Hoodoo East Ecosystem Restoration Monitoring Report 2013

Prepared for Fish and Wildlife Compensation Program AND the Ministry of Forests, Lands and Natural Resource Operations

November 15, 2013

Prepared by Original report completed by Julie Tyrrell and Barb Houston
Updated in 2013 by Becky Phillips (FLNRO)

Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and the public

Summary

The Fish and Wildlife Compensation Program- Columbia Basin (FWCP) installed 15 pre-treatment ecosystem restoration monitoring plots in July 2010 at The Nature Trust of British Columbia's (TNT) Hoodoo/Hofert conservation property. Plots were established in an area scheduled for ecosystem restoration (ER) activities during 2011-2012, establishing the framework to monitor the effects of restoration activities on overstory and understory vegetation characteristics. In 2013, one year post-treatment monitoring was completed. This report summarizes monitoring activities conducted pre-(2010) and post-treatments (2013).

In 2010, fifteen monitoring plots were permanently established based on methods developed by Machmer et al. (2002). Overstory characteristics including percent crown closure, tree density, and composition were conducted in July both years as well as some understory sampling, including species composition and percent cover by species. Production assessments of understory were completed in August 2010 and September 2013. All site establishment monitoring data were entered into Excel and summary statistics were calculated.

Crown closure opened up and stem densities declined one year post-treatment. Overstory stem density (dominant/veteran, mature, pole, sapling layers) decreased, but still remains high averaging 1026 stem per hectare. High densities are still observed in the sapling layer.

The treatment unit understory was characterized by relatively low vegetation cover and production prior to treatment and continues to remain this way. Although gains were monitored post-treatment, vegetative cover remains relatively low with small increases made in percent cover of all understory functional groups except sedges and grasses. Mean percent of shrub cover also increased post-treatment. Noxious weed species were present with minimal cover in 2013, which were not detected at the plots prior to treatment. Total production, including the bunchgrass functional group, increased after treatment.

Overall, treatment at the Hoodoo East site seems to have worked towards meeting restoration objectives at the site, opening up the overstory and increasing production levels in the understory. Post-treatment monitoring should continue as planned with the next reassessment to be carried out in 2015. Attention should be paid to the presence of noxious/invasive plant species and stem densities within layer 4.

Acknowledgements

This Project is funded by the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of B.C., First Nations and the public, who work together to conserve and enhance fish and wildlife impacted by the construction of BC Hydro dams.

Monitoring data collection and data input were completed by FWCP Contract Biologist Dave Lewis and Conservation Technician Claire Schadeli. Larry Ingham administered the project and funding was provided by the FWCP. Mapping was prepared by William Lavell with The Nature Trust of BC. Randy Harris from the Ministry of Forests, Lands and Natural Resource Operations Ecosystem Restoration Branch provided training prior to the monitoring in 2013.

Table of Contents

List of Tables

List of Figures

1.0 Introduction

The Nature Trust of British Columbia (TNT), a not-for-profit land conservation organization, acquires ecologically significant land for the protection and management of these values. In 2003, TNT purchased the 4037 ha Hoodoo/ Hofert property (Figure 1), with the support of several other conservation partners, including the Fish and Wildlife Compensation Program. Situated in the Rocky Mountain Trench, between Fairmont Hotsprings and Invermere, the property features internationally significant wetlands, forests, extensive grasslands, and hoodoo formations.

Located along the Pacific flyway, the wetlands on the property contribute to important nesting and migration staging habitat for waterfowl. The property also provides wintering habitat for at least 150 to 200 Rocky Mountain elk (Phillips et al., 2008) as well as seasonal habitat for white-tailed deer, mule deer and moose. Large, free-roaming carnivores, including the grey wolf and cougars, reside on the property from time to time. Black bear and grizzly bears (blue-listed) make use of various habitats on the property at different times of the year (The Nature Trust of BC, 2004).

The occurrence of large areas of successional grassland habitat on the property was a key reason for its acquisition. The grasslands are comprised of native bunchgrasses, shrubs, and small clumps of Douglas-fir and lodgepole pine trees. Grassland ecosystems are limited in southeastern BC and many species-at-risk including plants, animals and insects are associated with grassland habitats. The property is known to contain at least three wildlife species that are classified as species-at-risk including the red-listed badger, red-listed Lewis's woodpecker, and the blue-listed Great blue heron. Based on the BC Conservation Data Centre database, the Hoodoo property has the potential to contain 26 red and blue-listed wildlife species, 53 red and blue-listed plant species and 4 red-listed grassland plant communities.

These dry, low elevation grasslands and open forests of Southern Interior British Columbia are ecosystems characterized by "frequent stand maintaining fires" (Natural Disturbance Type 4) (Machmer et al., 2002). Recent human activities have altered fire regimes in much of this NDT, fostering litter accumulation and forest encroachment in some grasslands, and changing canopy composition and density in some forested areas (Ministry of Forests, Lands, and Natural Resource Operations, 2011). Due, in part, to fire suppression and conifer encroachment, an estimated 1% of grassland and open forest is lost annually in the Rocky Mountain Trench (Gayton, 1997).

The restoration and enhancement of ecosystems adversely affected by conifer in-growth and encroachment is a priority management issue for TNT, as identified in their 2004 Hoodoo/Hofert Management Plan (The Nature Trust, 2004). The conversion of native grassland and open forests to a closed forest condition has caused a loss and degradation of critical wildlife habitat and biodiversity, decreased forage production, establishment and spread of noxious weeds, decreased forest health, and an increased risk of catastrophic fires.

In response, ecosystem restoration and habitat enhancement programs have been occurring throughout the Rocky Mountain Trench to restore low-elevation grasslands and ponderosa Pine/Douglas-fir forests to a natural state. Ecosystem restoration activities are specific to site history and conditions, but usually

involve a prescriptive combination of three phases. Phase one involves the removal (through harvesting, spacing or slashing) of in-growth stands to between 20 and 70% crown closure (Powell et al., 1998). Phase two requires prescribed burning to kill tree seedlings, and smaller, undesirable trees, while maintaining the health and integrity of mature trees. Phase three is to implement periodic underburning of treatment sites to maintain open forest and/or grassland conditions (Machmer et al., 2002).

The Nature Trust of BC, in partnership with the FWCP, has implemented these restoration principles on several sites, referred to as management units, on the Hoodoo/Hofert conservation property. Management units are differentiated by physical characteristics including topography, aspect, slope, and elevation in addition to biogeoclimatic (BEC) zone classifications (Figure 1). Restoration objectives differ per management unit, but typically involve restoring the landscape to a grassland and/or open forest condition. To monitor the ecosystem changes imposed by restoration treatments, permanent monitoring installations in active restoration treatment units are monitored pre and post treatment. A control site was also established as a spatial control to differentiate between changes due to restoration treatments and intrinsic changes such as stochastic variation, successional trends and cyclic variation (Page, 2007).

The objective of this project was to establish fifteen permanent monitoring plots in management units scheduled for prescribed restoration treatments in 2011-2012. In addition to installing permanent monitoring plots, pre-treatment data for overstory and understory characteristics was collected and analysed. Post-treatment reassessment of the monitoring plots during year 1, 3, 5, and 7 will provide the basis for evaluating the success of restoration objectives. This report includes the results of the first year of post-treatment monitoring.

2.0 Restoration Objectives

Guided by the Trench Effectiveness Monitoring Plan (EMP) (Machmer et al., 2002) four restoration objectives were selected for monitoring purposes at this site:

1) To reduce tree density, increase tree size, and achieve a tree species composition that falls within the historical range of variability for treated areas.
2) To maintain or increase fire-adapted native understory vegetation in treated areas.
3) Minimize the establishment and spread of non-native plant species, particularly noxious species, in treated areas.
4) Maintain or increase forage production in treated areas.

3.0 Site Description

The 4037 ha Hoodoo/Hofert conservation property is located in the East Kootenay region of British Columbia approximately 2 kilometres north of Dutch Creek, BC and 30 kilometres south of Invermere, BC.

Previous land and resource uses on the property included domestic livestock grazing (ceased in 2003), firewood cutting, hunting, Christmas tree cultivation, and timber harvesting. The southeast corner of the property contains remnants of an old logging camp, circa 1940 (The Nature Trust of BC, 2004). The area was burned by a wildfire in 1971, which affected approximately 1200 ha on the lower eastern portion of the property.

Monitoring plot establishment occurred in the southeast corner of the Hoodoo property within portions of two distinct management units (unit numbers 17 and 43; The Nature Trust of BC, 2004), forming the 53 hectare restoration treatment unit (Figure 1). The treatment unit is situated in the Rocky Mountain Forest District IDFxk biogeoclimatic (BEC) subzone (Interior Douglas-fir Very Dry Cool). This BEC subzone is characterized by hot, dry summers and cool, dry winters with low snowfall. The IDFxk unit is very small, only being mapped from Canal Flats to Edgewater. Zonal sites have open stands of Douglas-fir; Bluebunch wheatgrass and Junegrass are the dominant understory species (Braumandl and Curran, 1992).

Elevations range from 840-880 m and the treatment unit is bisected North-South by Westside road. Topography is characterized by east facing slopes on the western edge and by rolling slopes with mesic depressions/gullies occurring primarily on the east side of the road; slopes range between 2-37%. Soils at this site are classified as Orthic Eutric Brunisols. Eutric soils are strongly calcareous and low in organic matter (Agriculture and Agri-Food Canada, 2011).

4.0 Methods

Plot Establishment

The following plot establishment and monitoring methodology was taken from "An Effectiveness Monitoring Plan (EMP) for NDT4 Ecosystem Restoration in the East Kootenay Trench" (Machmer et al., 2002).

Fifteen monitoring plots were systematically established, avoiding roads, gullies, retention zones, areas unrepresentative of the block or areas of heavy disturbance. Plot locations were recorded using a GPS; plot locations (UTMs) are provided in Appendix B.

Plot centers were permanently marked using galvanized spikes with 2 washers. Three 11.28 m transects were established radiating out from each plot center to form a spoke separated by 120° (Figure 2a). The first bearing was randomly selected, with subsequent bearings determined by adding 120° and 240° respectively. The second and third transects followed in a clockwise position (from plot center) to complete the spoke. All bearings were recorded and entered into a database (Appendix 1). Four Daubenmire frame locations were permanently marked along each transect (4 frames/transect= 12 total/plot) at meters 3, 5, 7 and 9 with a galvanized spike, and numbered flagging.

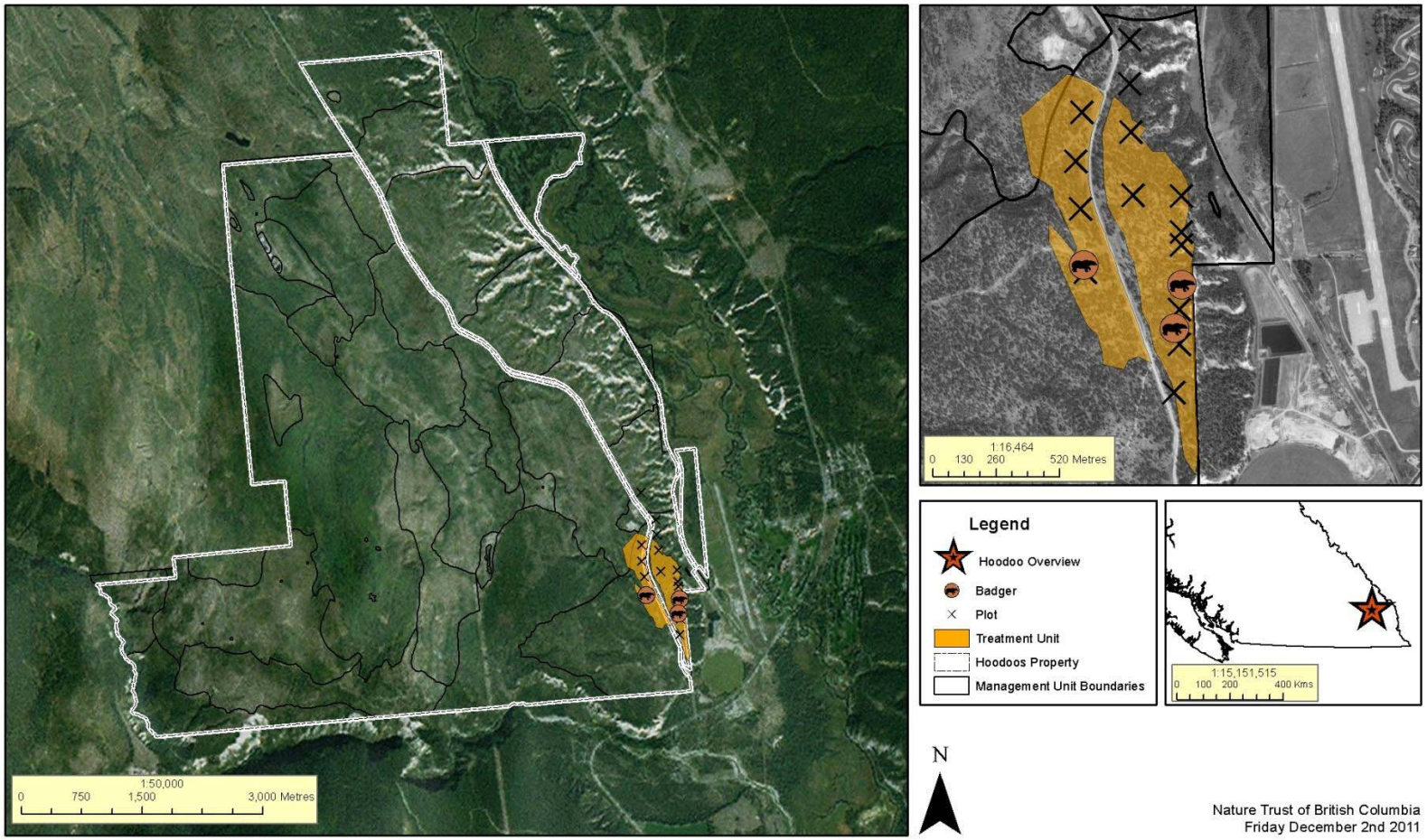

Figure 1. The Nature Trust of BC Hoodoo/Hofert conservation property with Management Unit boundaries (left); 2010 treatment unit, vegetation plot locations, and badger activity locations (top right); The Hoodoo/Hofert conservation property provincial context (bottom right).

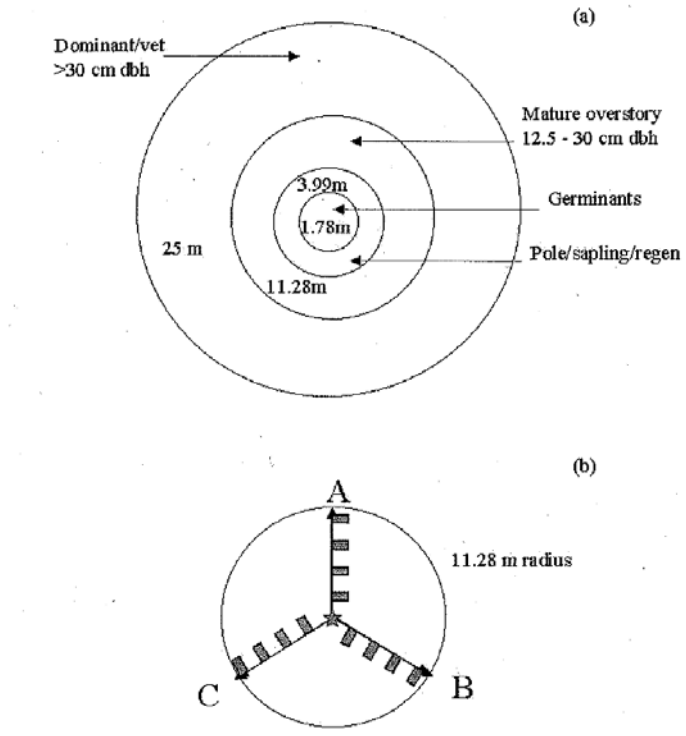

Figure 2: Layout of overstory (a) and understory (b) sampling plots (Machmer et al., 2000).

Restoration Monitoring Objectives

Restoration Objective 1:
To reduce tree density, increase tree size, and achieve a tree species composition that falls within the historical range of variability for treated areas.

Response variables: Tree density, crown closure, diameter and species composition.

Overstory plot layout conformed to methods developed by the BC Forest Service Permanent Plot procedures (BCMOF, 2000) and DeLong et al. (2001), with modifications to ensure that large trees and snags were adequately sampled. Overstory layers were sampled as follows: layer 4 (germinant)- 1.78 m radius; layer 4 (regeneration), layer 3 (sapling) and layer 2 (pole), - 3.99 m radius; layer 1 (mature)- 11.28 m radius; and layer 1 (dominant/veteran)- 25 m radius (Table 1). Tree species, diameter at breast height (dbh in cm), decay class, and evidence of insects or diseases were recorded for each tree in layers 1, 2, and 3 (Table 1, Figure 2b). A tally was made by species for layer 4 (live/dead). A convex spherical densiometer was used to measure crown closure at plot center. Percent mortality was calculated based on the number of overstory stems per layer assigned a decay class of 3 or higher.

Four photos were taken from plot centre facing each of the four cardinal directions (N, E, S, and W, respectively) in each of the 15 permanent plots. A ski pole was placed 8 m from plot centre on each cardinal direction and the picture was focused at 1 meter above ground on the ski pole.

Table 1. Layer descriptions used for overstory data classifications.

Layer Number	Layer Name	Layer Description
1	Dominant/veteran	>30 cm dbh
1	Mature	12.5 – 30 cm dbh
2	Pole	7.5 – 12.49 cm dbh
3	Sapling	1.3 m height and < 7.5 cm dbh
4	Regeneration	< 1.3 m height
4	Germinant	Seedlings < 2 years old

Restoration Objective 2:
To maintain or increase fire-adapted native understory vegetation in treated areas.

Response variables: Grass, herb and shrub cover by species, species richness and composition.

Understory vegetation cover and composition data was collected in the 12 Daubenmire frames at each of the fifteen plots. Within each Daubenmire frame, percent cover of all vegetation (herb, grass, weed and shrub) was recorded by species. Percent cover of bare soil, rock, live wood, dead wood (>1cm diameter), litter, bryophytes, feces, and cryptogamic crust was recorded as well. The depth of the duff and litter profile was measured at 50 cm past each transect spike and recorded in cm. Percent shrub cover was estimated in each plot using a 5.64m radius plot centred on the plot. Species richness and composition were recorded and summarized by plot.

To assess plant vigor, flowering culm counts were conducted for bunchgrasses and weeds within the Daubenmire frames when cover was less than 5% (Page, 2002). Bunchgrasses chosen for monitoring are species considered historically common in NDT4 stands and include: Stiff Needlegrass (*Achnatherum occidentalis*), Richardson's needlegrass (*Acnatherum richardsonii*), Rough Fescue (*Festuca campestris*), Idaho fescue (*Festuca idahoensis*), Needle-and-thread grass (*Stipa comata*), Junegrass (*Koeleria macrantha*), and Bluebunch wheatgrass (*Pseudoroegneria spicata*).

Restoration Objective 3:
Minimize the establishment and spread of non-native plant species, particularly noxious species, in treated areas.

Response variables: Number of species, cover, and noxious weed density (if cover <5%).

Non-native vegetation cover by species was estimated in the twelve Daubenmire frames (Figure 2b). If percent cover of non-native weed species (noxious and nuisance) was <5%, flowering culm counts were conducted.

Restoration Objective 4:
Maintain or increase forage production in treated areas.

Response variables: Total production.

Fifteen clip plots (one per plot) were established to estimate production at each plot. Total annual forage production was measured in a 0.5 m² (70.7 cm x 70.7 cm) quadrat, located on the right hand side of meter one on the first transect in 2010 and 2012, in each of the 15 permanently marked plots. Production quadrats will be rotated among transects in subsequent years to avoid confounding effects of destructive sampling. Herbaceous vegetation and current annual growth of shrubs was clipped to ground level in August 2010 and September 2013, after peak growth was reached each year. Kinnikinnick (*Arctostaphylos uva-ursi*) plants were not clipped, as they are not of direct interest for ecosystem restoration. Clip samples were separated into bunchgrass, other grass, pinegrass, forb, shrub or weeds and stored in paper bags. They were air-dried and then oven-dried at 70°C for 48 hours to a constant mass, and weighed to the nearest 0.1 g. Weights were then converted to kilograms per hectare (kg/ha). Grazing exclosures were not utilized pre-treatment.

Data Entry

Raw data were entered into Excel spreadsheets each year. Species codes and life-form identifications used were provided by the Ministry of Forests Research Branch.

Data Analysis

Data were summarized in Excel spreadsheets by species and by functional group and summary statistics were calculated. Prior to multi-year comparisons using ANOVA, data may require transformation.

5.0 Results and Observations

General Site Description

The Hoodoo East treatment unit is characterized by a Douglas-fir overstory of mature stems with many small diameter sapling layer thickets. There is also a small component of Rocky Mountain juniper and trembling aspen trees at the site. The understory plant community was dominated by the bunchgrass bluebunch wheatgrass and low shrub species including, common and Rocky Mountain juniper, kinnikinnick, and common snowberry.

Overstory Characteristics

The mean crown closure for all sites pre-treatment was 44.5% (SD=19.5). One year post-treatment, the estimated mean crown closure decreased to 24.3% (SD=32.6). (Crown closure at 5 plots were estimated without a densitometer in 2013).

The Hoodoo East treatment unit overstory is comprised predominantly of Douglas-fir (Fd). Prior to treatment mean coverage was 93% (SD= 8.9) and post-treatment mean coverage was 75.4% (SD=33.8). Rocky Mountain juniper (Jr) is the secondary species at the treatment unit along with a nominal trembling aspen (At) component (Table 2).

The stem diameter distribution shows that the majority of the trees counted were between 17.5 and 22.5 cm dbh pre- and post-treatment (Figure 3). The number of stems counted post-treatment has decreased by over half.

Table 2: Summary of overstory crown closure and species composition by percent, Hoodoo East 2010 and 2013.

	Crown Closure		Species Composition					
	%		% Fd		% Jr		% At	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2010	44.5	19.5	92.7	8.9	6.7	9.1	0.6	2.2
2013	24.3	33.8	75.4	36.1	11.3	21.2	6.7	25.8

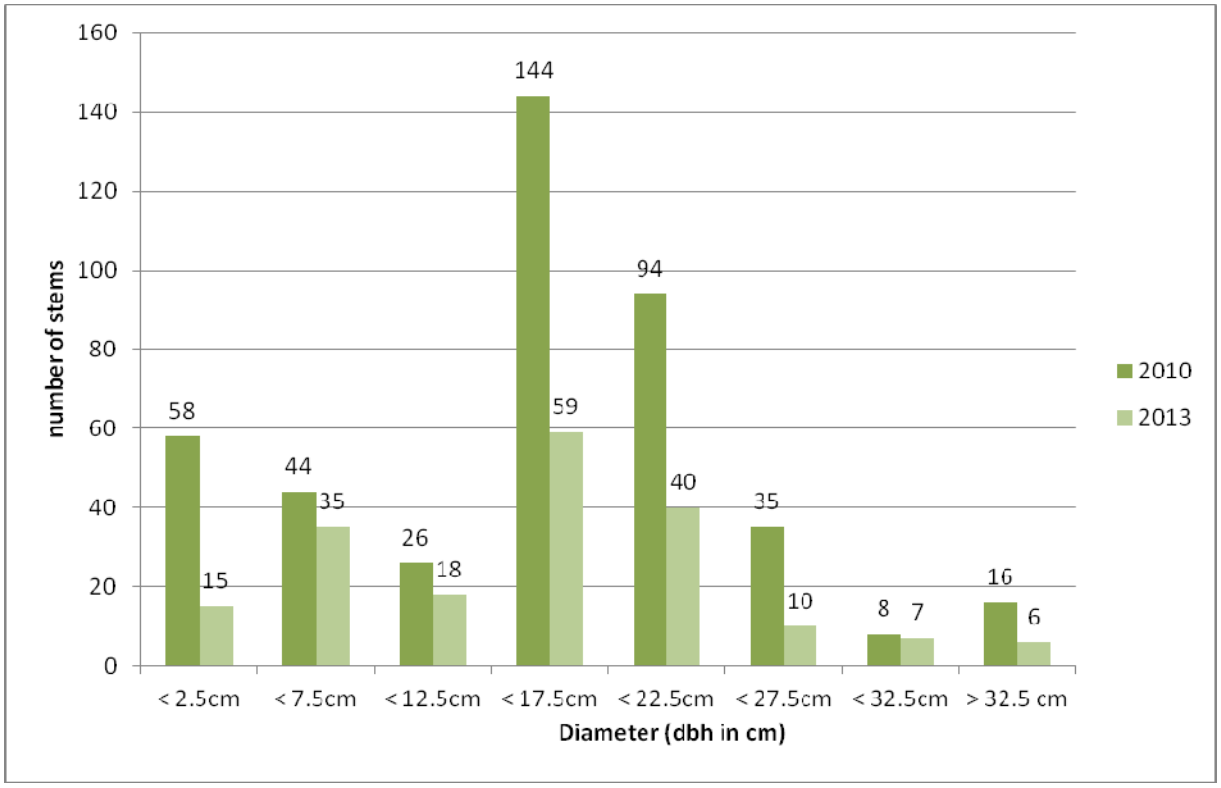

Figure 3. Stem diameter distribution for pre and post-treatment layers 1, 2, 3, and 4, Hoodoo East 2010 and 2013.
[See Table 1 for definitions of each layer. Note: these are stem counts in nested macroplots and have not been standardized by area (see sph results below for standardized numbers)].

Overstory stem density (dominant/veteran, mature, pole, sapling layers) across the site averaged 1025.7 stems per hectare (sph) (SD=1395.8). This was a decrease from 2010 (1641 sph; SD=993). There was also a decrease in average stem density for layer 4 (regeneration and germinant) from 960 sph (SD=1796) to 40.0 sph (SD=108.3). The highest calculated overstory densities continue to be observed in the sapling layer (Table 3), although the average stem density has been reduced with the ER treatment. There was a reduction in average stem density in all layers post-treatment.

Forest health within the treatment area continues to appear healthy. Percent mortality in the overstory decreased from 2010 in all layers except layer 1 (mature), where the percent mortality remained the close to the same (2010=1.4%; 2013=1.7%). The majority of dead stems remain in the dominant/veteran layer.

Table 3: Summary of densities (stems/hectare) for layers 1, 2, 3 and 4 pre and post-treatment, Hoodoo East in 2010 and 2013.

	2010: Pre-treatment			2013: Post-treatment		
	Mean	**SD**	**% mortality**	**Mean**	**SD**	**% mortality**
Layer 1 (Dominant/veteran)	6.7	8.2	35	4.0	6.4	16.7
Layer 1 (Mature)	461.7	189.4	1.4	195.0	223.6	1.7
Layer 2 (Pole)	346.7	287.5	0	240.0	427.1	0
Layer 3 (Sapling)	826.7	684	6.5	586.7	865.5	4.5
Layer 4 (Regeneration)	426.7	433.4	3.1	40.0	108.3	0
Layer 4 (Germinants)	533.3	1807.4	0	0	0	0

Understory Characteristics

Vegetative and non-vegetative components

Post-treatment monitoring showed increases in percent cover in all vegetative functional groups except sedges and grass (Table 4). Grass cover remained the same. Mean bunchgrass cover increased from 2.3% (SD=7.6) to 4.5% (SD=8.8). The majority of bunchgrass cover was from the wheatgrass species (*Agropyron spp.;* mean 1.1%, SD=5.8) and Junegrass (*Koeleria macrantha; mean=1.1%, SD=3.8*). Other bunchgrasses observed in 2013 include Richardson's needlegrass (*Achnatherum rishardsonii*), rough fescue (*Festuca campestris*), and bluebunch wheatgrass (*Pseudoroegneria spicata; mean=0.9%, SD=2.8*). In 2010, bluebunch wheatgrass percent cover was slightly higher (mean=1.6%, SD=7.2) than post-treatment cover.

Forb cover increased to 8.3% (SD=10.5) from 2.1% (SD=3.4). Both smooth aster (*Aster laevis;* mean=1.7%, SD=4.6) and showy aster (*Aster conspicuous; mean=1.0%, SD=4.6)*) remain the dominant forb species. All other forbs species present comprised <1% of the total understory cover.

Noxious plant species were found within the monitoring plots in 2013. The mean percent cover was 0.4% (SD=1.9). The species found include perennial sow thistle (*Sonchus arvensis*), yellow salsify (*Tragopogon dubius*) and Quackgrass (*Elymus repens*). During pre-treatment monitoring no noxious plant species were detected.

There remained a high percent cover of litter at the site post-treatment (mean=74.4%, SD=30.0; Table 5). Post-treatment there was a slight increase in percent soil cover (mean=8.0%; SD=20.8) and a decrease in cryptogramic crust cover (mean=5.5%, SD=14.8). In addition, dead wood cover increased from 3.1 (SD=7.4) to 7.2% (SD=15.1).

Table 4: Summary of vegetative understory cover characteristics by functional group, Hoodoo East 2010 and 2013.

	2010: Pre-treatment		2013: Post-treatment	
Vegetative Understory Components	**Mean**	**SD**	**Mean**	**SD**
Bunchgrass cover[1] (%)	2.3	7.6	4.5	8.8
Grass cover[2] (%)	0.2	1.1	0.2	1.1
Forbs cover (%)	2.1	3.4	8.3	10.5
Pinegrass cover (%)	0.7	5.8	1.7	6.2
Sedges cover (%)	0.1	0.6	0	0
Weeds Cover[3]	0	0	0.4	1.9

[1] Category includes native bunchgrasses considered historically common (listed on page 10)
[2] Category includes any native grass that is not classified as a bunchgrass or pinegrass
[3] Category includes any introduced or weedy species

Table 5: Summary of non-vegetative understory ecosystem characteristics, Hoodoo East 2010 and 2013.

	2010: Pre-treatment		2013: Post-treatment	
Non-vegetative Understory Components	Mean	SD	Mean	SD
Live wood cover (%)	0.8	7.4	0.9	6.8
Dead wood cover (%)	3.1	7.4	7.2	15.1
Litter cover (%)	82.0	72.3	74.4	30.0
Cryptogamic crust cover (%)	7.8	20.6	5.5	14.8
Rock cover (%)	0.0	0.3	0.4	3.3
Soil cover (%)	3.0	9.8	8.0	20.8
Feces cover (%)	0.4	1.4	0.8	2.9
Bryophytes cover (%)	2.8	12.5	3.8	12.6

Shrub cover

Shrub cover increased slightly in both layers (layer 1 and layer 2) post-treatment. Total shrub cover across the site increased from 10.7% (SD=7.7) in 2010 to 18.1% (SD=21.2) in 2013. Once again, low shrubs (<2 m, layer B2) were the dominant layer in 2013. The three most common species in the B2 layer in 2013 were: kinnikinnick (*Arctostaphylos uva-ursi*; mean=13.1%, SD=14.9), Birch-leaved spirea (*Spiraea betulifolia ssp. Lucida;* mean=7.7%, SD=10.7) and Rocky Mountain juniper (*Juniperus scopulorum;* mean=2.7%, SD=2.7). In 2010, three dominant species included common juniper (*Juniperus communis*; mean= 2.5%, SD= 6.3), kinnikinnick (*Arctostaphylos uva-ursi*; mean=2.3%, SD= 3.2), and common snowberry (*Symphoricarpos albus*; mean=1.8%, SD= 1.0). Rocky Mountain juniper (*Juniperus scopulorum*) was the only species in the B1 layer both years. In 2013, mean cover was 4.9% (SD=6.8) which is an increase in cover from 2010 (0.2%; SD=0.8).

Table 6: Summary of understory shrubs (layers B1 and B2) by mean percent cover, Hoodoo East 2010 and 2013.

	2010: Pre-treatment		2013: Post-treatment	
Shrubs	**Mean (% cover)**	**SD**	**Mean (% over)**	**SD**
B1(tall shrubs >2m)	0.2	0.8	2.6	5.4
B2 (low shrubs<2m)	10.5	7.5	15.5	17.5
Shrub Total (B1+B2)	10.7	7.7	18.1	21.2

Species Richness

Across all 15 monitoring plots, 56 different plant species were detected in 2013. This was an increase in species richness from 2010 when 39 different species were detected. Similar to 2010, species richness in 2013 within individual plots was variable with a mean of 16.6 species (SD=3.8) (Mean in 2010 was 12.5, SD= 3.8) and ranged between 10 species (Plot 11) and 22 species (Plot 1) (Figure 4).

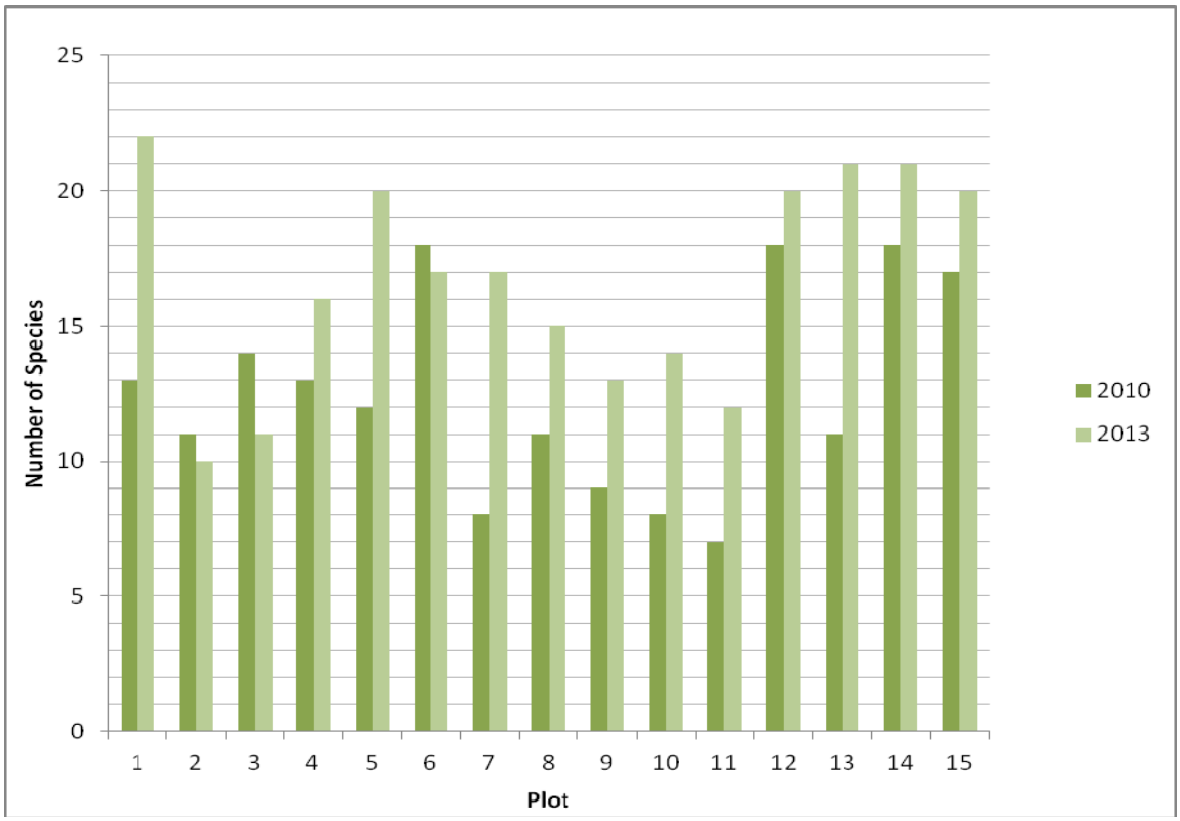

Figure 4. Species richness (including shrubs and trees) at each of the fifteen plots, Hoodoo East 2010 and 2013.

Forage Production

Overall production at the treatment site in 2013 (387.5 kg/ha; SD=345.8) increased from 2010 levels (123.7 kg/ha; SD=165.1, Table 7). Production in all functional groups increased with the exception of

other grasses. Bunchgrass production increased from 70.3 kg/ha (SD=142.5) in 2010 to 121.1 kg/ha (SD=208.9) in 2013. Shrub production increased from 28.9 kg/ha (SD=83.0) in 2010 to 112.3 kg/ha (SD=251.1) in 2013. No weeds were found at the site in 2010. In 2013, production of weeds were 86.4 kg/ha (SD=205.2). The large standard deviation indicates weeds were distributed unevenly and only found at a few plots.

As stated by Page (2007), higher bunchgrass production relative to pinegrass production indicates an understory that historically supported bunchgrass dominated communities (Figure 5).

Total production at the Hoodoo East site increased relative to 2010 production levels which was also the case at the adjacent control site established on the Hofert property. In 2010, production levels were 423.5kg/ha in the uncaged control plots (B. Houston, pers. comm.) and in 2013 the same plots produced 747.1 kg/ha (unpublished data, 2013).

Table 7: Summary of understory production (kg/ha) by functional group, Hoodoo East 2010 and 2013.

	2010: Pre-treatment		2013: Post-treatment	
Production	**Mean (kg/ha)**	**Standard Deviation**	**Mean (kg/ha)**	**Standard Deviation**
Bunchgrass[1]	70.3	142.5	121.1	208.9
Grass[2]	0.9	3.1	0.0	0.0
Forbs	8.5	16.0	27.5	32.4
Shrubs	28.9	83.0	112.3	251.1
Pinegrass	15.1	40.5	40.3	104.7
Weeds[3]	0	0	86.4	205.2
Total	**123.7**	**165.1**	**387.5**	**345.8**

[1] Category includes native bunchgrasses considered historically common (listed on page 10)
[2] Category includes any native grass that is not classified as a bunchgrass or pinegrass
[3] Category includes any introduced or weedy species

Discussion

Overall, treatment at the Hoodoo East site seems to have worked towards meeting restoration objectives at the site, opening up the overstory and increasing production levels in the understory.

Overstory

With the ecosystem restoration activities that occurred on the Hoodoo East site in 2011-2012, crown closure opened up and stem densities declined one year post-treatment. After treatment the site remained comprised predominantly of Douglas fir with nominal components of Rocky Mountain juniper and trembling aspen.

Overstory stem density (dominant/veteran, mature, pole, sapling layers) decreased from 2010, but still remained high averaging 1026 stem per hectare. High densities are still observed in the sapling layer. A large decrease was made in the average stem density in layer 4 (regeneration and germinant). A number of mature (n=7) and dominant (n=6) trees were retained on the site.

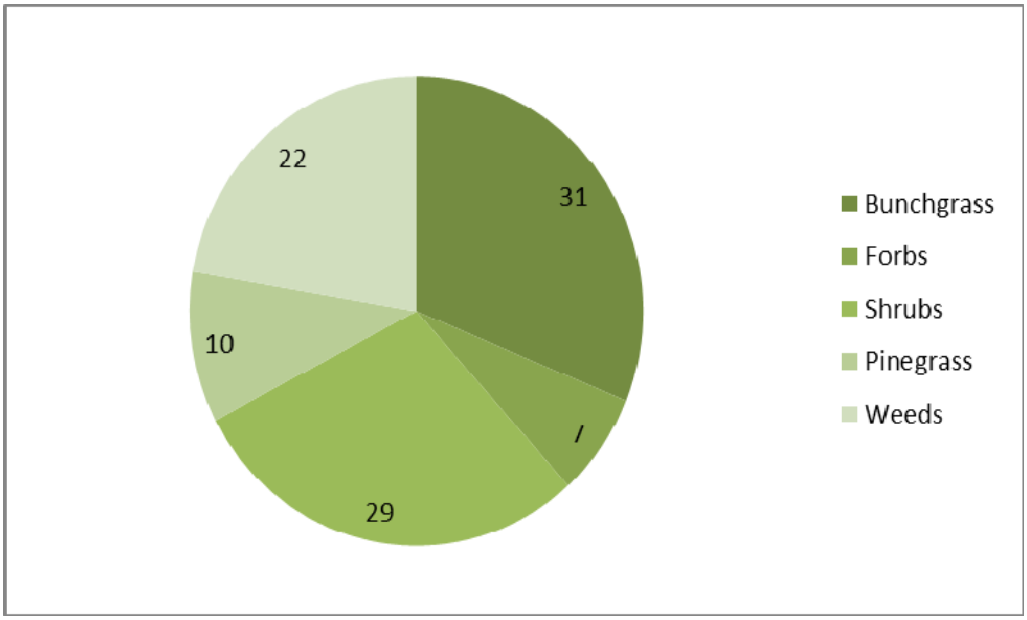

Figure 5: Total production (kg/ha) as a percentage by functional group, Hoodoo East, 2013.

Understory

The treatment unit understory was characterized by relatively low vegetation cover and production prior to treatment and continues to remain this way. Although gains were monitored post-treatment, vegetative cover remains relatively low.

Post-treatment monitoring showed increases in percent cover in all understory functional groups except sedges and grasses. Grass cover remained the same. Mean percent cover of bunchgrasses showed a small increase, however species composition changed. In 2010, bluebunch wheatgrass was a dominant bunchgrass species whereas in 2013, the dominant bunchgrass species' were Junegrass and wheatgrass species (*Agropyron sp*.; not including bluebunch wheatgrass).

Forbs cover increased post-treatment with both smooth aster (*Aster laevis)* and showy aster (*Aster conspicuous)* remaining the dominant species.

Both layers of mean percent shrub cover increased in 2013. Rocky Mountain juniper (*Juniperus scopulorum*) remained the only shrub species in the tall layer whereas the low shrub layer saw a change in 2 of the 3 dominant species. In 2010, the three dominant species were kinnikinnick (*Arctostaphylos uva-ursi)*, common juniper (*Juniperus communis) and* common snowberry (*Symphoricarpos albus).* In 2013, the three dominant species were kinnikinnick (*Arctostaphylos uva-ursi*), birch-leaved spirea (Spiraea *betulifolia ssp. Lucida*) and Rocky Mountain juniper (*Juniperus scopulorum*). In 2010, one plot had a large component of common juniper which inflated the mean coverage of this species. During treatment, some common juniper was removed, reducing its coverage at the site. Although mean coverage of snowberry in 2013 remained similar to pre-treatment coverage, mean coverage of birched-

leaved spirea increased from 0.2 (SD=0.6) to 7.7% (SD=10.7), with the bulk of coverage showing up at one plot.

Prior to treatment, noxious species were not detected at the monitoring sites. In 2013, noxious species were detected at 6 plots (plot 1, 5, 8, 9, 12 and 13). Weed cover was minimal (<0.5% across the sites) and can be attributed to perennial sow thistle (*Sonchus arvensis*), yellow salsify (*Tragopogon dubius*) and Quackgrass (*Elymus repens*). In addition, invasive species were found at plot 8, although the sampling data did not capture this (pers. comm. Claire Schadeli, November 6, 2013). Species detected include: bull Thistle (*Cirsium vulgare),* perennial Sow Thistle (*Sonchus arvensis),* Canada Thistle (*Cirsium arvensis*), blue bur or bristly stickweed (*Lapulla squarrosa),* shepards purse (*Capsella bursa-pastoris) and* lambsquaters (*Chenopodium album).* Plot 8 became a landing site during the treatment process. Seeds may have been deposited here from equipment and also the creation of the landing may have increased the amount of bare soil in the area.

The slight decrease in cryptogramic crust cover and the increase in bare soil could indicate some disturbance to the non-vegetative understory during treatment. Both of factors can contribute to decreased moisture retention.

Total production at the Hoodoo East site increased after the treatment. Production increased in all functional groups with the exception of other grasses. There was a large increase in bunchgrass production between the monitoring periods. Adjacent control plots on the Hofert property also had increases in production from 2010 to 2013, suggesting some of the increase may have been due to climatic conditions, in addition to the treatment.

Summary and Recommendations

Post-treatment monitoring should continue as planned with the next reassessment to be carried out in 2015. Attention should be paid to the presence of noxious/invasive plant species and stem densities within layer 4. If stem densities within layer 4 increase, steps should be taken to keep stem densities down. If coverage and production of noxious weeds increase, treatment should be considered.

Plot 8 should be removed from future analysis because it does not fit into the site requirements (page 7) anymore. During treatment the area surrounding the plot became a landing site. Plot 8 should continue to be monitored for noxious/invasive species and if necessary treatment should implemented. Claire Schadeli recommended native seeding at the plot prevent the spread of weedy species further due to amount of exposed soil (pers. Comm. November 6, 2013).

Literature Cited

Agriculture and Agri-Food Canada. Canadian System of Soil Classification 3rd Edition. http://sis.agr.gc.ca/pls/meta/web_taxonomy?order3=BR&ggroup3=EB&lang=en. Accessed Nov. 7, 2011.

Braumandl, T.F., and Curran, M.P. 1992. A Field Guide for Site Identification and Interpretation for the Nelson Forest Region. BC Ministry of Forests. Victoria, BC. pp.63.

British Columbia Ministry of Forests. 2000. Resource inventory Committee- Growth and Yield- Standards and Procedures. BC Ministry of Forests, Victoria, BC.

B.C. Conservation Data Centre. 2011. BC Species and Ecosystems Explorer. B.C. Ministry of Environment Victoria, B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Mar 30, 2011).

Delong, D. 2001. Old growth restoration monitoring in the Interior Douglas-fir zone. Terrestrial Ecosystem Restoration Program Application For Funding. Fiscal Year 2001-2002.

Gayton, D. 1997. Preliminary calculation of excess ingrowth and resulting forage impact in the Rocky Mountain Trench. BC Ministry of Forests, Nelson Region, Mimeo. 5p.

Grasslands Conservation Council of British Columbia. http://www.bcgrasslands.org/ekdigdeeper.htm#1. Accessed Dec. 7, 2011.

Machmer, M., H. N. Page and C. Steeger. 2002. East Kootenay Trench restoration Effectiveness Monitoring Plan. Submitted to Habitat Branch, Ministry of Water, Land and Air Protection. Forest Renewal British Columbia Terrestrial Ecosystem Restoration Program. Pandion Ecological Research. Nelson, BC. 50p.

Ministry Of Forests, Lands and Natural Resource Operations. Forest Practices Code Guidebook. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm. Accessed Dec. 5, 2011

Page, H. 2007. Hofert Control Site Monitoring- Site Establishment and Summary Report. Submitted to John Krebs. The Fish and Wildlife Compensation Program. 13p.

Page, H. 2005. Hoodoo/Hofert Restoration Treatment Monitoring- Site Establishment Report. Submitted to John Krebs. The Fish and Wildlife Compensation Program. 29p.

Page, H. 2002. Monitoring Restoration Effectiveness in Fire-Maintained Ecosystems of the East Kootenay. M.Sc. Thesis, Dept. Of Rangeland and Wildlife Management, University of Alberta, Edmonton. AB. 136p.

Phillips, B., Szkorupa, T., Mowat, G. Stent, P. 2008. 2008 East Kootenay Trench Elk Inventory. Ministry of Environment, Environmental Stewardship Division. 40pp.

Powell, G., White, D., Smith, D., Nyberg, B. 1998. Monitoring restoration of fire-maintained ecosystems in the Invermere Forest District. BC Ministry of Forests, Research Branch, Victoria. 29pp.

The Nature Trust of BC. 2004. Hoodoo/Hofert Property Management Plan. 73pp.

Appendices

Appendix A: List of EXCEL data and associated files provided and their description (RW-CD Format)

Folder/File Name	Description
Hoodoo East Source files (xls)	Includes plot locations, overstory and understory raw data.
Hoodoo East Data Summary files (xls)	Includes summary tabulations of cover by species, plot and site for understory, overstory, shrubs, crown closure, as well as production and species richness calculations.
Hoodoo East Pre-treatment photos	Includes all plot photos and additional treatment unit photos.
Background Documents	Hoodoo/Hofert Property Management Plan.

Appendix B: Monitoring Plot Locations

plot_ no	sampled by	measurement date	UTM zone	Easting	Northing	Elevation	transect 1	transect 2	transect 3	slope	aspect	phot o plots	tran or N/S/E/W	clipped (date)	cage
HE01	BH/CS	July 2010	11	579430	5575023	843 m	196	316	76	2	96	yes	N/S/E/W	18-Aug-2010	no
HE02	BH/CS	July 2010	11	579451	5575222	856 m	178	298	58	32	148	yes	N/S/E/W	18-Aug-2010	no
HE03	BH/CS	July 2010	11	579453	5575364	860 m	182	302	62	4	308	yes	N/S/E/W	18-Aug-2010	no
HE04	BH/CS	July 2010	11	579459	5575629	861 m	212	332	92	25	92	yes	N/S/E/W	18-Aug-2010	no
HE05	BH/CS	July 2010	11	579461	5575682	860 m	42	162	282	2	282	yes	N/S/E/W	18-Aug-2010	no
HE06	BH/CS	July 2010	11	579461	5575828	858 m	304	64	184	21	76	yes	N/S/E/W	18-Aug-2010	no
HE07	BH/CS	July 2010	11	579262	5575831	875 m	266	26	146	3	326	yes	N/S/E/W	18-Aug-2010	no
HE08	BH/CS	July 2010	11	579253	5576092	859 m	204	324	84	4	64	yes	N/S/E/W	18-Aug-2010	no
HE09	BH/CS	July 2010	11	579249	5576288	845 m	212	332	92	37	98	yes	N/S/E/W	18-Aug-2010	no
HE10	BH/CS	July 2010	11	579248	5576470	857 m	298	58	178	35	108	yes	N/S/E/W	18-Aug-2010	no
HE11	BH/CS	July 2010	11	579091	5576828	856 m	348	108	228	8	12	yes	N/S/E/W	18-Aug-2010	no
HE12	BH/CS	July 2010	11	579052	5576173	861 m	178	298	58	1	118	yes	N/S/E/W	18-Aug-2010	no
HE13	BH/CS	July 2010	11	579029	5575971	862 m	230	350	110	2	88	yes	N/S/E/W	18-Aug-2010	no
HE14	BH/CS	July 2010	11	579048	5575776	861 m	108	228	348	3	100	yes	N/S/E/W	18-Aug-2010	no
HE15	BH/CS	July 2010	11	579066	5575517	869 m	44	164	284	7	83	yes	N/S/E/W	18-Aug-2010	no