Churn Creek Protected Area:
Dry Farm Ecosystem Restoration Plan

March 2003

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Table of Contents

1 Introduction

The management plan for Churn Creek Protected Area (CCPA)[3] identifies conservation of Bunchgrass (BG) and Interior Douglas-fir (IDF) ecosystems as a primary role of the protected area. Additionally, the CCPA protects regionally significant habitats of mule deer, California bighorn sheep, and a number of red- and blue-listed species.

The management plan identified past interventions in natural disturbance regimes as a concern and provided direction to develop a fire management plan to address conifer ingrowth and encroachment, habitat for red- and blue-listed species, California bighorn sheep, and mule deer, and control of noxious weeds.

The fire management plan[4] was completed in 2001. Using fire scar analyses, the fire management plan determined that IDF forests historically burned on average every 14 years and the most recent fire scar was from 1890. Several fires were recorded from 1950 to 1999; but nearly all of these were less than 4 ha in size. Open, multi-aged forests were maintained in the IDF by frequent low-intensity surface fires (Figure 1).

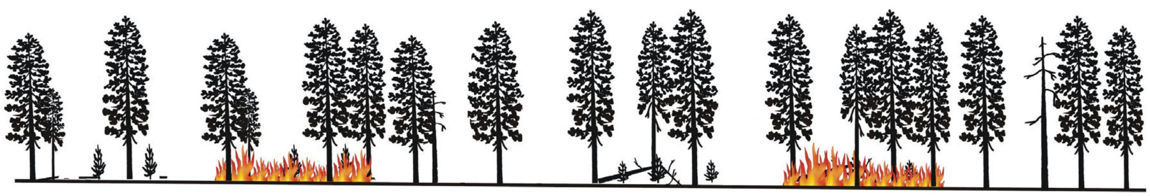

Figure 1. Schematic diagram illustrating historically open forest maintained by surface fires. Source: BA Blackwell and Associates Ltd.

With reduced fire frequency since the late 1800's, nearly all forests in the CCPA have become infilled with Douglas-fir trees (ingrowth), and many grasslands have been lost to encroachment of trees onto grasslands.

IDF forests are now highly susceptible to insect attack and catastrophic crown fires. Forest understories, formerly dominated by grasses, shrub, and forbs are now either absent or limited to mosses and scattered remnants of other species. Current high surface fuel loads have the potential to kill trees and plants and sterilize soils if burned[5].

[3] BC Parks 2000

[4] Blackwell et al. 2001

[5] Blackwell et al. 2001

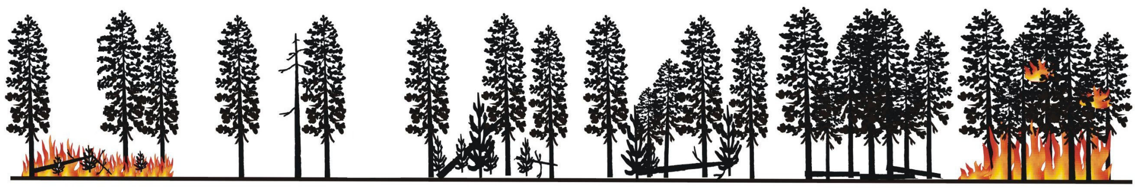

Figure 2. Schematic diagram illustrating the transition from historical open forests maintained by frequent surface fires (left), to current potentially high severity crown fires in ingrown forests (right).

The fire management plan also indicated the need to identify an area of ingrowth where different treatment strategies can be evaluated for cost and effectiveness. Five trial treatment areas were identified; a portion of the Dry Farm area has been chosen as the first area for ingrowth treatment.

The Dry Farm treatment area includes two primary forest types:

1. Level to gently sloping ingrown Douglas-fir forests that have little or minimal harvesting history.
2. Gently to moderately sloping, warm aspect, Douglas-fir forests that were selectively harvested in the early 1990's.

Other smaller types include areas of grassland with Douglas-fir encroachment and steeper forested slopes with moderate ingrowth and generally open stand structure.

2 Trial Objectives

The following objectives have been identified for the Dry Farm treatment area:

- Gather knowledge on the effectiveness of different treatments of ingrowth.
- Gather knowledge on understory plant community response.
- Restore historical forest structure by reducing forest ingrowth and retaining large, old Douglas-fir trees and some trees to recruit future large trees.
- Increase quantity and quality of forage for mule deer.
- Enhance traditional use plants.
- Enhance grass forage productivity.
- Protect or re-establish fencing.

A combination of tree removal, understory tree slashing, and prescribed fire have been identified as the key treatment tools to meet the above objectives.

The following potential negative side effects have been identified:

- site and soil degradation associated with roads, skid trails, and tree removal equipment;
- loss of veteran Douglas-fir trees and large snags;
- site degradation associated with high fire severity; and
- noxious weed invasion.

3 Restoration Treatments

Below, treatment specifications are outlined to meet restoration objectives and to avoid and minimize potentially negative side-effects outlined above.

3.1 *Treatment Boundaries*

Treatment boundaries were delineated by field verifying the area of merchantable timber and by determining the appropriate boundaries necessary for conducting a prescribed burn. The treatment area is quite variable with regards to slope and merchantable timber. There are some areas too steep to treat with conventional equipment inside of the treatment boundary and these areas will have to be slashed and burned without tree removal. The responsibility for maintaining safe working conditions will lie with the tree removal contractor chosen for the job. The contractor will know the safe working limits for their machines and will be expected to work in a safe manner. There are also some patches of non-merchantable trees inside merchantable types, these patches will have to be addressed by manual slashing after the tree removal phase is completed.

3.2 *Stand Structure Targets*

Historical[6] stand densities were determined using circular 400 m^2 plots. All trees old enough to be part of the historic stand (pre-1880), and any stumps, snags and stems of coarse woody debris that were likely part of the historical stand were tallied in each plot.

The previously logged area had average historical densities of 50 trees/ha, but they ranged from 0 to 100 trees/ha at the scale of measurement. The unlogged area had average historical densities of 75 trees/ha and they ranged from 0 to 150 trees/ha. Historical stand densities on the previously logged site were probably lower because the site has a greater slope and a warm aspect. This difference in historical stand densities is reflected in target stand structure densities.

We do not know how many trees may be killed by fire, Douglas-fir beetle, or other causes post-treatment. Thus, we are recommending two levels of retention to maintain stand densities at the desired level allowing for this mortality: twice and four times the measured historical density. Results of this trial can inform retention levels for future treatments.

3.3 *Infrastructure*

Several fences run through the treatment site and one fence borders the western edge of the treatment area. For safety, it is imperative that the wire is dropped or removed on all fences prior to tree removal and prescribed burning treatments. All fences will be re-established in their present location except the fence currently running east-west just south of the Blackdome road. This fence will be completely removed from its current location and re-established along the Blackdome road where it can be more easily maintained.

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[6] 1880 was used as an approximate reference date. Trees were bored and aged to determine threshold diameters for trees originating prior to 1880.

3.4 *Tree Removal*

3.4.1 Timing

To minimize soil compaction and disturbance all tree removal treatments must be carried out on frozen soils.

3.4.2 Retained Trees

Retained trees will be 'marked-to-leave' over most of the treatments. Some areas may be left unmarked once the operators are familiar with the treatment; operators must be closely supervised. The following criteria are recommended for marking retained trees:

- retain all veteran trees and trees greater than 40 cm dbh;
- once all veteran and large trees have been marked, retain the largest trees less than 40 cm dbh to meet treatment unit tree density objectives. Subjectively retain trees with good wildlife tree characteristics and high crown ratios;
- approximately one to fifteen meter inter-tree spacing (for an evenly spaced stand 100 stems per hectare would have 11 m inter-tree spacing and 300 sph would have 6 m inter-tree spacing based upon triangular spaced trees);
- actual spacing should be based on the location of the veteran and largest recruitment trees;
- reserved trees should be slightly clumped with some small openings;
- retain all deciduous trees (applicable only to the north edge of the treatment area). These deciduous stems do not contribute to the stem density targets.

3.4.3 Removed Trees

The following criteria are recommended for tree removal:

- all unmarked trees 12.5cm dbh and larger must be removed from the site (any smaller unmarked trees may be removed at the operators discretion);
- fall all stems not marked for reserve around all large snags within 1.5 times the height of the snag with machines so that slashing crews do not need to work in dangerous areas. The machine must also move cut stems 5 m or more from the base of the snag to protect these features during the burning phase;
- cut stumps as low to the ground as possible; and
- cut down as many small trees (<12.5 cm dbh) as possible to get to removal trees.

3.4.4 Tree-removal Equipment

Operators are free to use any equipment for tree removal that can be used safely and meet the following criteria:

- no new roads or bladed skid trails are to be constructed in the treatment area (some of the distances to existing roads will exceed 500 m);

- soil compaction and forest floor displacement must meet the Forest Practices Code criteria;
- stems around the base of large snags must be able to be felled safely according to WCB regulations;
- must be able to operate on slopes up to 30%.

3.4.5 Roads

Many roads and landings are present in the previously logged area, and there are roads surrounding the unlogged area. *No new roads will be built.* If any road upgrades are required, soil exposed by road upgrading must be seeded with native grass seed as deemed appropriate by BC Parks.

Existing roads in the previously logged part of the treatment unit should be re-contoured and seeded with native grasses following the second prescribed burn treatment. Access to the site should be maintained for water tankers and other fire equipment until fuels have been minimized through prescribed fire treatments.

3.4.6 Supervision

All tree-removal operations shall be supervised by a BC Parks staff person or other person designated by BC Parks. The supervisor must be very familiar with treatment objectives and safe use of tree removal equipment.

3.5 *Slashing*

Small trees within the treatment unit are very dense in some areas and may prevent effective restoration of the site. Removing these trees through slashing is expensive, time consuming and necessitates extra machine work around snags and other areas where it is unsafe for ground workers. To test whether slashing of these small trees is required to meet restoration objectives, half of each treatment unit will be slashed following tree removal, and the other half will remain unslashed.

The slashing treatment required here differs from that normally used in selection harvesting. "Lop and scatter" slashing is not required, only slashing the stems and leaving them whole on the ground. Slashed stems may need to be piled if they would otherwise create unacceptable fuel accumulations. The piles, if required, would need to be burned during winter or otherwise removed prior to prescribed fire treatment.

If funding permits, encroached grassland patches within the forested area should be slashed, followed by encroached areas surrounding the forested areas.

3.6 *Prescribed Burning*

Hire a qualified prescribed fire specialist to develop specific burn prescriptions. Dormant season spring or fall burning to meet complex ecological objectives requires accurate assessments of fuel moisture combined with an accurate, *quantitative* description of fuelbed characteristics, and input into a fire behaviour prediction model. The use of the U.S. time-lag fuel moisture tracking system input into the BEHAVE suite of fire behaviour prediction models or an equivalent system should be used to develop the burn prescription.

Quantifiable burn objectives:

- retain overstory Douglas-fir, large Douglas-fir snags, and large pieces of coarse woody debris;
- increase rangeland productivity by stimulating grass growth and re-establishment;
- reduce the spatial extent and crown closure of understory Douglas-fir, common juniper, and Rocky Mountain juniper;
- stimulate mule deer browse; and
- stimulate traditional-use plants.

Once fuels have been measured, a burn plan including fuel moisture parameters, weather parameters, predicted fire behaviour (flame length, crown scorch height, crown scorch volume), ignition, burn organization chart, holding/contingency/mop-up, safety plan, communication, and public information, must be developed.

3.7 *Controls*

Untreated controls must be established in adjacent areas. A control must be established in both the unlogged and previously logged types.

3.8 *Summary of Treatment Units*

Treatment Number	Previously Logged?	Retention Level	Slashing
1	yes	100 stems/ha	yes
2	yes	100 stems/ha	no
3	yes	200 stems/ha	yes
4	yes	200 stems/ha	no
5	no	150 stems/ha	yes
6	no	150 stems/ha	no
7	no	300 stems/ha	yes
8	no	300 stems/ha	no
control 1	yes	n/a	n/a
control 2	no	n/a	n/a

4 Wildlife

A number of wildlife species of concern may occur in the treatment area (Table 1). The ecosystem restoration treatments must be carried out in a way that protects both individuals of these species and the habitats upon which they rely. Table 1 indicates the degree and timing of the risk to individuals of these species, the important habitat features that need to be retained or protected during restoration work, and the potential benefits of properly conducted restoration treatments for each of the species of concern that may be found in the Dry Farm treatment area.

Restoration treatments outlined above are designed to address all wildlife concerns, except for temporary displacement of mule deer from their winter range during tree removal. Any such displacements would be short-term and unlikely to affect deer populations in the area.

Table 1. Fire effects and benefits to species of concern at the Dry Farm restoration site.

Species	Risk to individuals	Timing of Habitat Use	Habitat Related Fire Effect	Benefits to Species	References
Rubber Boa	LOW-MODERATE: highly nocturnal	Hibernate from Nov-Mar; disperse in Apr; breed from Apr-May; young born in late summer or fall	• avoid fires that consume wildlife trees and large coarse woody debris (particularly in forests adjacent to grasslands) • fires that create large coarse woody debris could be beneficial • do not burn adjacent to hibernacula/nesting sites from April – August	• increase foraging habitat • increase thermoregulatory habitat	Cannings et al. 1999; Gregory & Campell, 1984; Province of B.C. 1997
Lewis' Woodpecker	NIL: habitat is currently unsuitable for Lewis' Woodpeckers but may be used after restoration	Arrive May; lay eggs	• require moderately soft snags in or adjacent to open grassland for nesting	• increased berry production, increased available habitat	Campbell et al. 1990; Fraser et al 1999
Northern Goshawk, *atricapillus* subspecies	LOW: burning window unlikely to overlap with nesting	Lay eggs in May – June; young fledge by the end of August	• dense, ingrown forests targeted for burning are unlikely to provide Goshawk habitat • long-term development of understories after burning could increase prey base	• removal of ingrowth could improve quality of forests for hunting and nesting for goshawks	Campbell et al. 1990; Fraser et al. 1999; Reynolds et al. 1992
Sharp-tailed Grouse, columbainus subspecies	LOW: unknown if present in adjacent grasslands, risk present only if they are present on grasslands and the grasslands are burned	Leks active from March – May; lay eggs in April – June; young fledge by the end of August	• avoid burning near leks in March and April	• may increase winter habitat by increasing shrub cover • increase grassland area for potential nesting habitat	Campbell et al. 1990; Connelly et al. 1998; Fraser et al. 1999; Ritcey 1995; Tesky 1994; van Rossum 1992
Flammulated Owl	LOW: timing of burning unlikely to overlap with nesting	Lay eggs from May 1st – July; young fledge by mid-August	• avoid burning during the breeding season • increased understory development (resulting from reduced ingrowth) should improve insect prey base • reduction of crown closure (<30%) & snag creation could expand habitat	• may create additional nesting and foraging habitat	Bull and Wright 1990; Campbell et al. 1990; Fraser et al. 1999; Goggans 1986; Howard 1994; McCallum 1994; Roberts and Roberts 1995; St. John 1991; van Woudenberg 1992; van Woudenberg 1999
Townsend's Big-eared Bat	LOW: unlikely to be using structures in the treatment area during burning windows	Breeds from Nov to Feb; young born 50-100 days later	• avoid burning snags near grasslands	• reduction of ingrowth in Douglas-fir stands on valley slopes may improve foraging habitat	Cannings et al. 1999; Holroy et al. 1994; Nagorsen & Brigham 1993
Mule Deer	LOW	Areas to be burned are used as winter habitat for most deer. Any deer in area during burn are likely to easily escape.	• burning of large Douglas-fir and vets would reduce snow interception, winter forage and security/thermal cover • reduction of ingrowth could improve spring & winter forage	• increase quantity and palatability of forage species • maintain large Douglas-fir trees to maintain for snow interception cover • reduction of encroachment could increase spring foraging areas	Armleder et al. 1994 Carlson et al. 1993 Hobbs 1989

5 Monitoring

Monitoring is a key to ensure that project objectives are met, or, where they are not met, to provide information to guide future restoration treatments. The following elements will be monitored:

- forest structure
- vegetation
- fuels
- wildlife

5.1 *Forest Structure, Vegetation, and Fuels Monitoring*

Randomly locate (using a dot grid and random XY coordinates) one plot in each of the eight treatment types (eight plots) and one an untreated control with no previous logging, and one in an untreated control with previous logging, for a total of 10 plots.

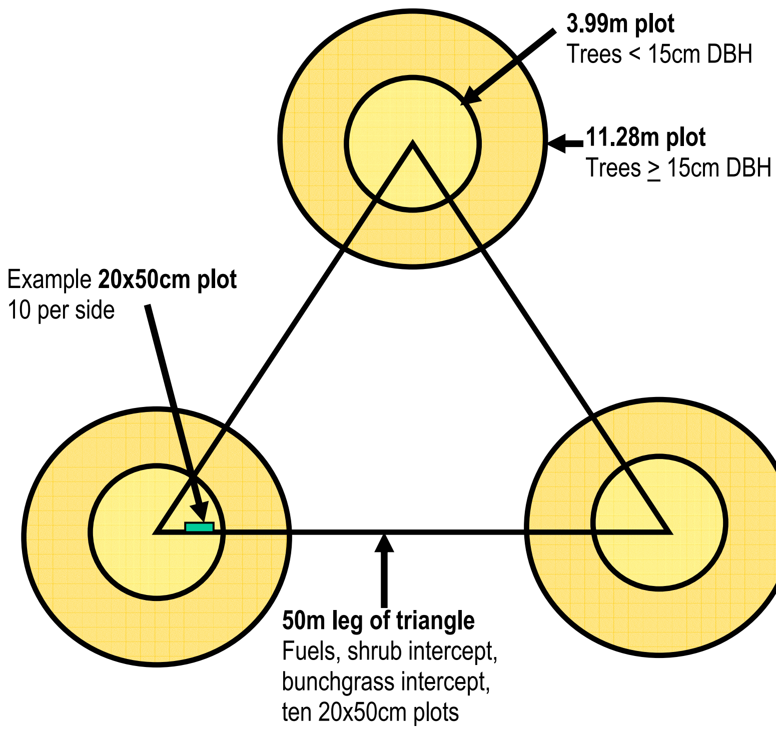

Figure 3. Monitoring layout for vegetation, fuels, and forest structure. Not drawn to scale.

5.2 *Wildlife Monitoring*

5.2.1 Pre-treatment Monitoring

Prior to harvest treatments, surveys for a number of species should be carried out. Flammulated owls, which nest in cavities, may be displaced by tree removal operations or prescribed fire during the nesting season if they occur. One evening survey in June in favourable conditions is recommended if tree removal operations or prescibed burining are to occur during the nesting season, between May and mid-August.

High quality snags should be located and classified prior to tree removal operations so that the effectiveness of the prescription is retaining these habitat features can be monitored. Relatively high densities of these habitat features are found in portions of the treatment area.

During site evaluation and layout, no habitat features for other species were found and no further pre-treatment wildlife monitoring is recommended.

5.2.2 Post-treatment Monitoring

Snags are critical habitat features for a number of red- and blue-listed and numerous other species in the CCPA. The retention of existing snags should be monitored both for tree removal operations and prescribed burning. Snag creation, through fire or insect related mortality must also be monitored so that the creation of these features can be accounted for in future prescriptions.

Churn Creek Protected Area also acts as an important winter range for large numbers of mule deer. Directly monitoring deer population and reproductive response to prescribed burning is difficult and costly and indirect monitoring methods should be used instead. Winter pellet group counts in treated areas and nearby untreated areas will give an indication of relative use in the two habitat types. Pellets can also be collected during this work for diet analysis. Winter track transects may be a more reliable method of assessing relative use among habitat types, but data collection is inconsistent and dependant upon snowfall events and usually many years of data collection are required to get enough data for analysis.

Forage is an important component of mule deer winter habitat. Vegetation monitoring will give indications of browse species response to the treatment. Samples of the vegetation could be collected and analysed for trace minerals, digestible energy, and protein to evaluate the response of forage quality to prescribed fire.

Treatment Schedule

Activity	Timing
Pre-treatment monitoring	
Forest structure, vegetation, and wildlife monitoring	Summer 2003
Tree removal	
Tree removal	Winter 2003/04
Slashing	Winter 2003 – Summer 2004
Monitor fuels post tree removal & slashing	Spring or Summer 2004
Prescribed burn	
Develop burn plan	post-fuel monitoring
Burn	Spring 2003, Fall 2004 or Spring 2005
Post-burn monitoring	
1st post burn monitoring	1st summer after burning
2nd post burn monitoring	2nd summer after burning
3rd post burn monitoring	4th summer after burning
4th post burn monitoring	6th summer after burning

6 Literature Cited

Armleder, H.A., M.J. Waterhouse, D.G. Keisker and R. J. Dawson. 1994. Winter habitat use by mule deer in the central interior of British Columbia. Can. J. Zool. 72(10):1721-1725.

Bailey, A. W. and M. L. Anderson. 1978. Prescribed burning of a *Festica-Stipa* grassland. J. Range Manage. 31:446-449.

BC Parks. 2000. Management plan for Churn Creek Protected Area. Cariboo District, Williams Lake, B.C.

Blackwell, B., B. Gray, K. Iverson, F. Steele, and K. MacKenzie. 2001. Fire management plan Churn Creek Protected Area. Unpublished report prepared for BC Parks, Cariboo District.

Bradley, Anne F. 1986. Pseudoroegneria spicata. In: Fischer, William C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Bull, E. L. and A. L. Wright. 1990. Nesting habitat of Flammulated Owls in Oregon. J. Raptor Res. 24(3):52-55.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, M.C.E. McNall. 1990. The Birds of British Columbia Volume 2. UBC Press, University of British Columbia, Vancouver, B.C.

Cannings, S.G., L.R. Ramsay, D.F. Fraser and M.A. Fraker. 1999. Rare Amphibians, Reptiles, and Mammals of British Columbia. Wild. Branch and Resour. Inv. Branch, B.C. Minist. Environ., Lands and Parks, Victoria, B.C. 198pp.

Carlson, P.C., J. W. Tanner, J. M. Wood, and S.R. Humphrey. 1993. Fire in Key deer habitat improves browse, prevents succession and preserves endemic herbs. J. Wildl. Manage. 57(4):914-928.

Connelly, J.W., M.W. Gratson, and K.P. Reese. 1998. Sharp-tailed Grouse (*Tympanuchus phasianellus*). *In* The Birds of North America, No. 354 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Crane, M. F. 1990. Rosa acicularis. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Crane, M.F. 1991. Arctostaphylos uva-ursi. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Fraser, D.F., W.L. Harper, S.G. Cannings and J.M. Cooper. 1999. Rare Birds of British Columbia. Wild. Branch and Resour. Inv. Branch, B.C. Minist. Environ., Lands and Parks, Victoria, B.C. 236pp.

Gerling, H. S., A. W. Bailey and W.D. Willms. 1995. The effects of burning on Festuca hallii in the parklands of central Alberta. Can. J. Bot. 73:937-942.

Goggans, Rebecca. 1986. Habitat use by Flammulated Owls in Northeastern Oregon. Master of Science Thesis. Oregon State University.

Gregory, P.T. and R.W. Campbell. 1984. The Reptiles of British Columbia. Royal British Columbia Museum Handbook. Province of British Columbia, Victoria, B.C.

Habeck, R.J. 1991. Spirea betulifolia. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Howard, Janet L. 1996; Tirmenstein, D. 1988. Populus tremuloides. *In*: Simmerman, Dennis G., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Howard, Janet L. 1997; Hickerson, Jody. 1986. Amelanchier alnifolia. *In*: Simmerman, Dennis G., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.Hobbs, N.T. 1989. Linking energy balance to survival in mule deer: development and test of a simulation model. Wildl. Monogr 101:1-39.

Holroy, S.L., R.M.R. Barclay, L.M. Merk, and R.M. Brigham. 1994. A survey of the bat fauna of the dry interior of British Columbia. Wildlife Working Report No. WR-63. Wild. Br., Minist. of Env., Lands and Parks, Victoria, B.C.

Howard, Janet L.; Griffith, Randy S. 1994. Asio flammeus. In: Fischer, William C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

McCallum, D. A. 1994. Flammulated Owl (*Otus flammeolus*). *In* The Birds of North America, No. 93 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Nagorsen, D. W. and R. M. Brigham. 1993. The bats of British Columbia. Volume 1: The Mammals of British Columbia. UBC Press and the Royal British Columbia Museum.

Province of British Columbia. 1997. Species and Plant Community Accounts for Identified Wildlife. Volume 1. B.C. Minist. Environ, Lands and Parks and BC Minist. of Forests. Victoria. B.C.

Redmann, R. E., J. T. Romo and B. Pylypeg. 1995. Impacts of burning on primary productivity of *Festuca* and *Stipa-Agropyron* grasslands in central Saskatchewan. Am. Midl. Nat. 130:262-273.

Reed, W. R. 1993a. Arnica cordifolia. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Reed, W. R. 1993b. Aster conspicuus. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Reynolds, R. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, Jr., G. Goodwin, R. Smith and E. L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. Gen. Tech. Rep. RM-217. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 90p.

Ritcey, R. 1995. Status of the Sharp-tailed Grouse – *columbianus* subspecies in British Columbia. Wildlife Working Report WR-70. Minist. of Environ., Lands and Parks, Victoria, B.C.

Roberts, G. and A. Roberts. 1995. Distribution, habitat selection , and densities of Flammultated Owls (*Otus flammeolus*) in the Cariboo-Chilcotin. Unpub. report prepared for the Ministry of Environment, Lands and Parks, Wildlife Branch, Williams Lake, British Columbia.

Snyder, S.A. 1991a. Calamagrostis rubescens. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Snyder, S.A. 1991b. Symphoricarpos albus. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

St. John, Dennis. 1991. The distribution of the Flammulated Owl (*Otus flammeolus*) in the South Okanagan. unpub. report prepared for B.C. Environment and Okanagan Region Wildlife Heritage Fund Society.

Tesky, Julie L. 1994. Tympanuchus phasianellus. In: Fischer, William C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Tirmenstein, D. A. 1987. Koeleria macrantha. In: Fischer, William C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Tirmenstein, D. A. 1988. Juniper communis. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Turner, N. J. 1991. Burning mountainsides for better crops: aboriginal burning in British Columbia. Archaeology in Montana. 32:57-73.

Uchytil, R. J. and M. Crane. 1991. Pseudotsuga menziesii var. glauca. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

van Rossum, G. 1992. Habitat of the Columbian Sharp-tailed Grouse in the southern interior of British Columbia. Unpub. report submitted to Minist. of Env., Lands and Parks, Kamloops, B.C.

van Woudenberg, Astrid M. 1992. Integrated managemend of Flammulated Owl breeding habitat and timber harvest in British Columbia. Master of Science Thesis. University of British Columbia.

van Woudenberg, Astrid M. 1999. Status of the Flammulated Owl in British Columbia. Wildlife Working Report No. WR-95. B.C. Minist. of Environ., Lands and Parks, Wildlife Branch, Victoria.

Walkup, C. J. 1991a. Mahonia repens. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Walkup, Crystal J. 1991a. Stipa spartea. In: Fischer, William C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Walkup, C. J. 1991b. Shepherdia canadensis. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

Williams, T. Y. 1990. Allium fibrillum. *In*: Fischer, W. C., compiler. The Fire Effects Information System [Data base]. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600 bpi, ASCII with Common LISP present.

7 Appendix I – Fire Effects and Fire Ecology

Dominant and traditional-use vascular plants that occur in the study area: fire effects and fire ecology.

7.1 *Tree Species*

Scientific Name Common Name	Fire Effects	Fire Ecology
Populus tremuloides trembling aspen (Howard 1996)	• thin-barked stems easily top-killed by fires • fire stimulates the production of suckers from roots • sapling or smaller trees can regenerate through root or stump sprouting	• species is well adapted to fire through vegetative regeneration
Pseudotsuga menziesii Douglas-fir (Uchytil and Crane 1991)	• saplings often killed by surface fire (due to low branches, thin bark, closely-spaced flammable needles) • large trees with thicker, insulating bark; larger crowns are more fire-resistant and can withstand greater bole and crown damage	• mature trees can survive moderately severe surface fire • species relies on wind-dispersal of seeds to colonize burned areas • mineral soil exposed by burning provides a good seedbed

7.2 *Shrub and Dwarf Shrub Species*

Scientific Name Common Name	Fire Effects	Fire Ecology
Amelanchier alnifolia saskatoon (Howard 1997) (Turner 1991)	• easily top-killed by fire but vigorously re-sprouts from rhizomes and root crowns • can survive severe fires if the soil is moist or rhizomes are deep	• aboriginal burning is known to have enhanced the growth of saskatoon stands • moderately adapted to fire through vegetative regeneration • greater twig production and nutritional content after fire • re-establishes from seed over longer time-frame
Arctostaphylos uva-ursi kinnikinnick (Crane 1991)	• can survive moderate fires when rooted in mineral soil • when rooted in organic material, is killed by fires that consume those horizons	• re-sprouts from buds on stems or root crowns after low-intensity fires • may be a seed-banking species with fire resistant seed
Juniperus communis common juniper (Tirmenstein 1988)	• upright branches are susceptible to fire • death usually occurs when the crown is consumed by fire	• re-establishes very slowly by seed from on site or dispersed by mammals or birds

Scientific Name Common Name	Fire Effects	Fire Ecology
Mahonia aquifolium tall Oregon grape (Walkup 1991a)	• top-killed by fire • usually survives all but severe fires that remove duff an heat the upper soil	• re-sprouts from buds on rhizomes • establishes from on-site seed
Rosa acicularis prickly rose (Crane 1990)	• fires usually kill aboveground parts of the plant • severe fires may kill shallow rhizomes	• re-sprouts from rhizomes and the base of stems • seeds are fire-resistant and may germinate after fire
Shepherdia canadensis soopalallie (Walkup 1991b)	• top-killed by fire • severe fires can kill the whole plant	• re-sprouts from surviving root crowns • re-establishes from off-site seed • fire increases density and vigour
Spiraea betulifolia birch-leaved spiraea (Habeck 1991)	• top-killed by fires • rhizomes are seldom killed by fire	• re-sprouts from rhizomes and root crowns • highly resistant to fire-kill
Symphoricarpus albus common snowberry (Snyder 1991b)	• readily top-killed by fire but resprouts from rhizomes • rhizomes are seldom affected by low to moderate fire intensity	• species is moderately adapted to fire through vegetative regeneration • infrequent fires can increase snowberry cover; intolerant of frequent burning

7.3 *Forb and Grass Species*

Scientific Name Common Name	Fire Effects	Fire Ecology
Allium cernuum nodding onion (Williams 1990)	• below-ground part of plant unlikely to be harmed by fire	• likely re-sprouts from bulbs after fire
Arnica cordifolia heart-leaved arnica (Reed 1993a)	• top-killed by fire • rhizomes may be killed by more severe fires	• re-sprouts from surviving rhizomes • regenerates from wind-dispersed seed and seed from 1 or 2 year post-fire flowering
Aster conspicuus showy aster (Reed 1993b)	• top-killed by fire • rhizomes may be killed by severe fires that cause excessive soil heating	• re-sprouts from rhizomes • establishes from wind-dispersed seeds and seed in the soil • mass flowering the first few years after fire
Calamagrostis rubescens Pinegrass (Snyder 1991a)	• top-killed by low intensity fires • fires that consume the duff layer can sometimes kill pinegrass rhizomes	• regenerates by rhizomes • can reproduce by seed if the forest canopy is opened • often increases after fire

Hesperostipa curtiseta Porcupine Grass (Bailey & Murray 1978) (Gerling et al. 1995) (Redmann et al. 1993) (Walkup1991a)	• above-ground portions are destroyed but survives low to moderate intensity fires (reserves are stored in underground root crown) • severe fires can kill the root crown • often displaced by tree encroachment in the absence of fire (shade intolerant)	• spring burning can either increase or decrease frequency, canopy cover and seed production (late spring burns more harmful than early spring burns) • fall burning reduces production and seed production • production generally unaffected if burned when dormant
Koeleria macrantha jumegrass (Tirmenstein 1987)	• undamaged to moderately damaged by fire • is killed when dry vegetation is consumed by fire • late spring burns are the most damaging • little heat is transferred below the soil and there is some residual survival	• usually shows little change following fire • readily reoccupies sites through seed • small clumps make the plant relatively fire resistant
Pseudoroegneria spicata Bluebunch wheatgrass (Bradley 1986) (Redmann et al. 1995)	• leaves and stems burn quickly • most basal buds survive at the root crown	• regrows from basal buds on root crown following fire • protein concentrations in forage increase after fires • variable productivity after fire (may increase or decrease)

8 Appendix II – Detailed Monitoring Methods

8.1 *Plot Establishment*

Establish one triangle with 50m long sides at each monitoring. The first leg of the triangle is selected by choosing a random compass bearing. Each successive leg is 120° less than the previous leg (thus the triangle is established counter-clockwise). The final leg is established such that it intersects the first pin (start of Transect 1). Establish rebar posts at the each apex of the triangle and paint them. Use a distinctive piece of rebar for the start of the first leg (e.g. a flat top or a hook) All legs are 50m in slope distance. Record slopes for each line so that actual horizontal distance can be calculated.

At each plot measure: tree subplots, fuel transects, herbaceous fuel clippings, vegetation quadrats, shrub intercept, and bunchgrass basal intercept.

Record plot locations using a GPS and NAD83 UTMs. Establish a tie-point near a road or other marker and flag and tag the tree with plot number and bearing and distance to the plot. Navigate to the plot using a hipchain and compass. Mark all tie-points and plot locations aerial photographs. Draw a diagram showing directions to the plot on the back of each site sheet for each plot.

8.2 *Tree Plots*

Establish three tree subplots, one centred on each apex of the triangle. Use two nested plots sizes: 3.99m (50m^2) radius and 11.28m radius (400m^2). Take four crown closure measurements at each subplot using a spherical densiometer and facing in each of the cardinal directions from the subplot centre.

<u>3.99m plot</u>

- Tally live trees by species in the following classes:
    - 0.3-1.3m tall,
    - 0.1-1.9cm DBH, and
    - 2-3.9cm DBH;
    - estimate average height to live crown for each class
- Record tree species, measure diameter at breast height (DBH), and estimate height to live crown for each live tree 4cm to 14.9cm DBH

<u>11.28m plot:</u>

- Record species, live/dead, and measure each tree 15cm and greater DBH

Record dead trees if they are >1.3m tall and had a DBH greater than or equal to 15cm.

8.3 *Fuel Transects*

Three 15m long transects are located along each leg of the triangle starting at the beginning of each transect.

The following fuel size classes were tallied (woody fuel):

- 0 to 0.6cm – tally from 0 to2m
- 0.61cm to 2.5cm – tally from 0 to 2m
- 2.51 to 7.5cm – tally from 0 to 4m
- >7.5 cm – tally and measure all pieces in sound and rotten classes from 0 to 30m

Measure litter and duff depths (with moss depth measured separately) at 1.5, 3, 4.5, 6, 7.5, 9, 10.5, 12, 13.5, and 15m for each of the three transects.

8.4 *Herbaceous Fuels*

Measure herbaceous fuels by taking clippings. Clip six 20x50cm plots using the frame used for vegetation monitoring. Starting at T1, walk ten steps towards the middle of T2 and then tossed the frame to the right. Each time walk ten more steps and alternate between tossing to the right and left. Clippings are not necessary for the control plot. Do not clip trees and woody shrubs.

8.5 *Fuel Loading Calculations*

8.5.1 Woody Fuel Loading

Calculate fuel loading by converting size classes into inches and using the following formulae from Brown et al. 1982.

size class (inches)	constant	d^2 squared diameter	s specific gravity	a angle factor
0-0.25	11.64	0.0151	0.48	1.13
0.25-1	11.64	0.289	0.48	1.13
1-3	11.64	2.76	0.40	1.13
3+ sound	11.64		0.40	1.0
3+ rotten	11.64		0.30	1.0

The formula for tons/acre by size class is:

0-3" diameter: $$\frac{(11.64)(n)(d^2)(s)(a)(c)}{Nl} = \text{tons/acre}$$

where n is the number of intercepts,

and Nl is the plane length in feet,

and c is the slope correction factor

>3" diameter: $$\frac{(11.64)(\text{sum}d^2)(s)(a)(c)}{Nl} = \text{tons/acre}$$

These calculations are then converted into kg/m^2.

8.5.2 Duff Fuel Loading

Duff depth measurements were averaged for each plot. Estimated bulk densities were used to calculate average duff fuel loading. Bulk density for estimated at 6.0 lb/ft^3 for duff under Douglas-fir, 5.0 lb/ft^3 under mixed Douglas-fir and ponderosa pine, and 5.0 lb/ft^3 for moss. Fuel loading was calculated using the following formula:

w = 3630 x bulk density (lb/ft^3) x average depth (inches)

where **w** is the average loading in lb/acre

This loading was then converted into kg/m^2.

8.6 *Vegetation Monitoring*

8.6.1 Vegetation quadrats

Each side of the triangle also forms one vegetation transect. Along the ***left*** side of each transect (looking from start to finish), place a ***20x50cm frame*** with the bottom of the frame at ***1, 6, 11, 16, 21, 26, 31, 36, 41, and 46m*** for a total of ***ten*** quadrats on each side and ***thirty*** quadrats all together. Place the frame with the ***long axis parallel to the transect***. Record vascular plant cover for each species in the quadrat (using ***drip-line canopy cover***). Record cover for moss and lichens genera or species. Record substrate cover for mineral soil, litter, standing litter, rock, wood, and cryptogams (total moss and lichen cover).

Line intercept

Each side of the triangle is used as a line intercept for shrubs and the base of bunchgrasses. Line intercepts are recorded by projecting a vertical plane along the tape and recording the length of the vegetation that intercepts it in centimetres.

For ***shrubs***, record the intercept for occurrences of ***5cm*** or greater by shrub species and layer: B1 for shrubs $\geq$2m tall, and B2 for shrubs <2m tall.

Record bunchgrass basal intercept for occurrences of 2cm and greater. Do not include the dead centres of bunches if they are 2cm or greater. Use calipers at the base of the plant to record basal intercept. If calipers are not available, a plumb bob should be used to determine the start and end of an intercept.