PROVINCE OF BRITISH COLUMBIA

Ecosystem Restoration Monitoring: Columbia Lake East

Fish and Wildlife Compensation Program
Columbia Region

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The Fish & Wildlife Compensation Program is a partnership between BC Hydro, the Province of B.C., Fisheries and Oceans Canada, First Nations and Public Stakeholders to conserve and enhance fish and wildlife impacted by BC Hydro dams.

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Introduction

The Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD) has identified the east side of Columbia Lake as important habitat for wildlife. Due to its high wildlife values, the Province designated a Wildlife Management Area (WMA) in this area in 1997 (Province of British Columbia 2021). The area provides important ungulate winter range (UWR) for blue-listed Rocky Mountain bighorn sheep (Ovis canadensis), Rocky Mountain elk (*Cervus canadensis)*, mule deer (*Odocoileus hemionus)* and white-tailed deer (*Odocoileus* virginianus) as identified under Order UWR U-4-008 Invermere TSA (Province of British Columbia 2005). In addition to providing important UWR, this area is used by many other wildlife species including several red and blue listed species. Listed species that occur in this area include: American badger (*Taxidea taxus*), grizzly bear (*Ursus arctos*), and flammulated owl (*Psiloscops flammeolus*) (Province of British Columbia 2021). Limber pine (*Pinus flexiliis*), a blue-listed tree species, has been identified on the eastern slopes above the lake (B.C. Conservation Data Centre, 2021). In order to continue to provide quality habitat for wildlife, ecosystem maintenance and restoration is required on the east side of Columbia Lake.

Over the last century, the quantity and quality of wildlife habitat in the Rocky Mountain Trench has decreased partly due to the suppression of wildfire (Bond et al. 2013, Bircher et al. 2001). Many fire-maintained ecosystems are experiencing forest in-growth (Bond et al. 2013). Forest in-growth is a concern for wildlife managers because denser canopies result in much less forage production (Bond et al 2013). Reduced forage on the landscape increases stress on local herds and populations (Demarchi et al. 2000, Stent et al. 2013). Resource managers have identified forest ingrowth as a threat to ecosystem health on the East side of Columbia Lake.

To mitigate some of the impacts of forest in-growth, resource managers have been working to restore important habitat through ecosystem restoration activities such as prescribed burning and forest thinning (Bond et al. 2013, Davidson 2012, Bircher et al, 2001,). These activities open up the landscape and promote the grown of important forage species (i.e. bunchgrasses and shrubs; Bond et al. 2013).

In 2017, MFLNRORD retained Tanglefoot Forestry Consultants Ltd. to create an ecosystem restoration plan (ERP) for the Columbia Lake East treatment area with the goal of reducing forest cover (Byford 2017). This goal was to be achieved using two methods: 1) thinning forest in-growth conifers, and 2) re-introducing fire on the landscape. A number of treatment objectives were identified in the plan for the Columbia Lake East (Byford 2017):

- To restore/promote forest and grassland conditions that favour wildlife species that have historically used ecosystems within the East Columbia Lake WMA;
- To restore forest and range conditions to those that promote the diversity of plants and animals that have had historical distribution or have historically used ecosystems contained within the East Columbia Lake WMA;
- To minimize the impact of current and future forest and grassland health factors to the range expected with pre-fire exclusion stands;
- To minimize the impact of invasive plants on the grassland resource by encouraging forest and grassland conditions that promote healthy and vigorous native plant communities;
- To return stand and range conditions to those that are more representative of natural conditions that would be expected in the absence of fire exclusion;
- To reduce fuel loading to the range of conditions expected within pre-fire exclusion stand; and,
- To re-introduce fire to restored ecosystems within the historical frequency and intensity expected in pre-fire suppression stands.

In the fall of 2018, the first phase of the ERP (thinning of conifer in-growth) was completed through slashing and piling. As of fall 2020 phase two of the ERP (re-introducing fire) has yet to be carried out.

This report summarizes vegetation monitoring data collected in the Columbia Lake East treatment area during the growing season in 2020. These data were collected after the completion of thinning forest in-growth. Post treatment data were compared with pre-treatment data (collected in 2017) in this report. This comparison helps determine whether the desired results of the ecosystem restoration plan have been achieved.

Study Area

The Columbia Lake East treatment area is located approximately 7.5 km north of Canal Flats, BC (Figure 2). The treatment area lies on the west-facing slopes above Columbia Lake. The treatment area is within the East Columbia Lake WMA which includes most of the east side of the lake as well as wetlands at the north and south ends of the lake (Province of BC 2021). The treatment area also falls within the Columbia Lake Access Management Area which restricts vehicle access between December 1 and April 30. The treatment area consists of two treatment blocks with a total area of 21.0 hectares (ha).

The treatment area falls within two biogeoclimatic zones: 1) Very Dry Cool Interior Douglas-Fir (IDFxk) and 2) Dry Cool Columbia Interior Douglas-Fir (IDFdk5; McKillop et al. 2018). Typically, IDFxk sites are very dry and include forests dominated with Douglas-fir and common rabbitbrush in the shrub layer (McKillop et al. 2018). IDFdk5 sites are dominated by Douglas-fir and lodgepole pine with common juniper and Rocky Mountain juniper represented in the shrub layer (McKillop et al. 2018). Historically, both biogeoclimatic zones were more open than today as fire suppression has led to forest in-growth (McKillop et al. 2018).

The elevational range of the treatment area is between 900 metres (m) and 1160 m. The vegetation plots for the treatment area range in elevation from 934 m to 1021 m.

The forest within the treatment area is considered NDT4 (Byford 2017). However, stand densities are higher than what would typically be considered for NDT4 forests (Byford 2017). Since the 1930s fire suppression has occurred, which has led to forest in-growth (Bond et al. 2013)

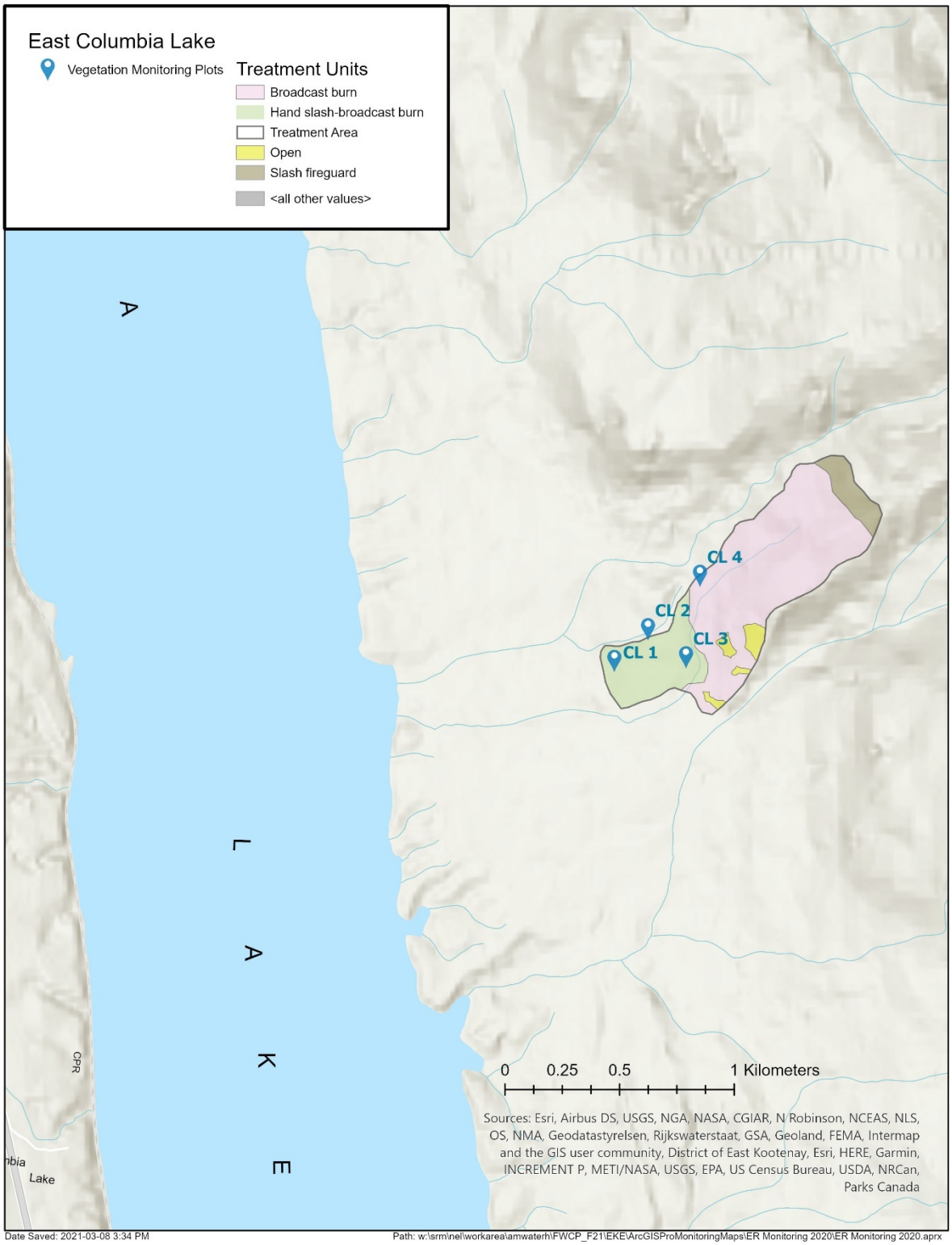

Figure 1. Columbia Lake East Treatment Area and Plot Locations for Vegetation Monitoring, 2020.

Methods

Methodology outlined below follows the Ecosystem Restoration Program Intensive Monitoring Protocols (Greene and Harris 2015). Data were collected on the following: 1) Plot Site Characteristics, 2) Understory Monitoring, and 3) Overstory Monitoring.

Plot Establishment and Site Characteristics

Plots established in 2017 were revisited in 2020. The spike at each plot centre was located using a Garmin Vista HCx GPS unit. Once plot centre was located, the four 25 meter (m) long transects that radiate out from plot centre (all 90 degrees apart) were located along with each of the spikes (i.e. 5 m, 10 m, 15 m, 20 m and 25 m) along the transects. Daubenmire frames were placed at each spike location when the Daubenmire sampling was completed.

Four photos were taken at each plot. From plot centre, one photo per cardinal direction (north, east, south and west) was taken. Within each photo a plot card was placed in view with the following information: Treatment Unit, plot number, date, UTM easting and northing and cardinal direction.

Site characteristics such as UTM location of plot centre, elevation, slope and aspect were not recorded as these data were recorded in 2017.

Understory monitoring

Along each transect, Daubenmire frames were placed on the right side of the transect at the five, ten, fifteen, twenty and twenty-five metre permanent markers (20 Daubenmire frame locations per plot). At each Daubenmire frame location, an estimate of percent cover of forbs and grasses by species was recorded. If an endangered species was recorded with a percent cover < 5%, individual plants were counted. Percent cover of abiotic components (rock, bare soil, bryophytes, dead and live wood, litter, cryptogrammic crust and scat) were recorded as well as the depth of the duff and litter layers combined. Cryptogrammic crusts are a thin layer of crusts, composed of mosses, lichens, algae, and bacteria. Species and ground cover with less than 1 % cover were recorded as 1 %.

Along each of the four 25 m transects, shrub data were collected using the line-intercept method. Shrub species that intersected the transect line were recorded to the nearest centimetre. To determine the mean percent cover of each shrub species along a transect, the species occurrences in centimeters were summed and then divided by 25 m.

Coarse woody debris (CWD) was measured along the second and forth 25 m transect (i.e. 90° and 360°). Coarse woody was defined as in Section 7 of the Land Management Handbook 25 (BC Ministry of Forests and BC Ministry of Environment 2010). If a piece of CWD intersected a transect, the diameter (cm) at the point of intersection was recorded as well as the length (m) that crossed the transect. Where possible species was recorded. Volume per plot (m^3/ha) was calculated and a mean volume (m^3/ha) calculated. Volume per plot was calculated using the following formula adapted from Van Wagner (1982):

$$V = \sum d^2 \left\lfloor \frac{(\pi^2)}{(8*l)} \right\rfloor$$

Where:

V=Volume per unit area

d= piece diameter (cm) at intersection

l= length of transect (m).

Overstory Monitoring

Nested fixed-radius plots (Figure 2) were established at each plot centre to monitor each layer of overstory structure. Overstory structure layers surveyed included regeneration, sapling, pole, mature and dominant. A description of each overstory structure layer sampled within each radius plot is outlined in Table 1. Species, diameter at breast height (DBH) in centimetres, decay class and overstory structure layer were recorded for each tree within the appropriate nested fixed-radius plot. If germinant trees (<10cm in height) were present, a tally was taken within 1.78 radius plot to determine density. To calculate stand density [stems per hectare (stems/ha)] by layer, the conversion factors outlined in Table 1 were used.

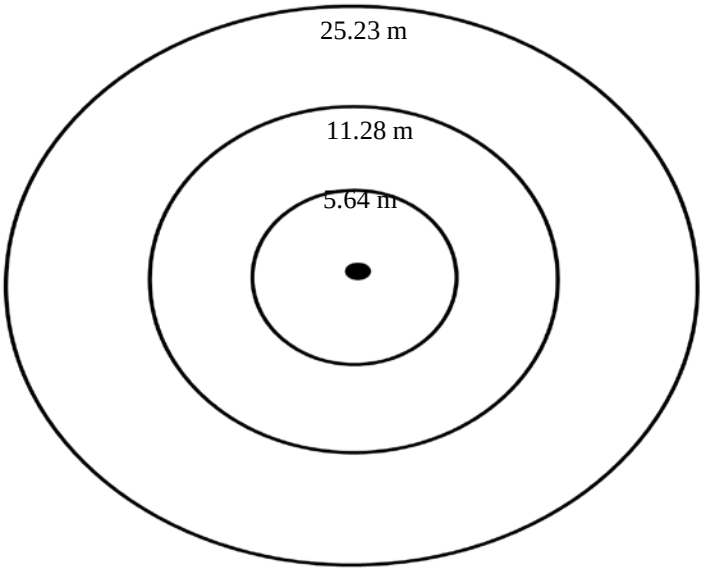

Figure 2. Configuration of nested fixed-radius plots (in metres) used to monitor overstory structure.

Table 1. Description of overstory structure layers including the height (m) and/or DBH range (cm) of each structure layer and measurements of nested fixed-radius plots.

Structure layer	Height (m) and/or dbh range (cm)	Radius (m)	Area (m^2)	Conversion factor to hectares (ha)
Germinant	<10 cm height	1.78	10	1,000
Regeneration	>10 cm to 130 cm height	5.64	100	100
Sapling	>1.3 m height and < 7.5 cm DBH	5.64	100	100
Pole	7.5 – 12.49 cm DBH	5.64	100	100
Mature	12.5 -30 cm DBH	11.28	400	25
Dominant	>30 cm DBH	25.23	1999	5

Additionally, canopy cover was estimated using a spherical densiometer. From plot centre, estimates of canopy cover were recorded in the four cardinal directions (north, east, south and west).

Results

Plot Establishment

In 2020, four of the eight plots established in 2017 were visited for sampling on 7 July and 8 July. Plots resampled in 2020 were located in areas were ecosystem restoration occurred in 2018. Plot locations and characteristics are outlined in Appendix 1.

Understory Monitoring

The species richness (shrubs, forbs and grasses) per plot ranged from 17 (plot 2) to 22 species (plot 1) (mean = 19.8; SD = 2.1) (Figure 3).

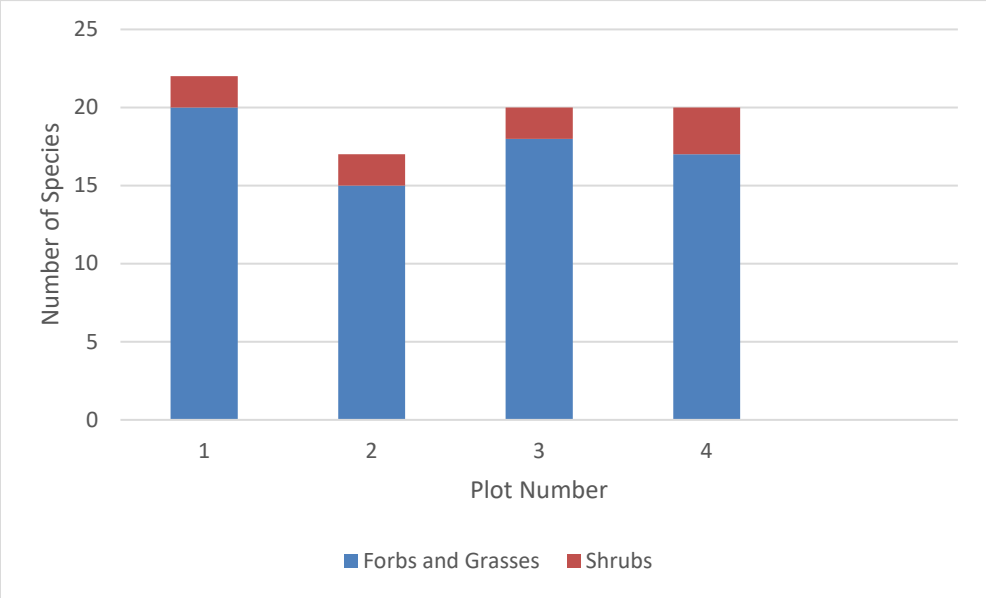

Figure 3. Species richness (number of species of shrubs, forbs and grasses) by plot number at Columbia Lake East, 2020.

Forbs were the most abundant functional group in the understory (total mean cover = 14.4%, SD = 2.7; Table 2). The three most dominant forb species were spikelike goldenrod (*Solidago spathulata*) (mean cover = 3.5%, SD = 3.4), rosy pussytoes (*Antennaria microphylla)* (mean cover = 3.3%, SD = 3.7), and showy daisy (*Erigeron speciosus* var. *speciosus*) (mean cover = 1.7 %, SD = 2.9).

Bunchgrasses were the next most abundant functional group (total mean cover = 6.2%; SD = 4.0;Table 2). Junegrass (*Koeleria macrantha*) was the dominant bunchgrass species recorded (mean cover = 2.9%, SD = 3.3), followed by bluebunch wheatgrass (*Pseudoroegneria spicata*) (mean cover = 2.6%, SD = 2.5). Other bunchgrasses recorded were include Stipa species (*Stipa spp.*) and fescue species (*Festuca spp*.).

Grass and sedge were not recorded within the plots in the treatment area (Table 2).

Two invasive species were recorded within the plots in the treatment area. Total mean percent cover of all invasive species within the plots was 0.6% (SD = 0.7; Table 2). The mean percent cover of both species was the same. Mean cover of cheatgrass (*Bromus tectorum*) and goatsbeard or yellow salsify (*Tragopogon dubius*) was 0.3% (SD = 0.7 and SD = 0.3, respectively).

Table 2: Total mean percent cover of understory functional groups by plot, Columbia Lake East 2020.

Functional Group	Plot 1	Plot 2	Plot 3	Plot 4	Average
Forbs	18.3	12.1	13.2	13.9	14.4
Grass	0	0	0	0	0
Bunchgrass	7.8	4.1	11.1	2.0	6.2
Sedge	0	0	0	0	0
Invasive plants	1.6	0.7	0.1	0	0.6

Mean ground cover at the treatment unit was composed of predominately litter (41.8%, SD = 13.0), followed by bare soil (28.0%, SD = 21.0), byrophytes (12.3%, SD = 8.8), cryptogrammic crust (7.7%, SD = 5.3) and dead wood (58%, SD = 3.9; Table 2). Mean percent cover of rock, live wood and feces were each under 5%. Mean depth of duff/litter was 0.9 centimeters (cm) (SD = 0.5).

Table 3: Mean percent cover of ground cover by plot, Columbia Lake East, 2020.

Ground Cover	Plot 1	Plot 2	Plot 3	Plot 4	Average
Litter	25.0	56.5	40.9	44.9	41.8
Rock	3.6	0.5	2.3	5.1	2.9
Bare Soil	57.0	15.0	32.0	10.0	28.0
Live Wood	0.5	0	0	0	0.1
Dead Wood	2.3	9.3	2.5	9.0	5.8
Byrophytes	1.5	17.0	9.1	21.5	12.3
Crust	9.5	0	12.1	9.3	7.7
Feces	1.5	3.3	2.5	0.1	1.8

No coarse woody debris (CWD) was recorded at the Columbia Lake East plots.

Three species of shrubs were recorded at the plots within the treatment area (Table 4). Common juniper (*Juniperus communis*) was most dominant species, followed by rabbitbrush (*Chrysothamnus nauseosus*) and Rocky Mountain juniper (*Juniperus scopulorum*). Total mean percent of all shrub cover at the plots averaged 7.3 (SD = 3.6). Plot 4 had the most shrub cover (10.5%) and plot 1 has the least (2.3%).

Table 4: Mean percent cover of shrub species by line intercept per plot and averaged over all plots and total mean percent cover of all shrub species by plot, Columbia Lake East 2020.

Species	Plot 1	Plot 2	Plot 3	Plot 4	Average
Rabbitbrush *(Chrysothamnus nauseosus)*	1.7	1.8	4.3	0.6	2.1
Rocky Mountain Juniper (*Juniperus scopulorum*)	0	0	5.0	2.0	1.8
Common Juniper (*Juniperus communis*)	0.6	5.5	0	7.6	3.5
Total mean percent cover of shrubs	2.3	7.3	9.3	10.5	7.3

Overstory Monitoring

Douglas-fir (*Pseudotsuga menziesii*) was the only species recorded in the overstory at the plots within the Columbia Lake East treatment area. Mean percent crown closure was 3.9% (SD = 3.8). Plot 2 had the greatest cover (7.3%). Plot 1 was open with no crown closure. The stem diameter distribution indicates the majority of trees within the treatment area have a diameter at breast height greater than 30 cm

DBH, followed by 12.5 - 29.9 cm DBH (Figure 4). Douglas-fir germinates were counted at plot 4 (n = 28) and have been excluded from Figure 4.

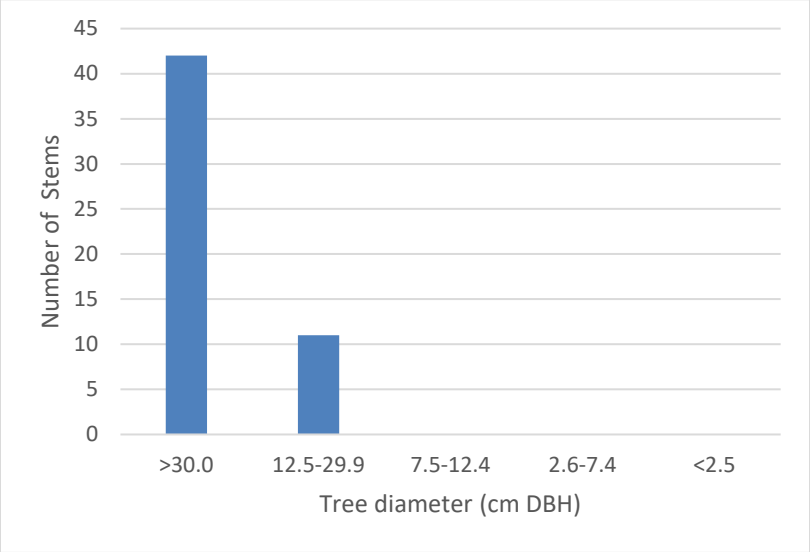

Figure 4. Stem diameter distribution (<2.5 cm indicating the regeneration layer) at Columbia Lake East, 2020.

Total stem density of live trees at Columbia Lake East averaged 7,119 stems/ha (SD = 2848; Table 5). The majority of Douglas-fir were in the germinant layer which averaged 7,000 stems/ha (SD = 14,000). Live Douglas-fir were also recorded in the mature and dominant layers. No live trees were recorded in the regeneration, sapling and pole layers.

Without the germinant layer, the average total stem density of the overstory layer was 118.8 stems/ha (SD=33.2).

Total stem density of dead trees (Class 3 or greater) at Columbia Lake East averaged 2.5 stems/ha (SD = 1.0; Table 5). Of the dead trees, Douglas-fir was the only species recorded. All dead trees were in the dominant layer (2.5 stems/ha).

Table 5: Stems per hectare by species averaged over all plots of live trees, Columbia Lake East, 2020.

Species	Germinant	Regeneration	Sapling	Pole	Mature	Dominant	Total
Live trees (Class 1 or 2)							
Fd	7,000	0	0	0	68.8	50	7,118.8
Dead trees (Class 3 or greater)							
Fd	0	0	0	0	0	2.5	2.5

Of the live trees, the germinant layer had the greatest stem density at 7,000 stems/ha (SD = 14,000; Figure 6). Excluding the germinant layer, the mature layer had the greatest stem density at 69 stems/ha (SD = 107; Figure 7), followed by the dominant layer (50 stems/ha; SD = 40).

Figure 5. Mean stems per hectare by age class (including germinant layer) of live trees at Columbia Lake East, 2020.

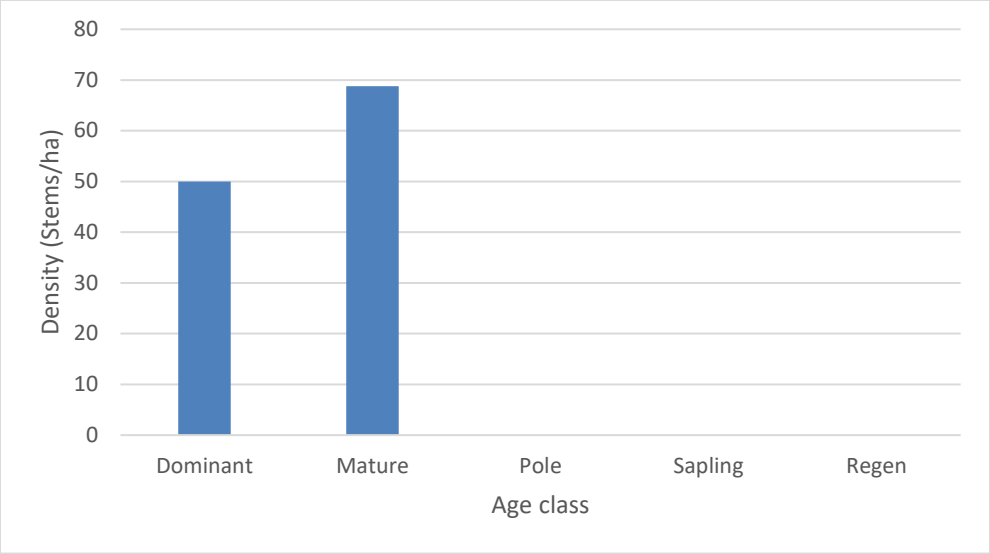

Figure 6. Mean stems per hectare by age class (excluding germinant layer) of live trees at Columbia Lake East 2020.

Discussion

Post treatment, crown closure opened up from 6.9% to 3.9% (unpublished data 2017). Through hand slashing, target stem densities (50-225 stems/ha) were met at 119 stems/ha (Byford 2017). Prior to treatment, the stem density was 346 stems/ha within the four plots monitored (unpublished data 2017). All of the trees measured in 2020 fell within the mature and dominant classes meeting the treatment objectives for TU1 (Byford 2017). A large number of germinants were recorded in 2020; however, it is unlikely that many of these will mature.

There were limited changes in the mean percent cover of the understory functional groups (forbs, bunchgrass, grass and invasive species) at Columbia Lake East post treatment. Grass was the exception. In 2017, a small amount of pinegrass (mean percent cover = 0.2) was recorded (unpublished data 2017), whereas grass was not recorded in 2020. The ER Intensive monitoring protocols suggest changes to the plant community may take several years to occur (up to 15 years), so it is likely too early to see many changes to the forbs and grasses (Greene and Harris 2015). Mean percent cover of invasive species changed very little (0.07% increase; unpublished data 2017), indicating both cheatgrass and yellow salsify did not spread between 2017 and 2020.

Some components of ground cover did change. Litter cover decreased by almost 20% and the percent cover of bare soil doubled (unpublished data 2017). These areas may be suspectable to the establishment of invasive species in the future and management actions should be looked into. As suggested in the ERP, bare soil should be seeded to ensure invasive plant species identified within the WHA don't establish in the treatment area (Byford 2017).

Percent cover of all three species of shrubs increased post treatment. The cover of common juniper increased the most, by almost two percent. This increase is expected as the shrubs continue to grow; however, it is possible the shrubs responded to the increased sunlight do to a more open area.

Once the second phase of the EPR is completed, the established plots should be monitored again to document further changes in the treatment area. Plots should survey ground cover, vegetation composition (including the presence of invasive species), shrub composition and overstory density to ensure the desired results from the ecosystem restoration treatments are achieved at East Columbia Lake. If action is taken to seed areas with bare soil, post seeding monitoring should occur to ensure the seeding takes.

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Appendix 1. Plot names, UTM locations and plot characteristics, Columbia Lake East, 2020.

name	plot_no	Sampled By	Date	UTM Zone	Easting	Northing	Elev (m)	Slope (%)	Aspect (°)	trans 1 (°)	trans 2 (°)	trans 3 (°)	trans 4 (°)
Columbia Lake	CL 1	DL/BP	07-Jul-20	11	583378	5565263	934	22	276	50	140	230	320
Columbia Lake	CL 2	DL/BP	07-Jul-20	11	583525	5565402	981	17%	266	51	141	231	321
Columbia Lake	CL 3	DL/BP	07-Jul-20	11	583691	5565279	990	17%	212	315	45	135	225
Columbia Lake	CL 4	DL/BP	08-Jul-20	11	583752	5565635	1021	7%	228	42	132	222	312