Monitoring Ecosystem Restoration Treatments in Kootenay National Park

Site Establishment Report

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Summary

In June of 2004, Kootenay National Park initiated year one of a multi-year field study designed to monitor the effects of ecosystem restoration treatments on overstory and understory vegetation characteristics in fire-maintained ecosystems located in the Park. This report summarizes activities associated with year one (2004): sample plot establishment and the treatment monitoring that occurred at two IDFun sites located within Kootenay National Park.

Restoration monitoring sites were established at the south end of Redstreak Campground which is 3km southeast of Kootenay National Park's western entrance. Fifteen and fourteen plots were permanently located and systematically sampled at each of the two sites as well as one control plot, according to general methods outlined in Machmer et al. (2002). Understory sampling (% cover by species, species composition and richness) was conducted from July 17 to 31, 2004. Overstory sampling (tree density by species, diameter, and decay class) in nested fixed radius plots was completed in October. The data were entered into EXCEL spreadsheets for easy import into a statistical analysis program or into an ACCESS relational database. A summary of understory and overstory vegetation conditions is provided for each site.

Acknowledgements

This project was conducted by Hillary Page. All of the photographs in the report were taken by Hillary Page. I would like to thank the Dimple Roy, Marlene Machmer and Victoria Page for their assistance with this project. Finally, I would like to thank Rick Kubian for administering the project and acknowledge the Parks Canada Agencies Ecological Integrity Innovation Fund for providing funding.

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1. Introduction

The current management philosophy on forested lands throughout the western United States is to manage ecosystems within the historic range of variability (HRV) (Gray et al. 2002). The HRV refers to the full spectrum of ecosystem states and processes encountered over the long-term, the concept is frequently applied in the context of disturbance regimes. Management of ecosystems is thought to be more sustainable if they are managed so the natural disturbance regime falls within the HRV (Gayton 2001). Determining the historic fire return interval, other disturbance regimes, and the range of historic ecosystem structure and species is a pre-requisite to this management regime (Gray et al. 2002). The goal of this style of management is maintenance of ecosystem integrity which includes managing for historic species composition and structure (Naumberg and DeWald 1999).

These concepts and ideas are being widely applied in the Natural Disturbance Type 4 (NDT4) ecosystems of the Rocky Mountain Trench. Because NDT4 ecosystems are well outside their range of their HRV (Gray et al. 2002), the negative impacts of forest ingrowth and encroachment have been relatively well documented and to a lesser extent current restoration efforts within the NDT4. In contrast, far less is known about the historic stand structure and disturbance regimes in adjacent Natural Disturbance Type 3 (NDT3) ecosystems (Gray et al. 2002), such as those found at the south end of Kootenay National Park (KNP). This is likely because ingrowth and encroachment is not assumed to be as severe problem in the NDT3 zones. The lack of restoration efforts in monitoring in NDT3 systems is due to the definition of the disturbance types. NDT3 ecosystems are defined as having an infrequent, stand-replacement fire regime as opposed to the frequent stand-maintaining fire regime that characterizes the NDT4 (Province of British Columbia (1995). However, on many landscapes NDT4 BEC subzones transition directly into NDT3 subzones along an aspect and elevation gradient. Although, NDT3 ecosystems are defined as ecosystems with frequent stand-initiating events (Province of British Columbia 1995), Gray et al. (2002) suggests that mixed-severity fire regimes have influenced historic stand structure and ecosystem processes in biogeoclimatic subzones currently considered to be functioning as historic, infrequent stand-replacement fire regimes. This implies restoration has to be considered not only in NDT4 ecosystems but in adjacent NDT3 ecosystems being affected by ingrowth and encroachment.

Historically, low elevation NDT3 forests of the Columbia Valley were influenced by periodic, low-intensity surface fires that maintained the open forest structure and ecosystem function. Fire suppression has resulted in the loss of open Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] forests and grassland ecosystems due to forest ingrowth and encroachment. This has resulted in a large number of native species being adversely affected, such as, the Rocky Mountain bighorn sheep (*Ovis canadensis*) who rely on the open grasslands for winter foraging. High quality forage species are negatively affected by closed-canopy, such as, rough fescue (*Festuca campestris* Rydb.) and bluebunch wheatgrass (*Pseudoroegneria spicata* (Pursh) A. Löve)

Parks Canada is initiating a multi-year ecosystem based management program in the south end of Kootenay National Park to enhance Rocky Mountain Bighorn sheep habitat by restoring fire-maintained grasslands and open forest ecosystems. The first phase of restoration requires significant harvesting and tree removal to reduce overstory cover and the fuel load at the site. Fuel reduction at the site will allow for the safe introduction of prescribed fire over the next several years.

Parks Canada land managers hope restoration activities hopes will achieve the following broad-scale objectives:

- Reduce dangerous forest fuel levels in and around Redstreak Campground;
- create a fire guard on the east side of the campground;
- create an overstory structure consistent with historical stand models;
- create an restoration site adjacent to a provincial block that has already undergone restoration as part of the regional restoration effort

This project is in response to a Request for Proposals from KNP. Specific objectives of the project were to (1) establish two permanent monitoring sites within a historically open NDT3 site in the Park, (2) collect data on vegetation overstory and understory conditions at two restoration sites, (3) summarize the data which will serve as the baseline for determining if objectives have been achieved at both sites. Long term re-assessments are planned for each site.

2. 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), with modifications based on discussions with Rick Kubian (KNP). The following three restoration objectives outlined in the EMP were chosen for monitoring purposes:

Restoration Objective 1:

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:

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

Restoration Objective 3:

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

2.1 Study area

Two treated sites (Fig. 1) were selected for this project (hereafter referred to as sites 1 and 2 respectively):
(1) Site 1 (81 ha in Kootenay National Park; IDFun); and 2002/03
(2) Site 2 (60 ha of Provincial Crown adjacent to Kootenay Natiaonal Park; IDFun)harvested 2001/02;

Sites were both harvested in the winter to avoid soil compaction by heavy machinery.

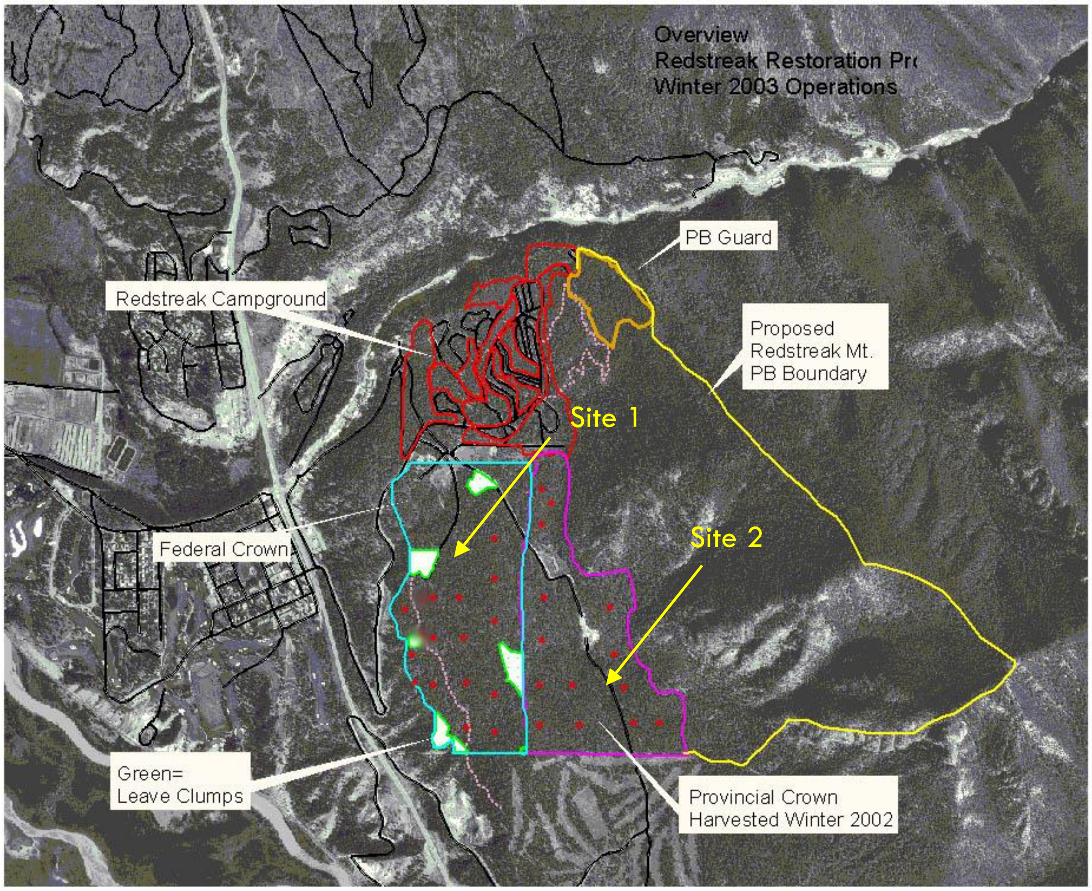

Figure 1 Location of permanent monitoring plots (installed in 2004). at both Redstreak Restoration Sites

The plan is to follow the winter harvesting treatment by prescribed burning. Prescribed burning (broadcast or sloop) is planned for both sites over the next 1–3 years.

Fifteen plots were systematically established at site one, fourteen at site two and one control plot (Fig. 1). Plots were located to avoid areas that were heavily disturbed or unrepresentative of the rest of the block. Plots were generally located 200m apart on a North-South grid and 100m apart on an East-West grid. Plot locations were recorded using a Global Positioning System (GPS) and plot locations (UTMs) are provided in Appendix 1.

Plot centers were permanently marked using a 12” galvanized spike and 1” diameter electrical conduit. Three 11.28 m transects (Fig. 2b) were established radiating out from each plot centre to form a spoke separated by 120º. 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. 2b). All bearings were recorded and entered into a database (Appendix 1). Four Daubenmire frame locations were permanently marked on each transect (4 frames/transect = 12 total/plot). Daubenmire frames were located on the left hand side of the transect at meters 3, 5, 7 and 9. The left hand corner located on the transect was permanently marked with an 8” galvanized spike and 1 spray painted washer. Each spike was marked with flagging. Flagging will have to periodically be replaced to ensure easy re-location.

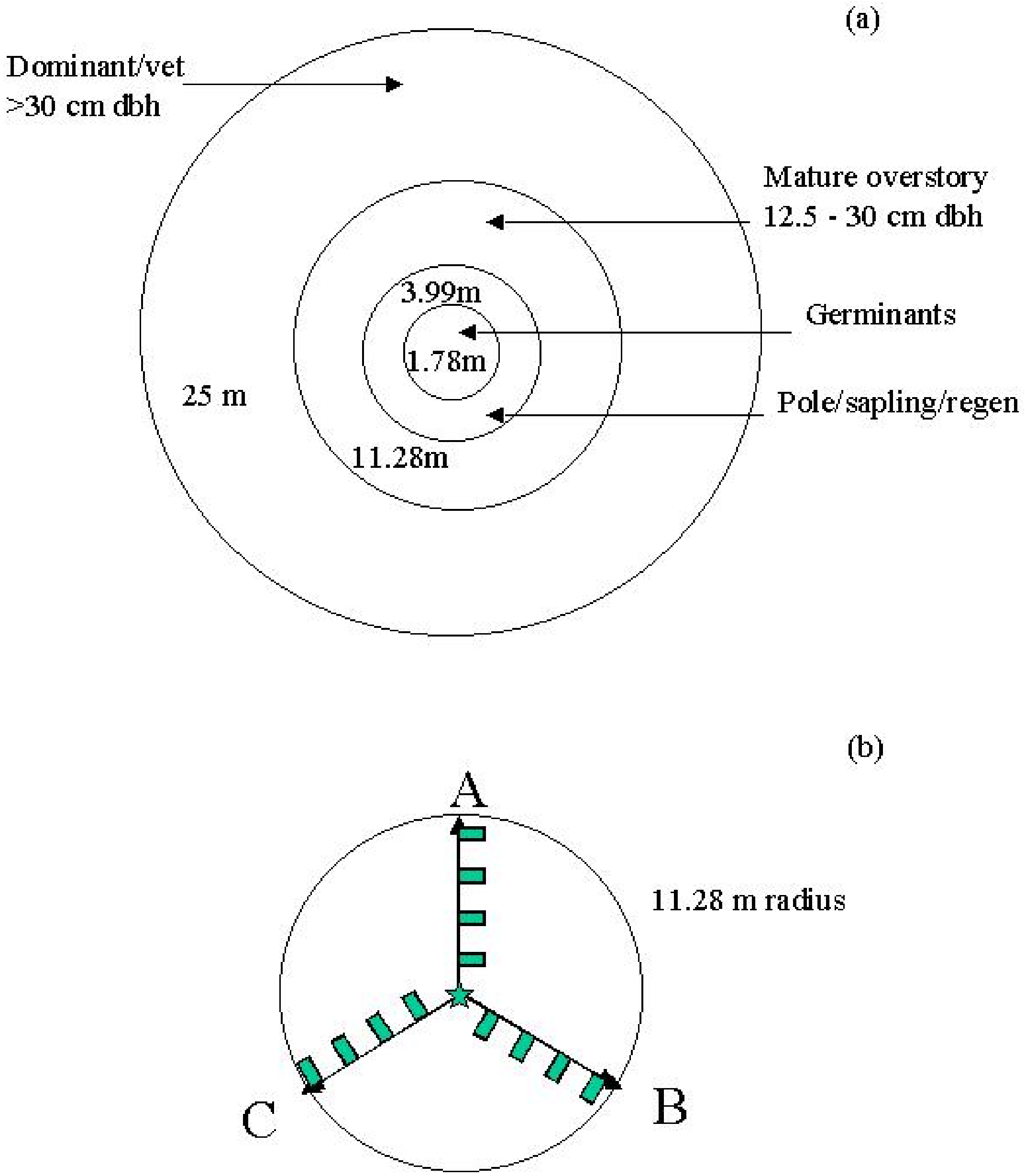

Figure 2a&b Layout of overstory (a) and understory (b) sampling plots adapted from DeLong et al. (2001).

2.2 Restoration objective monitoring

2.2.1 Restoration objective 1

Objective: 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, etc.) (Machmer et al. 2001).

Response Variables: Tree density, diameter and species composition.

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. 4a) were established to sample each layer as follows: layer 1 (1.78 m radius), layer 2, 3 and 4 (3.99 m radius), layer 1 mature (11.28 m radius), and layer 1 dominant/veteran (25 m radius) (Table 1). 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.

Table 1 Tree descriptions by layer used for overstory measurement.

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

2.2.2 Restoration objective 2

Objective: Maintain or increase fire-adapted native vegetation (grass, herb, shrub) in treated areas.

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

Understory plot layout conformed to methods developed by DeLong et al. (2001) and Powell et al. (1998). Three 11.28 m transects (Fig. 2b) were established radiating out from each plot center to form a spoke separated by 120°. Understory vegetation cover and composition data were collected in Daubenmire frames (Daubenmire 1959). In each frame, percent herb and grass cover by species was recorded. Species richness was recorded by plot, and species diversity (by plot and overall) was determined using the Shannon-Weiner diversity index ($H=-P_i\log[P_I]$) (Bonham 1983).

To assess plant vigor, flowering culm counts were conducted for bunchgrasses (see Page 2002). Bunchgrasses chosen for monitoring are species considered historically common in NDT4 stands and include: rough fescue, Idaho fescue (*Festuca idahoensis* Elmer), bluebunch wheatgrass, Junegrass (*Koeleria macrantha* (Ledeb. J.A. Schultes f.), Richardson's needlegrass (*Stipa richardsonii* Link.), needle-and-thread grass (*Stipa comata* Trin.&Rupr.) and stiff needlegrass (*Stipa occidentalis* Thurb. ex S. Wats. var. *pubescens* Maze, Tayor and MacBryde). At this time, percent cover of domestic and native ungulate feces was also recorded, in order to provide an indicator of animal use.

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).

2.2.3 Restoration objective 3

Objective: 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 Daubenmire frames in each of the 15 plots per site (Fig. 2b). If weed cover (noxious and nuisance weeds) was less than 5%, individual plants in the Daubenmire frames were counted to provide a density measure. Additionally, flowering culm counts were recorded for non-native, invasive grasses (e.g., cheatgrass [*Bromus tectorum* L.], quackgrass [*Elymus repens* (L.) Gould] to assess their vigor and health.

2.3 Data entry

Raw data were entered into EXCEL spreadsheets (Appendix 1) in a format that permits easy import into an ACCESS relational database or into the SAS STAT program. Species codes and life-form identifications used were provided by the British Columbia Ministry of Forests Research Branch.

2.4 Data summary and analysis

Data were summarized in EXCEL spreadsheets (Appendix 3) and summary statistics were calculated using SAS (1999). Data were summarized by species and by functional/descriptive group (e.g., shrubs, forbs, grasses, etc.). Due to inherent variability at sites sampled, understory cover data had very large variances (Appendix 3) and these data will require transformation (arcsine or square root) prior to undertaking inter-year comparisons using ANOVA.

3. Results and observations

3.1 General site descriptions

Both sites are located in the IDFun biogeoclimatic subzone (Undifferentiated Interior Douglas-fir. This site is in transition to MSdk (Dry Cool Montane Spruce Subzone) (Braumandl and Curran 1992). Zonal IDFun sites have open stands of Douglas-fir with bluebunch wheatgrass and junegrass being the dominant understory species. Zonal warm aspects in the MSdk are dominated by Saskatoon (*Amelanchier alnifolia* Nutt.) Soils at both 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).

3.1.1 Site 1

Site 1 is located on relatively level ground (mean slope = 3%) with few slopes and gullies, except for a strong slope on the eastern boundary of the block. The eastern boundary of the site has a East aspect with Douglas-fir thickets located on the slope, with the western half of the block on level ground. Site 1 was more recently harvested (2003). Recent disturbance is evidenced by a greater cover of bare soil (Site 1: mean=3.07%; SD=3.63 versus Site 2: mean=1.43; SD=2.43; Appendix 3) and is thus treated as a different unit for monitoring. Site 1 also has significantly more ($p<0.0001$) fuel on the ground as measured by percent cover of dead wood (Site 1: 14.67% SD=3.98% versus Site 2: 7.39% SD=4.81%).

3.1.2 Site 2

Site 2 has variable topography (slopes range from 5–15% with an average of 6.64%). Variation in topography contributes to varied moisture regimes at this site. This site overall has a slightly drier moisture regime, largely due to topography (southwest facing slopes). The southwest facing moderate slopes at this site are prone to erosion and disturbance.

3.2 Overstory characteristics

3.2.1 Site 1

Stem density is very low at site 1. The greatest number of stems occur in the dominant/veteran layer (>30cm DBH) (8 stems/ha; SD=10) (Table 2). If the dead dominant layer is included there are 12 stems ha^{-1} in the dominant layer (Table 1). There are 5 live stems ha^{-1}in the mature layer (SD=14).

In comparison, the restoration treatment goal for a NDT4 site in the Cranbrook forest district was a post-harvest target density of 26-36 stems ha^{-1} of 20-65 cm diameter at breast height (dbh) healthy, well-formed veteran/dominant ponderosa pine and Douglas-fir; 5-20 stems ha^{-1} of 15-20 cm dbh ponderosa pine and Douglas-fir; 10-20 stems ha^{-1} of layer 10-15 cm dbh ponderosa pine and Douglas-fir; and 50-60 stems ha^{-1} of 3-5 cm dbh ponderosa pine (Machmer 2002). Stand/Site level management objectives stated by the East Kootenay Ungulate Winter Range Committee (2003) recommend 20 stems ha^{-1} for open range (with no minimum) and 150 stems ha^{-1} for open forest (76 stems ha^{-1} minimum).

There is a relatively high level of mortality in the dominant/veteran layer (4 stems/ha; SD=5). Of the 12 dead veteran/dominant trees found at this site, 11 had been 'topped' to create wildlife tree 'stubs' (Fig. 3). The creation of stubs as opposed to retaining wildlife trees of full height is of questionable wildlife value. Harris (2001) monitored 170 stubs created over a 10 year period in the IDF zone. No new cavities were created in the stubs in that 10 year period, although some existing cavities were re-used for cavity nesting. Machmer (pers. comm., Pandion Ecological Research, 2004) states that this is greater than two orders of magnitude less than what would be expected in a natural stand. It was noted, at Site 1, that some of the stubs are currently being used for feeding and nesting (approximately 1/3, Appendix 1) although these trees were likely used prior to stub creation. There is also some concern that these stubs are more prone to nest predation than full-length wildlife trees (Machmer, pers. comm., Pandion Ecological Research, 2004). Non-excavator species (birds who use nest boxes or existing cavities) in nature suffer higher nest failure than do excavators because they use older cavities that are lower to the ground (Li and Martin 1991).

Figure 3 Example of a wildlife tree stub at Redstreak restoration Site 1. Photograph taken in 2004.

Conifer regeneration at site 1 is negligible (201 dead Douglas fir stems/ha). Regeneration at this site in the short term will be due to aspen (*Populus tremuloides* Michx.) suckering (1206 live stems/ha; SD=3205). Regeneration of aspen occurs following disturbances such as fire and logging. Regeneration occurs mostly through root suckering. Root suckers are produced after disruption of apical dominance (Farmer 1962), and increased soil temperature (Maine and Horton 1966) created by the removal of the overstory (DesRochers and Lieffers 2001). After establishment, aspen can exist on the landscape for 30 to 70 years, until the species is eventually replaced by conifers such as Douglas-fir. Aspen suckering appears to be restricted to the northern end of site 1.

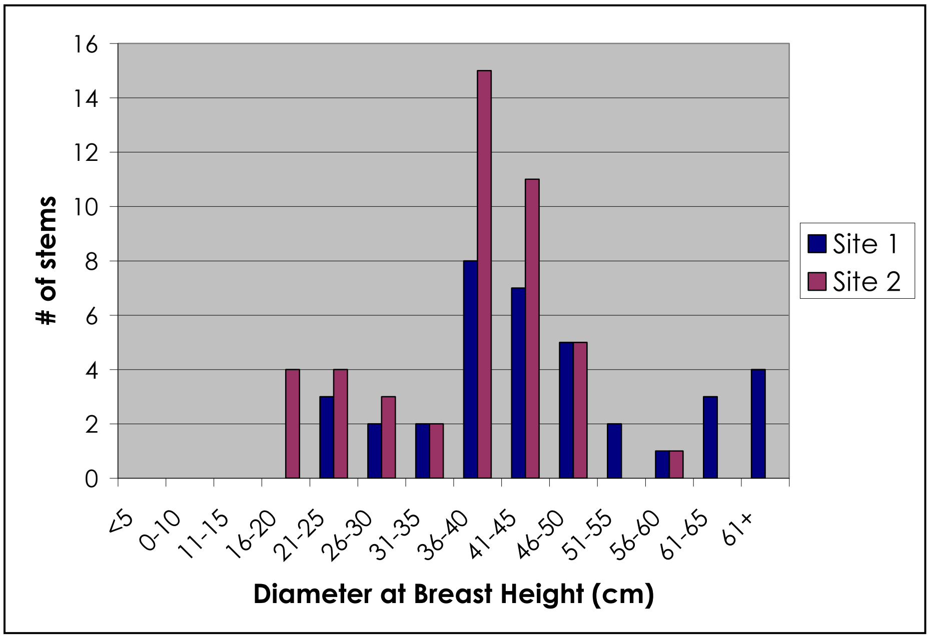

Figure 4 Stem diameter distributions for layers 1a, 1, 2 and 3 at two restoration sites sampled in 2004.

3.2.2 Site 2

There are 28 stems/ha (versus 13 stems/ha at site 1) (live stems in the dominant/veteran layer as well as the mature layer). This site is slightly over stocking recommendations for open range but well under the minimum stocking level recommended for open forest (East Kootenay Ungulate Winter Range Committee 2003). The bulk of the trees at this site are found in the 40cm dbh to 55cm dbh zone (Fig. 3). All dominant/veteran trees found at this site were alive, therefore, there were no wildlife tree stubs surveyed at this site. There is a well established mature stand of trees at this site (16 stems ha^{-1}; SD=23).

There is slightly more conifer regeneration occurring at this site (215 stems ha-1; SD=806; Table 4). This figure is slightly misleading as all conifer regeneration is occurring at one plot (2-13), which explains the large variation about the conifer regeneration mean (Table 3). There is also slightly increased aspen regeneration at this site (1809 stems ha^{-1}; SD=6733). This is largely due to plots located in slight depressions where the moisture regime is more conducive to aspen regeneration (e.g. plots 2-1 and 2-8).

Table 2 Summary of stems/hectare of layer 1, 2 and 3[1] trees (total trees and dead trees only) at two restoration sites sampled in 2004. The only species present in layers 1, 2 and 3 was Douglas fir.

Site	layer 1 (dom/vets)		layer 1 dead (dom/vets)		layer 1 (mature)		layer 1 dead (mature)		layer 2 (pole)		layer 2 dead (pole)		layer 3 (sapling)		layer 3 dead (sapling)	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Site 1	8	10	4	5	5	14	2	6	0	0	0	0	0	0	0	0
Site 2	12	7	0	0	16	23	0	0	0	0	0	0	0	0	0	0

[1] Layers as defined in Table1.

Table 3 Summary of stems/ha of layer 4[1] trees (regeneration) at two restoration sites sampled in 2002. Aspen and Douglas fir were the only two species present in layer 4.

Site	Douglas fir regen (live)		Douglas fir regen (dead)		Aspen regen (live)		Aspen regen (dead)	
	mean	SD	mean	SD	mean	SD	mean	SD
Site 1	0	0	201	416	1206	3205	0	0
Site 2	215	806	72	267	1809	6733	67	259

[1] Layers as defined in Table1.

3.3 Understory Characteristics

There were 70 species recorded in the monitoring plots at both sites. The most common species recorded, across both sites, was pinegrass (*Calamagrostis rubescens* Buckl.)and birch-leaved spirea (*Spiraea betulifolia* Pall. ssp. lucida), both common species of ingrown forests. Conifer regeneration in the understory at both sites is negligible.

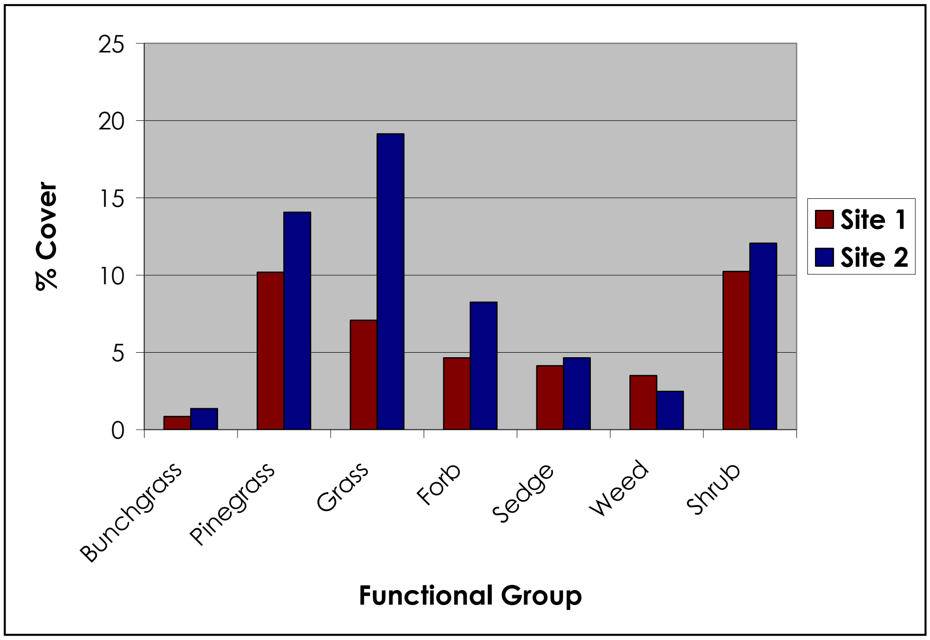

Figure 5. Summary of understory characteristics at both sites as monitored in 2004.

3.3.1 Site 1

The Site 1 understory was dominated primarily by shade-tolerant grasses and shrubs. Extensive pinegrass cover (10.2%; SD=6.51%; Appendix 1) is likely due to the relatively high pre-treatment canopy closure and presence of Douglas-fir thickets. Pinegrass is a rhizomatous perennial that remains abundant under shade and is prevalent under dense fir canopies (Steele and Geier-Hayes 1993). Page (2002) found a significant inverse relationship between pinegrass cover and bunchgrass cover prior to restoration treatments in the Trench. Pinegrass as well as competing for limited moisture can withstand low-light environments whereas native bunchgrasses require increased light levels. Bunchgrass cover is low as well as highly variable at this site (0.84%; SD=1.415).

After pinegrass, birch-leaved spirea and perennial sow-thistle (*Sonchus arvensis* L.) (Fig. 6) had the second highest (3.64%; SD=2.98%; Appendix 3) and third-highest (2.44%; SD=4.01%; Appendix 1) cover respectively at this site. Perennial sowthistle is classified as a noxious weed in British Columbia (Province of British Columbia 2002). Perennial sowthistle leaves are edible (Elias et al. 1982) and there was evidence of substantive use at this site, probably by bighorn sheep (*Ovis canadensis*). The author expects that cover of this species will decline with time. In Douglas-fir forests of Washington, Thysell and Carey (2001) observed a 280% initial increase in exotic species post-mechanical restoration, but recorded a decline in the first to third year post-thinning. The initial increase in exotic species may be temporary as weed species may have 'transient occupancy' at this site (Thysell and Carey 2001).

Figure 6 Example of sowthistle cover at Site 1. Photograph taken in 2004 at plot 1-13.

Forb cover was relatively high (4.64%; SD=4.28) with showy aster (*Aster conspicuus* Lindl.) comprising nearly 50% of cover at site 1 (1.9%; SD=2.14). The high cover of showy aster is an indication of the transition of this site between a IDF and MSdk subzone classification.

Site 1 had low species richness (10.13 species; SD=3.46) as well as a low species diversity index (1.47; SD=0.45).

3.3.2 Site 2

Site 2 had slightly higher cover of bunchgrasses (1.36%; SD=1.79%; Fig.4; Table 4), although still relatively low compared to open NDT4/NDT3 sites in the Trench (see Page 2002). Forb cover was significantly higher at this site (p=0.05). This was not due to any one species dominating cover at site 2. Species diversity was significantly higher than at Site 1 (p=0.02) meaning not only was species richness significantly (p=0.0002) higher (15 species; SD=2 versus 10 species at Site 1; SD=3; Appendix 1), but species distribution across the site was more 'even'.

There was a relatively high cover of bull thistle (*Cirsium vulgare* (Savi) Tenore) at this site (1.3%; SD=4.4%). Bull thistle is classified as a 'nuisance' weed by the British Columbia Weed Control Act (Province of British Columbia 2002). Bull thistle seeds are highly viable and usually germinate rapidly whenever conditions are favourable i.e. recently disturbed sites. Seeds have silky down and can be windblown for long distances, but most seeds land near the parent plant (Province of British Columbia 2004). Bull thistle infestations at this site were largely restricted to a few plots. Precautions have to be taken to prevent bull thistle establishment after prescribed fire. Observations in Tallgrass prairie sites in South Dakota indicate that a program of prescribed burning designed to simulate the historic fire regime encourages the growth of native plants and discourages the growth of invasive thistles (USDA 2003). However, site-specific circumstances e.g. precipitation, fire intensity will determine the restoration outcome at this site.

Table 4 Summary of understory cover characteristics by functional/descriptive group at three restoration sites sampled in 2004.

	Site 1		Site 2	
Understory component	**mean**	**SD**	**mean**	**SD**
Bunchgrass Cover[1] (%)	0.84	1.41	1.36	1.79
Grass Cover[2] (%)	7.07	10.51	19.14	27.85
Forb Cover (%)	4.64	4.28	8.24	5.08
Carex Cover (%)	4.13	6.40	4.64	7.64
Shrub Cover (%)	10.24	7.55	12.06	7.42
Exotics species cover	3.5	4.32	2.47	6.47
Conifer cover[2] (%)	0	0	0	0

[1] Includes native bunchgrasses considered historically common listed on pg. 9.
[2] Includes any native grass that is not classified as a bunchgrass.

4. Recommendations

4.1 Site 1

Site 1 has been harvested to an open range unit, with a large amount of timber being removed from this site. Due to the large volume to timber removed there has also been a significant amount of disturbance at this site. Disturbance has resulted in moderate amounts of bare soil (3.07%; Appendix 3), a large amount of dead wood on the ground (14.67%; Appendix 1) and has likely contributed to significant amount of non-native species cover (3.5%; Table 4). Due to the lack of pre-treatment monitoring the effects of restoration harvesting cannot be determined, only hypothesized.

Prescribed fire has to be applied to this unit with extreme caution. Primarily due to the possibility of perennial sow thistle cover expanding with the introduction of fire. Perennial sowthistle populations will likely resist fire because buried seeds and vegetative buds on rhizomes are protected from fire by soil. Perennial sowthistle may expand its range with rapid dispersal of seeds onto recently burned sites. However, if fire enhances growth of native vegetation which competes with perennial sowthistle, perennial sowthistle cover and abundance may decline after fire (USDA 2003).

The enhancement of native vegetation cover will likely only be possible with a reduction of dead wood on the ground. Due to the large amount of fuel on the ground it is possible that the fire may exceed ideal fire intensities. However, Antos et al. (1983) examined the recovery after burning by a hot summer wildfire, of a foothills fescue (bunchgrass-dominated) grassland in west-central Montana, and found these grasslands to be resilient to wildfire. They deduced that the high resilience is related to the phenology of grassland plants. Since most plants complete their life cycles by the onset of summer drought, burning during the summer season tended to have a minimal effect on reproduction and carbohydrate storage. Similarly in Alberta, a foothills rough fescue plant community was characterized as being resilient to wildfire (Bork et al., 2002). With the exception of Parry's oatgrass, foothills rough fescue and all other dominant grasses appeared to recover by the second year after wildfire. Although forage production declined by 40% in the first year, it had recovered fully by the third year after fire. Most importantly, in the context of restoration, burning increased seed head densities to nearly twice that of the unburned area ($p<0.10$). The authors concluded that this was likely due to loss of litter, or perhaps to the addition of soil nutrient from fire effects (Bork et al., 2002).

The benefits of introducing fire to this site will likely outweigh the negative impacts, but the trade-off will only be determined by further monitoring at this site. The author suggests that distinct sow thistle patches be mapped using a GPS and that the boundaries be monitored for expansion or shrinkage. This is an easy cost-effective method of monitoring the effects of fire on non-native plant populations.

Additionally, this site is of interest for monitoring due to the large amount of timber removed from this site. Increased timber removal (relative to other restoration projects) may have a differential impact on the understory, due to increased light and decreased competition from the overstory for belowground resources. The effect of overstory treatments will be determined by further monitoring.

Wildlife tree stubs need to monitored for continued use, especially relative to other full height wildlife trees in other restoration blocks or in adjacent control blocks. The effects of this practice on cavity-nesters should be determined before applying this practice in all restoration blocks in the Park. Machmer (pers. comm., Pandion Ecological Research. 2004) suggests focusing on retention of wildlife tree patches and the creation of no-work zones around these patches. If financial resources permit, the Park may be an ideal venue to study the two different methods of retaining wildlife trees in restoration blocks. There is the additional concern that the lack of a mature overstory layer (layer 2) may result in a deficiency of wildlife trees as the dominant/veteran layer dies off. The effect of structural diversity in this stand on cavity nesting species should be closely monitored.

4.2 Site 2

Site 2 has greater structural overstory diversity (i.e. the presence of a low-density mature overstory layer). The long-term response of cavity-nesters to restoration activities at site 2 will serve as a useful comparison to site 1. In addition to the response to structural diversity it will also be useful to compare cavity-nester use of the dominant/veteran layer between both sites. This may be difficult in the short-term as there is little to no mortality in the dominant/veteran layer at site 2.

There is virtually no conifer regeneration at this site and relatively little fuel on the ground. The benefits of prescribed fire would be largely due to promotion of fire-resistant bunchgrasses and shrubs, although generalized responses of bunchgrasses to prescribed fire is not conclusive. Response of the understory to fire should be monitored closely. The necessity of fire to restoration activities at this site cannot be determined at this time. Increased light and increased evapotranspiration (i.e. less soil moisture) due to overstory removal may be sufficient to initiate understory recovery, but fire may be needed to reduce woody debris and promote nutrient cycling.

Fire should be applied with caution due to the presence of bull thistle and Canada thistle (Canada thistle was not found in the monitoring plots, but was observed on this site). Introduction of fire could potentially increase the rate of invasion of both thistle species at Site 2. As with monitoring perennial sow thistle at Site 1, the author suggests mapping and monitoring the boundaries of thistle invasions in response to restoration activities.

4.3 Weeds to Watch

It is clear that perennial sowthistle and bull thistle cover needs to be monitored at this site, to ensure restoration activities are no way benefiting the spread of these species. The following non-native species were present at this sites but not recorded in the plots:

- Canada thistle [*Cirsium arvense* (L.) Scop. Var. *horridium* Wimm. & Grab.] – found at Site 2 scattered throughout the block.
- Spotted knapweed (*Centaurea biebersteinii* DC.) – found one plant at Site 1 in the vicinity of Plot 1-5. Plant was pulled at that time.
- Sticky ragwort (*Senecio viscosus* L.) – found at Site 1 scattered throughout the block.

These species should be monitored for closely to ensure their range does not expand within the restoration sites.

4.4 General recommendations

Both sites are ideally suited to some type of restoration prescription. It is essential to monitor these sites one year after mechanical treatment and in the longer term (i.e., post-mechanical treatment years 3, 5 and 10 if restoration burning is not planned, or post-prescribed burn treatment years 1, 3, 5 and 10; see Machmer et al. 2002). This will provide feedback with respect to the attainment of short- and longer term site-specific objectives and permit some refinement of practices in order to meet broader program-level restoration goals. Monitoring will also contribute to a growing body of knowledge in the Rocky Mountain Trench about restoration and its effects on different ecosystems.

The lack of pre-treatment monitoring at both sites highlights the need for clearly defined goals. Due to lack of pre-treatment monitoring at both sites, long-term monitoring cannot determine the effect of restoration on the overstory and understory. Therefore goals need to be defined that indicate a desirable states for both sites. For example, managers may want to achieve75% native species composition by year 5 post restoration initiation. By describing the desirable plant community, managers will be able to gauge success of restoration at these sites. Monitoring will provide timelines needed to achieve these goals on other restoration sites in the Park as well as determine if more intensive restoration is warranted (i.e. planting desirable species).

The author suggests looking for an appropriate control site (e.g. immediately south of both sites) to more accurately determine the effects of restoration activities. The presence of a control site will also increase managers ability to evaluate the trade-off between the potentially negative effects of restoration (e.g.

increase in non-natives) and the positive effects of restoration (e.g. decreased wildfire risk, increased forage production).

Monitoring at both these Sites is a valuable component of Kootenay National Park's fire-maintained ecosystem restoration program. Time and financial resources invested in projects such as these are essential to landscape level restoration programs to ensure the goals of restoration are being met.

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5. Literature Cited

Antos, J.A., B. McCune, C. Bara. 1983. The effect of fire on ungrazed western Montana grassland. American Midland Naturalist 110: 354 – 364.

Arno, S.F., M.G. Harrington, C.E. Fiedler, and C.E. Carlson. 1996. Using Silviculture and Prescribed Fire to Reduce Fire Hazard and Improve Health in Ponderosa Pine Forests. Pp. 114-118 *In* Proceedings of the 17th Annual Forest Vegetation Management Conference, Redding, California.

Bai, Y., N. Walsworth, B. Roddan, D.A. Hill, K. Broersma, and D. Thompson. 2001. Quantifying tree encroachment in rangelands using image classification and pattern detection. Poster Presentation. Society for Range Management 54th Annual Meeting. Kona-Kailua Hawaii.

Bonham, C. 1983. Measurements for Terrestrial Vegetation. John Wiley & Sons. New York, NY. 338p.

Bork, E.W., B.W. Adams, and W.D. Willms. 2002. Resilience of foothills rough fescue, Festuca campestris, rangeland to wildfire. Canadian Field Naturalist 116: 51 – 59.

Braumandl, T.F. and M.P. Curran. 1992. A field guide for site identification and interpretation for the Nelson Forest Region. B.C. Ministry of Forests, Research Branch, Land Management Handbook Number 20, Victoria, B.C. 311p.

Daigle, P. 1996. Fire in the dry interior of British Columbia. Extension Note 8. B.C. Ministry of Forests Research Program. Victoria, B.C.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science **33:** 43–64.

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

DesRochers, A. and V.J. Lieffers. 2001. Root biomass of regenerating aspen (Populus tremuloides) stands of different densities in Alberta. Canadian Journal of Forest Research **31:** 1012-1018.

Elias, Thomas S.; Dykeman, Peter A. 1982. Field guide to North American edible wild plants. Outdoor Life Books. Sterling Publishing 286 p.

Farmer, R.E. 1962. Aspen root sucker formation and apical dominance. Forest Science **8:** 403 – 410.

Gayton. D.V. 2001. Ground work: basic concepts of ecological restoration in British Columbia. Southern Interior Forest Extension and Research Partnership. Kamloops, BC.

Gayton, D. 1997. Preliminary calculation of excess forest ingrowth and resulting forage impact in the Rocky Mountain Trench. B.C. Ministry of Forests, Nelson Region.

Gray, R.W., B. Andrew, B.A. Blackwell, A. Needoba and F. Steele. 2002. The effect of physiography and topography on fire regimes and forest communities. DRAFT. Report submitted to: The Habitat Conservation Trust Fund. Victoria, BC.

Harris, B. 2001. Observations of the use of stubs by wild birds. A 10-year update. BC Journal of Ecosystems and Management. **1:** 19 – 23.

Li, P. and T.E. Martin. 1991. Nest-site selection and nesting success of cavity-nesting birds in high elevation forest drainages. Auk. **108:** 405 – 418.

Machmer, M.M. 2001. Development and testing of fine-filter prescriptions for listed and fire-adapted species in conjunction with NDT4 Ecosystem restoration in the Rocky Mountain Trench: Literature Search and Preliminary Work Plan. Terrestrial Ecosystem Restoration Program and Habitat Conservation Trust Fund, Victoria. 91pp.

Machmer, M.. 2002. Effects of ecosystem restoration treatments on cavity nesting birds habitat and their insectivorous prey in fire-maintained ecosystems of southeastern British Columbia. United States Department of Agriculture. Forest Service. General Technical Report PSW-GTR-181.

Machmer, M.M., H.N. Page and C. Steeger. 2002. East Kootenay Trench Restoration Effectiveness Monitoring Plan. Report prepared by Pandion Ecological Research Ltd. for the Habitat Branch, Ministry of Water, Land and Air Protection and Forest Renewal B.C. Terrestrial Ecosystem Restoration Program, Victoria, B.C. 50p.

Maine, J.S. and K.W. Horton. 1966. Vegetative propagation of Populus spp. I. Influence of temperature on formation of initial growth suckers. Canadian Journal of Botany. **44:** 1183 – 1189.

Lacelle, L.E.H. 1990. Biophysical resources of the East Kootenay area : soils. Victoria, B.C. Wildlife Branch, Habitat Inventory Section, [1990].

National Research Council of Canada. 1998. The Canadian System of Soil Classification. Agricultural and Agri-Food Canada Publication 1646. (Revised). 187p.

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.

Powell, G.W., D. White, D. Smith, B. Nyberg. 1998. Monitoring Restoration of Fire-Maintained Ecosystems in the Invermere Forest District. Interim Working Plan. B.C. Ministry of Forests, Research Branch.

Province of British Columbia. 2002. Field Guide to Noxious and Other Selected Weeds of British Columbia. BC Ministry of Agriculture, Food and Fisheries.

Province of British Columbia. 1995. Biodiversity Guidebook. Forest Practices Code of BC Act. Strategic Planning Regulations. Operational Planning Regulation. BC Ministry of Forests. Victoria, BC.

Province of British Columbia. 2004. Weeds BC. Identification and Management. BC Ministry of Agriculture, Food and Fisheries. Online: [accessed on October 18, 2004: available at www.weedsbc/resources.html].

Ritchie, M.W. and K.A. Harcksen. 1999. Long-term interdisciplinary research on the Goosenest Adaptive Management Area, Klamath National Forest, California. The Forestry Chronicle **75:** 453–456.

Rocky Mountain Trench Ecosystem Restoration Steering Committee. 2000. Fire-maintained ecosystem restoration in the Trench: a blueprint for action. February 2000. 16p.

SAS Institute Inc. 1999. SAS/STAT guide for personal computers. Version 8. SAS Institute, Cary, NC.

Smith, H.Y. and S.F. Arno. 1999. Eighty-eight years of change in a managed ponderosa pine forest. Gen. Tech. Rep. RMRS-GTR-23. USDA For. Serv., Rocky Mountain Research Station, Ogden, UT. 55p.

Steele, R. and K. Geier-Hayes. 1993. The Douglas-fir/Pinegrass Habitat Type in Central Idaho: Succession and Management. Gen. Tech. Rep. INT-GTR-298, USDA For. Serv., Intermountain Research Station, Ogden, UT.

Thysell, D.R. and A.B. Carey. 2001. Manipulation of density of Pseudotsuga menziesii canopies: preliminary effects on understory vegetation. Canadian Journal of Forest Research **31:** 1513 – 1525.

U.S. Department of Agriculture (USDA), Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. 2003. Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/.

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

File/Folder Name	Description
KNPER_understory	Includes plot location and ID information, as well as understory species composition raw data (species richness, species canopy cover, flowering culm and weed density).
KNPER_overstory	Includes all overstory data (tree species, diameter at breast height, height, decay class, presence of insects and disease)

Appendix 2 Scanned photos (RW-CD format)

Photos were taken from the plot centre in the direction of each transect. Photos were numbered and ordered to match the number of the transect (1 – 3)

Appendix 3 Names and descriptions of EXCEL spreadsheets in the "Summary Data" file (RW-CD format)

Spreadsheet Name	Description
Overstory	Includes summary tabulations for all overstory characteristics by plot and site. Including species richness and diversity calculations.
Understory	Includes summary tabulations of understory cover by species, plot and site.