COLUMBIA BASIN
FISH & WILDLIFE
COMPENSATION
PROGRAM

BRITISH COLUMBIA

MONITORING ECOSYSTEM RESTORATION TREATMENTS IN THE ROCKY MOUNTAIN TRENCH

SITE ESTABLISHMENT REPORT

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Summary

In June of 2002, the Columbia Basin Fish and Wildlife Compensation Program (CBFWCP) and the Ministry of Water, Land and Air Protection (WLAP) initiated year one of a multi-year field study designed to monitor the effects of ecosystem restoration treatments on overstory and understory vegetation characteristics. This report summarizes activities associated with year one (2002): sample plot establishment and pre-treatment monitoring at three sites located in the Rocky Mountain Trench of southeastern British Columbia.

Restoration monitoring sites were established at Gina Lake (15 km east of Wasa) in the north Trench, and at Hatchery Ridge (20 km east of Cranbrook) and Rock's Pasture (32 km south of Newgate Provincial Park) in the south Trench. Fifteen plots were permanently located and systematically sampled at each of the three sites, according to general methods outlined in Machmer et al. (2002). Understory sampling (% cover by species, species composition and richness) was conducted from July 10-17, 2002. Overstory sampling (% crown closure, and tree density by species, diameter, and decay class in nested fixed radius plots) and forage production assessments were completed from September 5-11, 2002. The data were entered into EXCEL spreadsheets for easy import into an ACCESS relational database. A summary of pre-treatment vegetation conditions is provided for each site. Post-treatment sampling is scheduled to occur on all three sites.

Acknowledgements

This project was conducted by Hillary Page, Jakob Dulisse and Marlene Machmer and photographs in the report were taken by Jakob Dulisse. Ian Parfitt (CBFWCP) prepared the maps and Dave Lewis and Larry Ingham (CBFWCP) placed production cages at each of the sites. We would like to thank the following individuals for their assistance with this project: Doug Adama, Greg Anderson, Phil Burke, Craig DeMaere, Reg Newman, Darrell Regimbald, and Irene Teske. Finally we would also like to thank John Krebs for administering the project and the CBFWCP and the Habitat Conservation Trust Fund (HCTF) for providing the funding.

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1. Introduction

An estimated 250,000 ha of Crown land within the Ponderosa Pine (PP) and Interior Douglas-fir (IDF) biogeoclimatic zones of the Rocky Mountain Trench and adjoining side valleys are classified as fire-maintained (i.e., Natural Disturbance Type 4; Province of British Columbia 1995, Gayton 1997). Prior to European settlement, these ecosystems experienced frequent (every 7–50 years), low intensity fires (Leiberg 1899, Cooper 1960, Arno et al. 1995). Recurrent fires promoted the development of fire-tolerant overstories of mature ponderosa pine (*Pinus ponderosa* Douglas ex Lawson & Lawson var. *ponderosa*), Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco), and western larch (*Larix occidentalis* Nutt.), with sparse conifer regeneration, and a vigorous understory of bunchgrasses, shrubs and forbs (Arno et al. 1995, Daigle 1996).

NDT4 ecosystems have undergone dramatic changes in structure and function partially attributed to fire suppression and concomitant forest ingrowth and encroachment (Daigle 1996, Gayton 1997, Rocky Mountain Trench Ecosystem Restoration Steering Committee 2000, Bai et al. 2001). Gayton (1997) estimates that 1% of grassland and open forest habitats in the Rocky Mountain Trench are lost annually due to ingrowth or encroachment. This rate is equivalent to approximately 3,000 ha per year, and is comparable to estimates from other parts of B.C. exhibiting similar changes (Bai et al. 2001). As a result of this conversion, domestic livestock and native ungulates are exerting increasing pressure on a declining land base as they compete for forage. Remaining grassland habitats are being further degraded by noxious weeds which may out-compete native vegetation and reduce residual forage quantity and quality. Densely stocked stands also pose an increased risk of severe insect outbreaks and catastrophic crown fires (Powell et al. 1998, Rocky Mountain Trench Ecosystem Restoration Steering Committee 2000).

To mitigate these changes, land management agencies in the East Kootenay Trench are currently undertaking ecosystem restoration or habitat enhancement programs intended to restore NDT4 ecosystems. The Trench Restoration Program is the most extensive restoration terrestrial initiative in B.C. An estimated 135,000 ha is planned for restoration (Rocky Mountain Trench Ecosystem Restoration Steering Committee 2000). The primary objective of this program is to remove excess immature and understory trees in order to create an ecologically appropriate mosaic of NDT4 habitats on Crown land. This mosaic is intended to mimic the historical landscape under natural conditions when fire was an integral part of the ecosystem (Rocky Mountain Trench Ecosystem Restoration Steering Committee 2000).

Ecosystem restoration is typically achieved through a three-phase process. In phase one, ingrown forest stands are thinned to between 20 and 70% of their basal area. Site conditions and stand history dictate what type of tree removal (harvesting, spacing or slashing) is carried out (Arno et al. 1996; Powell et al. 1999). Phase two involves periodic prescribed burning to kill tree seedlings and smaller undesirable trees, while minimizing fire damage to mature trees. In phase three, sites are rested to allow regenerated stems to grow to a height where they can withstand low-intensity burns. This final phase may coincide with a partial harvest of mature stems on the site. Because of the variable history of each site, pre-treatment conditions dictate what type and combination of treatments is carried out in any given area.

Although dry forest restoration treatments are being applied in several areas across western North America (e.g., Arizona, Colorado, Montana, Washington and British Columbia), associated monitoring tends to examine a narrow set of treatment effects (review in Machmer et al. 2002). Furthermore, while prescribed burning has been studied extensively, less attention has been given to ecological impacts of thinning treatments used to restore stand structure prior to fire re-introduction (Smith and Arno 1999). Treatment phases should be monitored in isolation to ensure that restoration goals and objectives are being met, as well as to obtain information that will fine-tune future restoration efforts (Ritchie and Harksen 1999).

This project is in response to a Request for Proposals from the Columbia Basin Fish & Wildlife Compensation Program (CBFWCP) and the Ministry of Water, Land & Air Protection (MWLAP). Specific objectives of the project were to (1) establish three permanent monitoring sites within the Trench, and (2) collect data on pre-treatment vegetation overstory and understory conditions at each site and summarize. Post-treatment 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 John Krebs (CBFWCP). The following four 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.

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

2.1 Study area

Three treatment sites were selected for this project (hereafter referred to as sites 1, 2 and 3 respectively):
(1) Gina Lake pasture (209 ha in the Invermere Forest District; IDFdm2);
(2) Hatchery Ridge pasture (117 ha in the Cranbrook Forest District; IDFdm2); and
(3) Rocks pasture (451.8 ha in the Cranbrook Forest District; IDFdm2).
Maps of each site showing the layout of numbered sampling plots are provided in Figures 1, 2 and 3, respectively.

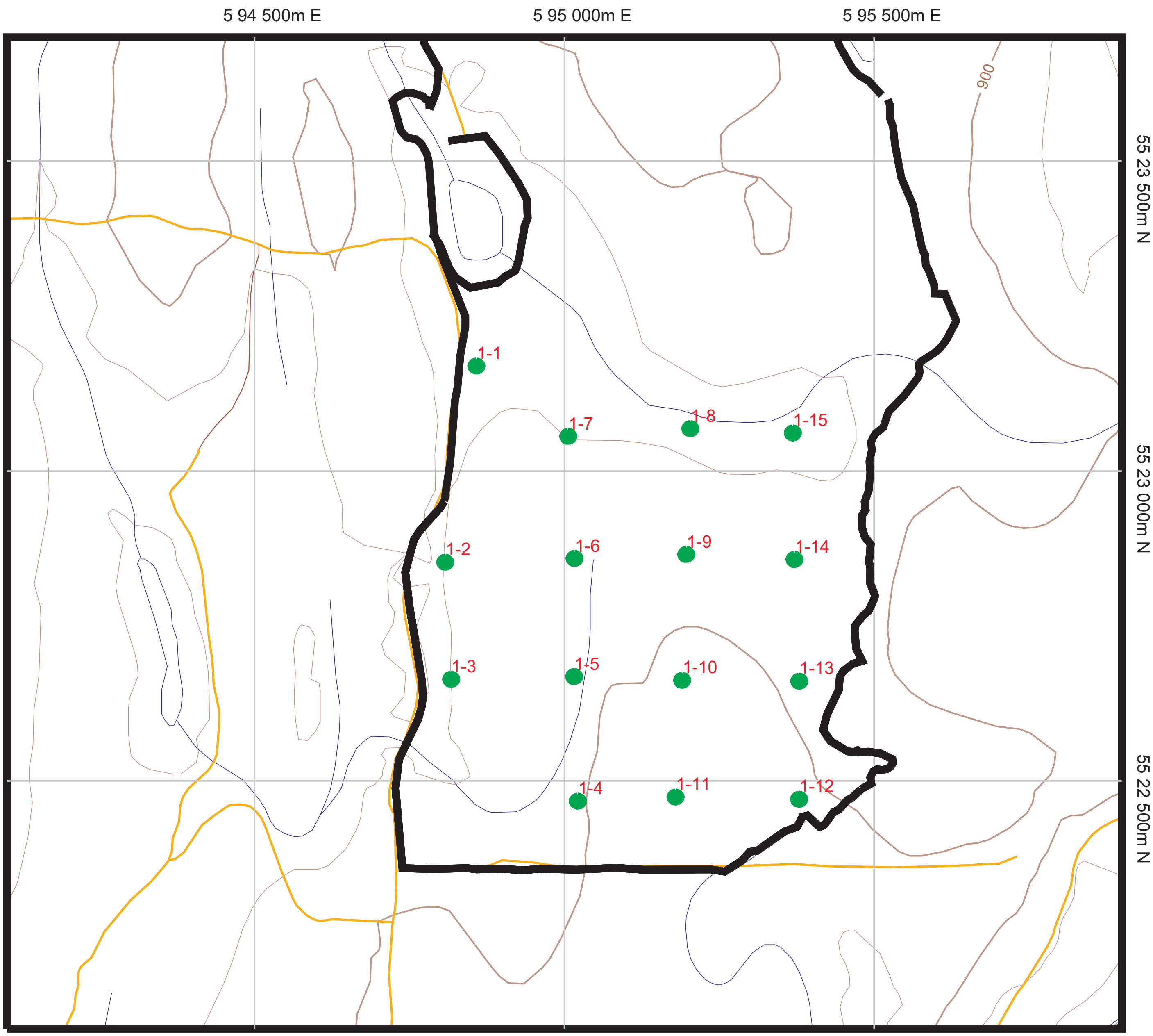


Figure 1. Gina Lake pasture (site 1) located in the Invermere Forest District
Columbia Basin Fish and Wildlife Compensation Program -- June 12, 2003

● Monitoring Location

▬ Treatment Unit Boundary

0 100 200 300 400 500 m

Scale: 1:10,000 - Projection: UTM Zone 11 - Datum: NAD 83

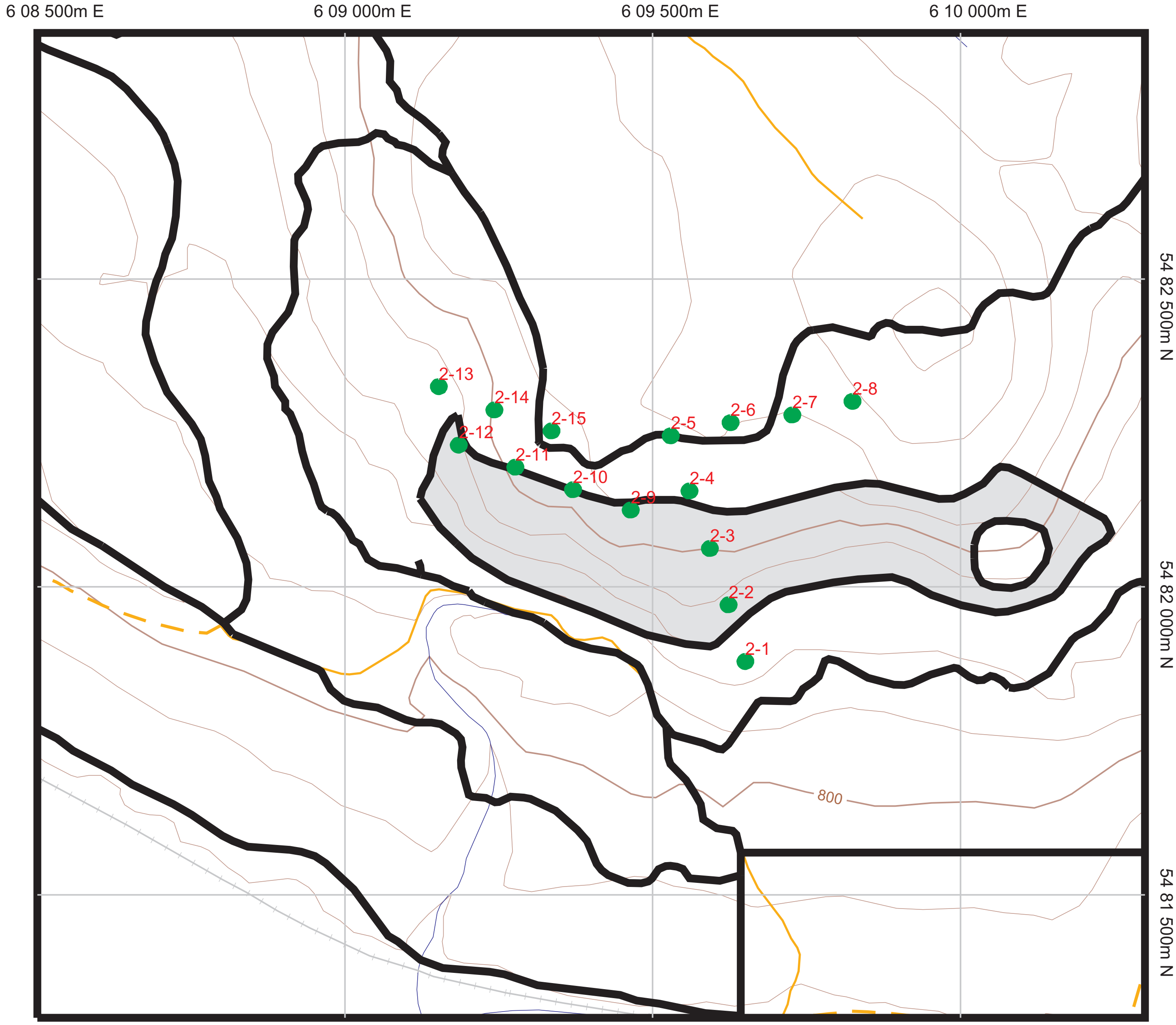


Figure 2. Hatchery Ridge pasture (site 2) located in the Cranbrook Forest District
Columbia Basin Fish and Wildlife Compensation Program -- June 12, 2003

- Monitoring Location
- Treatment Unit Boundary
- Rock Outcrop

0 100 200 300 400 500 m

Scale: 1:10,000 - Projection: UTM Zone 11 - Datum: NAD 83

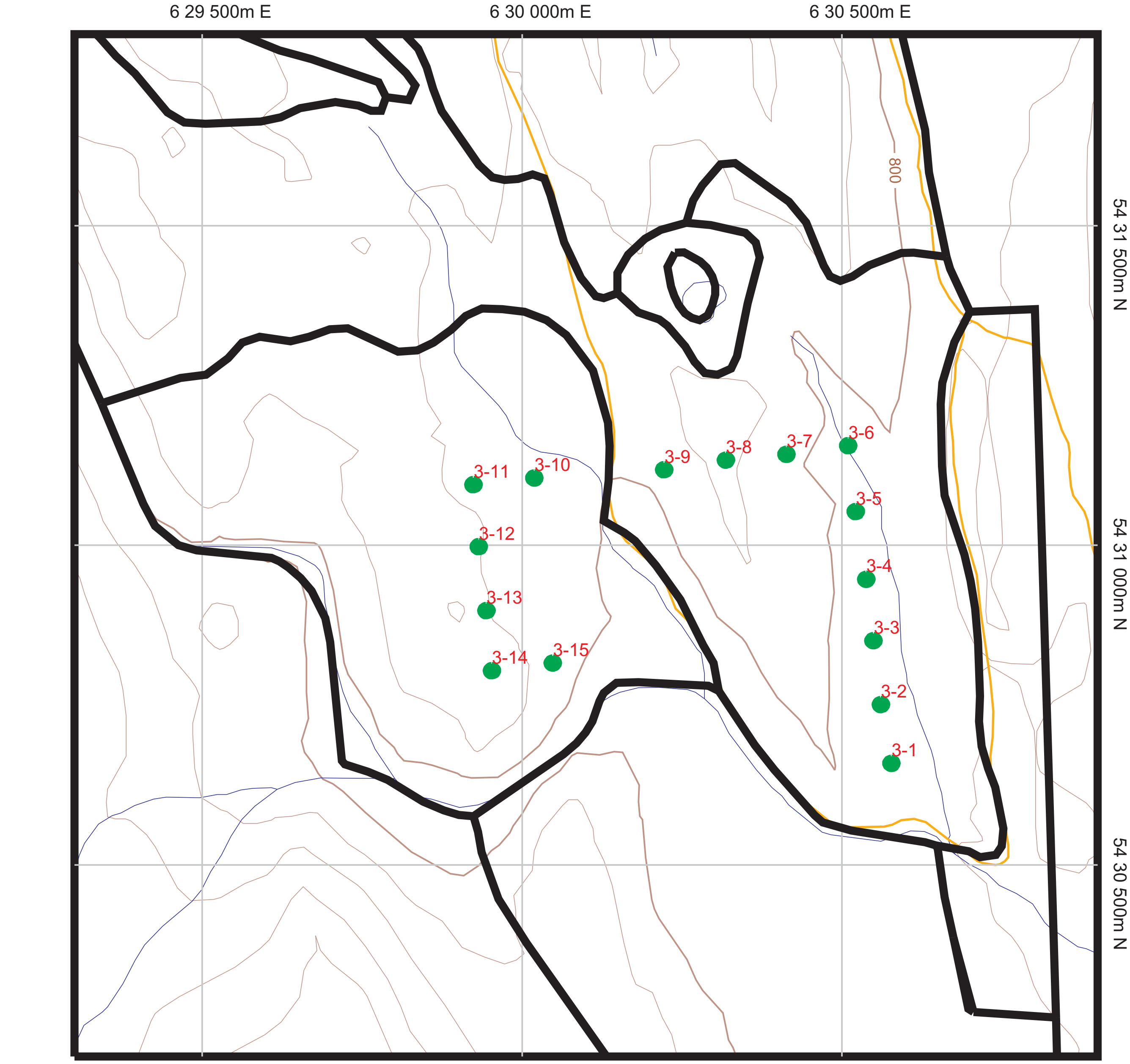


Figure 3. Rocks pasture (site 3) located in the Cranbrook Forest District
Columbia Basin Fish and Wildlife Compensation Program -- June 12, 2003

Monitoring Location

Treatment Unit Boundary

0 100 200 300 400 500 m

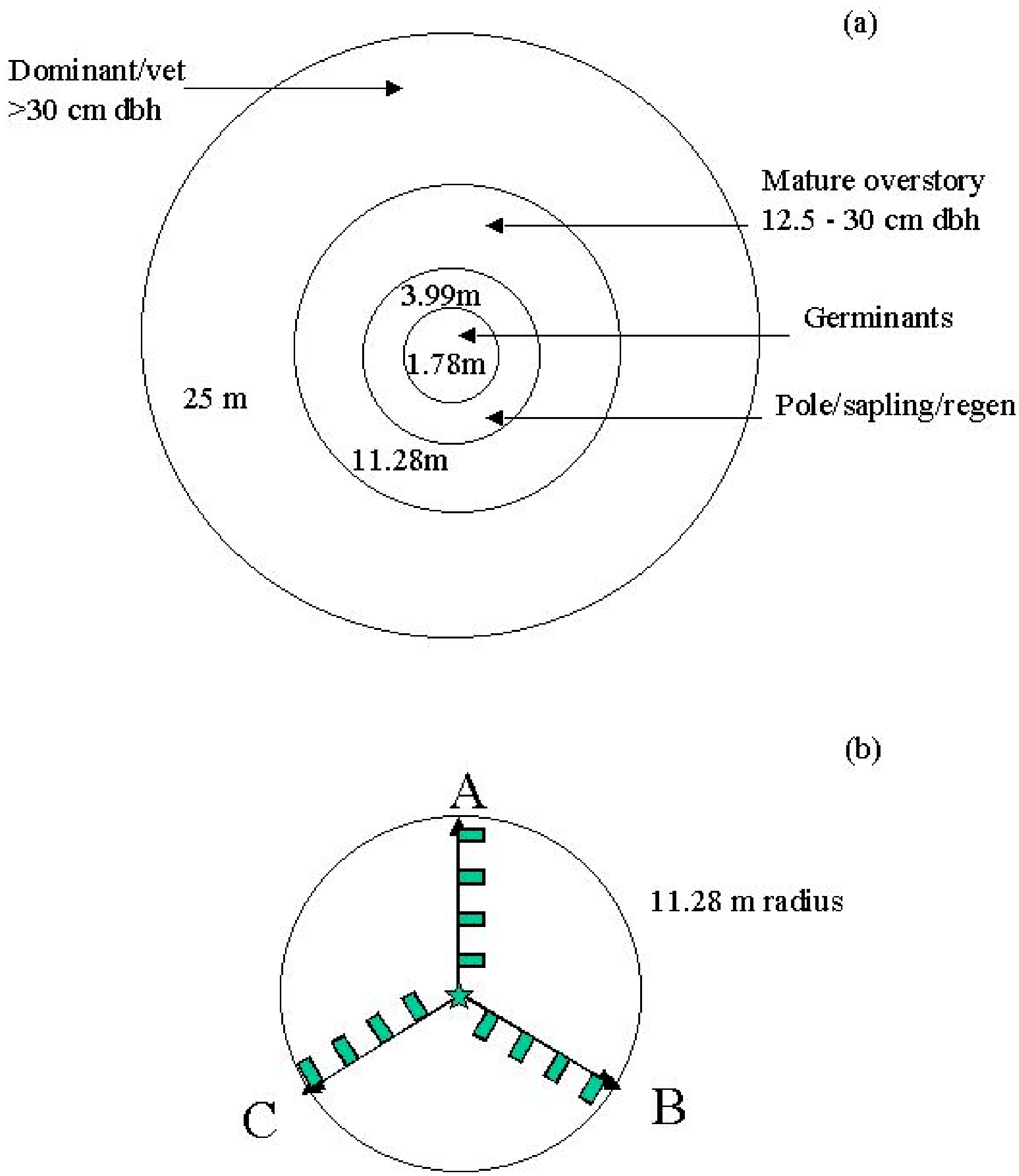
Scale: 1:10,000 - Projection: UTM Zone 11 - Datum: NAD 83

Burlott's pasture (located within the same range unit as Rock's pasture) was originally selected as site 3, but it was eliminated based on consultation with CBFWCP, due to recent harvesting activity. An SP/SMP has been completed for each site, and partial overstory removal (via logging and/or slashing) followed by prescribed burning (broadcast or sloop) is planned for each site over the next 1–3 years.

Fifteen plots (see Figure 4a) were systematically established at each of the three sites, avoiding areas that were heavily disturbed or unrepresentative of the rest of the block. At Gina Lake, monitoring plots were superimposed on existing timber cruise plots located at 200 intervals. Two of the plots were offset slightly to avoid a road and an open marshy area, respectively. Plot establishment at Hatchery Ridge was limited by available space, and plots were therefore located only 100 m apart. The first plot at Rocks pasture was located at a random distance and bearing, with subsequent plots spaced at 100 m intervals. Plot locations were recorded using a Trimble Pathfinder Global Positioning System (GPS) and plot locations (UTMs) are provided in Appendix 1.

Plot centers were permanently marked using an 8" galvanized spike and two spray-painted washers. Three 11.28 m transects (see Figure 4b) were established radiating out from each plot center to form a spoke separated by 120^{o}. 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) to complete the spoke (Figure 4b). 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 flagged and numbered and the flagging will have to replaced periodically.

Figure 4. 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: Crown closure, 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 some modifications, to ensure that large trees and snags were adequately sampled. Fifteen nested, fixed-radius plots (Figure 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. A spherical densiometer was used to measure percent crown closure at plot center. 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. Visual changes to the overstory will be documented by tracking changes in crown closure and stem density within plots. Photos were scanned and are provided in Appendix 2.

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), with modifications made based on the specific goals of this project. Three 11.28 m transects (Fig. 4b) 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, % 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 (*Festuca campestris* Rydb.), Idaho fescue (*Festuca idahoensis* Elmer), bluebunch wheatgrass (*Pseudoroegneria spicata* (Pursh) A. Löve), 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).

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). At this time, percent cover of domestic and native ungulate feces was also recorded, to provide an indication of animal use.

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 (Figure 4b). 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.], Japanese brome [*Bromus japonicus* Thunb.]) to assess their vigor and health.

2.2.4 Restoration objective 4

Objective: Maintain or increase forage production in treated areas.
Response variables: Total production, utilization (caged versus uncaged).

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 randomly 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 will be 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. Kinninick *spp*. 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. 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 m^2 (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.

2.3 Data entry

Raw data were entered into EXCEL spreadsheets (Appendix 1) in a format that permits easy import into ACCESS. Species codes and life-form identifications used were provided by the Ministry of Forests Research Branch. Data collected for this project will eventually be housed in an ACCESS database used by the Research Branch. An example of such a database is provided in Appendix 1, courtesy of Craig DeMaere and Dr. Reg Newman at the Ministry of Forests Research Branch in Kamloops. Raw data file names and descriptions are provided in Appendix 1 of this document.

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

All three pastures 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* Pall. ssp. *lucida* (Dougl. ex Greene) Taylor & MacBryde), common juniper (*Juniperus communis* L.), soopolallie (*Shepherdia canadensis* (L.) Nutt.), Saskatoon (*Amelanchier alnifolia* Nutt.), and common snowberry (*Symphoricarpos albus* (L.) Blake). 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).

3.1.1 Gina Lake pasture

Gina Lake pasture is in the (01) site series and is located on relatively level ground (mean slope = 7%) with few slopes and gullies.

3.1.2 Hatchery Ridge pasture

Hatchery Ridge pasture is in the (01), 03(02) site series and variable topography (slopes range from 7–45% with an average of 25%) contributes to the variation in moisture regimes at this site. Steep southwest-facing slopes appear to be prone to erosion and disturbance, as suggested by the fragile cryptogrammic crust that often forms the only observed ground cover (Figure 5). The site also has a significant amount of bare soil (mean = 8.5%; SD = 19%; Appendix 1). Several bedding areas were found on southwest-facing slopes in the eastern portion of the block. These are likely used extensively by bighorn sheep (*Ovis canadensis*), elk (*Cervas elaphus*), and white-tailed deer (*Odocoileus virginiana*).

3.1.3 Rocks pasture

Rocks pasture is in the 01(02) site series. It is relatively level (range of 0–49% and mean slope of 12%) with greater slopes found in the western portion of the block. There are scattered rocky outcrops throughout this site covered in crust lichens.

3.2 Overstory characteristics

3.2.1 Gina Lake pasture

The overstory at Gina Lake pasture is characterized by closed canopy, small-diameter lodgepole pine and Douglas-fir (layers 2 and 3) with only very few veteran (layer 1a) or dominant (layer 1) ponderosa pine scattered throughout the block (Table 2 and Figure 6a). Layer 3 stem densities are high (Table 3), due largely to the presence of several Douglas-fir thickets (Figure 7) with little to no understory vegetation. Conifer regeneration comprised of 10% lodegpole pine and 90% Douglas-fir is also abundant at this site. Average crown closure is 53% and endemic levels of mountain pine beetle were observed in this block (Table 2).

Figure 5. Southwest-facing slope located at Hatchery Ridge (plot 2-2).

Figure 7. Example of a Douglas-fir thicket at Gina Lake (plot 1-15).

Figure 8. Northern Goshawk nest located at Gina Lake (plot 1-11).

Figure 9. Conifer regeneration at Rocks pasture (plot 3-1).

Figure 6. Stem diameter distributions for pre-treatment layers 1a, 1, 2 and 3 at three restoration sites sampled in 2002.

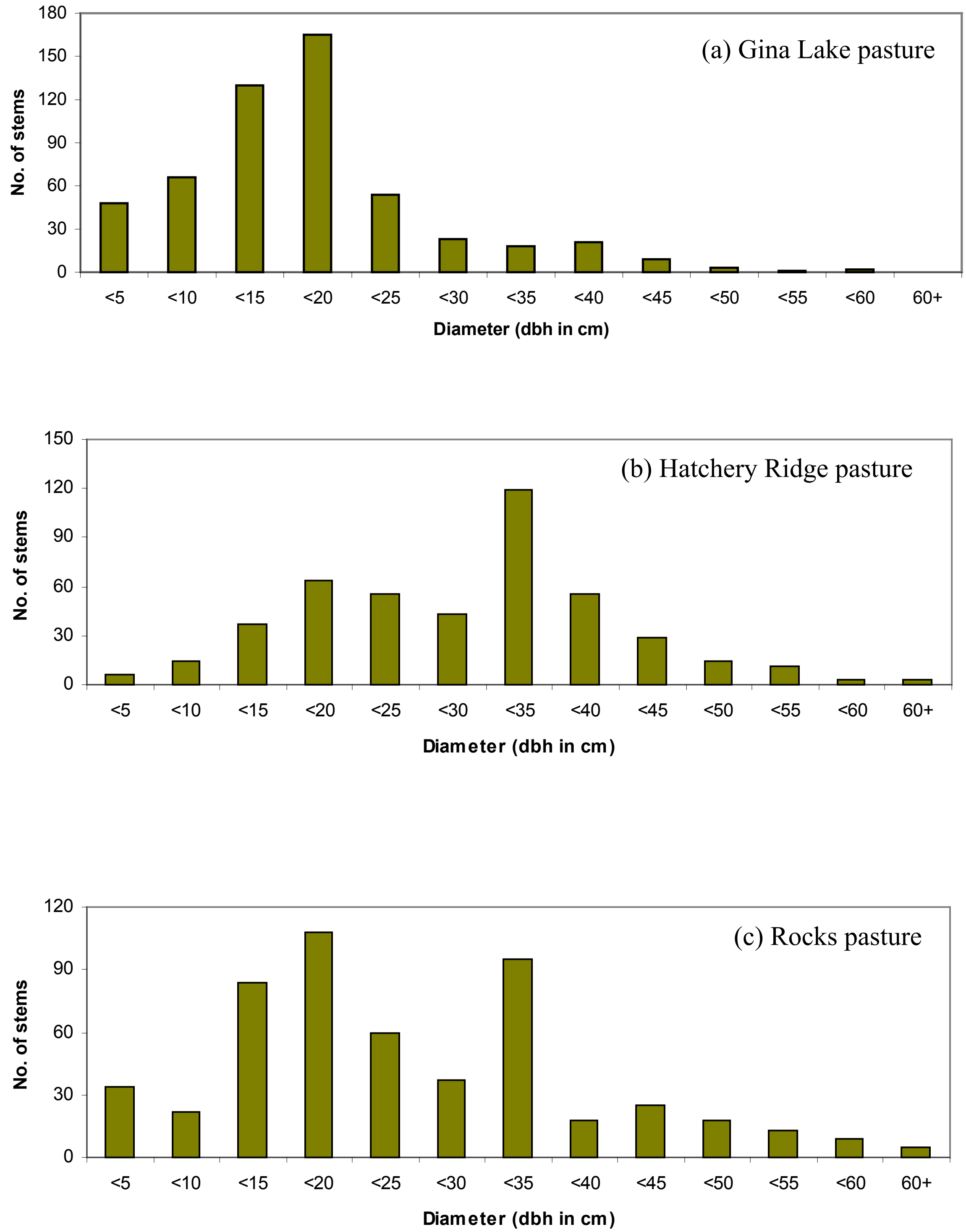


Table 2. Summary of pre-treatment overstory characteristics at three restoration sites sampled in 2002.

Site	Crown closure		Species composition									
	%		% Fd		%Py		%Pl		%Lw		% diseased trees	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Gina Lake	53	11	37	41	21	22	42	37	0	0	2	5
Hatchery Ridge	47	20	89	13	11	13	0	0	0	0	20	21
Rock's Pasture	58	8	69	24	21	13	0	0	10	24	4	5

Table 3. Summary of pre-treatment densities (stems/hectare) of layer 1, 2 and 3[1] trees (total trees and dead trees only) at three restoration sites sampled in 2002.

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
Gina Lake	18	21	0	0	550	203	38	32	320	281	71	111	1280	913	200	306
Hatchery Ridge	78	42	3	5	325	233	7	12	73	116	14	38	173	377	229	439
Rock's Pasture	76	32	6	5	458	277	39	38	113	188	14	38	693	1008	543	892

[1] Layers as defined in Table1.

Table 4. Summary of pre-treatment densities (stems/hectare) of layer 4[1] trees (regeneration/ germinants) at three restoration sites sampled in 2002.

Site	regen (live)		regen (dead)		germinants (live)		germinants (dead)	
	mean	SD	mean	SD	mean	SD	mean	SD
Gina Lake	5227	9327	40	83	600	828	0	0
Hatchery Ridge	0	0	0	0	0	0	0	0
Rock's Pasture	1553	4903	373	595	0	0	0	0

[1] Layers as defined in Table1.

One large ponderosa pine had an active Northern Goshawk (*Accipiter gentilis atricapillus*) nest with two young in summer 2002 (Figure 8). Nest location information is given in Appendix 4.

3.2.2 Hatchery Ridge pasture

Of the three sites sampled, Hatchery Ridge had the lowest crown closure (mean = 47%, SD = 20%; Table 2), the highest density and distribution of veteran/dominant layer 1 trees (mean = 78 sph, SD = 42 sph; Table 3), and the lowest densities of layer 2 and 3 trees (Table 3 and Figure 6b). Trees at this site are widely spaced, although higher density patches can be found on upper benches at the eastern end of the block. Overstory tree species composition is comprised of Douglas-fir and ponderosa pine (Table 2). In contrast to the other two sites, no conifer regeneration or germination was found at Hatchery Ridge (Table 4), likely due to its very dry southwest aspect exacerbated by recent drought conditions.

Approximately 20% of trees at Hatchery Ridge are affected by resinosus (Table 3). It is most prevalent in trees greater than 30 cm in diameter and resin occurs at heights greater than 2 m. Basal resinosus is a symptom of Armillaria root disease, but when found at heights above 2 m, it is likely a sign of accelerated growth which results in a split in the cork cambium (Emile Begin, Forest Health Officer, Invermere Forest District, per. comm.). The SP/SMP for Hatchery Ridge indicates unconfirmed Armillaria root rot on site, however our observations on resinosus height do not support this conclusion.

3.2.3 Rocks Pasture

Douglas-fir, ponderosa pine and western larch comprise the overstory at Rocks pasture (Table 2). This site has relatively high crown closure (Table 2), and moderate densities of layer 1 (mature), 2 and 3 trees relative to the other sites (Table 3 and Figure 6c). Rock's pasture is more mesic, which likely explains the presence of western larch at this site. It also has fairly extensive conifer regeneration (Table 4; Figure 9). Considerable regeneration mortality and an absence of germinating trees are likely due to recent drought conditions.

3.3 Understory Characteristics

3.3.1 Gina Lake pasture

The Gina Lake understory is dominated primarily by grasses and forbs (Table 5). Extensive pinegrass cover (9.3%, SD=13%, Appendix 3) is likely due to the relatively high canopy closure and presence of Douglas fir thickets. Pinegrass (*Calamagrostis rubescens* Buckl.) is a rhizomatous perennial that remains abundant under shade and is prevalent under dense fir canopies (Steele and Geier-Hayes 1993). Kinninick *spp*. (another indicator of mesic closed forest conditions) was the only other species that formed greater than 5% cover at this site (8.5%, SD=16%, Appendix 3). Noxious or nuisance weeds were not recorded in the block or observed along the periphery.

Bunchgrass cover is lowest at Gina Lake, likely due to reduced light and the competitive effects of pinegrass at this site. Page (2002) found an inverse relationship between pinegrass and bunchgrass prior to restoration treatments in the Trench. Gina Lake also had the lowest species richness (13.4 species, SD=5.4 species) and diversity (mean = 0.85, SD = 0.16) of the three sites (Appendix 3).

Production values at Gina Lake were the lowest of the three sites, averaging 98.9 kg/ha (Table 6). A third of the total production was attributed to bunchgrass, and pinegrass produced comparable amounts of forage as well. Higher bunchgrass production (relative to crown closure) is likely related to the tufted growing habit of these species and the fact that they experience renewed growth in the fall, after a period of summer dormancy. Estimates for Gina Lake are slightly lower than those obtained by Gayton (1997) for the East Kootenay Trench (i.e., 75 – 125kg/ha and 150 – 350kg/ha for closed and open forests, respectively). Production estimates for Gina Lake were also lower than those found by Page (2002) at ungrazed sites in the IDF (i.e., 131kg/ha) and significantly lower than those reported by Ross (2001) for dry open forest sites in the IDF (i.e., average of 750kg/ha). No livestock grazing was observed at Gina Lake during the growing season.

Table 5. Summary of pre-treatment understory cover characteristics by functional/descriptive group at three restoration sites sampled in 2002.

	Gina Lake		Hatchery Ridge		Rocks	
Understory component	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Bunchgrass Cover[1] (%)	6.7	8.8	17.7	8.9	8.7	7.5
Grass Cover[2] (%)	14.7	4.3	8.6	11.4	15.4	9.1
Forb Cover (%)	22.3	18.4	29.7	13.0	21.1	18.2
Carex Cover (%)	3.0	2.3	0.7	0.3	2.4	2.7
Shrub Cover (%)	3.0	1.7	0.5	1.2	7.8	7.1
Weed cover[3]	0	0	2.3	3.6	1.3	3.8
Conifer cover[2] (%)	1.5	2.6	0	0	0.8	2.0

[1] Includes native bunchgrasses considered historically common listed on page 9.
[2] Includes any native grass that is not classified as a bunchgrass.
[3]Includes any introduced or weedy species listed by the MoF/MoAFF Noxious and Nuisance Weed List.

Table 6. Summary of pre-treatment understory production (kg/ha) characteristics by functional/descriptive group at three restoration sites sampled in 2002.

	Gina Lake		Hatchery Ridge		Rocks	
Production (kg/ha)	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Bunchgrass[1]	33.1	68.0	66.1	67.8	28.6	65.2
Grass[2]	40.6	40.9	5.4	19.1	43.5	68.6
Forbs	11.5	23.1	71.1	112.7	13.1	32.6
Shrubs	11.9	21.6	2.6	9.7	71.5	84.9
Carex spp.	1.8	5.1	0	0	2.7	5.3
Weeds[3]	0	0	1.2	5.0	0.1	0.4
Total	**98.9**	**80.6**	**146.3**	**112.9**	**160.7**	**98.0**

[1] Includes native bunchgrasses considered historically common listed on page 9.
[2] Includes any native grass that is not classified as a bunchgrass.
[3]Includes any introduced or weedy species listed by the MoF/MoAFF Noxious and Nuisance Weed List.

3.3.2 Hatchery Ridge

The understory at Hatchery Ridge is characterized by extensive bunchgrass and forb cover and very little shrub cover (Table 5). The dominant bunchgrass is bluebunch wheatgrass (3.5%, SD= 7.6%; Appendix 3) and the dominant forb is arrow-leaved balsam root (Balsamorhiza sagittata

(Pursh) Nutt.). Very little shrub cover is found at this site (Table 5), and native ungulates likely rely on the bunchgrass community for winter forage.

Hatchery Ridge had the highest species richness (mean = 19 species, SD = 5.5 species) and diversity (mean = 1.00, SD = 0.16; Appendix 3). Non-native species are common throughout the block, and include japanese brome, cheatgrass and sulphur cinquefoil (*Potentilla recta* L.). There are also several non-native, highly invasive species on the periphery of the block, the most common being common hound's tongue (*Cynoglossum officinale* L.).

Production levels at Hatchery Ridge averaged 146.3 kg/ha (Table 6). These estimates are comparable to measures reported by Gayton (1997) and Page (2002) and significantly lower than estimates made by Ross (2001). The bulk of total production was attributed to forbs and bunchgrasses, with relatively little shrub production. No livestock grazing was permitted on this site during the growing season, however cattle were observed in the block on September 10, 2002.

3.3.3 Rocks Pasture

Understory species composition at Rocks pasture is similar to Gina Lake. The site has extensive forb and grass cover (Table 5), but the only grass species comprising greater than 5% cover is pinegrass (7.8%, SD = 14%, Appendix 3). Bunchgrass cover is relatively high, given this extensive cover of pinegrass (Table 5).

Shrub cover at Rocks pasture is high (Table 5), and it is comprised mainly of Oregon grape (*Mahonia aquifolium* (Pursh) Nutt.) (mean = 5.3%, SD = 6.0%; Appendix 3), with a minor component of birch-leaved spirea (*Spiraea betulifolia* Pall. ssp. *Lucida).* Non-native species cover is negligible and no significant invasions were observed along the periphery. Rocks pasture had intermediate levels of species richness (mean = 17, SD = 6.6) and diversity (mean = 0.98, SD = 0.18; Appendix 3).

Production was comparatively high at this site (160.7 kg/ha; Table 6), relative to the other two sites and to other estimates for the trench (Gayton 1997; Page 2002). Total production was comprised mainly of shrubs and grasses (pinegrass), and no livestock grazing was observed at this site during the growing season.

4. Recommendations

4.1 Gina Lake pasture

Gina Lake is likely to benefit from restoration activities including thinning and prescribed burning. Thinning will likely remove the majority of the pole-sized trees and some slashing will be required for the Douglas-fir thickets and sapling trees. A subsequent prescribed fire should largely eliminate conifer regeneration at this site. To allow for fine fuel build-up and ensure an effective burn, Gina Lake pasture should be rested from livestock grazing one year prior to burning.

Risk of weed invasion associated with prescribed fire is minimal at this site, due to a lack of non-native species currently found there. Post-treatment increases in non-native species cover occur primarily on highly compacted soils (Page 2002), so to further minimize the risk of weed invasion and damage to the native plant community, existing roads in this block should be used. If disturbance is minimized during treatment, desirable plant species composition will likely be achieved quickly because the historical bunchgrass community has maintained a foothold. Nevertheless, pinegrass cover and production may increase in the short term. It is hypothesized that increased light associated with thinning will alter the moisture regime in favor of drought-tolerant native bunchgrasses, and give them a competitive advantage over pinegrass.

Production levels are expected to decline significantly in the first few years post-restoration (Page 2002), but should then recover and exceed pre-treatment levels (Ross 2001). The time needed for recovery will largely depend on weather (i.e., drought) and land management. Grazing should be restricted at this site after burning to allow the plant community to respond with minimal disturbance and accelerate the recovery process.

Gina Lake has high ungulate winter range capability due to high potential bunchgrass and palatable shrub production. The latter has been reduced by ingrowth and restoration treatments should enhance the site capability of Gina Lake in the long-term.

Northern Goshawks in the East Kootenay tend to breed in mature forest stands with moderate to high crown closure (49% ± 2.4%), multi-layered canopies, and relatively open understories (Machmer 2002). Restoration treatment will reduce overstory canopy closure (currently averaging 53%) and is therefore likely to negatively impact the goshawk nest site active in 2002. It is not known whether this site has been used perennially for breeding or whether there are alternate nest sites nearby that form part of an overall goshawk “nesting area”. It is recommended that an intensive search of the treatment area and surrounding stands (for alternate goshawk nests, sign and evidence of activity) be conducted in April 2003, prior to proceeding with harvesting treatment. If other nest sites are found and/or further goshawk activity is noted, consideration should be given to modifying the treatment area boundaries and prescription to accommodate this nest area.

4.2 Hatchery Ridge pasture

The Hatchery Ridge SP/SMP states that this site will be subject to thinning followed by prescribed burning. The significant presence of non-native species in and along the periphery of this block suggests a cautious approach may be warranted. Prescribed burning could exacerbate non-native species invasion, which would likely offset the benefit of restoration activities in the short and long term. Lack of conifer regeneration at this site also suggests that a prescribed burn may not be warranted.

The plant community would benefit from thinning activities if disturbance is minimized in certain areas of this block (e.g., the upper benches used as bedding areas in the eastern half of the pasture). Steep slopes in this block are susceptible to erosion and should not be disturbed or subject to road construction. Furthermore, conifer thinning is not needed on these steep slopes.

The bunchgrass and palatable shrub community on the upper benches of this block should respond well to restoration thinning. Production levels in these areas will likely decline immediately post-thinning, but should recover to pre-treatment levels relatively quickly. Site recovery will also depend on post-restoration grazing management. Livestock grazing on restored grassland sites can "alter amounts, spatial patterns, and composition of nutrient accumulation in soil and can directly affect the species composition and ecosystem structure of grasslands. Heavy grazing can increase carbon allocation to leaves, decrease root biomass, and ultimately lower nutrient inputs into the soil" (Fuhlendorf et al. 2002). Restricting livestock grazing at this site for 1-2 years post-treatment will likely accelerate its rate of recovery.

4.3 Rocks pasture

Topography and current plant species composition at Rocks Pasture make this block ideally suited to restoration activities. Restoration thinning should shift the overstory closer to its historic structure and prescribed burning should largely eliminate the current widespread conifer regeneration at this site. Similar to Gina Lake, the lack of non-native species at this site suggests that a prescribed burn is relatively low-risk in terms of weed invasion. Livestock grazing should be restricted prior to burning to allow for fine fuel build-up and effective burning.

Because this site has a higher average cover of pinegrass, it is likely to require more time to achieve a desirable plant species composition. Fortunately, existing bunchgrasses should benefit from restoration activities as well. As with the other two blocks, livestock grazing should be restricted for 1-2 years after thinning and burning to allow the plant community to respond without disturbance.

4.4 General recommendations

All three sites are suited to some type of restoration prescription. As important as the SP/SMP is post-restoration activity stand management. Management should take into account current weather conditions (e.g., severity of drought) and early monitoring results. 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.

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

File/Folder Name	Description
FMER_composite1	Includes plot location and ID information, as well as understory species composition raw data (species richness, species canopy cover, flowering culm and weed density).
FMER_overstory1	Includes all overstory data (tree species, diameter at breast height, height, decay class, presence of insects and disease)
FMER_production1	Includes all production data. Production values are classified by vegetation groups (e.g., shrubs and bunchgrass).
FMER_database	This ACCESS database is an example of one used by the Ministry of Forestry Research Branch.

Appendix 2. Scanned photos (RW-CD format).

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.
Understory	Includes summary tabulations of understory cover by species, plot and site.
Richness & Diversity	Includes summary tabulations of species richness and diversity by plot and site.

Appendix 4. Northern Goshawk (*Accipiter gentilis atricapillus*) nest information and map (Sensitive Information)

Appendix 5. Locations of the three monitoring sites

Columbia Basin Fish and Wildlife Compensation Program -- June 04, 2003

● Monitoring Site

0 10 20 30 40 50 km

Scale: 1:1,000,000 - Projection: UTM Zone 11 - Datum: NAD 83