1364


DSCN1365


DSCN1367


DSCN1368


DSCN1369

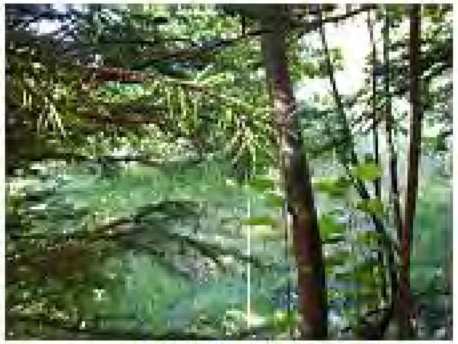

DSCN1370

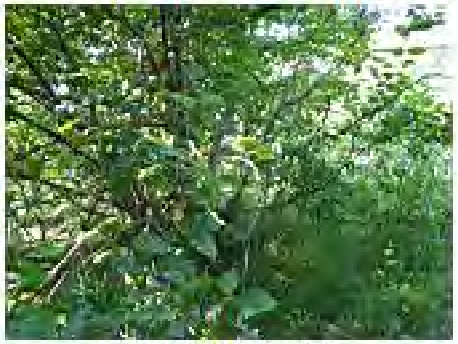

DSCN1371


DSCN1372

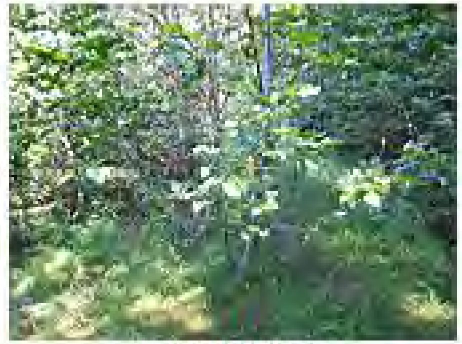

DSCN1373

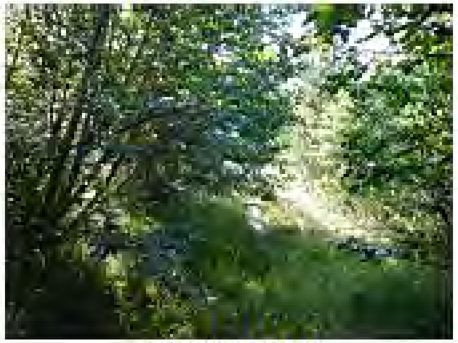
Duncan River D5T9, July 30, 2014


DSCN1374

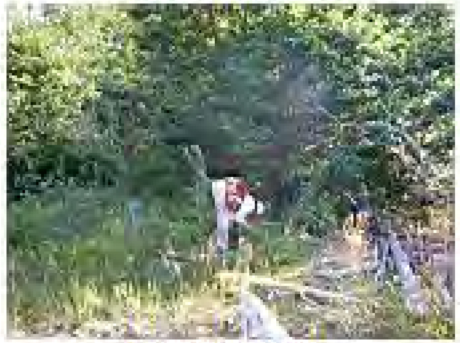

DSCN1375


DSCN1376


DSCN1377


DSCN1378

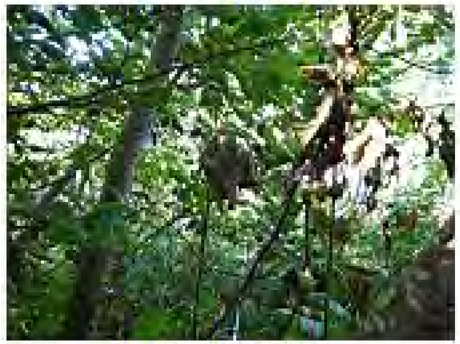

DSCN1379


DSCN1380

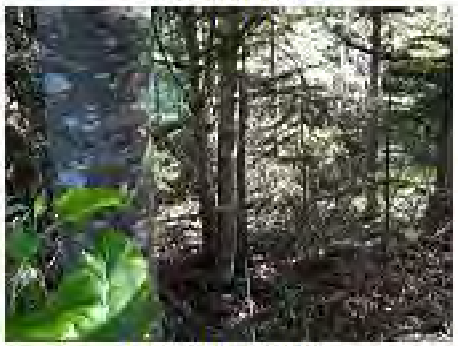

DSCN1381


DSCN1382


DSCN1383


DSCN1384

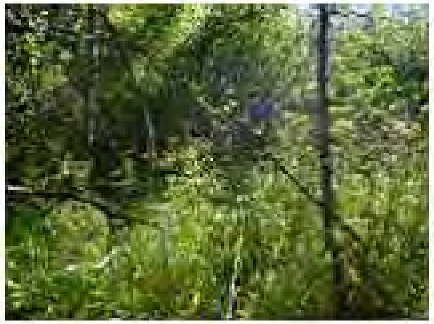

DSCN1385


DSCN1386


DSCN1387


DSCN1388

Duncan River D5T11, July 30, 2014

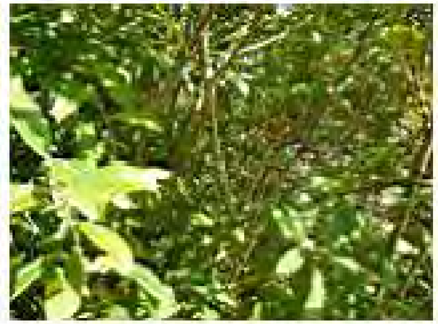


DSCN1389

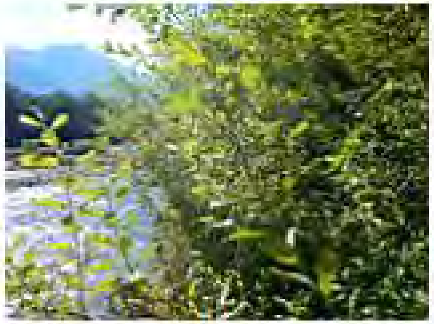
DSCN1390

DSCN1391

DSCN1392



DSCN1393



DSCN1394

DSCN1395

DSCN1396

DSCN1397

DSCN1398

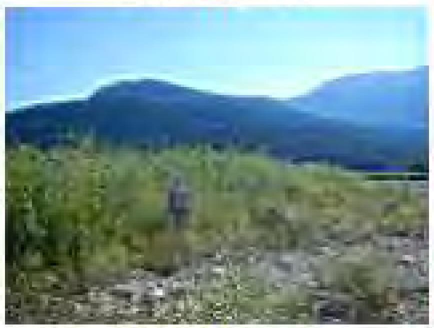
DSCN1399

DSCN1400

DSCN1401

DSCN1402

DSCN1413

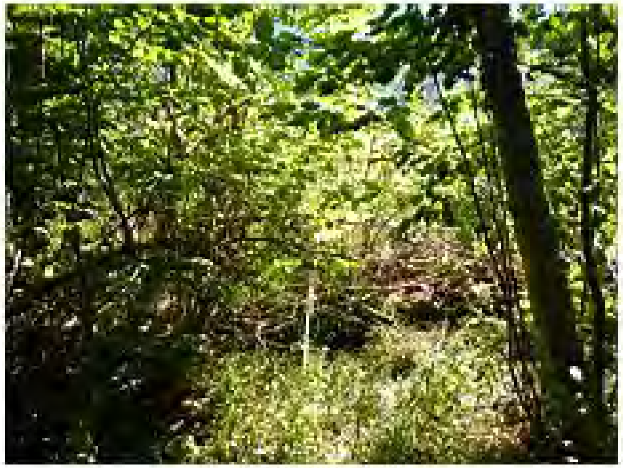


DSCN1414

DSCN1415

DSCN1416

Duncan River D5T12, July 30, 2014


DSCN1403


DSCN1404


DSCN1405


DSCN1406


DSCN1408

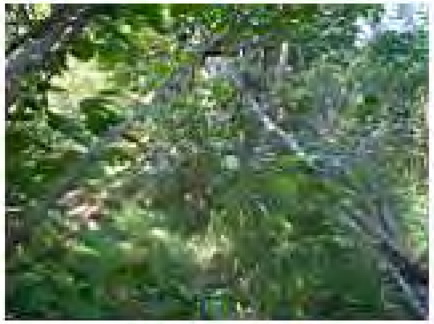

DSCN1409

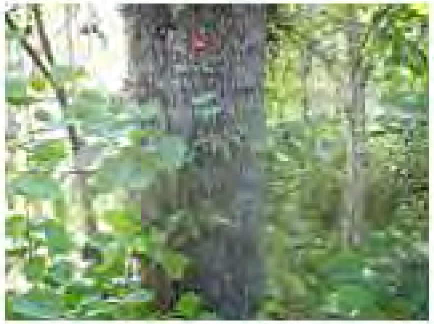

DSCN1410


DSCN1411

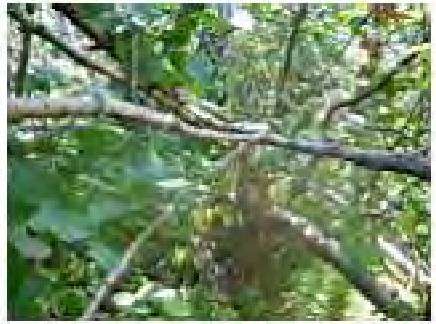

DSCN1412

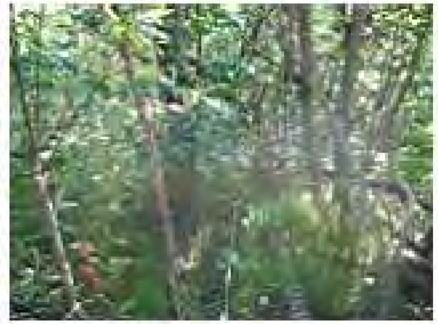
Duncan River D5T16, July 30, 2014

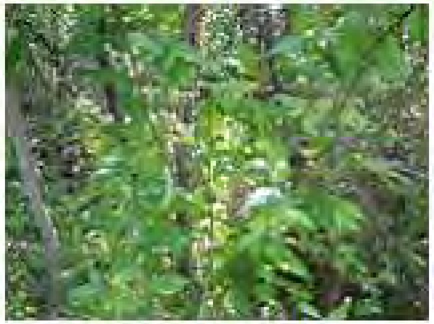

DSCN1417


DSCN1418


DSCN1419


DSCN1420


DSCN1421


DSCN1422


DSCN1423


DSCN1424


DSCN1425


DSCN1426


DSCN1427


DSCN1428


DSCN1429


DSCN1430


DSCN1431


DSCN1432


DSCN1433


DSCN1434


DSCN1435

Duncan River D5T19, July 30, 2014

DSCN1436

DSCN1437

DSCN1438

DSCN1439

DSCN1440

DSCN1441

DSCN1442

DSCN1443

DSCN1444

Duncan River D6T6, July 30, 2014

DSCN1472

DSCN1473

DSCN1474

DSCN1475

DSCN1476

DSCN1477

DSCN1478

DSCN1479

DSCN1480

DSCN1481

DSCN1482

DSCN1483

Duncan River D6T20, July 30, 2014


DSCN1461


DSCN1462


DSCN1463


DSCN1464


DSCN1465


DSCN1466


DSCN1467


DSCN1468


DSCN1469


DSCN1470


DSCN1471

Duncan River D6T29, July 30, 2014


DSCN1445


DSCN1446


DSCN1447


DSCN1448


DSCN1449


DSCN1450


DSCN1451

Duncan River D6T36, July 30, 2014

DSCN1452

DSCN1453

DSCN1454

DSCN1455

DSCN1456

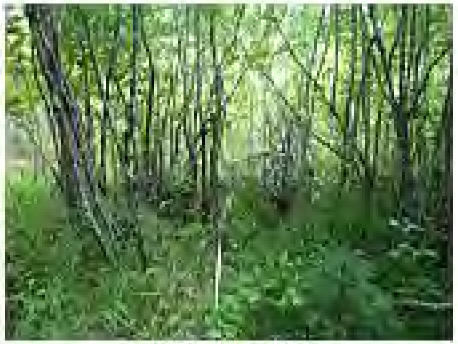
DSCN1457

DSCN1458

DSCN1459

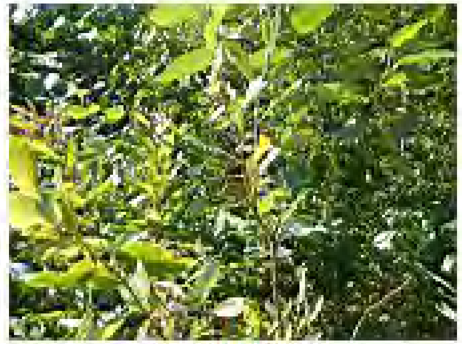
DSCN1460

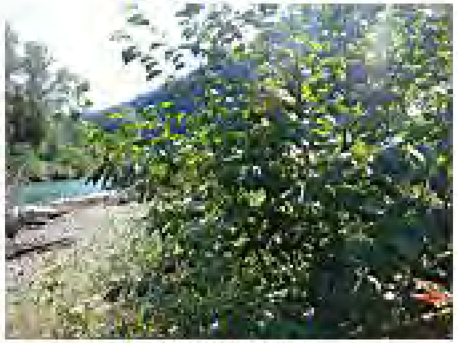
Lardeau River L1T1, July 31, 2014


DSCN1687


DSCN1688


DSCN1689


DSCN1690


DSCN1691


DSCN1692


DSCN1693


DSCN1694


DSCN1695


DSCN1696


DSCN1697

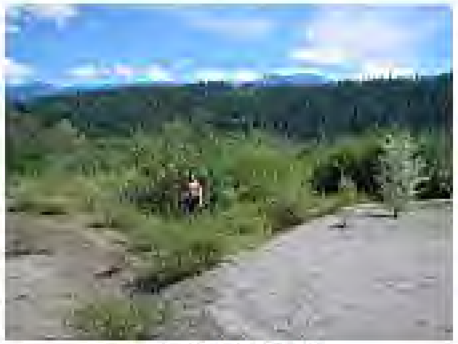

DSCN1698


DSCN1699


DSCN1700


DSCN1701

Lardeau River L1T10, July 31, 2014


DSCN1643


DSCN1644


DSCN1645


DSCN1646


DSCN1647


DSCN1648


DSCN1649


DSCN1650

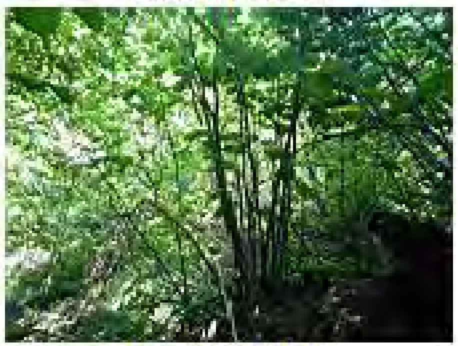

DSCN1651


DSCN1652


DSCN1653


DSCN1654


DSCN1655

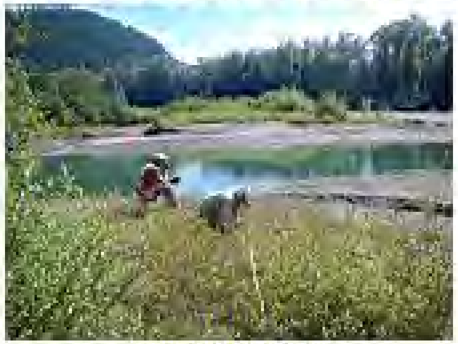

DSCN1656


DSCN1657

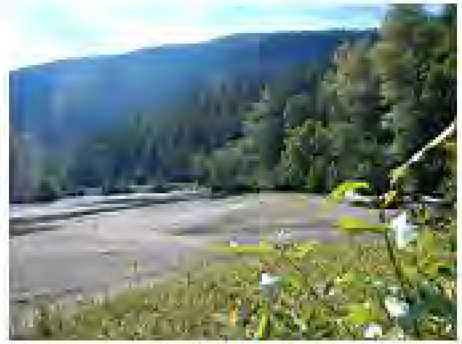

DSCN1658

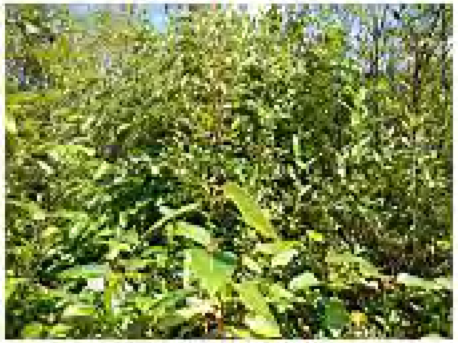
Lardeau River L1T10, July 31, 2014


DSCN1659


DSCN1660


DSCN1661


DSCN1662


DSCN1663


DSCN1664


DSCN1665


DSCN1666


DSCN1667


DSCN1668


DSCN1669


DSCN1670


DSCN1671


DSCN1672


DSCN1673


DSCN1674

Lardeau River L1T10, July 31, 2014


DSCN1675


DSCN1676


DSCN1677


DSCN1678


DSCN1679


DSCN1680


DSCN1681


DSCN1682

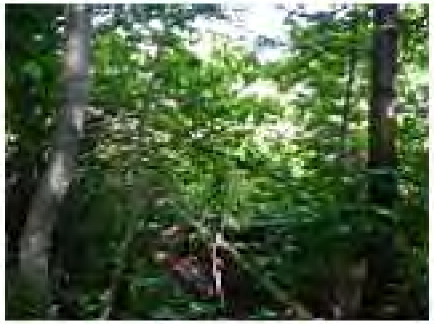

DSCN1683


DSCN1684

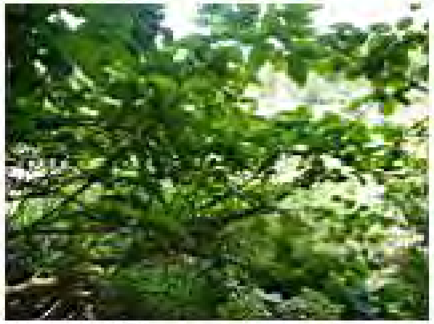

DSCN1685

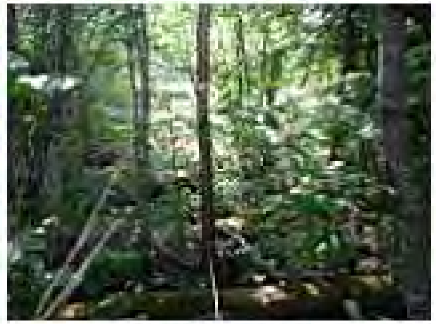

DSCN1686

Lardeau River L1T20, July 31, 2014

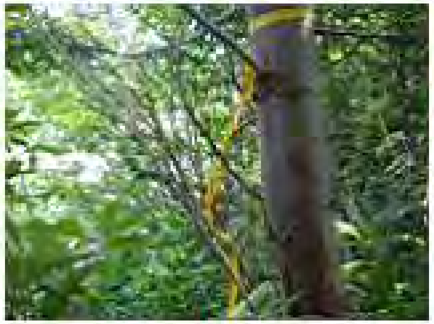

DSCN1587


DSCN1588


DSCN1589


DSCN1590

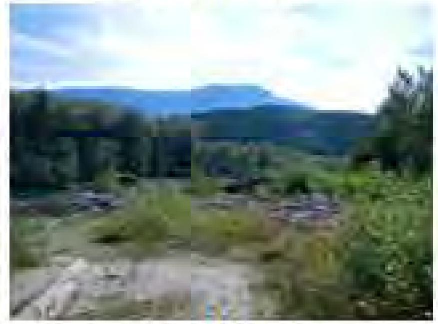

DSCN1591


DSCN1592


DSCN1593


DSCN1594


DSCN1595


DSCN1596


DSCN1597


DSCN1598


DSCN1599


DSCN1600


DSCN1601


DSCN1602


DSCN1603


DSCN1604


DSCN1605


DSCN1606

Lardeau River L1T20, July 31, 2014


DSCN1607


DSCN1608


DSCN1609


DSCN1610


DSCN1611


DSCN1612


DSCN1613


DSCN1614


DSCN1615

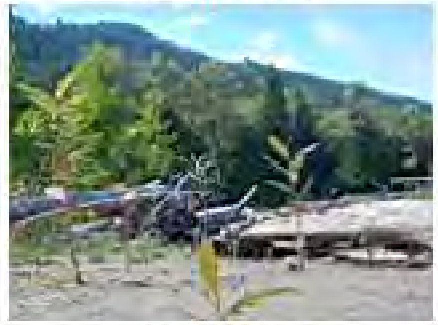

DSCN1616


DSCN1617


DSCN1618


DSCN1619


DSCN1620


DSCN1621


DSCN1622


DSCN1623


DSCN1624


DSCN1625


DSCN1626

Lardeau River L1T20, July 31, 2014


DSCN1627


DSCN1628

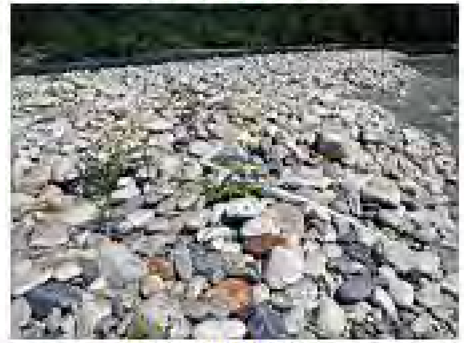

DSCN1629


DSCN1630


DSCN1631


DSCN1632

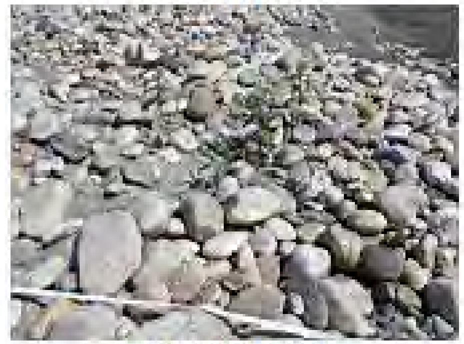

DSCN1633


DSCN1634


DSCN1635


DSCN1636


DSCN1637


DSCN1638


DSCN1639


DSCN1640


DSCN1641

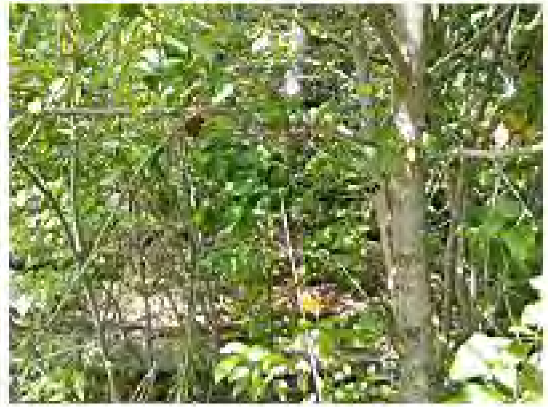

DSCN1642

Lardeau River L1T36, July 31, 2014

DSCN1575

DSCN1576

DSCN1577



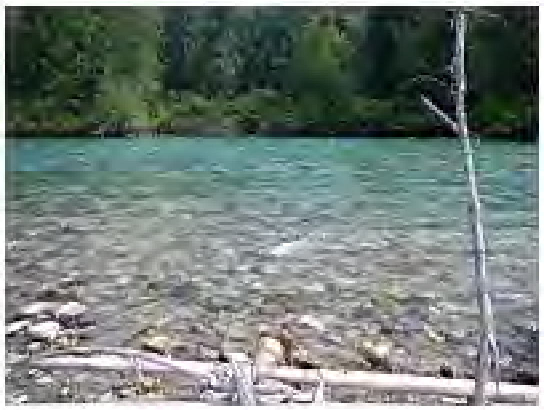
DSCN1578

DSCN1579

DSCN1580

DSCN1581

DSCN1582



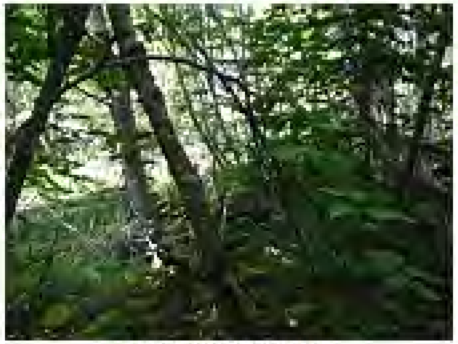
DSCN1583

DSCN1584

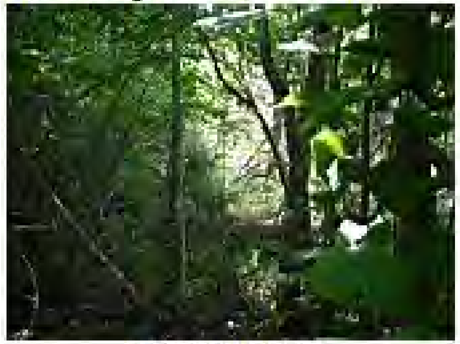
DSCN1585

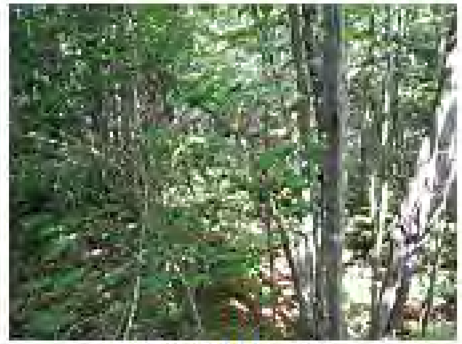
DSCN1586

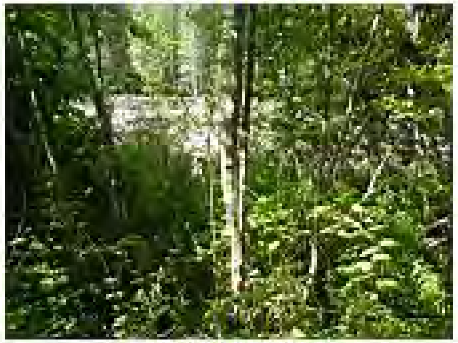
Lardeau River L2T6, July 31, 2014


DSCN1560

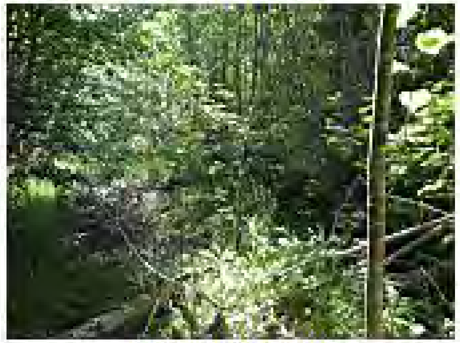

DSCN1561


DSCN1562

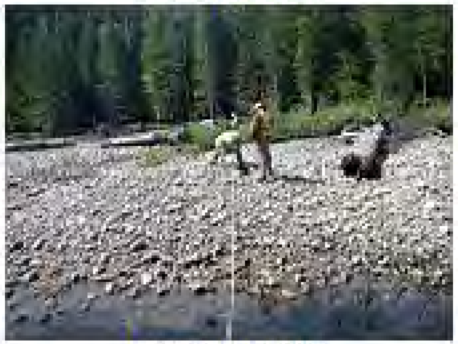

DSCN1563

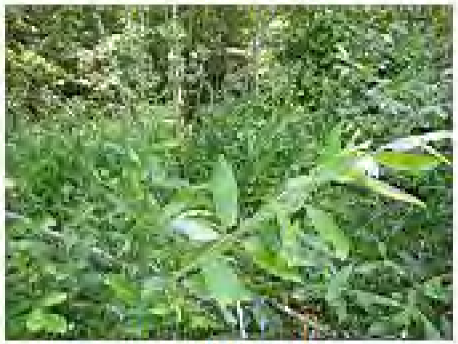

DSCN1564


DSCN1565

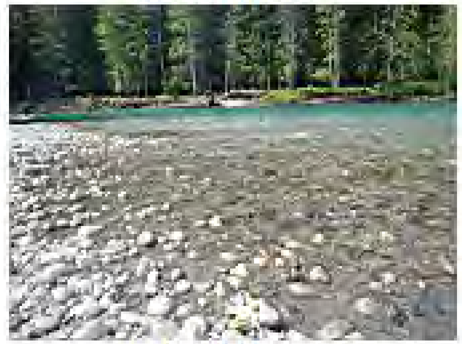

DSCN1566


DSCN1567


DSCN1568


DSCN1569


DSCN1570


DSCN1571


DSCN1572


DSCN1573

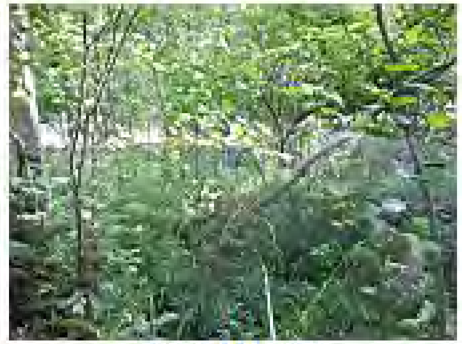

DSCN1574

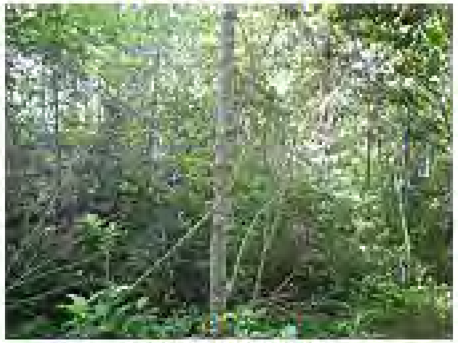
Lardeau River L2T15, July 31, 2014

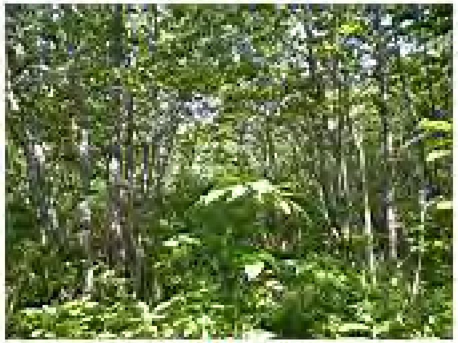

DSCN1546

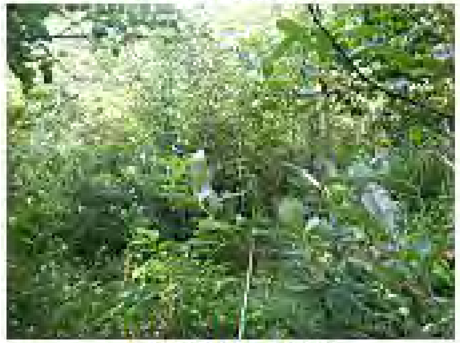

DSCN1547

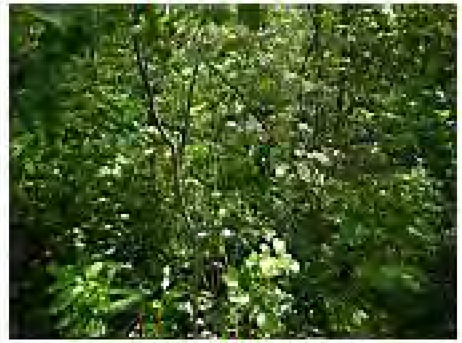

DSCN1548


DSCN1549

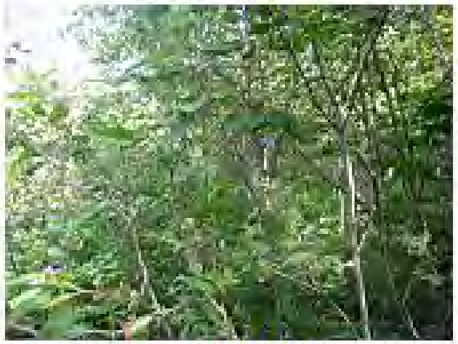

DSCN1550


DSCN1551

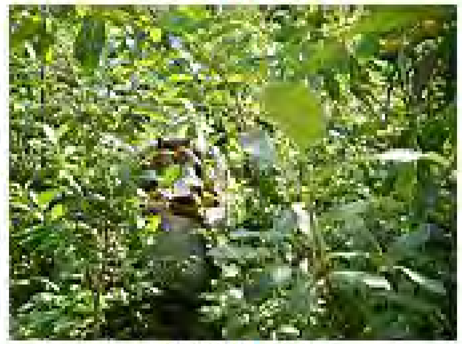

DSCN1552


DSCN1553


DSCN1554


DSCN1555

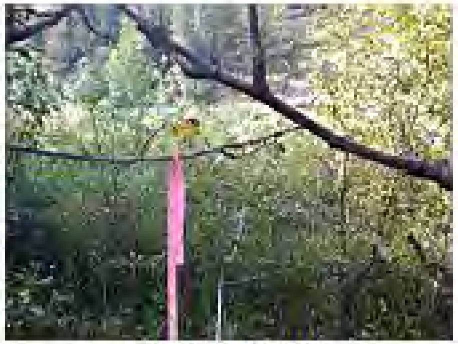

DSCN1556


DSCN1557

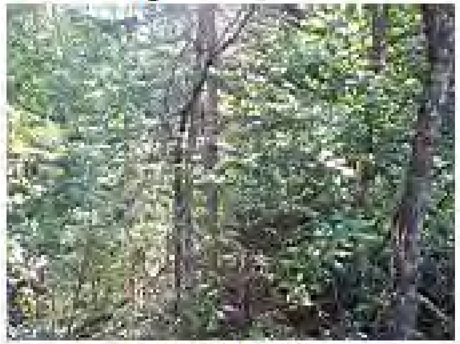

DSCN1558

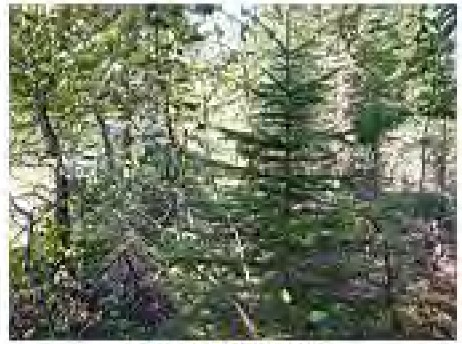

DSCN1559

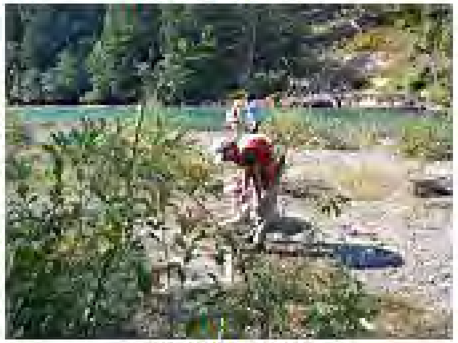
Lardeau River L2T18, July 31, 2014

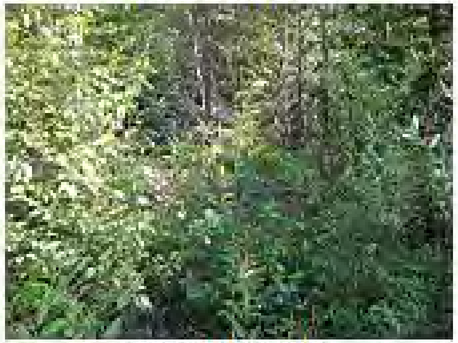

DSCN1530


DSCN1531

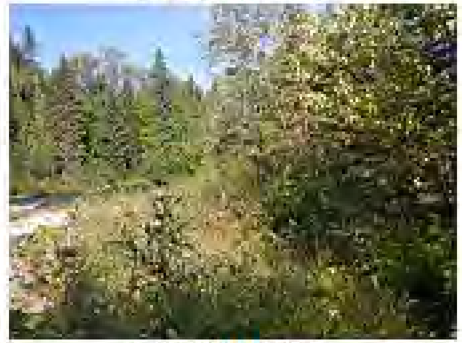

DSCN1532


DSCN1533


DSCN1534


DSCN1535


DSCN1536

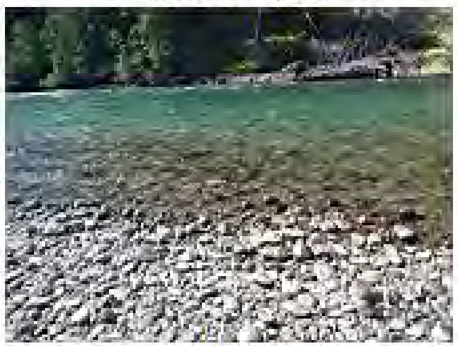

DSCN1537


DSCN1538


DSCN1539


DSCN1540


DSCN1541


DSCN1542


DSCN1543


DSCN1544


DSCN1545

Lardeau River L3T1, July 31, 2014


DSCN1522


DSCN1523


DSCN1524


DSCN1525


DSCN1526


DSCN1527

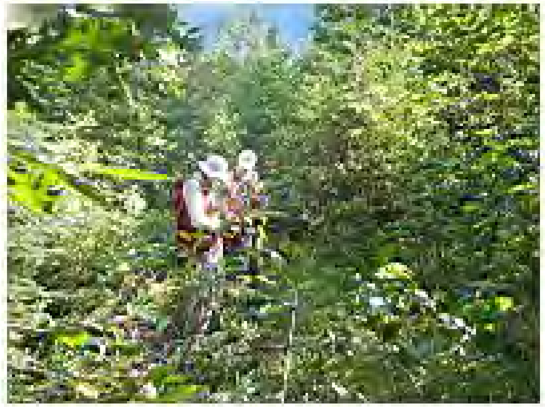

DSCN1528


DSCN1529

Lardeau River L3T9, July 31, 2014

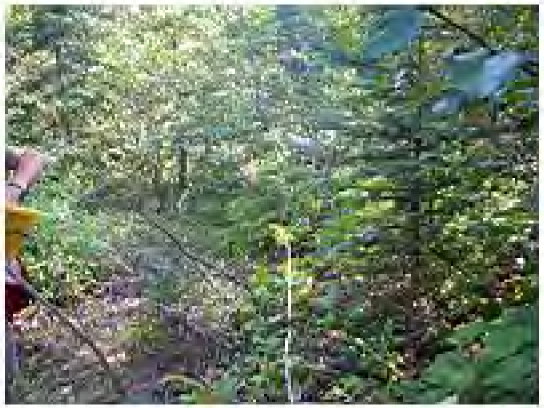
DSCN1512

DSCN1513

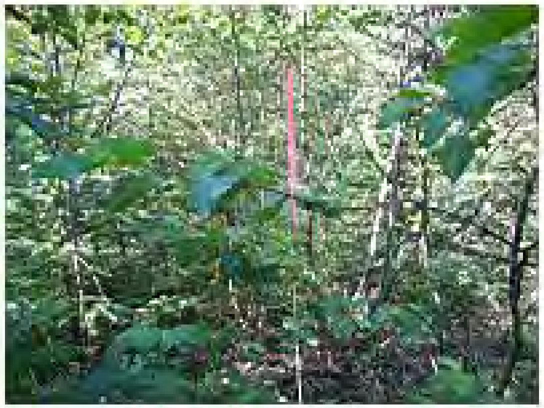


DSCN1514

DSCN1515



DSCN1516



DSCN1517

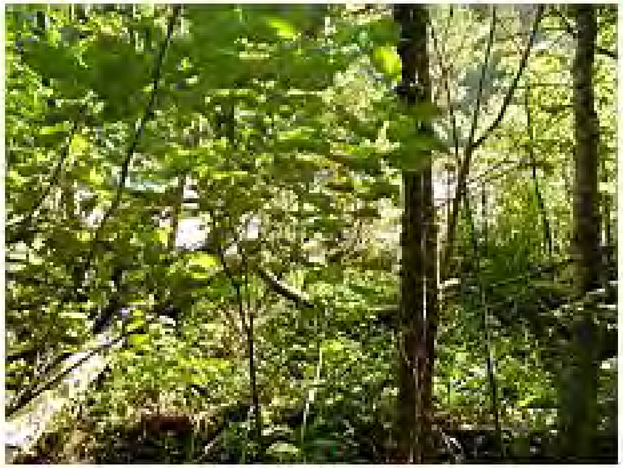
DSCN1518

DSCN1519

DSCN1520

DSCN1521

Lardeau River L3T30, July 31, 2014


DSCN1504


DSCN1505


DSCN1506


DSCN1507


DSCN1508


DSCN1509


DSCN1510


DSCN1511

Duncan River D1T3, September 29, 2014


DSCF0537


DSCF0538


DSCF0539


DSCF0540


DSCF0541


DSCF0542


DSCF0543


DSCF0544


DSCF0545


DSCF0546


DSCF0547


DSCF0548

Duncan River D1T4, September 29, 2014

DSCF0512

DSCF0513

DSCF0514

DSCF0515

DSCF0516

DSCF0517

DSCF0518

DSCF0519

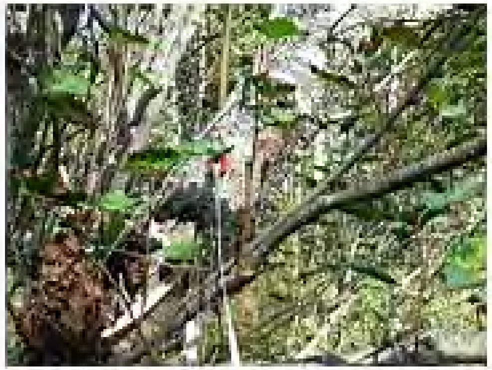
DSCF0520

DSCF0523

DSCF0524

Duncan River D1T5, September 29, 2014

DSCF0525



DSCF0526

DSCF0527

DSCF0528

DSCF0529

DSCF0530

DSCF0531

DSCF0532

DSCF0533

DSCF0534

DSCF0535

Duncan River D3T10, September 29, 2014


DSCN1735


DSCN1736


DSCN1737


DSCN1738


DSCN1739


DSCN1740


DSCN1741


DSCN1742


DSCN1743

Duncan River D3T11, September 29, 2014


DSCN1744


DSCN1745


DSCN1746

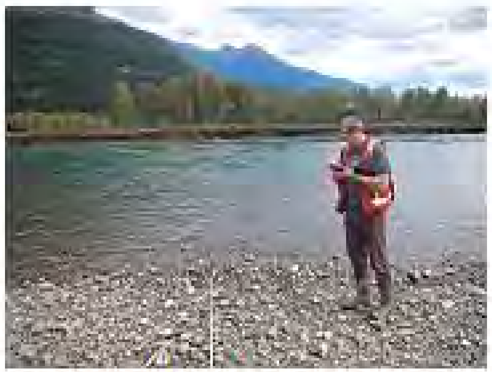

DSCN1747

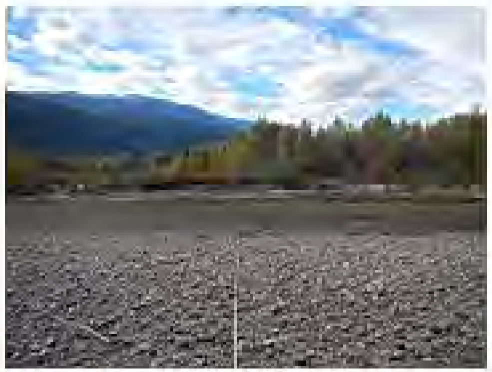

DSCN1748


DSCN1749


DSCN1750


DSCN1751


DSCN1752


DSCN1753


DSCN1754


DSCN1755

Duncan River D3T17, September 29, 2014


DSCN1784


DSCN1785


DSCN1786


DSCN1787


DSCN1788


DSCN1789


DSCN1790


DSCN1791

Duncan River D3T17, September 29, 2014


DSCN1784


DSCN1785


DSCN1786


DSCN1787


DSCN1788


DSCN1789


DSCN1790


DSCN1791

Duncan River D3T20, September 30, 2014


DSCN1792


DSCN1793


DSCN1794


DSCN1795


DSCN1796


DSCN1797


DSCN1798


DSCN1799


DSCN1800

Duncan River D3T20, September 30, 2014


DSCN1792


DSCN1793


DSCN1794


DSCN1795


DSCN1796

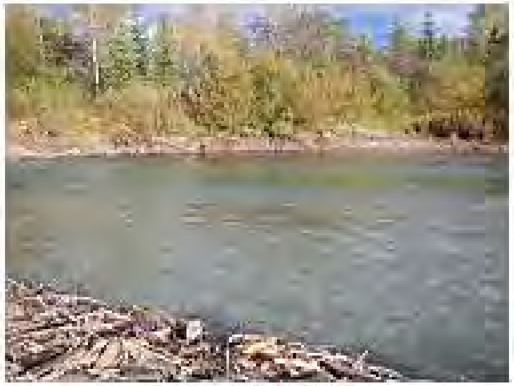

DSCN1797


DSCN1798


DSCN1799


DSCN1800

Duncan River D3T29, September 30, 2014


DSCN1757


DSCN1758


DSCN1759


DSCN1760


DSCN1761


DSCN1762


DSCN1763


DSCN1764


DSCN1765

Duncan River D3T35, September 30, 2014


DSCN1766


DSCN1767


DSCN1768


DSCN1769


DSCN1770


DSCN1771


DSCN1772


DSCN1773


DSCN1774

Duncan River D3T40, September 30, 2014

DSCN1818

DSCN1819

DSCN1820

DSCN1821

DSCN1822

DSCN1823

DSCN1824

DSCN1825

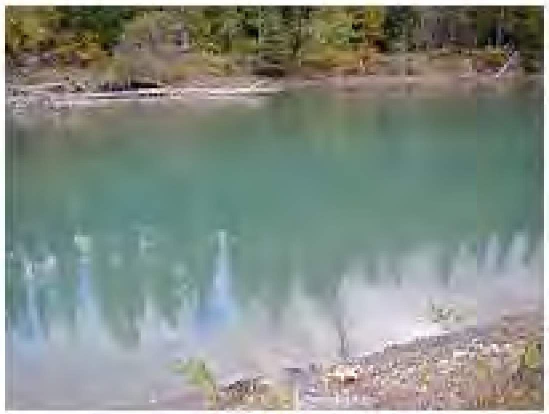
DSCN1826

Duncan River D3T45 September 30, 2014


DSCN1809


DSCN1810


DSCN1811


DSCN1812


DSCN1813


DSCN1814


DSCN1815


DSCN1816


DSCN1817

Duncan River D4T3 September 29, 2014


DSCF0555 (2)


DSCF0556 (2)


DSCF0557 (2)


DSCF0558 (2)


DSCF0559 (2)


DSCF0560 (2)


DSCF0561


DSCF0562


DSCF0563

Duncan River D4T5 September 29, 2014

DSCF0573

DSCF0574

DSCF0575

DSCF0576

DSCF0577

DSCF0578

DSCF0579

DSCF0580

DSCF0581

Duncan River D4T10 September 29, 2014

DSCF0564

DSCF0565

DSCF0566

DSCF0567

DSCF0568

DSCF0569

DSCF0570

DSCF0571

DSCF0572

Duncan River D5T2 September 30, 2014


DSCF0545 (2)

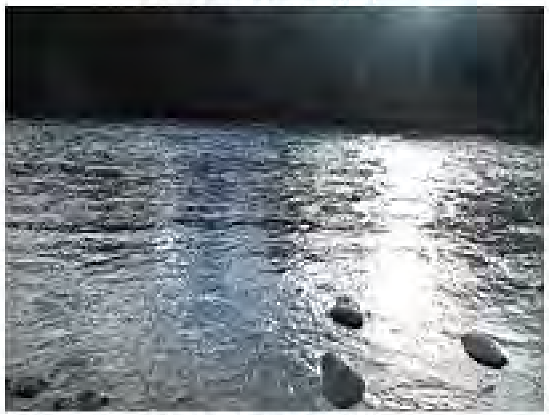

DSCF0546 (2)


DSCF0547 (2)


DSCF0548 (2)


DSCF0550 (2)


DSCF0551 (2)


DSCF0552 (2)


DSCF0553 (2)


DSCF0554 (2)

Duncan River D5T9 September 30, 2014


DSCF0549


DSCF0550


DSCF0552


DSCF0554


DSCF0557


DSCF0558


DSCF0555


DSCF0559


DSCF0560

Duncan River D5T11 October 1, 2014


DSCN1827


DSCN1828


DSCN1829


DSCN1830


DSCN1831


DSCN1832


DSCN1833


DSCN1834


DSCN1835

Duncan River D5T12 October 1, 2014

DSCN1836

DSCN1837

DSCN1838

DSCN1839

DSCN1840

DSCN1841

DSCN1842

DSCN1843

DSCN1844

Duncan River D5T16, October 1, 2014


DSCN1845


DSCN1846


DSCN1847


DSCN1848


DSCN1849


DSCN1850

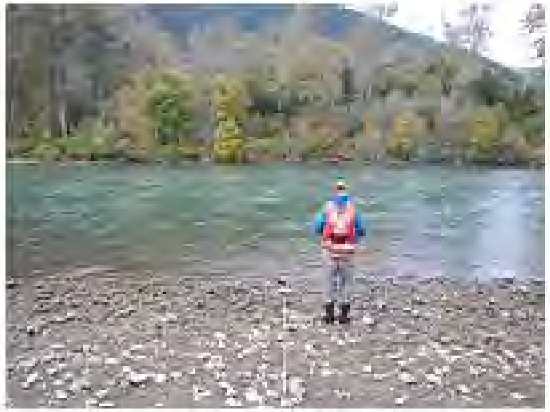

DSCN1851


DSCN1852


DSCN1853

Duncan River D5T19, October 1, 2014


DSCN1854


DSCN1855


DSCN1856


DSCN1857


DSCN1858


DSCN1859


DSCN1861


DSCN1862


DSCN1863

Duncan River D6T20, October 1, 2014


DSCN1882


DSCN1883


DSCN1884


DSCN1885


DSCN1886


DSCN1887


DSCN1888


DSCN1889


DSCN1890

Duncan River D6T29, October 1, 2014


DSCN1864


DSCN1865


DSCN1866


DSCN1867


DSCN1868


DSCN1869


DSCN1870


DSCN1871


DSCN1872

Duncan River D6T36, October 1, 2014


DSCN1873


DSCN1874


DSCN1875


DSCN1876


DSCN1877


DSCN1878


DSCN1879


DSCN1880


DSCN1881

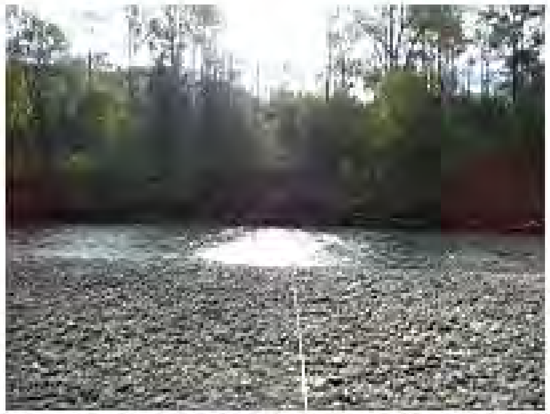
Lardeau River L1T1, October 2, 2014


DSCF0582


DSCF0583


DSCF0584


DSCF0585


DSCF0586


DSCF0587


DSCF0588


DSCF0589


DSCF0590

Lardeau River L1T10, October 2, 2014


DSCF0591


DSCF0592


DSCF0593


DSCF0594


DSCF0595


DSCF0596


DSCF0597


DSCF0598


DSCF0599

Lardeau River L1T20, October 2, 2014


DSCF0600


DSCF0601


DSCF0604


DSCF0607


IMGP0376


IMGP0377


IMGP0378


IMGP0379


IMGP0380

Lardeau River L1T36, October 2, 2014

DSCN1917

DSCN1918

DSCN1919

DSCN1920

DSCN1921

DSCN1922

DSCN1923

DSCN1924

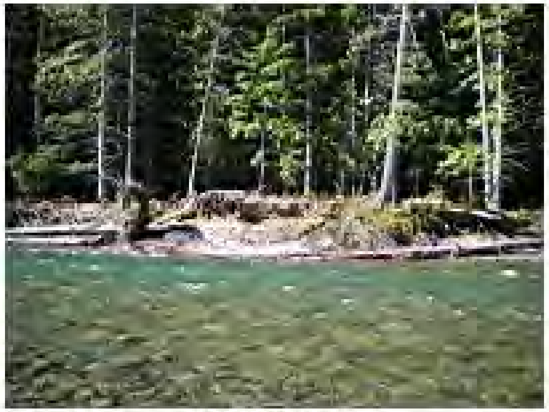
DSCN1925

Lardeau River L2T6, October 2, 2014

IMGP0358

IMGP0359

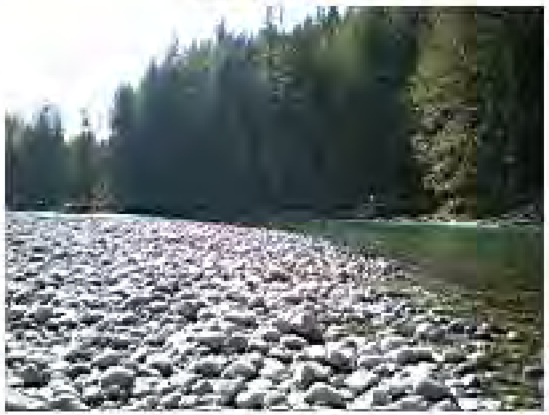
IMGP0360



IMGP0361

IMGP0362

IMGP0363



IMGP0364

IMGP0365

IMGP0366

Lardeau River L2T6, October 2, 2014


IMGP0367


IMGP0368


IMGP0369


IMGP0370


IMGP0371


IMGP0372


IMGP0373

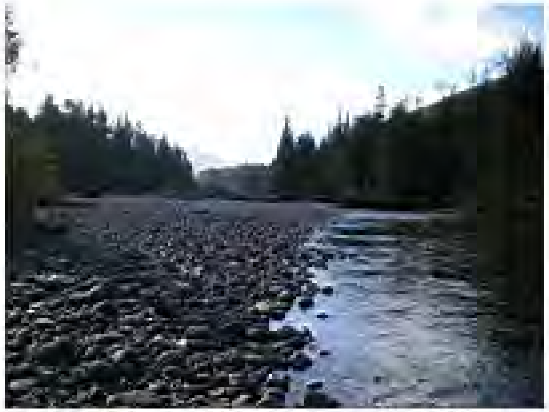

IMGP0374

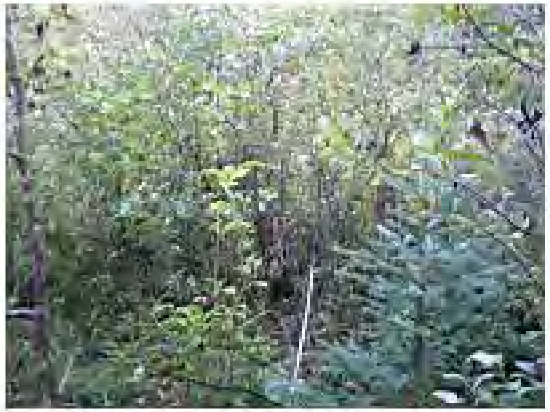
Lardeau River L2T15, October 2, 2014


IMGP0347


IMGP0348


IMGP0349


IMGP0350


IMGP0352


IMGP0353


IMGP0355

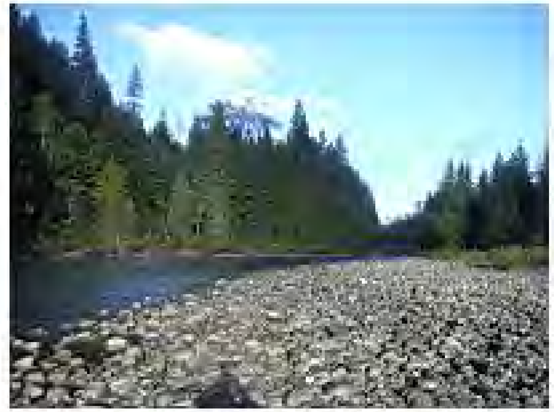

IMGP0356


IMGP0357

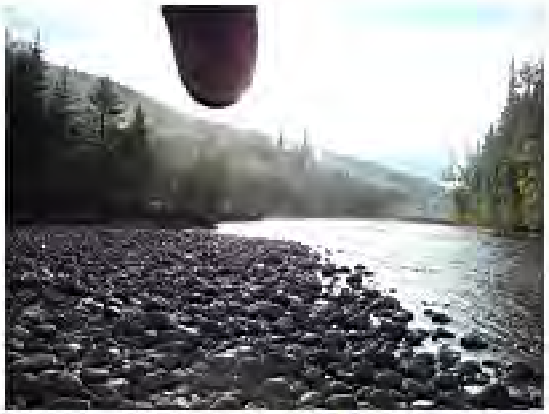
Lardeau River L2T18, October 2, 2014

DSCF0608

DSCF0609



DSCF0610



DSCF0611

DSCF0612

IMGP0344

IMGP0345

IMGP0346

Lardeau River L3T1, October 2, 2014


DSCN1908


DSCN1909


DSCN1910

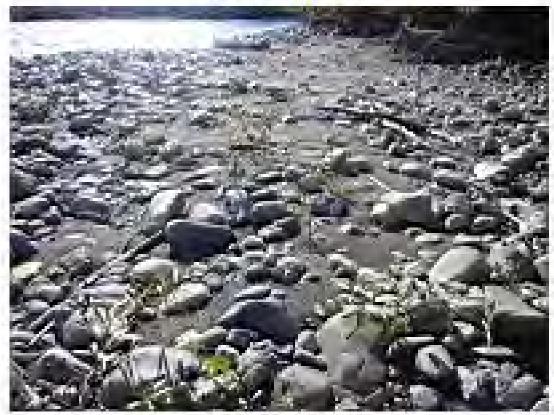

DSCN1911


DSCN1912


DSCN1913

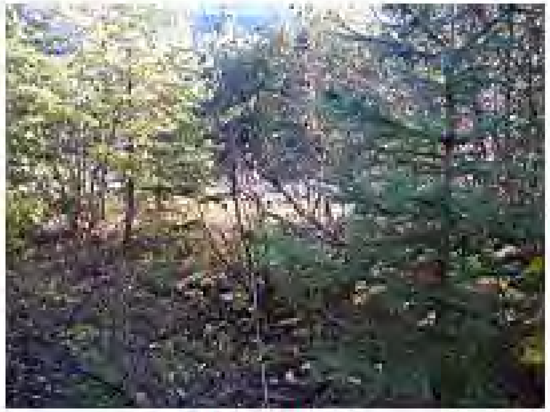

DSCN1914


DSCN1915

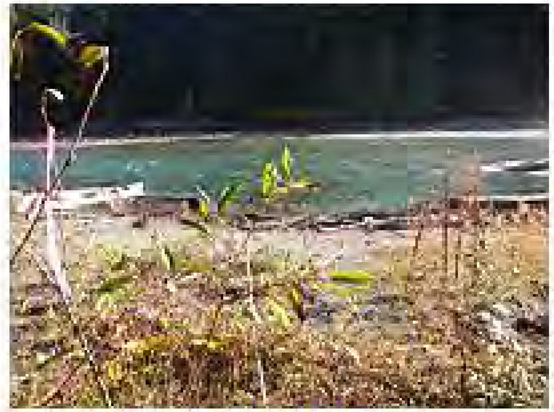

DSCN1916

Lardeau River L3T9, October 2, 2014

DSCN1899



DSCN1900



DSCN1901

DSCN1902

DSCN1903

DSCN1904

DSCN1905

DSCN1906

DSCN1907

Lardeau River L3T30, October 2, 2014


DSCN1891


DSCN1892


DSCN1893


DSCN1894


DSCN1895


DSCN1896


DSCN1897


DSCN1898

Appendix 4: Statistical Analysis Details

Duncan River seedling density

One Way Repeated Measures Analysis of Variance Tuesday, October 21, 2014, 9:26:19 AM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Treatment Name	N	Missing	Mean	Std Dev	SEM
D_Jul_14	547	11	42.184	78.673	3.398
D_Jul_13	410	79	41.885	68.320	3.755
D_Aug_12	249	239	5.700	3.057	0.967

Source of Variation	DF	SS	MS	F	P
Between Subjects	546	2483678.629	4548.862		
Between Treatments	2	142813.127	71406.564	9.891	<0.001
Residual	328	2368052.458	7219.672		
Total	876	4864826.455	5553.455		

The differences in the mean 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.

Power of performed test with alpha = 0.050: 0.981

Expected Mean Squares:
Approximate DF Residual = 328.000
Expected MS(Subj) = var(res) + 1.601 var(Subj)
Expected MS(Treatment) = var(res) + var(Treatment)
Expected MS(Residual) = var(res)

All Pairwise Multiple Comparison Procedures (Holm-Sidak method):
Overall significance level = 0.05

Comparisons for factor:

Comparison	Diff of Means	t	P	P<0.050
D_Jul_14 vs. D_Aug_12	141.409	4.274	<0.001	Yes
D_Jul_13 vs. D_Aug_12	130.291	3.908	<0.001	Yes
D_Jul_14 vs. D_Jul_13	11.118	1.668	0.096	No

Because normality test and equal variance test failed and all attempts to transform data (earlier) did not help a Kruskal-Wallis One Way Analysis of Variance on Ranks was completed with the similar results.

Kruskal-Wallis One Way Analysis of Variance on Ranks Tuesday, October 21, 2014, 9:30:53 AM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Group	N	Missing	Median	25%	75%
D_Jul_14	547	11	19.000	10.000	52.750
D_Jul_13	410	79	20.000	6.000	48.000
D_Aug_12	249	239	5.500	3.750	7.750

H = 17.335 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 (Dunn's Method) :

Comparison	**Diff of Ranks**	**Q**	**P<0.05**
D_Jul_14 vs D_Aug_12	314.098	3.885	Yes
D_Jul_14 vs D_Jul_13	32.103	1.813	No
D_Jul_13 vs D_Aug_12	281.995	3.468	Yes

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Testing for difference between the Duncan and Lardeau Reaches for seedling abundance in 2014

Mann-Whitney Rank Sum Test Tuesday, October 21, 2014, 9:56:45 AM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Group	**N**	**Missing**	**Median**	**25%**	**75%**
D_2014	536	0	19.000	10.000	52.750
L_2014	124	0	37.000	22.000	54.000

Mann-Whitney U Statistic= 26865.500

T = 47348.500 n(small)= 124 n(big)= 536 (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)

Lardeau seedling densities

Mann-Whitney Rank Sum Test Tuesday, October 21, 2014, 4:03:53 PM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Group	**N**	**Missing**	**Median**	**25%**	**75%**
L_2014	124	0	37.000	22.000	54.000
L_2013	91	0	11.000	3.000	59.000

Mann-Whitney U Statistic= 4212.000

T = 8398.000 n (small) = 91 n (big)= 124 (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 Tuesday, October 21, 2014, 4:32:44 PM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Group	**N**	**Missing**	**Median**	**25%**	**75%**
L_2014	124	0	37.000	22.000	54.000
L_2012	27	0	68.000	7.000	205.000

Mann-Whitney U Statistic= 1260.000

T = 2466.000 n (small)= 27 n(big)= 124 (P = 0.045)

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 = 0.045)

Mann-Whitney Rank Sum Test Tuesday, October 21, 2014, 4:14:57 PM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Normality Test (Shapiro-Wilk) Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
L1_Jul14	81	0	14.000	7.000	21.500
L1_Aug12	25	0	75.000	16.000	217.500

Mann-Whitney U Statistic= 443.000

T = 1907.000 n(small)= 25 n(big)= 81 (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 Tuesday, October 21, 2014, 4:15:58 PM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Normality Test (Shapiro-Wilk) Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
L1_Jul14	81	0	14.000	7.000	21.500
L1_Jul13	62	0	29.500	8.000	103.500

Mann-Whitney U Statistic= 1708.500

T = 5266.500 n(small)= 62 n(big)= 81 (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 Tuesday, November 04, 2014, 10:05:32 AM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Group	N	Missing	Median	25%	75%
L2_Jul14	32	0	37.000	5.500	53.500
L2_Jul13	25	0	3.000	2.000	7.000

Mann-Whitney U Statistic= 115.000

T = 440.000 n(small)= 25 n(big)= 32 (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 Tuesday, November 04, 2014, 10:07:54 AM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Group	N	Missing	Median	25%	75%
L2_Jul14	32	0	37.000	5.500	53.500
L2_Aug12	11	0	0.000	0.000	0.000

Mann-Whitney U Statistic= 16.000

T = 82.000 n(small)= 11 n(big)= 32 (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 Tuesday, November 04, 2014, 10:08:59 AM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Group	N	Missing	Median	25%	75%
L3_Jul14	11	0	32.000	22.000	54.000
L3_Jul13	11	0	0.000	0.000	1.000

Mann-Whitney U Statistic= 0.000

T = 187.000 n (small)= 11 n(big)= 11 (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 Tuesday, November 04, 2014, 10:10:26 AM

Data source: 2013Est_12_10Est_09Est in D_L_seedling density_2013_2014.JNB

Group	N	Missing	Median	25%	75%
L3_Jul14	11	0	32.000	22.000	54.000
L3_Aug12	11	0	0.000	0.000	0.000

Mann-Whitney U Statistic= 0.000

T = 187.000 n(small)= 11 n(big)= 11 (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)

Duncan and Lardeau Seedling Survival

Descriptive Statistics: Tuesday, November 04, 2014, 10:34:32 AM

Data source: Data 1 in 2013_14_survival.JNB

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
Dun Surv13	286	0	39.862	31.758	1.878	3.696
Dun Surv114	531	0	30.919	29.429	1.277	2.509
Lard Surv13	91	0	20.844	28.017	2.937	5.835

Lard Surv14	117	0	7.045	15.049	1.391	2.756

Column	Range	Max	Min	Median	25%	75%
Dun Surv13	100.000	100.000	0.000	43.824	5.842	64.179
Dun Surv114	100.000	100.000	0.000	24.194	0.000	58.333
Lard Surv13	100.000	100.000	0.000	6.667	0.000	33.898
Lard Surv14	100.000	100.000	0.000	1.351	0.000	6.905

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	SWilk W	SWilk Prob
Dun Surv13	0.138	-1.232	0.126	<0.001	0.909	<0.001
Dun Surv114	0.514	-1.019	0.153	<0.001	0.883	<0.001
Lard Surv13	1.477	1.457	0.233	<0.001	0.761	<0.001
Lard Surv14	4.028	19.550	0.320	<0.001	0.507	<0.001

Column	Sum	Sum of Squares
Dun Surv13	11400.410	741887.091
Dun Surv114	16417.750	966614.707
Lard Surv13	1896.777	110182.958
Lard Surv14	824.215	32075.787

One Way Repeated Measures Analysis of Variance Tuesday, November 04, 2014, 12:05:27 PM

Data source: Data 1 in 2013_14_survival.JNB

Normality Test (Shapiro-Wilk) Failed (P < 0.050)

Equal Variance Test: Passed (P = 0.309)

Treatment Name	N	Missing	Mean	Std Dev	SEM
Lard Surv14	117	0	7.045	15.049	1.391
Lard Surv13	91	0	20.844	28.017	2.937

Source of Variation	DF	SS	MS	F	P
Between Subjects	116	50178.508	432.573		
Between Treatments	1	6751.154	6751.154	13.000	<0.001
Residual	90	46738.127	519.313		
Total	207	106663.566	515.283		

The differences in the mean 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.

Power of performed test with alpha = 0.050: 0.946

Expected Mean Squares:
Approximate DF Residual = 90.000
Expected MS(Subj) = var(res) + 1.776 var(Subj)
Expected MS(Treatment) = var(res) + var(Treatment)
Expected MS(Residual) = var(res)

All Pairwise Multiple Comparison Procedures (Holm-Sidak method):
Overall significance level = 0.05

Comparisons for factor:

Comparison	Diff of Means	t	P	P<0.050
Lard Surv13 vs. Lard Surv14	12.181	3.606	<0.001	Yes

Comparison of seedling densities for Duncan to Lardeau 2014

Treatment Name	N	Missing	Mean	Std Dev	SEM
D_Jul_14	390	0	45.742	83.361	4.221
L_Jul2014	118	0	12.534	9.167	0.844

Source of Variation	DF	SS	MS	F	P
Between Subjects	389	1626849.132	4182.131		
Between Treatments	1	218353.139	218353.139	23.520	<0.001
Residual	117	1086182.215	9283.609		
Total	507	2812930.500	5548.186		

The differences in the mean 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.

Power of performed test with alpha = 0.050: 0.999

Expected Mean Squares:
Approximate DF Residual = 117.000
Expected MS(Subj) = var(res) + 1.301 var(Subj)
Expected MS(Treatment) = var(res) + var(Treatment)
Expected MS(Residual) = var(res)

All Pairwise Multiple Comparison Procedures (Holm-Sidak method):
Overall significance level = 0.05

Comparisons for factor:

Comparison	Diff of Means	t	P	P<0.050
D_Jul_14 vs. L_Jul2014	60.835	4.850	<0.001	Yes