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BC HYDRO FISH AND WILDLIFE COMPENSATION PROGRAM

ECOSYSTEM RESTORATION MONITORING. ROCKS PASTURE

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Abstract

In 2002, the BC Hydro Fish and Wildlife Compensation Program initiated a multi-year restoration monitoring program at Rocks Pasture in the Newgate Range Unit.

Rocks Pasture was selected due to its high value for wildlife including Flammulated Owls and native ungulates. Pre-treatment data were collected in 2002. The site was mechanically thinned in 2004 and a broadcast burn treatment applied in 2006. Post-treatment data were collected in 2007 and 2009.

Data collected and analyzed indicate that restoration objectives to restore historical stand structure and fire-adapted plant communities have not been met.

Overstory stem densities are higher than prescribed for open forest structures and there are some areas with remaining pole and sapling layers. Despite high stem densities there are a large number of stems in the dominant layer which is a positive attribute for wildlife use and future stand structure. Data also indicate significant increase in wildlife use of the overstory (e.g. bird feeding) post-treatment.

Understory cover has declined for all species groups (e.g. bunchgrass, forbs, sedges). Despite significant declines there were increases observed in some individual rhizomatous species. Production levels also declined post-treatment, although there was a slight increase observed in 2007. Low litter levels, high dead wood cover and increased bare soil caused by restoration treatments has likely compounded negative responses in the understory. Although there was no increase observed of non-native species cover in the restoration plots, localized infestations were observed outside the plots.

Low cover and production indicate the plant community is not on a positive response trajectory. This has implications for management. Further monitoring should confirm whether or not the decline in production and cover will continue in the long term. Additionally, some changes are recommended to data collection methods to more accurately characterize the response.

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1. Introduction

Ecosystems can generally be characterized by their natural disturbance regime. Dry, low-elevation systems of the southern interior of BC are characterized by grasslands and shrublands mixed with open stands of ponderosa pine (*Pinus ponderosa*) and interior Douglas fir (*Pseudotsuga menziesii* var. *glauca*). These systems historically experienced frequent (every 7 – 50 years), low-intensity fires which limited encroachment by most conifer species and shrubs (Province of British Columbia 1995). Due to the introduction of fire suppression policies introduced by the Ministry of Forests in the 1940's (Daigle 1996), these plant communities have undergone dramatic changes due to forest ingrowth and encroachment.

Conifer encroachment has contributed to the rapid disappearance of grassland ranges and open forests in BC (Strang and Parminter 1980, Gayton 1997, Bai et al. 2001). Gayton (1997) estimated that over 30,000 ha of grassland and open forest has been lost since the early 1950's. Extensive forest ingrowth and encroachment within dry, low-elevation ecosystems of the southern interior of BC, has resulted in the loss of wildlife habitat as well as decreased timber and forage production (Rocky Mountain Trench Ecosystem Restoration Steering Committee (RMTERSC) (2006). As a result of this conversion, domestic livestock and native ungulates are exerting increased pressure on the declining land base as they compete for forage. The East Kootenay Trench Agriculture/Wildlife Committee (EKTAWC) found that combined wildlife and livestock forage consumption averaged 60% across monitored sites (RMTERSC 2006). Generally range managers in the Trench consider 50% utilization between livestock and wildlife to be a 'safe' level of use. Remaining grassland habitats are being further degraded by noxious weeds which may out-compete native vegetation resulting in a loss of species diversity and a further loss in production. Densely stocked stands also increase the risk of severe insect outbreaks and catastrophic crown fires (Powell et al. 1998, RMTERSC 2000).

To mitigate these changes, government and non-government land management agencies (The Fish and Wildlife Compensation Program, Ministry of Environment, Ministry of Natural Resource Operations, The Nature Trust, The Nature Conservancy of Canada) and other agriculture and conservation stakeholders have adopted ecosystem restoration or habitat enhancement programs. These programs are intended to restore the required ecological processes of fire-maintained systems in the Rocky Mountain Trench.

The primary goal of ecosystem restoration in the Trench is to remove excess immature and understory trees from fire-maintained communities over the next several decades in order to create an ecologically appropriate mosaic of habitats on Crown land. The mosaic is intended to mimic the historical landscape under natural conditions when fire was an integral part of the ecosystem (RMTERSC 2000). The Trench Restoration Program is the largest, longest running terrestrial initiative underway in the province of BC (Machmer et al. 2002). Since 1997, approximately $6,000,000 has been spent on restoration and associated activities in Trench (RMTERSC 2006).

An integral component of a restoration plan is a detailed monitoring plan. Long-term monitoring of vegetation, of a particular species of interest, or of a key physical parameter is the only way to determine the success of a restoration effort (Gayton 2001). Monitoring will help in the development of future plans through the understanding of the ecological processes that link overstory management to understory dynamics and diversity (Naumberg and DeWald 1999). The objectives of dry forest restoration monitoring are to assess characteristics related to forest and ecosystem health, to forage production and to the maintenance of open forest habitat and associated plant species (Ritchie and Harksen 1999).

This report summarizes ecosystem monitoring completed by the FWCP at Rocks Pasture (176 ha) located in the Newgate Range Unit in 2002, 2007 and 2009. Because of the high value for wildlife the FWCP has taken a lead role in planning and implementing NDT-4 ecosystem restoration activities in the Newgate Range unit.

2. Study Area

The Newgate Range Unit is located north of the Canada-U.S. border, it is bisected north-south by the Newgate Road. The unit is bordered to the east by the Kootenay River (Lake Koocanusa) and to the north and west by the Gold Creek/Plumbob Range Unit. Private land holdings lie on the east side of the unit (Ross 2000).

The Newgate Range Unit and Rocks Pasture are located in the IDFdm2 biogeoclimatic subzone (Kootenay dry mild interior Douglas-fir variant; Braumandl and Curran 1992). Zonal IDFdm2 sites have climax stands of Douglas-fir with an understory dominated by pinegrass and shrubs. Common shrubs include birch-leaved spiraea (*Spiraea betulifolia*), common juniper (*Juniperus communis*), soopolallie (*Shepherdia canadensis*), Saskatoon (*Amelanchier alnifolia*), and common snowberry (*Symphoricarpos* *albus*). Soils at all three sites are classified as Orthic Eutric Brunisols (Lacelle 1990). Eutric Brunisols are strongly calcareous and low in organic matter (National Research Council of Canada 1998).

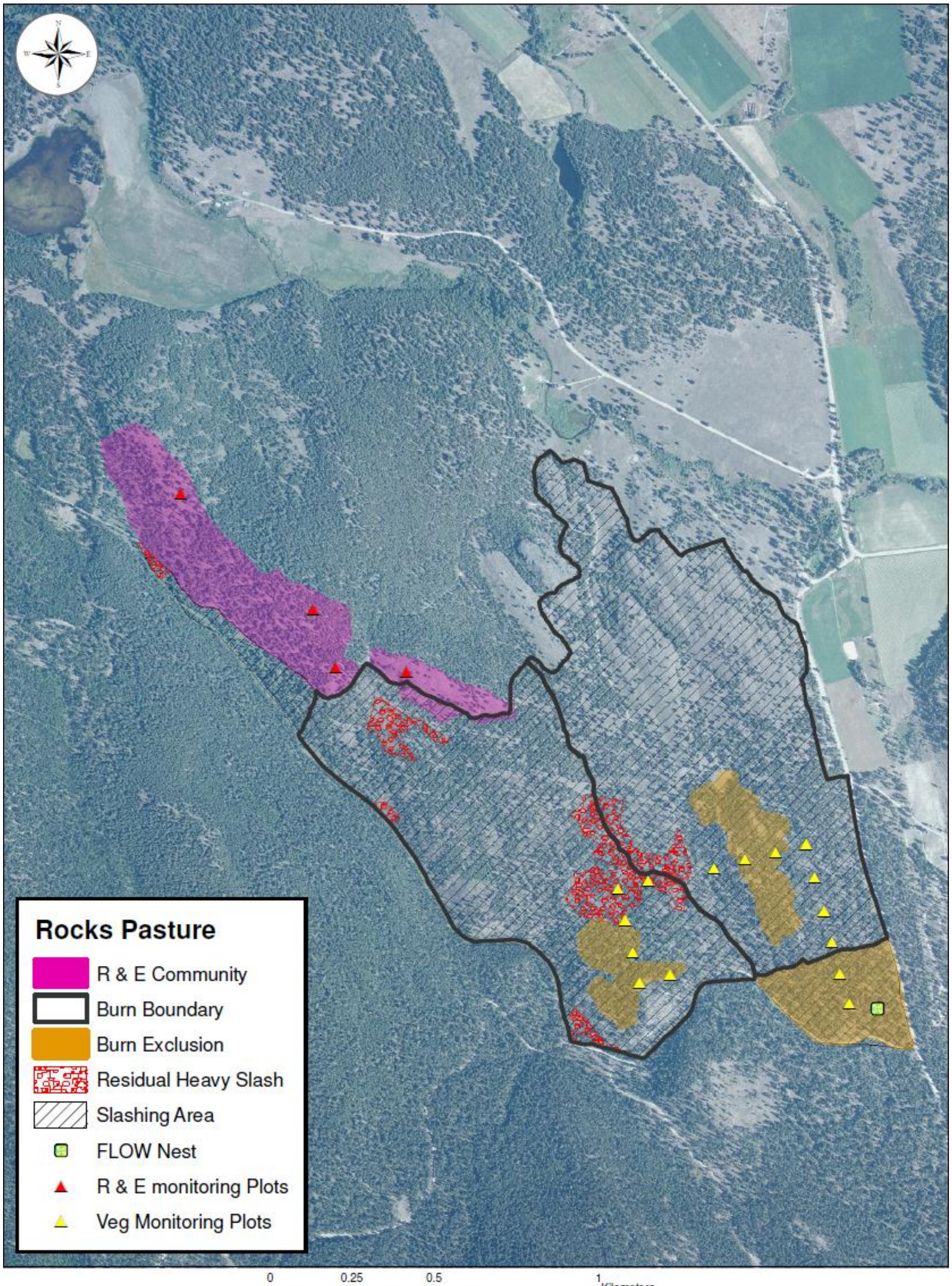

Figure 1. Location of Rocks Pasture ecosystem restoration monitoring plots.

Topography in the Range Unit is moderately rolling with many rock outcrops. Elevation ranges between 760 m and 880 m (Ross 2000).

The Newgate Unit provides important winter range for large numbers of deer and elk. The area also supports a number of threatened or endangered species and rare plant communities. Sharp-tailed Grouse (*Tympanuchus phasianellus*) historically occurred on a nearby Pasture (Ashfire) with sightings as recently as 2002. Lewis's Woodpeckers (*Melanerpes lewis*) and Badgers (*Taxidea taxus*) are common throughout the Newgate Range Unit and Flammulated Owls (*Otus flammeolus*) have recently been detected in and around Rocks Pasture. Two rare plant communities (both red-listed) have been identified in Rocks pasture: the ponderosa pine/bluebunch wheatgrass (*Pseudoroegneria spicata*)/silky lupine (*Lupinus sericea*) plant community and the antelope brush (*Purshia tridentata*)/bluebunch wheatgrass plant community (Adama 2007).

In 2004, 176 hectares of Rocks Pasture were slashed and a broadcast burn was conducted in 2006. About 30 hectares were excluded in order to protect Flammulated Owl nests and wildlife trees.

The general prescription was to slash layers 1, 2, 3, and 4 to reduce stem density from 4600 stems ha^{-1} to 135 stems ha^{-1} (Table 1).

Table 1.Target stem densities at Rocks Pasture (Adama 2007)

Layer	Target stem density (stems ha^{-1})[1]
1	80
2	30
3	25
4	25

[1] Target stem densities are averaged across treatment units within the Pasture

3. Methods

Methods are based on those described in "An Effectiveness Monitoring Plan (EMP) for NDT4 Ecosystem Restoration in the East Kootenay Trench" (Machmer et al. 2002). Three restoration objectives outlined in the EMP were chosen for monitoring purposes:

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 (based on aspect, slope, topography, moisture).

Restoration Objective 2:

To maintain or increase fire-adapted native understory vegetation in treated areas.

Restoration Objective 3:

To minimize the establishment and spread of non-native plant species, particularly noxious species, in treated areas.

3.1 Plot Establishment

Fifteen plots were systematically established avoiding areas such as roads and steep cliffs. Plot locations were recorded using a Trimble Pathfinder Global Positioning System (GPS) (UTMs).Plot centres were permanently marked with an 8" galvanized spike, two washers and flagging tape. Three 11.28m transects (Fig. 1) were established radiating out from each plot centre to form a spoke separated by 120°. 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, facing north) (Fig. 1). All plot specific information and bearings were recorded and entered into a database (Appendix 1).

3.2 Overstory Monitoring

An overstory monitoring plot was centred at each plot centre. Overstory plot layout conformed to methods developed by the BC Forest Service Permanent Sample Plot procedures (BCMOF 2000) and DeLong et al. (2001), with modifications, to ensure that large trees and snags were adequately sampled. Fifteen nested, fixed-radius plots (Fig. 2) were established to sample each layer (Table 2). Tree species, diameter (diameter at breast height in cm), decay class, and evidence of insects or diseases were recorded for each tree in layers 1, 2 and 3. A tally was made by species (live/dead) for layer 4.

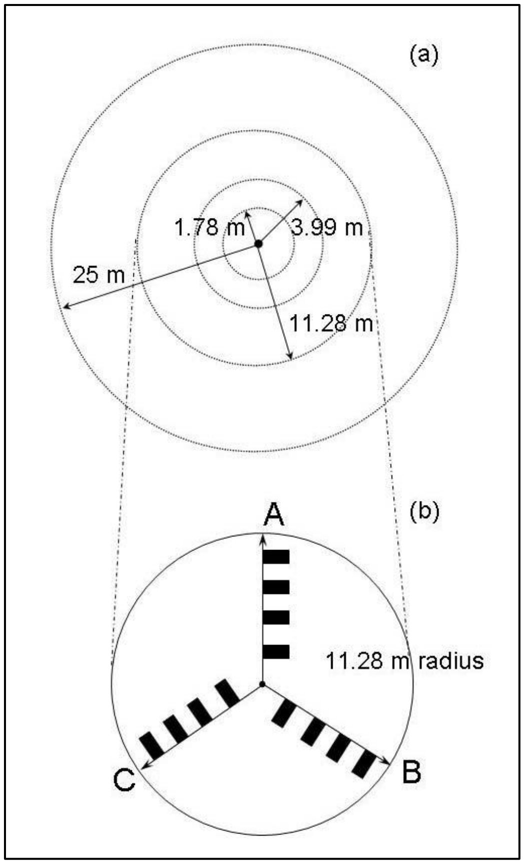

Figure 2. Layout of overstory (a) and understory (b) sampling plots adapted from DeLong et al. (2001).

A spherical densiometer was used to estimate canopy cover. Four densitometer readings were taken in cardinal directions from each plot centre. In 2002, at five randomly selected plots in each block, four photos were taken from plot center facing N, S, E, W, respectively (n = 20 photos per site). Photos were taken at ground level, due to difficulty in framing pictures of the overstory. In 2007 and 2009, photos were taken systematically at each plot center, one in each of the four cardinal directions focused at 8 metres from plot center using a 1 metre photo plot stake.

Table 2.Tree descriptions by layer used for overstory measurements.

layer number	layer name	layer description
1a	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

3.3 Understory Monitoring

Understory plot layout conformed to methods developed by DeLong et al. (2001) and Powell et al. (1998). Three 11.28m transects (Fig. 1) were established radiating out from each plot centre to form a spoke separated by 120°. Understory vegetation cover and composition data were collected in Daubenmire frames (Daubenmire 1959). Four Daubenmire frame locations were permanently marked on each transect. The left hand corner located on the transect was permanently marked with an 8" galvanized spike and 1 spray painted washer at intervals of 3, 5, 7 and 9 m along the transect. At each frame location, a Daubenmire frame was placed on the right hand side of the transect. In each frame, percent cover by species was recorded. Percent cover data were also collected for rock, bare soil, bryophytes, dead wood, live wood, litter, cryptogammic crust, and feces.

The line-intercept method (Bonham 1983) was used to estimate shrub cover along each 11.28 m spoke. All shrub species intersecting the three transects were recorded to the nearest centimeter. Canopy cover rather than foliar cover was used to determine plant 'interception' (i.e., the outside perimeter of the plant).

Depth of combined litter/duff measurements (cm) were taken at the 3.5m, 5.5m, 7.5m and 9.5m marks on the transect.

Understory sampling was completed on July 16-17 2002, July 17-24, 2007 and July 7-16, 2009.

3.4 Production Monitoring

Fifteen caged and fifteen uncaged clip plots (1 each per plot) were established to estimate production and utilization at each site. Total annual forage production was measured in a 0.5 m^2 (70.7 cm x 70.7 cm) quadrat located on an 11.28 m production transect (one of the transect spokes from the previous objectives) in each of the 15 permanently marked plots per site. Production quadrats were rotated among transects in subsequent years to avoid the confounding effects of destructive sampling. Herbaceous vegetation and current annual growth of shrubs were clipped to ground level in early September, after peak growth was reached. Kinnikinnick (*Arctostaphylosuva-ursi*) was not clipped, as it is not of direct interest for ecosystem restoration. Samples were separated into bunchgrass, other grass, forb, weed, sedge (*Carex* spp.) and shrub bags, and stored in paper bags. They were air-dried and later oven-dried at 70°C for 48 hours to a constant mass, and weighed to the nearest 0.1 mg. In 2002 and in 2009, one production cage was randomly established in each treatment plot (concurrent with plot establishment) and was clipped at the same time as production quadrats. A 0.5 m2 (70.7 cm x 70.7 cm) area was clipped to ground level within each cage. Locations of caged and uncaged quadrats are provided in a database (Appendix 1) along with other plot information.

3.5 Data Entry and Analyses

Data collected in 2002, 2007 and 2009 were entered into one Excel spreadsheet (Appendix 1). Species data were generally grouped into functional/descriptive groups in order to reduce the variability and increase the likelihood of detecting trends. Functional groups include bunchgrass, pinegrass, non-native species and sedges.

The percent cover for each species and the functional groups was analyzed to determine whether the cover of these species or groups had changed over time. Because much of the data included many zeros, it was not possible to normalize the data using transformation for analysis with standard least squares regression. In addition, the repeated measures from the same quadrats over time and the multiple quadrats per plot present two sources of correlation in the data. This correlation means that the samples are not truly independent and analyses should account for this. To deal with both the challenging distribution of the data and the correlation a multi-level Poisson regression was used. A Poisson distribution is not ideal because it is generated from count data and, unlike percent cover data, is not bounded at 100. It was, however, the best alternative because most of the values were zero or near zero and the regression allows for inclusion of two levels of grouping, repeated measures at the same quadrats over time and quadrats nested within plots. Using the *xtmepoisson* procedure in Stata, random intercepts were included for both plots and quadrats and tested for whether the response has changed over time. For many of the scarce species, the models were still unable to solve.

The shrub line-intercept cover data contained small non-integer percentages and a large number of zeros with measures repeated at the same plot. These data were analyzed using a generalized linear model assuming a gamma distribution. This did not account for the correlation of the repeated measures at the same plot, but was a better alternative than Poisson regression with a challenging distribution and non-integer values. The glm procedure in Stata 10.1 was used.

The production data contained zeros and larger numbers, but, unlike the percentages, was not bounded at 100 and measures were not repeated at the same site. A gamma distribution was the most flexible option to deal with the challenging distribution of the data. These data were analyzed using a generalized linear model assuming a gamma distribution. The glm procedure in Stata 10.1 was used.

4. Results

4.1 Overstory

4.1.1 Crown Closure

Crown closure at Rocks Pasture in 2002 was 59% (stdev=8). Crown closure decreased significantly in 2009 to 47% (stdev=12) ($p<0.05$).

4.1.2 Stem Density

Stems density (stems ha^{-1}) decreased significantly from 2002 in 2007 ($p<0.001$; Table 3). Stem density increased slightly in 2009, although this change was not significant. The increase in 2009 is likely due to recruitment of trees from the regeneration or seedling layer.

Layer 4 (regeneration/sapling) stem density was 7705 stems ha^{-1} (stdev=24 639) in 2002, 4594 stems ha^{-1} (stdev=13750) in 2007 and 2278 stems ha^{-1} (stdev=6507) in 2009. Variability in this layer did not allow for detection of a significant change between years. Additionally changes from 2007 to 2009 in the pole, sapling and layer 4 appear to be largely driven by changes in only 4 plots (plots 1, 2, 10 and 7).

Overstory species composition remained roughly constant from 2002 to 2009 (Table 3).

Table 3. Live (decay class 1 and 2) stem density (stems ha^{-1}) and overstory species composition at Rock's Pasture in 2002, 2007 and 2009

	veteran		mature		pole		sapling		total		species composition
	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	
2002	**69**	31	**433**	288	**213**	325	**293**	439	**1009**	687	$Fd_{76}Py_{20}Lw_4$
2007	**60**	37	**243**	234	**14**	53	**0**	0	**318**	218	$Fd_{77}Py_{19}Lw_4$
2009	**73**	26	**292**	250	**107**	361	**40**	112	**511**	663	$Fd_{74}Py_{21}Lw_5$

4.1.3 Decay Class and Wildlife Use

In 2002 there were 37 dead trees (decay class 3 or greater) surveyed in the mature and dominant layer. In 2009 there were 31 dead trees surveyed in the mature (22) and dominant layer (9).

In 2002, 8 surveyed trees showed sign of wildlife use, mostly all bird feeding. In 2007, 89 trees that were surveyed showed sign of wildlife use, mostly signs of bird feeding. In 2009, 67 trees surveyed showed signs of wildlife use, the majority of sign was bird feeding.

The proportion of trees in the higher decay classes has increased over time (Fig. 3).

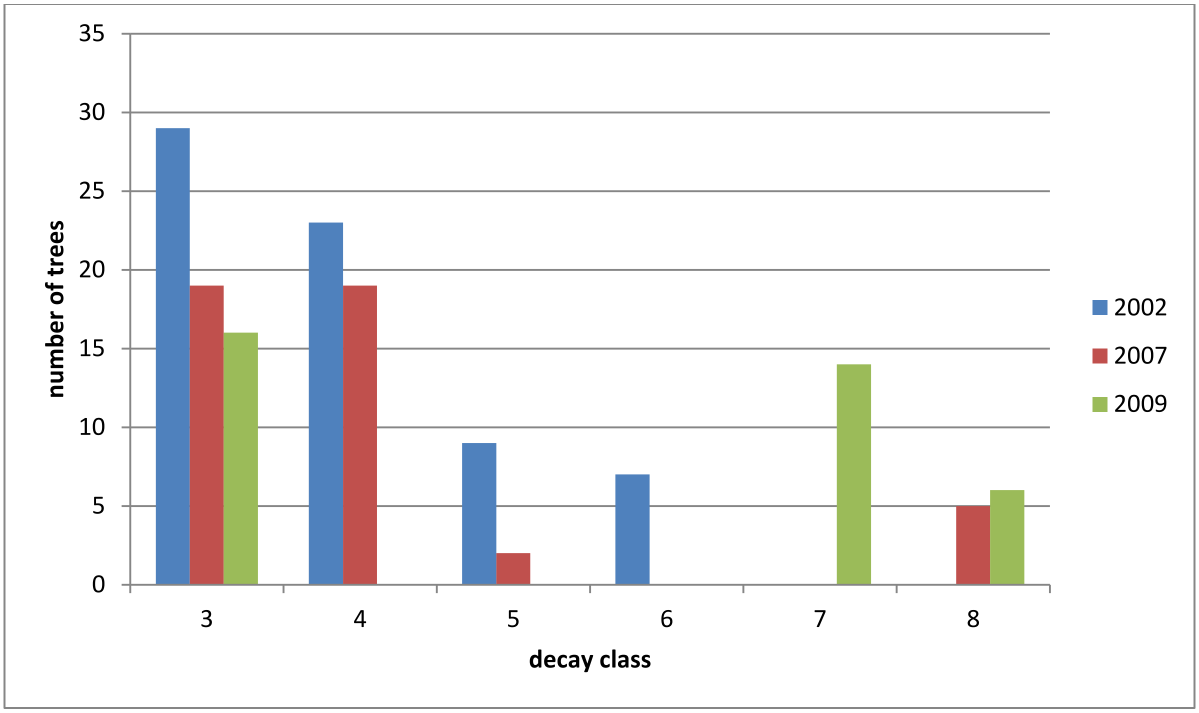

Figure 3.Decay class (decay class 3 or greater) of dead trees surveyed at Rocks Pasture in 2002, 2007 and 2009.

4.2 Understory

4.2.1 Understory Cover

All understory functional groups experienced significant declines in cover from pre-treatments levels (Table 4).When individual species cover data were analyzed there was a significant decline detected in percent cover of 20 species (Appendix 2).

There was also a significant decline in bryophyte cover from 2002 (8% stdev=16) to 2009 (6% stdev=15) ($p<0.001$).

Table 4.Understory functional group cover (%) at Rocks Pasture in 2002, 2007 and 2009. A negative coefficient indicates percent cover has declined has declined since 2002, a positive coefficient indicates percent cover has increased since 2002.

	2002	2007	2009	coefficient	p-value
bunchgrass	3	1	1	-0.179	<0.001
forbs	8	5	5	-0.077	<0.001
pinegrass	9	1	1	-0.064	<0.001
sedges	1	1	trace	-0.303	<0.001
weeds	1	1	trace	-0.140	<0.001

In contrast to the observed cover declines, there was a significant increase in percent cover observed in 7 species: umber pussytoes (*Antennaria umbrinella*), racemose pussytoes (*Antennaria racemosa*), smooth aster (*Aster laevis*), unknown sedge species (*Carex* spp.), Scouler's hawkweed (*Hieracium scouleri*), Menzie'scampion (*Silene menziesii*) and early-blue violet (*Viola adunca*).

Shrub species cover data were also collected in the Daubenmire frames. There was a significant decline in cover detected in Saskatoon and birch-leaved spirea (p<0.001). There was a significant increase in cover observed in tall Oregon-grape (*Mahonia aquifolium*) and prickly rose (*Rosa acicularis*) (p<0.001).

The three most common species observed in the Daubenmire quadrats in all 3 years were tall Oregon-grape (*Mahonia aquifolium*), pinegrass and birch-leaved spirea (Table 5).

Table 5. Changes in percent cover of the three most common species at Rock's Pasture. A negative coefficient indicates cover has declined since 2002 and a positive coefficient indicates cover has increased since 2002.

	2002		2007		2009			
	mean	stdev	mean	stdev	mean	stdev	p-value	coefficient
tall Oregon-grape	7	10	8	11	7	11	<0.001	0.021
pinegrass	9	15	1	2	1	2	<0.001	-0.303
birch-leaved spirea	4	2	1	3	1	4	<0.001	-0.308

There were significant changes detected in abiotic cover groups as well (Table 6).

Table 6. Abiotic elements with significant changes in percent cover since 2002 (p<0.05). A negative coefficient indicates cover declined since 2002, a positive coefficient indicates cover increased since 2002.

	2002		2007		2009			
	mean	stdev	mean	stdev	mean	stdev	p-value	coefficient
litter	80	25	75	23	79	27	0.026	-0.004
dead wood	7	14	8	16	8	15	<0.001	0.024
rock	4	16	4	13	6	24	<0.001	0.047
soil	0	3	3	7	2	6	<0.001	0.168

4.2.2 Shrub Cover

Based on the analysis of the shrub intercept data there was no significant change in shrub cover over time (Fig. 4). The dominant shrub species in all three years was tall Oregon-grape. There was one significant change detected in an individual species: birch-leaved spirea. Birch-leaved spirea cover declined significantly from 2002 (1%; stdev=2) to 2009 (<1%; stdev=1).

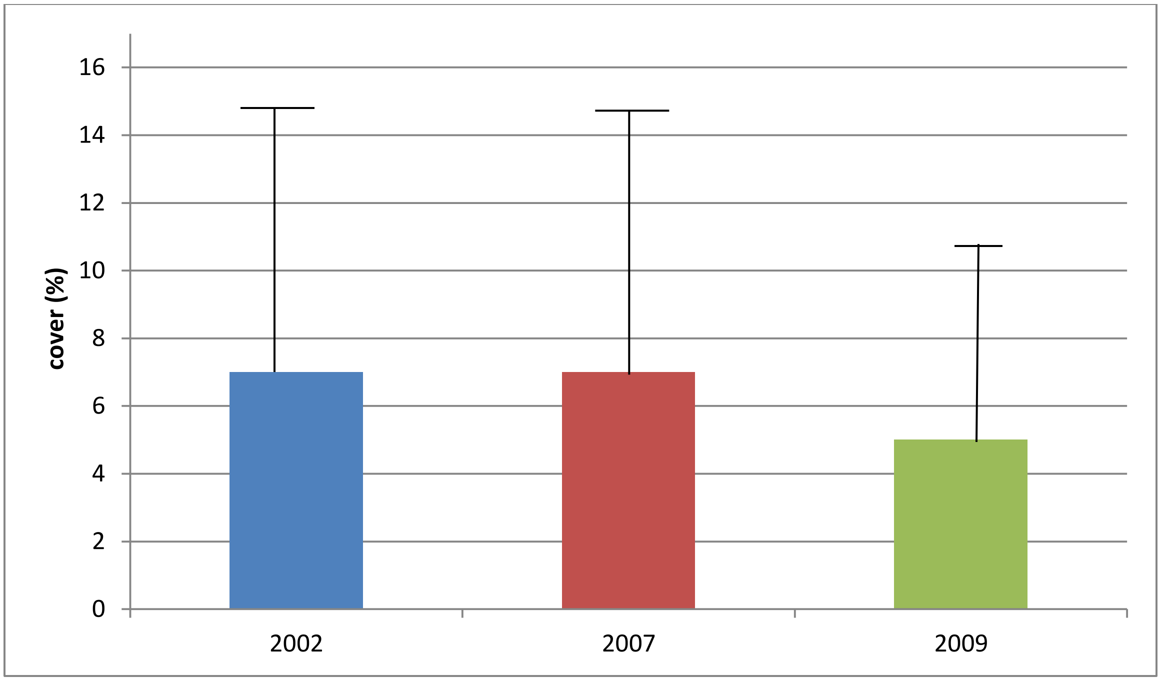

Figure 4. Shrub cover (all shrub species combined) (%)(line-intercept data) in 2002, 2007 and 2009 at Rocks Pasture.

4.2.3 Production

There were no significant changes detected in production levels over time and no significant difference observed between caged and uncaged quadrats (Fig. 5). Total production levels in 2002 were 160 kg/ha, 277kg/ha in 2007 and 134kg/ha in 2009.

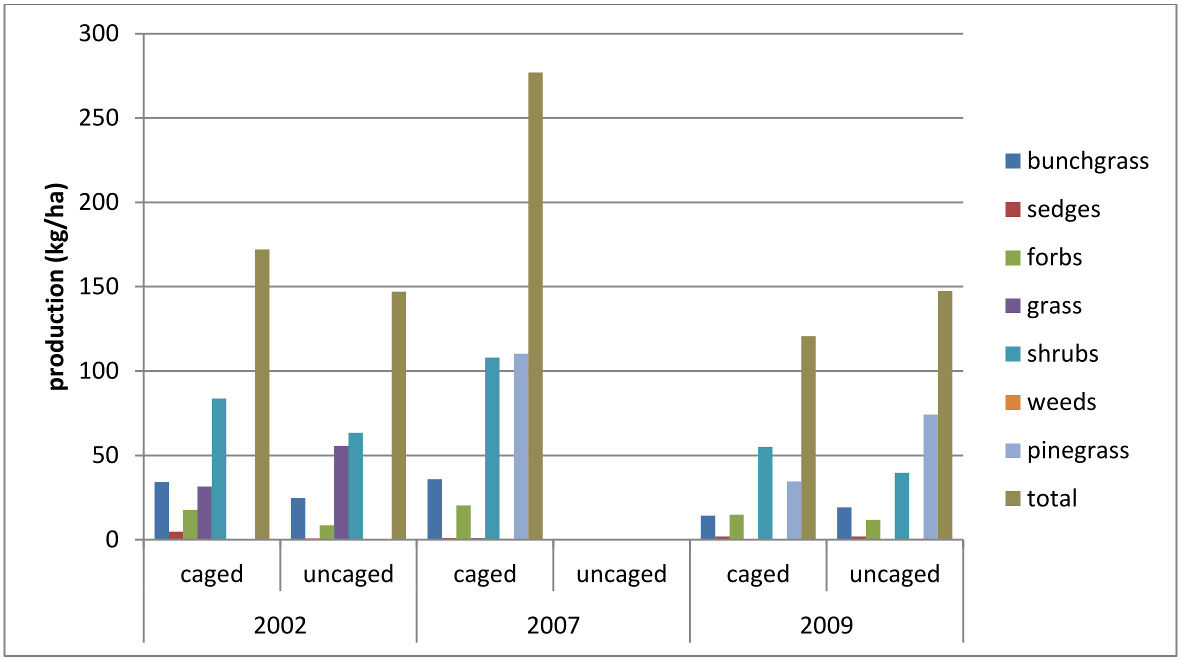

Figure 5. Caged and uncaged production values (kg/ha) at Rocks Pasture in 2002, 2007 and 2009.

5. Discussion

5.1 Overstory

Although stem density declined significantly ($p<0.05$ (1009 stems ha^{-1} to 511 stems ha^{-1})) and canopy closure declined from 57% to 49%, overstory management objectives were not met (Table 2 and Table 3). These results should be interpreted with caution as the pole and sapling trees surveyed in 2007 and 2009 were only found in two plots (14 and 15). Despite variable responses in the pole and sapling layer the current mature stem densities are higher (292 stems ha^{-1}) than are generally prescribed for open forest systems.

Although the desired stem density reduction has not being achieved, the objective to retain dominant trees in the stand has been met. Current stem density in the dominant layer is 73 stems ha^{-1}.

There were no appreciable differences observed in trees in upper decay classes (i.e. dead trees). This is surprising given the prescribed burn treatment applied in 2006. It is possible that the majority of trees killed in the broadcast burn became blow down. This may be reflected in the significant increase ($p<0.05$) in dead wood and the relatively high levels on site (8%), although cover was high pre-treatment as well (7%) (Table 6).

There was a significant increase in the amount of bird feeding occurring at the restoration site in 2007, this was also observed at the Airport restoration site one year post-restoration thinning (Page 2011).

5.2 Understory

Restoration treatments applied at Rocks Pasture in 2004 and 2006 appear to have had a largely negative effect on all understory functional groups. A significant decline was observed in all functional groups from pre-treatment to 3 years post-fire (Table 5). This decline was likely caused by a relatively high-intensity surface fire and compounded by a significant increase in bare soil and loss of litter (Table 6). It appears there was a slight flush in production post-thinning (Fig. 5), but levels in 2009 dropped significantly from 2007 levels. For example pinegrass production increased from 43kg/ha to 111 kg/ha in 2007 but then declined to 54kg/ha in 2009. In 2009 production levels were lower than pre-treatment levels (160kg/ha to 134kg/ha). These production figures are low relative to other sites in the Trench and have implications for wildlife and livestock utilizing the site for forage.

Despite significant declines across the site, there were species that have benefitted from the treatments, particularly forbs: Umber pussytoes, racemose pussytoes, smooth aster, Scouler's hawkweed, Menzie's campion and early-blue violet. All these species are rhizomatous and able to colonize a site through spreading rhizomes. At a restoration site in Kootenay National Park, significant increases were also observed for some pussytoe species and earl-blue violet (Page 2009). There was also a significant increase observed in tall Oregon-grape cover at Rocks Pasture.

Although non-native species increases were not detected in the restoration plots, surveyors did observed localized increases in non-native species outside the monitoring plots.

Responses across the site were highly variable which indicates the treatments were variable across the site as well. Variability in the shrub line-intercept data and production data are also likely due to prescribed data collection methods. It appears that line-intercept data collection vastly underestimates shrub cover. For example, tall Oregon-grape cover, as collected in the Daubenmire frames, in 2009 was 7%. Shrub cover for all species combined, as estimated by the line-intercept method in 2009 was 5%. Production data collection methods appear to be appropriate, but based on the variability of the data, it is likely that more than one sub-sample is required per plot. Despite variable responses, cover and production levels are still low and require further monitoring. The site is currently being grazed (70 animal unit months in 2010), this is likely to have further adverse impacts on production levels.

6. Summary and Recommendations

Based on data collected to date, restoration objectives have not yet been met at Rocks Pasture.

It is possible that the overstory can be treated again to meet overstory objectives, although charred timber will likely prevent a second mechanical treatment in the short-term.

Declines in understory functional group cover, low production levels, low litter levels and high bare soil all indicate the plant community is not on a positive response trajectory. Despite the lack of observed increase in non-native species cover in the monitoring plots, there were localized occurrences of non-native species infestations outside the monitoring plots.

Despite negative responses in the plant community, it does appear that bird feeding opportunities have improved on-site, post-treatment.

It is recommended that monitoring be completed year 5 post-fire to see if the negative response trend continues and to ensure non-native species do not spread. It is also recommended that more intensive production sampling be conducted to more accurately assess production levels and that shrub data are collected in 5.64m radius plots rather than using the line-intercept method.

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Appendix 1.List of EXCEL raw data files and their descriptions (CD format).

Folder/File Name	Description
Rocks 2011 Source Files	Includes all files used to create the Rocks Data Summary – 2008 and 2010
Rocks Data Summary	Summarizes all data collected from 2002 - 2009
Rocks Plot Photos	Includes 2002, 2007 and 2009 photos
Background Documents	Background documents for Rocks Pasture

Appendix 2.List of species that experienced significant changes in cover at Rocks Pasture from 2002 to 2009. A negative coefficient indicates a decline in cover.

species	coefficient	*P*
achnocc	-0.126	<0.001
achnric	-0.134	<0.001
anteneg	-0.107	<0.001
anterac	0.271	<0.001
anteumb	0.891	<0.001
arnicor	-0.075	<0.001
arctuva	-0.161	<0.001
astecon	-0.142	0.019
astefol	-0.420	<0.001
astelae	0.572	<0.001
camprot	-0.285	<0.001
carespp	0.122	<0.001
calarub	-0.303	<0.001
festcam	-0.174	<0.001
festida	-0.572	<0.001
fragvir	-0.066	0.037
hiersco	0.571	0.044
hierumb	-0.589	<0.001
koelmac	-0.139	<0.001
lithrud	-0.401	0.006
micrgra	-0.369	<0.001
penstcon	-0.115	<0.001
poa_com	-0.185	<0.001
silemen	0.418	<0.001
taraoff	-0.067	0.023
violadu	0.133	<0.001