Fire Management Plan
Churn Creek Protected Area

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EXECUTIVE SUMMARY

The following report provides the background and framework to implement a fire management program in Churn Creek Protected Area. The plan was developed to fulfill several objectives including reducing conifer encroachment and ingrowth, maintaining and enhancing red and blue listed species habitat as well as California bighorn sheep, mule deer and other species habitat, controlling noxious weeds and maintaining cattle grazing to approved AUM levels.

Historically the Churn Creek Protected Area contained a mosaic of grassland and open forest and supported a wide diversity of habitat and species. Fire suppression has resulted in ingrowth in the open forests, encroachment of grasslands, increased fuel loads in forested areas and decreased productivity for wildlife and livestock. Part A of this report identifies prescribed fire opportunities and discusses how these opportunities will be used to restore and enhance the Protected Area. Part B of this report contains background information discussing all aspects of the current and historic conditions of the Protected Area including fire history and disturbance patterns, vegetation succession, the fire environment, fuels and social concerns. Part B also discusses recommended policy changes.

The focus of all prescribed burning within the Protected Area is the maintenance of long-term productivity, biodiversity, and restoration of natural vegetation communities. Four candidate burn areas have been identified. The primary focus of the burning will be to remove ingrowth and encroachment while at the same time restore native grassland communities and open forests. These four areas were selected based on their ability to provide forage for wildlife and cattle, to fulfill the needs of California bighorn sheep and based on their capacity to undergo experimental treatments, the results of which can be applied to other ingrown and encroached areas. In addition to prescribed fire a number of areas were identified where prescribed fire alone will not meet vegetation management objectives. In areas where fuel accumulations are excessive, mechanical and manual fuel treatments will be required to reduce fuel loading to avoid undesirable fire effects. This issue is addressed in the context of current B.C. Parks policy.

The plan recommends that monitoring of outcomes should be undertaken at the various stages of prescribed burning. This will provide feedback that managers can use to adapt management strategies appropriately. Vegetation and forest structure monitoring will involve establishing permanent plots within each vegetation type, treatment type and in unburned and untreated areas. Wildlife monitoring will involve assessing pretreatment use and whether objectives where met post treatment.

ACKNOWLEDGEMENTS

In addition to the authors of the report, many people contributed to this project. Carmen Wong and Ralph Thevarge assisted with field work. Eva Riccius completed the master chronology, and analyzed tree cores and fire scar samples. Steve Grimaldi prepared the mounted and sanded tree cores and fire scar samples. We would also like to thank Ken Lertzman for the use of his lab. Joyce and John Holmes kindly provided us with a place to stay at the Empire Valley Ranch.

INTRODUCTION

Churn Creek Protected Area was established in July 1995 as a result of the protected area recommendations contained in the Cariboo-Chilcotin Land Use Plan (CCLUP). It was among 16 other park and protected area designations in the Cariboo-Chilcotin. Although the Churn Creek Protected Area was established to protect its ecological values, a commitment was made to incorporate the continuation of activities such as recreation, cattle grazing, hunting, trapping and backcountry tourism in the area.

An approved (2000) Park Management Plan for the area identified the need for a Fire Management Plan (FMP). The management plan identified five major objectives including:

- Reduction of conifer encroachment and ingrowth
- Maintain/enhance red and blue listed species habitat
- Maintain/enhance habitat for California bighorn sheep, mule deer and other wildlife habitat
- Control noxious weeds
- Cattle grazing to approved AUM levels

The foundation for the FMP was to develop an understanding of historical fire and climate patterns within each biogeoclimatic subzone in the Protected Area. This understanding was based on the following recommended studies:

- Analysis of fire-scarred trees to determine frequency, intensity, seasonality, and extent of historic fires.
- Determine historic climate cycles (including drought cycles) using dendroclimatoloical techniques to help determine ecosystem structural and compositional change over time.
- Document the fire ecology and fire effects (including fire adaptations) of species of interest in the protected area.

Over the past 100 years human settlement, logging, grazing and fire suppression have negatively impacted the ecosystems within the Churn Creek Protected Area (CCPA). Historically, the area was dominated by a mosaic of grasslands and open forest that supported a wide diversity of habitat and species. The greatest changes to ecosystem structure and function can be attributed to fire suppression that has resulted in significant ingrowth of the open forests and encroachment of grassland communities. These alterations have resulted in decreased productivity for wildlife and domestic livestock. Additionally, ingrowth and encroachment have increased fuel loading across the landscape to a level where fire behavior and resultant fire severity will negatively impact long-term site productivity, vegetation, wildlife and domestic livestock.

In the fall of 2000 B.A. Blackwell and Associates Ltd., Iverson & MacKenzie Biological Consulting Ltd., and R.W. Gray Consulting Ltd. formed an interdisciplinary team contracted by BC Parks to develop a Fire Management Plan for the Churn Creek Protected Area. From the onset of this project it was evident that identification of prescribed fire opportunities should be considered as a method for restoration and enhancement of ecological communities of the protected area required to meet higher level ecosystem management goals.

PART A. FIRE MANAGEMENT PLAN

RECOMMENDED TIMELINE

A summary of the recommended course of action is provided in Table 1. Further discussion of each action can be found in section 1.2.

Table 1. Summary of recommended course of action.

Phase	Year	Recommended Action
I	1	• Select a candidate area of encroachment for treatment and monitoring. • Select a candidate area of encroachment that has been heavily grazed for monitoring. • Develop an inventory plan for areas of in-growth. • Select an in-growth area for treatment and monitoring.
II	2-5	• Assess monitoring results from encroachment treatments to see if additional treatment strategies need to be tested. • Continue to monitor heavily grazed plots. • Test inventory strategy for in-growth areas and begin the inventory process. • Assess monitoring results from in-growth treatment areas.
III	5	• Develop 5-10 year strategic plan for vegetation management and monitoring.

RECOMMENDATIONS SUMMARY TABLE

A summary of the recommendations made throughout the Churn Creek Fire Management Plan is provided in Table 2.

Table 2. Summary of recommendations

Management Issue	Management Objective	Section Reference	Recommendation
Values at Risk	Protection of values at risk	14.3	• For areas where prescribed fire severity may result in anacceptable damage to ecosystems being restored, mechanical fuel or other alternative treatments may be required. This issue needs to be addressed within the context of BC Parks vegetation management policy. • Removal of excess fuels in areas of potential high fire severity should take place prior to the use of prescribed fire. • Inconsistencies in BC Parks conservation policies dealing with "insect and disease control actions", "vegetation removal or modification", and "habitat manipulation parameters" should be cleared up. The widest range of vegetation management strategies are needed in order to maintain and restore successional stages, critical species, and critical habitat attributes in the dry ecosystems of the CCPA. • Given the high fuel loading associated with many of the ingrowth areas prescribed natural fires cannot be considered as a management tool at this time. • Any physical damage to range improvements resulting from prescribed burning should be assessed immediately post-burn and an estimate of replacement costs established.
Prescribed fire	Re-introduction of fire to the ecosystem	3.0; 4.3; 5.0; 5.3; 5.2	• It is recommended that BC Parks adopt the most rigorous burn planning format developed and institute the additional requirement of an environmental assessment to accompany any burn plans • Implement fire behavior monitoring in addition to standard fire effects monitoring. • Fire effects tables (Appendix C) should be used to determine which red and blue listed species may be found in habitat types affected by the fire. • Burn objectives should focus on maintaining the habitat attributes of threatened species where appropriate. • For each prescribed burn it is recommended that permanent plots be established within each major vegetation type, within each treatment type and within unburned, untreated control areas adjacent to the burn area to determine plant community response. Methods for plot establishment are

Table 1. Cont…

Management Issue	Management Objective	Section Reference	Recommendation
Prescribed fire cont…	Re-introduction of fire to the ecosystem cont…		outlined in section 5.2. • All plots should be established and measured prior to the burn. Vegetation should be re-measured the first summer post-burn and again 1, 3 and 5 years post-burn. • Forest structure plots and fuel transects should be measured 1-2 weeks post burn once scorched needles have completely lost their chlorophyll and turned red. • Forest structure plots should be re-measured again 1 and 5 years later. • Duff pins should be re-measured immediately following the burn.
Grazing		4.0; 5.0	• Prior to burning, areas with insufficient fuels should be rested for one to two years. • After burning, areas should be rested from grazing for one to three years. • Thin and mechanically remove biomass in ingrowth areas to provide substitute grazing lands. • Grazing decisions should be tied to site specific monitoring of vegetation.
Noxious weeds		4.2	• Areas should be surveyed and treated for noxious weeds prior to burning. • Treatment of noxious weeds in grassland and forested areas should take priority over those restricted to moist areas. • Treatment recommendations for noxious weeds should be obtained from the regional or district range agrologists. • Cheatgrass is presently not listed as a noxious weed in British Columbia. However, any cheatgrass in or directly adjacent to a burn area should be controlled prior to prescribed burning.
Enhancement, maintenance and monitoring of red and blue listed wildlife species.	Douglas-fir habitats (along slopes and crests of hills	4.3; 4.3.1; 4.3.1; 6.1	*These areas are used as nesting and foraging habitat by flammulated owls and Townsend's big-eared bats* • Maintain all large trees and snags for nesting/roosting. • Open forests with small thickets of smaller trees should be maintained as foraging habitat. • Burns planned between early May and August require that surveys be conducted in the prior field season to determine flammulated owl use. • If owls are found nesting in the site, burns should be planned for before or after the nesting period or a 50m no burn buffer should be maintained around the nest tree. • Townsend's big-eared bats use these habitats from late June and August. If prescribed fires are conducted during this period extra care must be taken to protect snags and live trees with cavities. • Conduct post-treatment monitoring of flammulated owl re-occupancy to ensure

Table 1. cont…

Management Issue	Management Objective	Section Reference	Recommendation
Enhancement, maintenance and monitoring of red and blue listed wildlife species cont…	Douglas-fir habitats (along slopes and crests of hills cont…		• treatments did not affect habitat use by the species. *Slopes may be used by mule deer and bighorn sheep.* • It is recommended that ingrowth of Douglas-fir be reduced and the cover of herb and palatable shrubs be increased.
	Very open forest	4.3.2; 6.2	*Western-small-footed myotis, Townsend's big-eared bat and Lewis' woodpecker use these forests as foraging habitat.* • Maintain sites in an open condition. • Retain all large Douglas-fir, ponderosa pine trees and a small number of smaller trees for recruitment into the overstory. • Berry-producing shrubs should be promoted for Lewis' woodpecker feeding. • Conduct surveys for Lewis' woodpecker prior to prescribed burning if burning is planned between early May and late July. • Western-small-footed myotis and Townsend's big-eared bat may nest in cavities in these habitats. If burning is planned in July or August extra care must be taken to protect snags and cavity trees from fire. • Maintain or enhance sage and other shrubs for Western-small-footed myotis foraging habitat. • Monitoring the retention of snags and wildlife trees in these areas should be conducted to ensure adequate snag retention was achieved. • Fire retardant or fire shelter material should be used to protect trees with scars that are particularly prone to damage from fire.
	Grasslands	4.3.4; 6.3	*All types of grasslands are used by racer, rubber boa, short-eared owl, Swainson's hawk, gyrfalcon, peregrine falcon, prairie falcon, western small-footed myotis, spotted bat, deer and bighorn sheep as foraging habitat.* • Encroached grasslands should be restored in order to increase available habitat. • Grasslands should be maintained with abundant vegetation cover to provide a sufficient prey population (small mammals) for the predatory species. • Prescribed burning in these habitats will improve the palatability and nutritional quality of forage species for deer and bighorn sheep. *Grasslands with a component of big sage are used by Brewer's sparrow and sage thrasher as foraging and nesting habitats.* • Manage areas with confirmed sage thrasher occurrences for dense cover of large old sage. • Areas used for nesting by Brewer's sparrows should not be burned during the nesting season.

Table 1. Cont…

Management Issue	Management Objective	Section Reference	Recommendation
Enhancement, maintenance and monitoring of red and blue listed wildlife species cont…	Grasslands cont…		• Any areas with a big-sage component should be surveyed for Brewer's sparrow and sage thrasher prior to any burns being conducted. • Areas occupied by sage thrashers should be removed from the burn area. • Areas occupied by Brewer's sparrow should be treated to retain some sage cover by spot burning or removing from the treatment area. • Other sage grassland areas may be burned in patches to thin the sage and maintain more scattered cover. Patch burning in these habitats will improve the quality of forage species for ungulates. *Non-shrubby grasslands are used by long-billed curlew and upland sandpiper for nesting and foraging habitat.* • Maintain grass cover as tall as possible in areas where upland sandpipers are found. • Areas used by curlews must be maintained in a short condition and prescribed fire may accomplish this. • All burning should take place outside of the nesting season in areas where these species are found. For curlews, pre-nesting burning may best maintain habitat. • Periodic burning of small areas in upland sandpiper habitats should be used to prevent shrub establishment in the grasslands. *Open grasslands are used by Sharp-tailed grouse, long-billed curlews, bobolinks and upland sandpipers.* • Surveys for these species should be conducted so that they can be accommodated in the burn prescription. • Sharp-tailed grouse may begin nesting as early as mid-April so fires should not be conducted within 1km of known lek sites between then and late August. • Long-billed curlew nest in grasslands between early April and mid-August and upland sandpipers nest between May and September. If these species are confirmed in an area, burn timing should be planned outside of those times. • Burning should be done outside of the nesting season for bobolinks, late may to early August.
	Cultivated field	4.3.5; 6.4	*Wet cultivated hayfields are often used as breeding habitat by bobolinks.* • Timing of hay harvest or burning must be done after young have fledged (mid-August). • Cultivated fields should be surveyed for bobolinks before prescriptions are developed. • Burning should be done outside of the nesting season for bobolinks, late May to early August.

Table 1. Cont…

Management Issue	Management Objective	Section Reference	Recommendation
Enhancement, maintenance and monitoring of red and blue listed wildlife species cont…	Aspen copses, Aspen forest	4.3.6; 6.5	• These habitats do not generally need restoring, however some aspen stands may be lacking regeneration and burning may stimulate vegetative propagation. *Flammulated owl, Lewis' woodpecker, fringed myotis, Townsend's big-eared bat, western small-footed myotis and spotted bat forage in aspen copses and aspen forests. Sharp-tailed grouse use aspen stands for winter roost sites and forage on aspen buds and catkins.* • Surveys for these species should be conducted so that they can be accommodated into the burn prescription. *Coarse woody debris in these sites is used by rubber boa, racer, gopher snake.* • Any burning prescriptions for these sites should have coarse woody debris retention or enhancement as an objective. *Fisher use large aspen in riparian areas for den trees* • Habitat trees should be retained.
	Shrubland	4.3.8; 6.6	*Shrublands are used as foraging habitat by Lewis' woodpecker, western small-footed myotis, Townsend's big-eared bat, spotted bat, fringed myotis, gopher snake, racer, rubber boa, and sharp-tailed grouse. Yellow-breasted chats use the area for nesting.* • Yellow-breasted chat surveys should be conducted in shrublands in riparian areas. Occupied areas should not be treated. • No pre- or post-treatment monitoring is required for other species.
	Buildings	4.3.3	*Fringed myotis, Townsend's big-eared bat and western small-footed myotis use old buildings as roosting or denning sites. Barn owls (a possible species in the protected area) also use buildings as nest sites.* • All old buildings should be retained.
Mule deer	Mule deer management and monitoring.	4.4; 6.7	• Retain all large overstory Douglas-fir. • Reduce densities of intermediate and suppressed trees to allow understory vegetation to establish. • Winter track counts should be conducted a few days after significant snow events (greater than 6 cm accumulations) so that only recent tracks are tallied. Snow depth transects are suggested. • Snow depth should be measured after snowfall events (when track counts are conducted) as well as other times to measure snow persistence. • Snow depths should be taken concurrently in areas with no tree cover to evaluate the snow-reducing effect of tree canopies. • Deer diets should be evaluated by fecal analysis.

Table 1. Cont…

Management Issue	Management Objective	Section Reference	Recommendation
California big horn sheep	Enhancement and maintenance of California bighorn sheep.	4.5; 6.8	• Monitoring and management recommendations will be proposed in a research project being prepared under another contract and these should be included in the monitoring program suggested in section 6.8 of this document.
Enhancement, maintenance and monitoring of red and blue listed plant species.	Determine response of red- and blue-listed plant species to prescribed fire.	5.1.1; 5.2	• Conduct rare plant surveys by walking the area pre-burn. • Collect voucher specimens. • Note locations of rare plants using GPS. • Strategies to maintain any rare plants sensitive to burning should be developed within the burn plan. • Monitoring plant communities in specific areas should follow the methods laid out in section 5.2.

1.0 PRESCRIBED BURN PLANNING

1.1 Outline Burn Planning/Prescriptions (Fuel Treatment)

The intentional application of fire is used to achieve an effect associated with the pyrolisis process. The successful prescribed burn is contingent on a full understanding of the fire ecology of the objectives as well as the three component parts of fire behaviour: fuels, weather, and topography. The process of constructing a prescribed fire plan is the first opportunity to determine whether or not enough is known of the burn objectives and the input fire behaviour elements to justify the use of fire. In addition to providing the operational guidance for the burn, the finished plan must also provide strong ecological rationale for the use of fire, while also serving as the legal document that sets the parameters for due diligence in the event of a liability issue.

Historically in B.C., the use of prescribed fire in resource management only required a single page FS117B form be filled out and submitted to either the Forest District or Protection Branch for burn plan approval. Recently, following significant issues of prescribed fire liability in the U.S. and Australia, a provincial Task Team made up of representatives from Forest Districts, Protection Branch, and BC Parks, have developed a series of burn plan outlines to be used in the various situations where prescribed fire may be operationally applied (Appendix A). These burn plan outlines are still in the formative stage and will be continually improved upon. It is recommended that BC Parks adopt the most rigorous burn planning format developed and institute the additional requirement of an environmental assessment to accompany any burn plans (Appendix B Hat Creek Burn Plan).

Prescribed fire planning must also fit within the framework of strategic planning. Fire, and its attendant effects, is not a panacea to all problems on the landscape. The misuse of fire can create more problems than it was intended to solve. In the CCPA encroachment and in-growth areas, there are opportunities where the appropriate use of prescribed fire can be beneficial to those ecosystems. In most cases, however, the conditions are not currently available to use prescribed fire. The issues around both encroachment and in-growth are interrelated and are going to require an integrated approach in order to resolve them (Figure 1). As can be seen in Figure 1, resolving the encroachment issue is dependent on resolving the in-growth issue and vice versa. In the case of in-growth, too much fuel currently exists, while in encroachment areas, not enough fuel exists. Solving the fuel issue in encroachment areas is dependent on resting the areas from grazing in order to grow a fuel bed. In order to rest enough area, substitute grazing areas must be found. These can be found in in-growth areas once tree density is substantially reduced and more forage produced. In order to reduce stand density in in-growth areas, BC Parks must thin these areas and remove the biomass from the site; burning it standing is not an option.

Scattered through the various stages of this strategic approach are critical points of "outcome monitoring." These can also be referred to as adaptive management stages. At these points feedback from operations, in the form of monitoring, should be used to test whether or not the hypothesis being tested is true or false. By building these points into the framework at frequent intervals, managers will be able to react to ecosystem responses in a timely fashion.

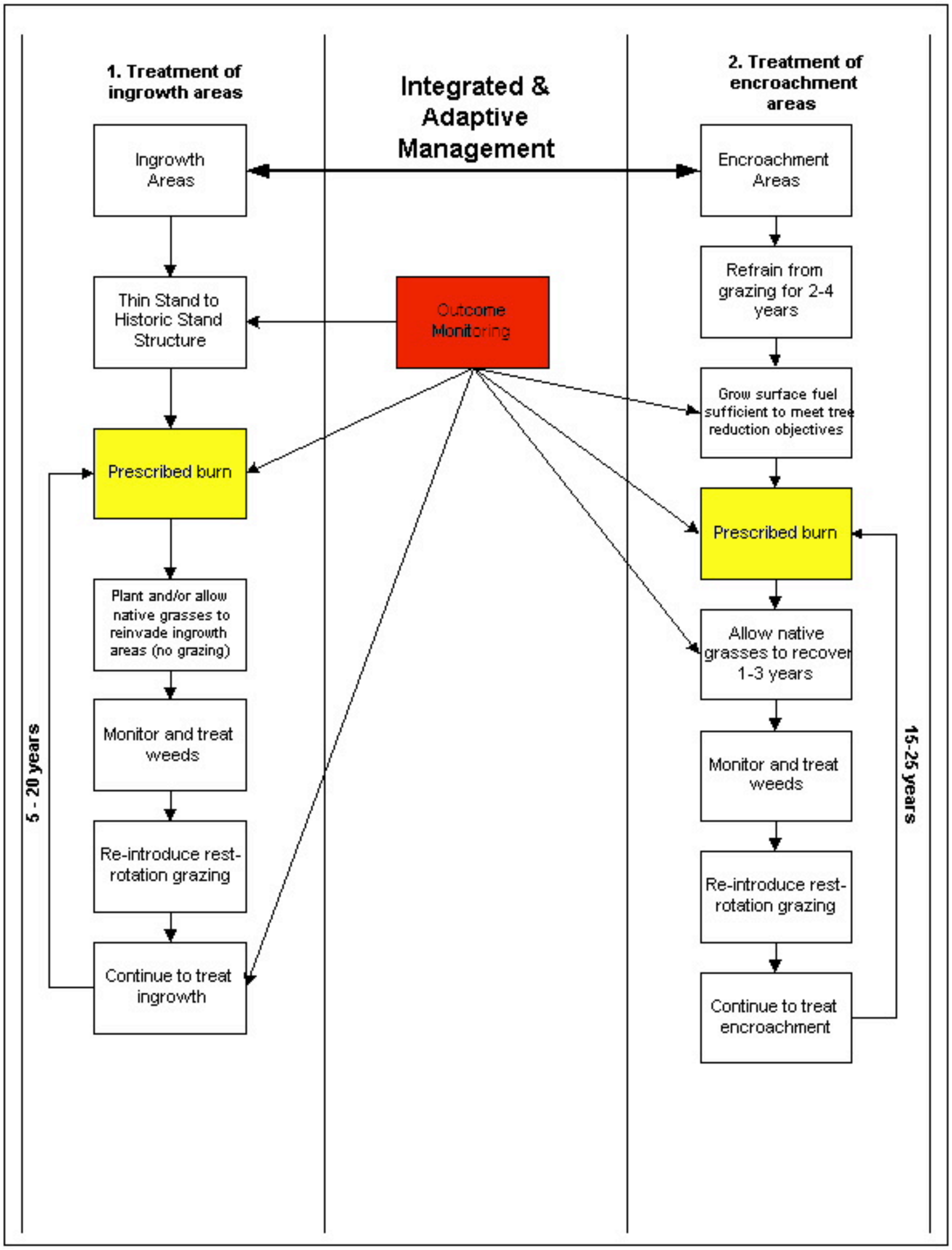


Figure 1. Integrated and adaptive management flowchart.

1.2 Timeline of events

1.2.1 Phase I: Year One

Select a candidate area of encroachment for treatment and monitoring.
In an area containing adequate surface fuels (grass), set up a series of treatment test plots. The plots will focus on burning with no prior cutting of encroached trees, burning with prior cutting of all encroached trees, burning with prior strategic cutting of encroached trees, and a control. Monitoring will focus on: treatment cost/ha, prescription accuracy, prescription effectiveness, and the temporal effectiveness of these treatments.

Select a candidate area of encroachment that has been heavily grazed for monitoring.
Select a heavily grazed area within the larger encroachment area and erect a series of small exclosures. Monitor the time it takes to grow an adequate surface fuelbed of grass. Choose separate areas containing native grasses, introduced grasses, and noxious weeds (test assumption that in some areas prior seeding of grasses may be necessary in order to ultimately treat encroaching conifers).

Develop an inventory plan for areas of in-growth.
The structure of forest in-growth stands is highly variable. In order to develop a range of vegetation management (ecosystem restoration) strategies the characteristics of these stands need to be inventoried. The plan should focus on how to collect (intensity of sampling, developing predictive systems) the following variables: tree density, diameter distribution, heights, yield characteristics, surface fuels, and understory plant community.

Select an in-growth area for treatment and monitoring.
Select candidate in-growth stands containing a very high density of small-diameter trees (<10cm dbh). Setup a series of treatment plots and test the following treatment strategies: thin and broadcast burn, thin and pile and burn (burn piles in winter and broadcast in spring), thin and no burn, thin and pile and no burn (burn piles in winter), and control. Treatment monitoring should focus on: treatment cost/ha, prescription accuracy, prescription effectiveness in meeting objectives, fuelbed characteristics post-treatment and over time, fire severity, and plant community (predominantly grass) response over time. The treatment area as a whole must be fenced and excluded from grazing. Treatment timing must be sensitive to the seasonal timing of the Douglas-fir beetle flight.

1.2.2 Phase II: Year 2-5

Assess monitoring results from encroachment treatments to see if additional treatment strategies need to be tested.
As part of adaptive management, assess the outcomes (from quantitative monitoring of objectives) from treatments to determine what treatments are valid from a ecological, social, and economic perspective. If, in the course of monitoring analysis, or through on-site observation, issues become apparent that could affect the success of future operations, those issues must be addressed through further experimentation and monitoring.

Continue to monitor heavily grazed plots.
Assess the rate at which plant communities (native grasses, introduced grasses, noxious weeds) develop in the established exclosures.

Test inventory strategy for in-growth areas and begin the inventory process.
Assess the accuracy of the in-growth structure inventory design. Prioritize areas for in-growth structure inventory and prepare a timetable and budget for project (PA-wide) completion.

Assess monitoring results from in-growth treatment areas.
As part of adaptive management, assess the outcomes (from quantitative monitoring of objectives) from treatments to determine what treatments are valid from a ecological, social, and economic perspective. If, in the course of monitoring analysis, or through on-site observation, issues become apparent that could

affect the success of future operations, those issues must be addressed through further experimentation and monitoring.

1.2.3 Phase III: Year 5

Develop 5-10 year strategic plan for vegetation management and monitoring.
Develop an integrated, ecosystem restoration strategic plan that will carry operations through for a 5-10 year period. This plan will include operational prescriptions for treatment of both encroachment and in-growth based on previous experimental treatments and monitoring results. In addition to ongoing project monitoring at the operational-scale, additional adaptive management monitoring will need to be incorporated at the larger, operational, landscape scale of activities. The plan will provide a timetable and budget of activities over the planning horizon; and will require a detailed environmental assessment including an assessment of ecological, social, and economic impacts of proposed activities.

2.0 PRIORITIZATION OF AREAS FOR TREATMENT

Four candidate burn areas were selected based on the following criteria:
- Forage for wildlife and cattle
- California bighorn sheep habitat needs
- Good candidates for experimental treatments that can then be applied elsewhere in ingrown and encroached areas

These four candidates (Churn Flats, Clyde Mountain, Dry Farm, and Koster Creek) and the associated objectives are described below. These burn areas are shown in Figure 2. These areas are large and it is not intended that all areas within the proposed areas would necessarily burn nor that all burning would necessarily occur within a one-year time period.

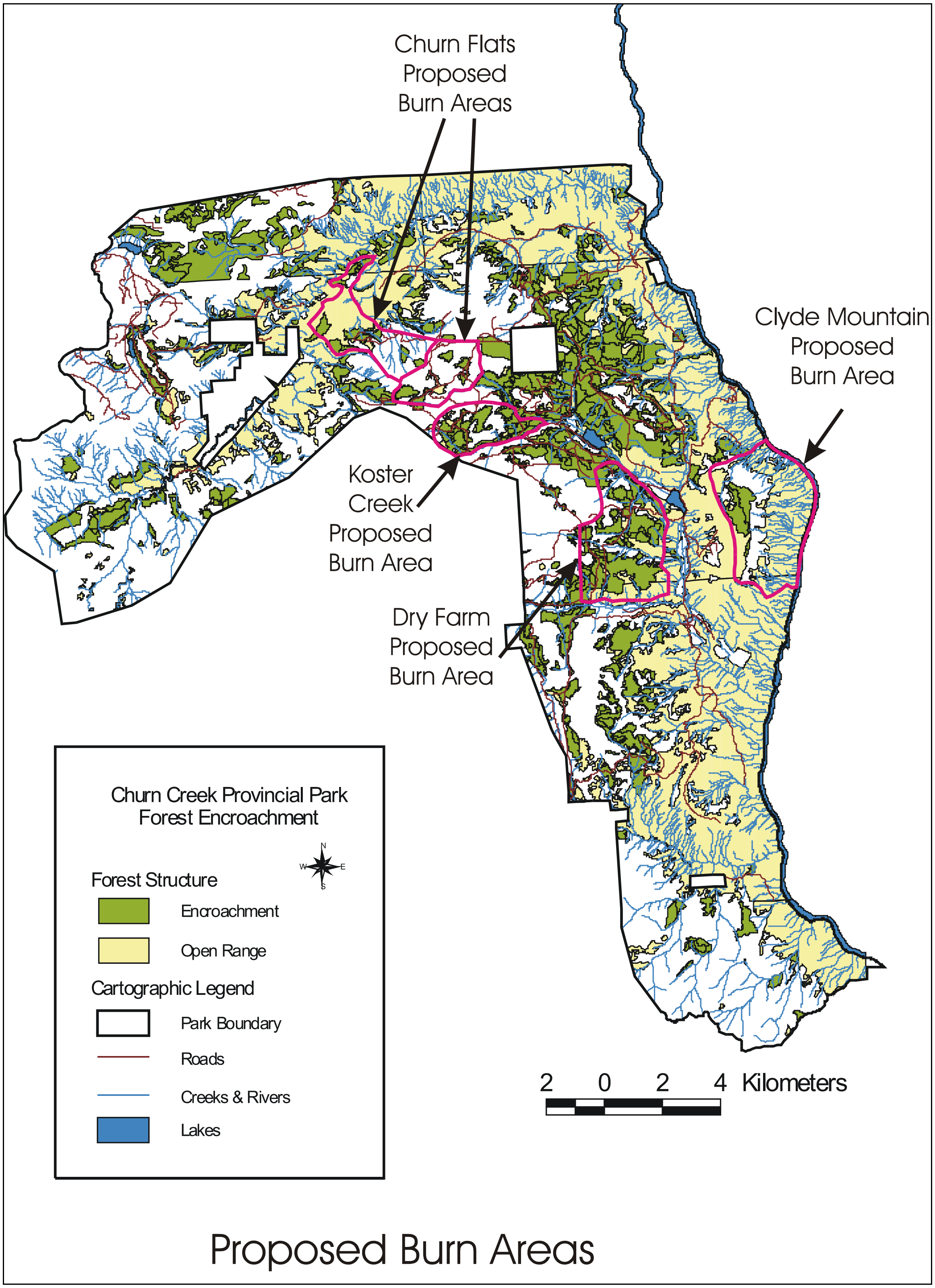


Figure 2. Proposed burn areas.

2.1 Churn Flats Burn Area

The Churn Flats burn area is comprised of several ecological types. The area is illustrated in Figure 3. The flats and the slumps below (north of) the flats are grasslands dominated by bluebunch wheatgrass. Much of the grasslands within the slump terrain have grass with thick, unpalatable litter build-up. To the south of the flats are north-facing forests (Type 2b) and encroachment patches (Type 2a), some of which has been logged (Type 7). A second portion of the burn area is located above the flats to the south. This area includes gently sloping ingrown forests, both logged (Type 7), and unlogged (Type 6) and some grasslands with encroachment (Types 4 and 5). The intention is to treat the grassland and ingrowth areas initially, while allowing recovery of fuels in the grassland encroachment areas by resting them from grazing for 2-4 years. If they cannot be rested from grazing initially, they may have to be rested after the ingrown forests have been treated and are producing forage. The management objectives for the Churn Flats Burn Area is outlined in Table 3.

Table 3. Management objectives for the Churn Flats Burn Area.

Management Area	Ecosystem Type	Management Objective
Churn Flats Burn Area	All ecosystem types	• Gather knowledge on plant community recovery. • Gather knowledge on the effectiveness of different treatments of ingrowth. • Enhance traditional use plants including nodding onion and Mariposa lily. • Protect range improvements (fences, watering developments).
	Grassland areas	• Increase palatability of bluebunch wheatgrass for native ungulates (sheep, mule deer) and cattle by reducing coarse, dead grass component in bunchgrasses and stimulating tiller production.
	Type 2b and Type 6 (ingrown, unlogged forests)	• Increase quality and quantity of browse for mule deer and California bighorn sheep in forested areas. • Reduce the amount of forest ingrowth (return forest to historical extent and structure) by reducing the extent and cover of small diameter Douglas-fir. • Retain large, old Douglas-fir trees, particularly those with cavities. • Maintain and enhance foraging and nesting habitat for Flammulated Owls. • Increase visibility for California bighorn sheep in forested areas
	Type 7 (logged forests)	• Increase quality and quantity of browse for mule deer and California bighorn sheep in forested areas. • Reduce the amount of forest ingrowth by reducing the extent and cover of small diameter Douglas-fir. • Retain enough Douglas-fir stems to recruit structure similar to the historic forest structure.
	Types 4 and 5 (encroached grasslands)	• Allow, if necessary the recovery of grasslands and accumulation of sufficient fuels to kill encroachment with fire by treating adjacent ingrowth. • Increase quality and quantity of forage for mule deer. • Eliminate encroachment. • Re-establish the native vegetation community

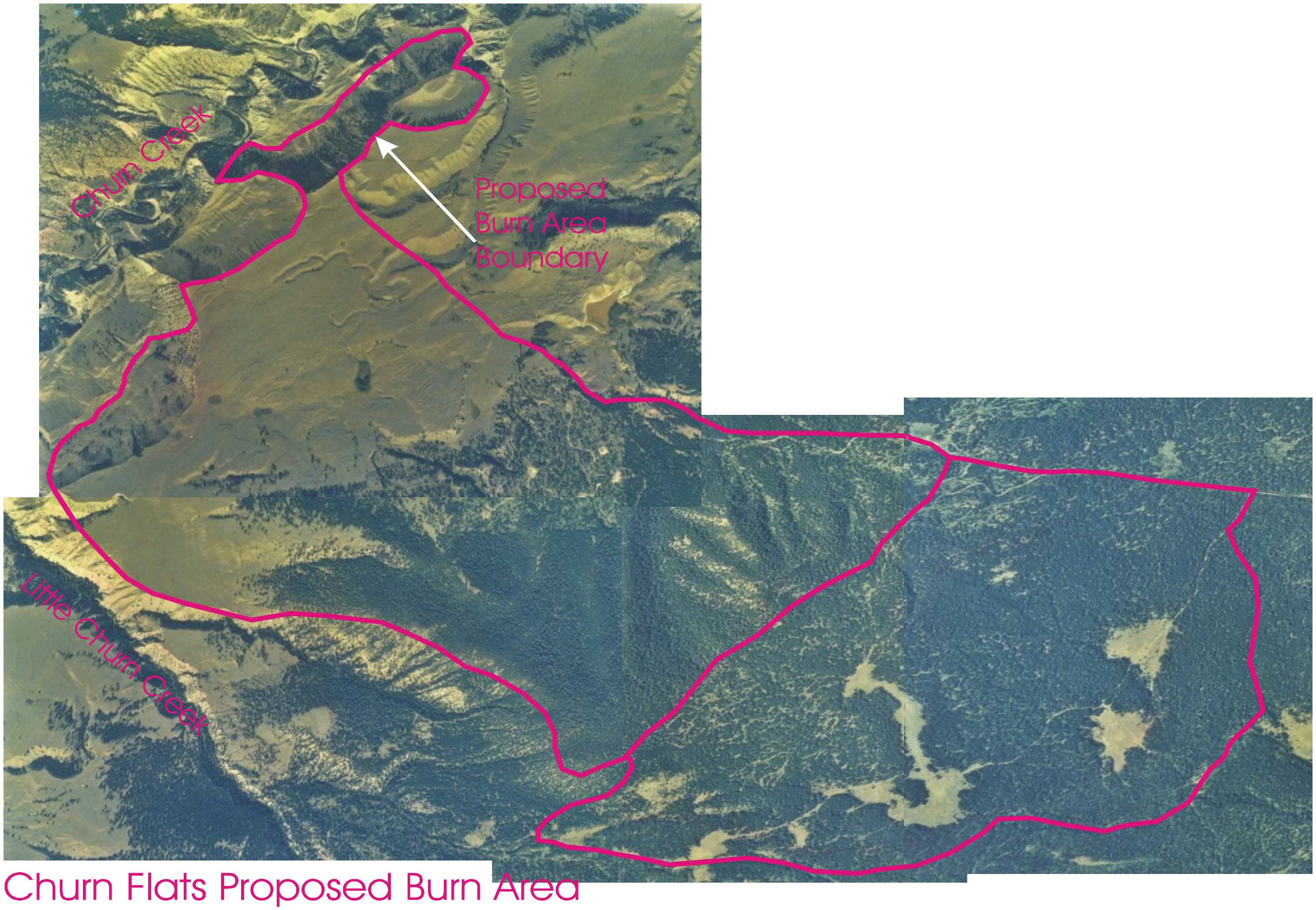


Figure 3. Churn Flats proposed burn area.

2.2 Clyde Mountain Burn Area

The Clyde Mountain burn area is comprised of several ecological types. The area is illustrated in Figure 4. The terraces above the Fraser river are dominated by needle-and-thread grass near the river and dominated by bluebunch wheatgrass at the base of the slope. Much of the area dominated by bluebunch wheatgrass has thick, unpalatable litter build-up. To the west of the terraces are steep east-facing slopes with both grasslands and Douglas-fir trees in draws, and some areas of logged (Type 7) and unlogged ingrown forests (Type 2b). Above the slopes is the top of Clyde Mountain, which is dominated by grasslands, some of which has Douglas-fir encroachment. See Figure 4 for an illustration of the area. The management objectives for the Clyde Mountain Burn Area are outlined in Table 4.

Table 4. Management objectives for the Clyde Mountain Burn Area

Management Area	Ecosystem Type	Management Objective
Clyde Mountain Burn Area	All ecosystem types	• Gather knowledge on plant community recovery. • Gather knowledge on the effectiveness of different treatments of ingrowth. • Enhance traditional use plants including nodding onion and Mariposa lily.
	Type 2b (ingrown, unlogged forests)	• Increase quality and quantity of browse for mule deer and California bighorn sheep in forested areas. • Reduce the amount of forest ingrowth (return forest to historical extent and structure) by reducing the extent and cover of small diameter Douglas-fir. • Retain large, old Douglas-fir trees, particularly those with cavities. • Maintain and enhance foraging and nesting habitat for Flammulated Owls. • Increase visibility for California bighorn sheep in forested areas.
	Type 7 (logged forests)	• Increase quality and quantity of browse for mule deer and California bighorn sheep in forested areas. • Reduce the amount of forest ingrowth by reducing the extent and cover of small diameter Douglas-fir. • Retain enough Douglas-fir stems to recruit structure similar to the historic forest structure.
	Types 4 and 5 (Encroached grasslands)	• Eliminate encroachment. • Increase quality and quantity of forage for mule deer.

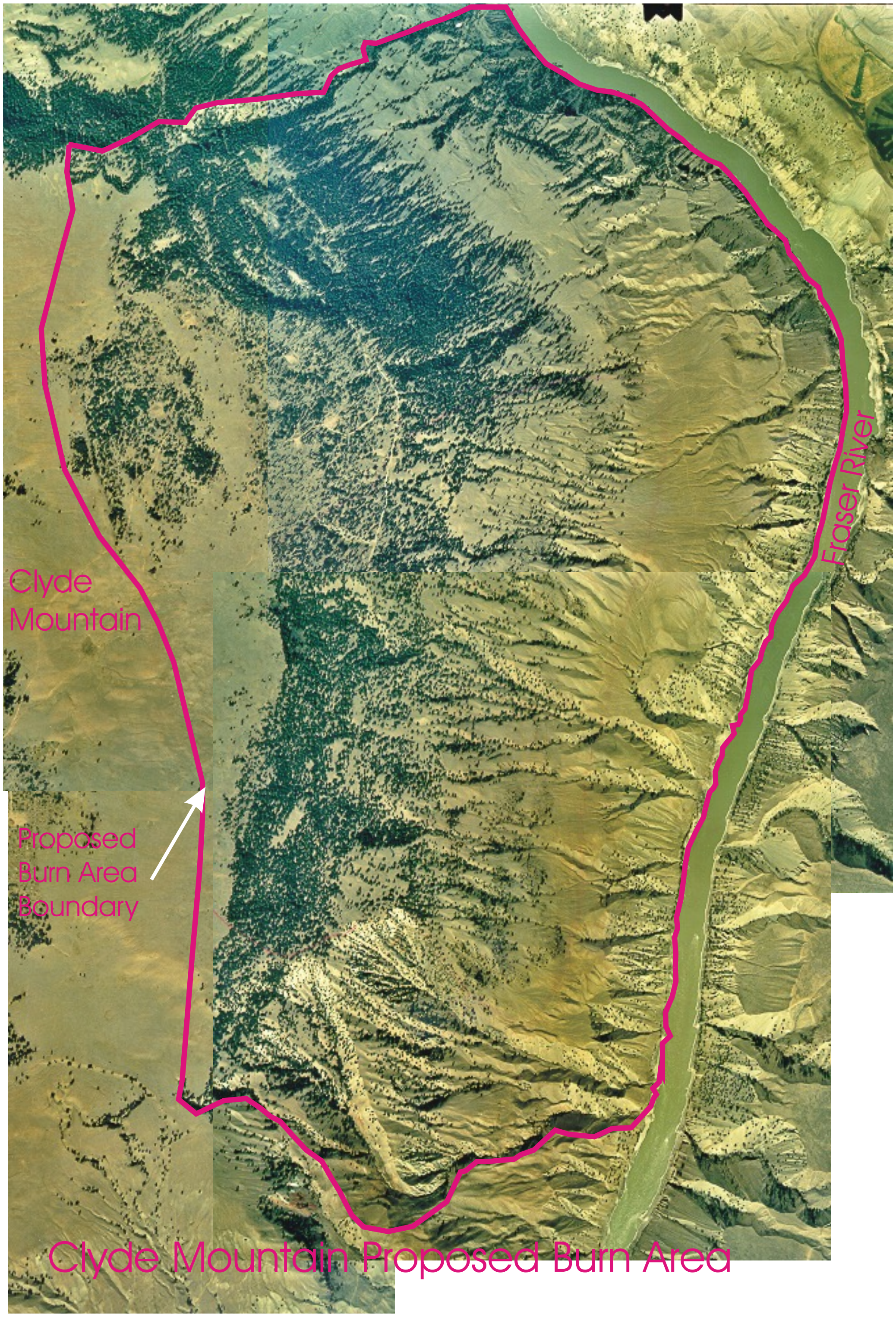


Figure 4. Clyde Mountain proposed burn area.

2.3 Dry Farm Burn Area

The Dry Farm burn area is primarily gently sloping. It has a combination of unlogged ingrown forests (Type 6), logged ingrown forests (Type 7), grasslands, and encroached grasslands (Types 4 and 5). There are small patches of south facing encroachment (Type 1) and north facing encroachment and ingrowth (Types 2a and 2b). The area is illustrated in Figure 5. The management objectives for the Dry Farm Burn Area are outlined in Table 5.

Table 5. Management Objectives for the Dry Farm Burn Area.

Management Area	Ecosystem Type	Management Objective
Dry Farm Burn Area	All ecosystem types	• Gather knowledge on plant community recovery. • Gather knowledge on the effectiveness of different treatments of ingrowth. • Enhance traditional use plants including nodding onion and Mariposa lily. • Protect range improvements (fences, watering developments).
	Types 6 and 2b (ingrown, unlogged forests)	• Increase quality and quantity of browse for mule deer. • Reduce the amount of forest ingrowth (return forest to historical extent and structure) by reducing the extent and cover of small diameter Douglas-fir. • Retain large, old Douglas-fir trees, particularly those with cavities.
	Type 7 (logged forests)	• Increase quality and quantity of browse for mule deer. • Reduce the amount of forest ingrowth by reducing the extent and cover of small diameter Douglas-fir. • Retain enough Douglas-fir stems to recruit structure similar to the historic forest structure.
	Types 1, 2a, 4 and 5 (encroached grasslands)	• Allow the recovery of grasslands and accumulation of sufficient fuels to kill encroachment with fire by treating adjacent ingrowth • Eliminate encroachment • Re-establish the native vegetation community • Increase quantity and quality of forage for mule deer

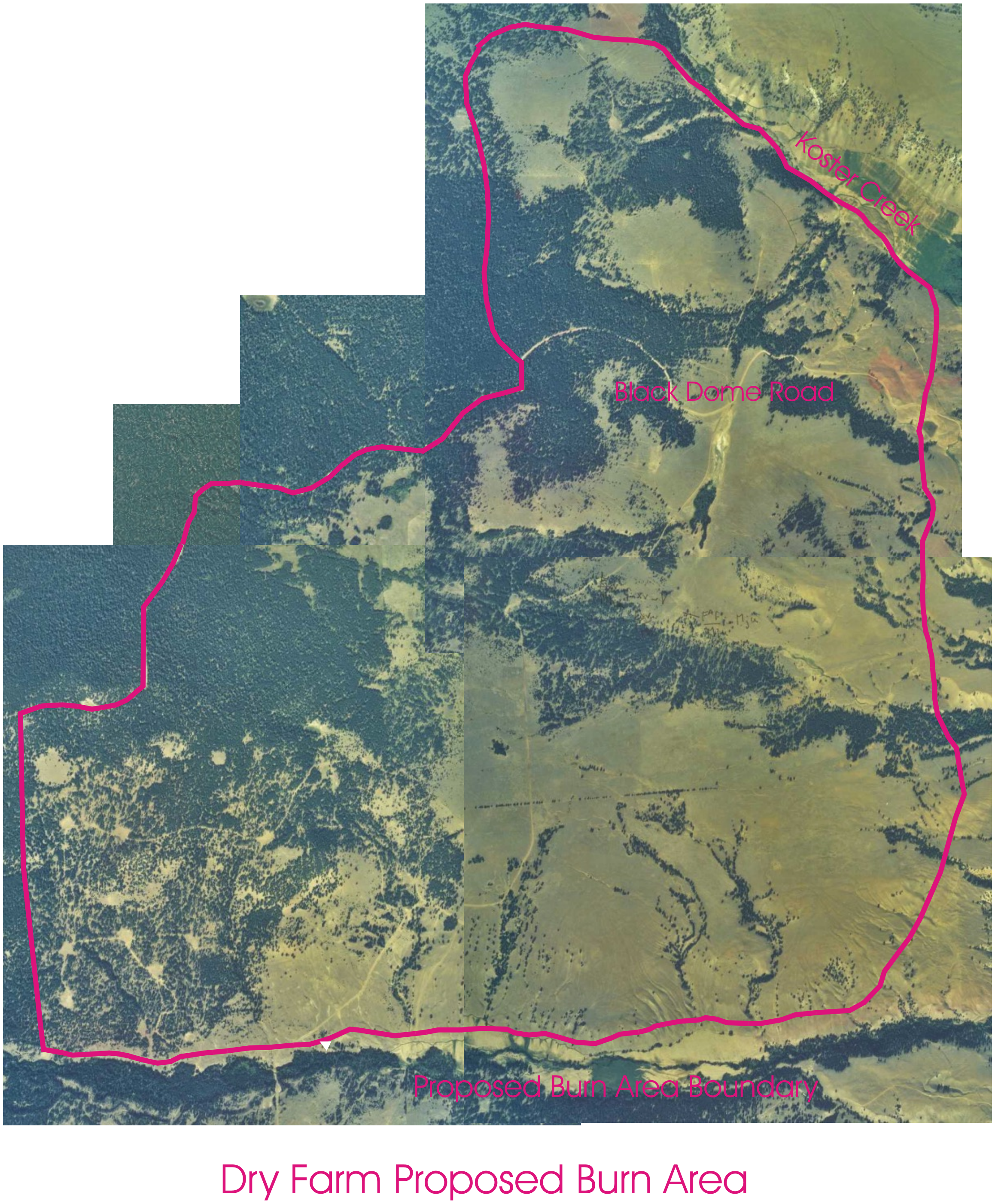


Figure 5. Dry Farm proposed burn area.

2.4 Koster Creek Burn Area

The Koster Creek burn area is primarily gently sloping with a south facing slope above Koster Creek. It has a combination of unlogged ingrown forests (Type 6), logged ingrown forests (Type 7), grasslands, and encroached grasslands (Types 4 and 5). There is an area of south facing ingrowth (Type 1) above Koster Creek. The area is illustrated in Figure 6. The management objectives for the Koster Creek Burn Area are outlined in Table 6 below.

Table 6. Management objectives for the Koster Creek Burn Area

Management Area	Ecosystem Type	Management Objective
Koster Creek Burn Area	All ecosystem types	• Gather knowledge on plant community recovery. • Gather knowledge on the effectiveness of different treatments of ingrowth. • Enhance traditional use plants including nodding onion and Mariposa lily. • Protect range improvements (fences, watering developments).
	Types 6 and 2b (ingrown, unlogged forests)	• Increase quality and quantity of browse for mule deer. • Reduce the amount of forest ingrowth (return forest to historical extent and structure) by reducing the extent and cover of small diameter Douglas-fir. • Retain large, old Douglas-fir trees, particularly those with cavities.
	Type 7 (logged forest)	• Increase quality and quantity of browse for mule deer. • Reduce the amount of forest ingrowth by reducing the extent and cover of small diameter Douglas-fir. • Retain enough Douglas-fir stems to recruit structure similar to the historic forest structure.
	Types 1, 2a, 4 and 5 (encroached grasslands)	• Increase quality and quantity of forage for mule deer. • Allow the recovery of grasslands and accumulation of sufficient fuels to kill encroachment with fire by treating adjacent ingrowth. • Eliminate encroachment . • Re-establish the native vegetation community.

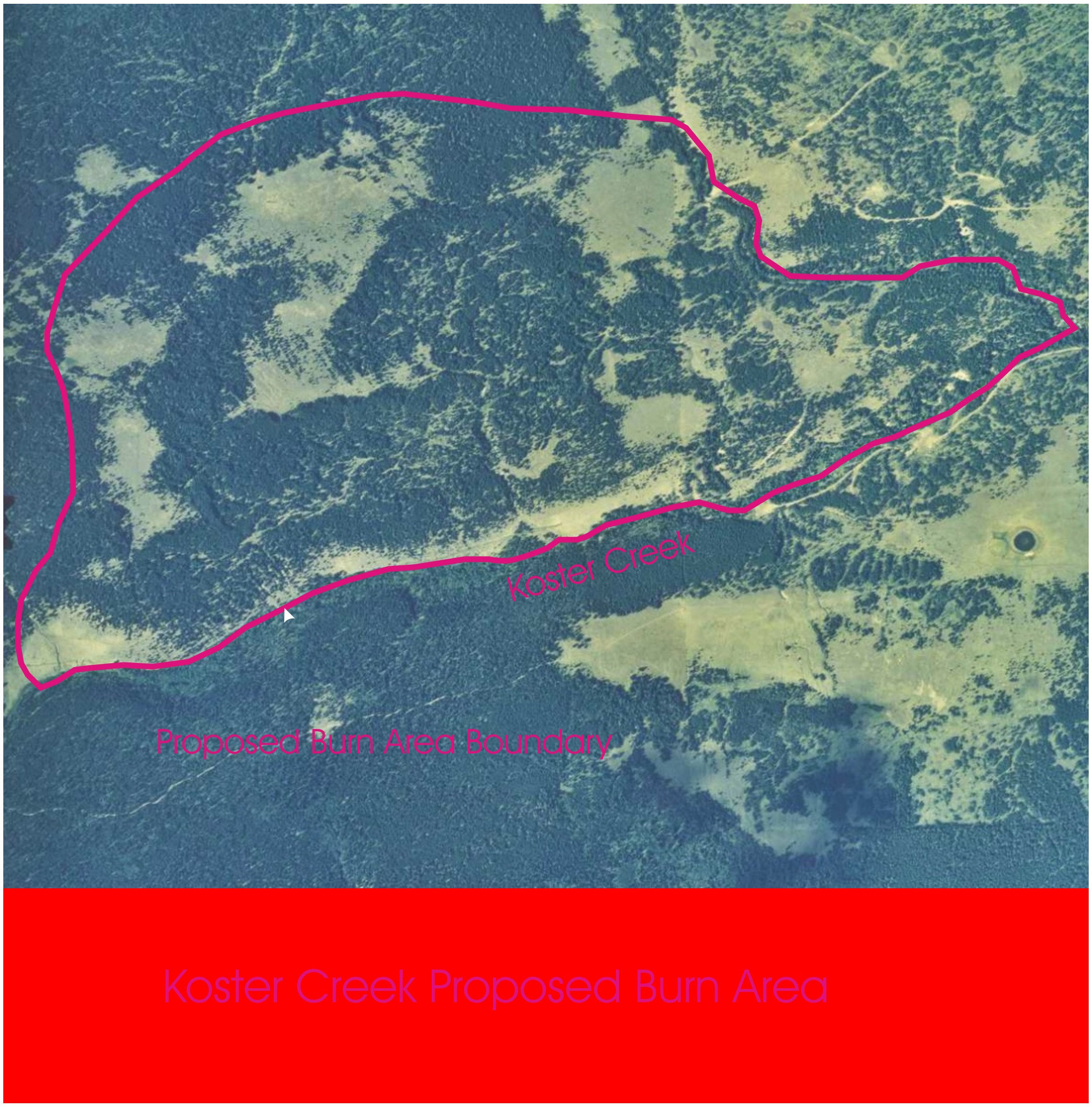


Figure 6. Koster Creek proposed burn area.

3.0 MONITORING PRESCRIBED FIRE

Fire behaviour monitoring needs to be implemented in addition to standard fire effects monitoring. The prescribed use of fire is intended to meet a range of fire effect objectives. Fire effects are a product of fire behaviour, or burning conditions. In order to meet these conditions a predicted level of fire behaviour is modeled in the prescription. Input variables can include Fire Weather Index System moisture codes (FFMC, DMC, DC), direct measures of fuel moisture by size class, windspeed, wind direction, temperature, relative humidity, fuel type or model, etc. Determining whether or not the burn met its intended objectives is met through a comparison of predicted fire behaviour and actual fire behaviour. Monitoring this comparison is easily met by quantifying the fire behaviour outputs, flame length (FL) and rate of spread (ROS). These variables should be measured at a number of locations and times throughout the operation. Flame length is easily measured against a stationary object such as a tree and doesn't need to be overly accurate. Rate of spread is a distance/time measurement, measured in m/min, and can be derived by lighting a spot fire below the main fire and measuring the time it takes to cover a set distance. More accurate measurements can be taken if test locations are established ahead of time and points are measured out and marked on the ground.

If predicted values do not match actual values within a relative range, chances are burn objectives were not met. This indicates problems with either the accuracy of input values or the fire behaviour model or both. This problem then would need to be corrected, as part of adaptive management, prior to proceeding to the next project.

4.0 VEGETATION AND HABITAT OBJECTIVES

4.1 Ecological Implications of Grazing

Grazing of domestic livestock in the CCPA dates back to the late 1800's when the area had several small ranches grazing sheep, cattle and horses (BC Parks 2000). Grazing by domestic livestock would have removed much of the fine fuel available to carry fires. It is highly probable that fire was effectively excluded from many areas by grazing. As a result, fires had been prevented from removing Douglas-fir encroachment and ingrowth long before any active suppression of fires in the area. Additionally, the cessation of aboriginal burning would have also reduced the fire frequency in these areas in the early 1900's. Grazing may have also allowed trees to establish more readily, further contributing to encroachment and ingrowth (Madany and West 1983).

Within the Specialty Pastures of the Churn Creek Protected Area, many areas of grasslands were historically overgrazed. Up to the time that the Empire Valley Ranch was purchased by the Province of British Columbia and became part of the CCPA, these pastures were fenced private lands that were managed solely by the private landowner. An illustrative example of the management of these pastures occurred during the 1970's. At this time, the Empire Valley Ranch had 450 cattle above the number specified by the Ministry of Forest's grazing permit for crown land. The additional 450 cattle were grazed on the Specialty Pastures for the entire grazing season (BC Parks 2000).

Many areas of upper grasslands in the Specialty Pastures would have been dominated by larger native bunchgrasses (including *Stipa curtiseta*, *S. richardsonii* and *Elymus spicatus*) at climax. The majority of these grasslands are now dominated by lower profile bunchgrasses such as junegrass (*Koelaria macrantha*), Sandberg's bluegrass (*Poa secunda*) and a non-native rhizomatous grass, Kentucky bluegrass (*Poa pratensis*;Year 2000 monitoring data from the CCPA). The low profile growth form of these early seral grasses is such that they do not produce the same upright litter that is characteristic of later seral bunchgrasses. As a result, it is probably more difficult to carry a fire on grassland sites dominated by early seral grasses.

The Specialty Pastures have also experienced significant encroachment of Douglas-fir that has reduced the extent of the grasslands and therefore, forage for both native species and domestic livestock. Many areas have recent encroachment that will negatively impact the availability of forage in the near future.

The majority of areas within the Specialty Pastures currently have insufficient fuels to carry fires and remove encroachment even if most of the encroachment was cut down and cured prior to burning. Thus, there is a need to build up fuel on these sites prior to the treatment of encroachment. This may require resting these pastures for a period of time to rebuild fuels sufficient to carry a burn (possibly two years, but this is not known). Due the early seral condition of many areas dominated by smaller bunchgrasses and Kentucky bluegrass, these sites may not build up enough litter without further recovery of seral condition. This process would require a longer period to develop enough cover of late seral species. Following this recovery, the site would then have to be rested from grazing to allow fuel accumulation. There are, however, some areas sufficiently far removed from water that they have enough fuel to carry a burn.

Other areas of encroached grasslands may also lack the fuels necessary to support a burn. Potential burn candidates will need to have fuel assessments conducted. If the fuel assessment indicates a lack of fuel in some areas, these areas may have to be rested from grazing for two years prior to treatment.

Conversely, many areas that are inaccessible to cattle but have had fire excluded from them are dominated by bunchgrasses with a build up of thick, unpalatable litter. Fire exclusion in these areas has resulted in less palatable forage for native ungulates and these sites likely have reduced productivity due to the lack of burning. Both mule deer and cattle are discouraged from utilising bluebunch wheatgrass with standing litter (Willms et al. 1980). Mule deer, California bighorn sheep, and cattle prefer bluebunch wheatgrass that has been burned over unburned grass (Willms et al. 1980; Peek et al. 1979). Burned grass is preferred over clipped grass and clipped grass is preferred over untreated grass (Willms et al. 1980). This preference is strong enough that deer will graze more heavily in burned areas and avoid untreated areas (Willms et al. 1980). Ungulates will benefit from the vegetation response to burning and will likely utilize the area heavily post-burn. However, combining domestic grazing pressure with native ungulate grazing would likely damage many native grass species and cause a regression of seral condition. This preference for burned grasses in addition to the recovery time needed by burned grasses (Bunting et al. 1998) requires that burned areas be rested from domestic grazing for at least one year following burning, and possibly three. Grazing decisions should be tied to site specific monitoring of vegetation.

Given the complex terrain that dictates the seasonal movements of cattle, it may not be feasible to rest pastures from grazing for two consecutive years. One alternative may be to treat ingrown areas in these pastures that will result in increased forage for cattle. This may allow the adjacent grasslands to rest enough to build up sufficient fuel for burning. This presents a much longer-term proposition, as it would likely be five or more years before the treated forests provided sufficient forage to replace a significant component of the grassland forage.

Without the treatment of ingrowth and encroachment, cattle and native ungulates will concentrate grazing on increasingly smaller and smaller areas, with forage becoming more and more limiting. Increased grazing pressure will result in a static seral stage or, more likely, a continual shift to earlier seral stages. Increased grazing and therefore, disturbance of soil, can create conditions that allow weeds to establish more readily.

4.2 Noxious Weed Management

Within the CCPA, several noxious weeds (including spotted knapweed, diffuse knapweed, leafy spurge, and blueweed) have taken hold in some areas of the grasslands and forested areas. Presently, these weeds are mostly localized problems. Other noxious weeds (including hound’s tongue, burdock and Canada thistle) occur in moister sites or sites with disturbed soils. Known noxious weed occurrences are indicated in Figure 7. However, any disturbance, including prescribed burning, has the potential to increase the spread of weeds to adjacent areas. Utilizing prescribed fire in any area will require a survey of the area for noxious weeds and the treatment of those weeds prior to burning. Treatment of noxious weeds in grassland and forested areas should take priority; noxious weeds that are restricted to moist areas are less of a concern for prescribed burns. Treatment recommendations for noxious weeds can be obtained from the regional or district range agrologists.

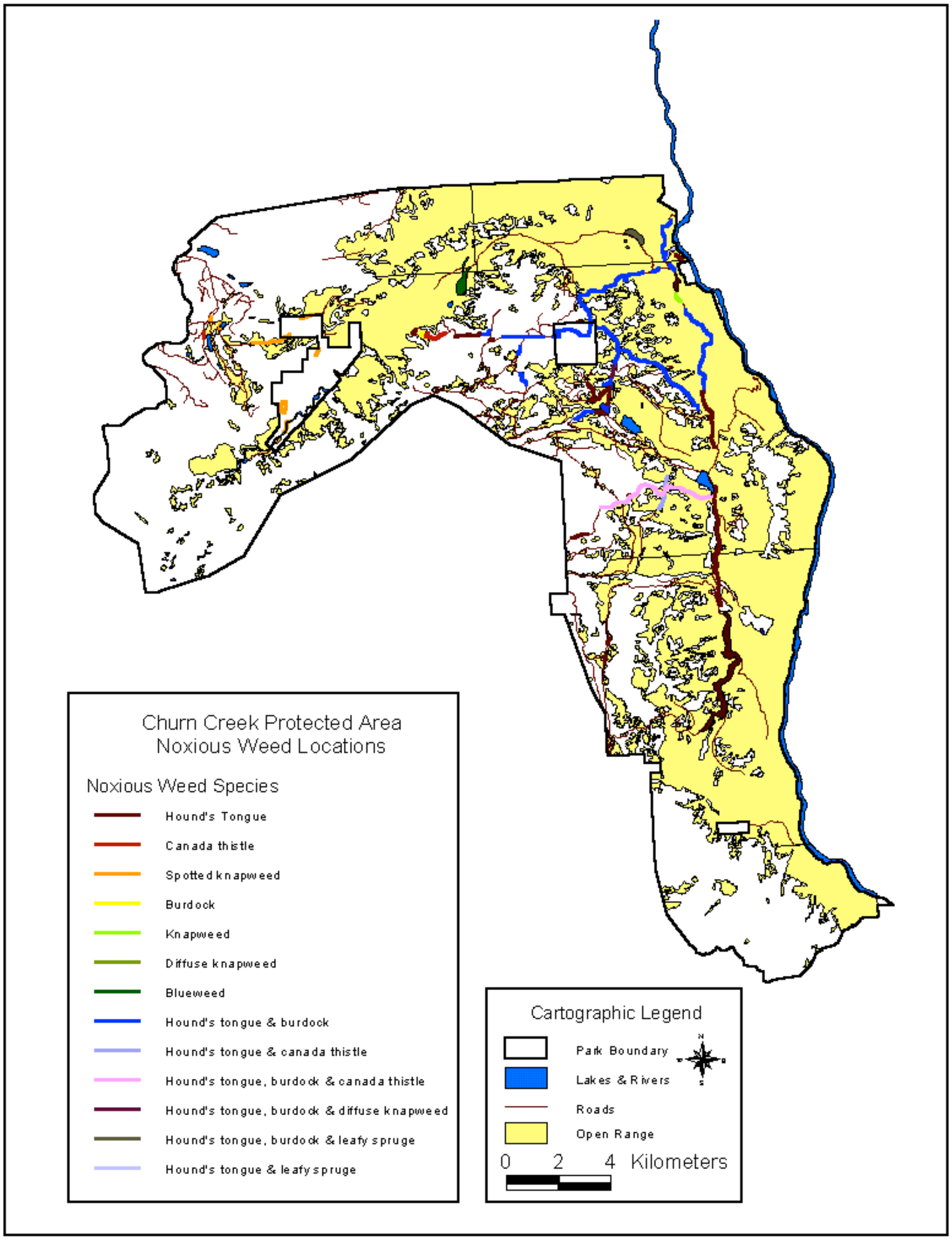


Figure 7. Noxious weed locations in Churn Creek.

Most non-native plants that are not listed as noxious weeds are undesirable but do not represent a direct threat to the ecological health of grasslands and forests in the CCPA. However, cheatgrass (*Bromus tectorum* L.) and other non-native annual bromes present a serious threat to these ecosystems.

Cheatgrass is a non-native annual grass introduced from southwestern Asia that occurs throughout most of Canada and the United States. It was first reported in western North America in 1890 at Spences Bridge, British Columbia. Cheatgrass is a winter annual that germinates in early fall and overwinters as small seedlings. Plants resume growth in spring and produce seed in early summer. Under some conditions, cheatgrass germinates in spring and produces seed in the fall. (Mosley et al. 1999; Pyke and Novak 1994)

Presently, cheatgrass is not listed as a noxious weed in British Columbia. However, this weed and other non-native annual bromes have the potential to significantly negatively affect grassland and forest ecosystems, as has happened in the parts of the Okanagan and many areas of the United States. Cheatgrass is a prolific seed producer and has the ability to displace native plants and lower plant diversity. It can outcompete seedlings of many native perennials and prevent their establishment. By progressively colonizing areas during conditions that favour it, it can overtake larger and larger areas. Cheatgrass is unpalatable and non-nutritious relative to native perennial grasses. (Mosley et al. 1999) Additionally, cheatgrass has altered the frequency and intensity of fire in many areas (Peters and Bunting 1994).

Burning is ineffective at controlling cheatgrass. Fire usually reduces the density of cheatgrass plants the next growing season, but the plants that do establish produce proportionally large number of seeds on each plant (Young 1983), allowing cheatgrass to exceed pre-burn densities within one to five years (Wright et al. 1979).

Any cheatgrass in or directly adjacent to a burn area will have to be controlled prior to prescribed burning. Cheatgrass can be hand-pulled (this should be done prior to seed set) and can be chemically controlled with paraquat and glyphosate in the spring when seedheads begin to emerge. Cheatgrass needs to be treated for two to three consecutive years. Seeding native grass seed into these areas will also help re-vegetate them and reduce the chance of other weeds invading the site. Presently there are no biological control agents available for cheatgrass. (Mosley et al. 1999)

4.3 Enhancement and maintenance of red and blue listed species

A number of red- and blue-listed species and species of interest are found in CCPA (Figure 8). An overview of the critical habitat types used by these species (Figure 9) is given here with some of the fire effects on those habitats. When planning prescribed burns in the various habitat types, managers should refer to Appendix C (fire effects tables) to determine which of the species may be found in the habitat types affected by the fire. The tables, with timing periods, prescribed fire objectives and habitat fire effects, can be used to develop specific objectives for the sites being treated. The objectives should focus on ensuring that the habitat attributes required by each species will be maintained where appropriate and the risk of individual animals being adversely affected by fire is minimised.

Most of the species listed use only a few, critical habitat types and have small home ranges in the protected area. Managing these critical habitats for the attributes and conditions listed in the tables is sufficient for these species. Other species have large home ranges, different seasonal habitat requirements and require a landscape approach to maintain the required pattern and proportion of habitat types. Two of these species, mule deer and California bighorn sheep are discussed in more detail below.

4.3.1 Douglas-fir habitats (along slopes and crests of hills)

These areas are used as nesting and foraging habitat by flammulated owls and roosting and foraging habitat by Townsend's big-eared bats. All large trees and snags should be maintained for nesting/roosting. Open forest with small thickets of smaller trees should be maintained as foraging habitat for these two species. Slopes may be used by mule deer and bighorn sheep. Objectives should be to reduce ingrowth of Douglas-fir and increase the cover of herb and palatable shrubs.

4.3.2 Very open forest

Western-small-footed myotis, Townsend's big-eared bat and Lewis' woodpecker use these forests as foraging habitat. These sites should be maintained in an open condition with all large Douglas-fir and ponderosa pine trees retained and a limited number of smaller trees retained for recruitment into the overstory. Berry-producing shrubs should be promoted for Lewis' woodpecker feeding. Sage and other shrubs should be maintained or enhanced for Western-small-footed myotis foraging habitat.

4.3.3 Buildings

Fringed myotis, Townsend's big-eared bat and western small-footed myotis use old buildings as roosting or denning sites. Barn owls (a possible species in the protected area) also use buildings as nest sites. All old buildings should be retained.

4.3.4 Grasslands

All types of grasslands are used by racer, rubber boa, short-eared owl, Swainson's hawk, gyrfalcon, peregrine falcon, prairie falcon, western small-footed myotis and spotted bat as foraging habitat. Restoring encroached grasslands will increase the habitat available for these species. Maintaining grasslands with abundant vegetation cover will provide an abundant prey population (small mammals) for the predatory species. Deer and bighorn sheep use grasslands for foraging, and prescribed burning in these habitats will improve the palatability and nutritional quality of forage plant species.

Grasslands with a component of big sage are used by Brewer's sparrow and sage thrasher as foraging and nesting habitats. Areas with confirmed sage thrasher occurrences should be managed for dense cover of large old sage. Other sage grassland areas can be burned in patches to thin the sage and maintain more scattered cover. Inn areas used for nesting by Brewer's sparrows burning should not take place during the nesting season. Patch burning in these habitats will improve the quality of forage species for ungulates.

Non-shrubby grasslands are used by long-billed curlew and upland sandpiper for nesting and foraging habitat. Grass cover should be maintained as tall as possible in areas where upland sandpipers are found. Areas used by curlews need to be maintained in a short condition and prescribed fire may accomplish this. Any burning should be done outside of the nesting season in areas where these species are found. For curlews, pre-nesting burning may best maintain habitat. Periodic burning of small areas in upland sandpiper habitats will prevent shrub establishment in the grasslands.

4.3.5 Cultivated field

Wet cultivated hayfields are often used as breeding habitat by bobolinks. Timing of hay harvest or burning must be done after young have fledged (mid-August).

4.3.6 Aspen copses, Aspen forest

Flammulated owl, Lewis' woodpecker, fringed myotis, Townsend's big-eared bat, western small-footed myotis and spotted bat forage in aspen copses and aspen forests. Sharp-tailed grouse use aspen stands for winter roost sites and forage on aspen buds and catkins. These habitats do not generally need restoring, however some aspen stands may be lacking regeneration and burning may stimulate vegetative propagation. Coarse woody debris in these sites is used by rubber boa, racer, gopher. Any burning prescriptions for these sites should have coarse woody debris retention as an objective. Fisher use large aspen in riparian areas for den trees and these should be retained.

4.3.7 Open Water, Vernal Ponds and Rock or Talus

No prescribed fire objectives apply.

4.3.8 Shrubland

Shrublands are used as foraging habitat by Lewis' woodpecker, western small-footed myotis, Townsend's big-eared bat, spotted bat, fringed myotis, gopher snake, racer, rubber boa, and sharp-tailed grouse. Sharp-tailed grouse will use shrublands as winter roost sites and winter foraging. Shrublands, particularly along riparian areas are used as nesting habitat by yellow-breasted chats and should not be burned. Monitoring shrublands for use by chats should be done prior to burns being planned for these areas.

4.4 Mule deer management objectives for Churn Creek Protected Area

Current mule deer management philosophy in the Cariboo Forest Region centers on maintaining snow interception cover and Douglas-fir litterfall as the key components of mule deer winter habitat (Armleder *et al.* 1994, Waterhouse *et al.* 1994). This approach is based upon the extensive research conducted by Ministry of Forests research staff that shows that mule deer preferentially use high crown closure Douglas-fir forests in the winter (Armleder et al. 1994) and that a high proportion of mule deer winter diet is Douglas-fir foliage (Dawson *et al.* 1990, Waterhouse *et al*. 1994).

Management strategies and prescriptions have been developed to maintain desired forest characteristics both at the stand and landscape levels (Committee 2000). The stand level prescriptions are primarily designed to maintain or enhance habitat characteristics using forest harvest and have as one objective maintaining periodic re-entry opportunities for timber extraction while providing winter habitat for deer. The management strategies spatially locate various harvest types on the winter range and set limits on the amount of harvest that can occur in a given time period.

Managing for deer in a protected area differs in several key ways from management where balancing timber extraction while maintaining mule deer habitat is the major objective. Firstly, to maintain growing stock and provide re-entry opportunities when timber production is an objective, some of the larger trees on a site must be harvested. Growing space needs to be provided for young trees to become established and thrive. Many trees on sites managed in this way are smaller in diameter with corresponding small crowns and higher numbers of trees are required to maintain a given crown closure. Where timber extraction is not a goal, all of the largest trees on a site can be retained, and with their larger crowns high crown closures can be maintained with fewer stems.

A second major difference between sites managed for timber production and those in the CCPA is the desired condition of understory vegetation. A vigorous understory of grasses, herbs and shrubs is desired in the protected area to support deer and other wildlife while this same vegetation is often looked at as competition with conifers in forests managed for timber. The increased availability of these forage species for deer after prescribed fire treatments will likely affect habitat use patterns of deer, something that has not been well studied in B.C.

Prescribed fire can be a useful tool for mule deer management. In the CCPA most stands have significant ingrowth of Douglas-fir regeneration. These smaller, younger trees are not a source of forage for mule deer, provide little snow interception and exclude forage species. Mule deer usually avoid areas of particularly dense regeneration (Armleder et al. 1994). Prescribed fire is the only practicable method of reducing the ingrowth and stimulating other understory vegetation establishment and growth.

The four sites indicated as the first priorities for prescribed fire in this plan include north slopes, east slopes, generally flat with some south aspect, and flat. These four areas comprise a small proportion of the forested area in the protected area and should be treated to re-establish historic forest conditions. This will allow evaluation of the effectiveness of this prescription to maintain mule deer habitat values in a range of site conditions. Alterations to the prescriptions can be made to better meet objectives if required. Habitats used by deer during deep snow periods, those with high crown closure Douglas-fir forests, are the most common forest type in the Protected Area and are not in limited supply. Treating the proposed areas to re-establish historic conditions does not place habitat supply at risk.

Specific objectives for prescribed fire in the proposed treatment areas are:

1. Retain all large overstory Douglas-fir. These trees will intercept snow, slow radiative and convective heat loss and provide forage for deer,
2. Reduce densities of intermediate and suppressed trees to a level sufficient to allow understory vegetation to establish. In areas where few or no overstory trees (particularly those areas that have been logged) this density will be higher than sites with abundant overstory trees and needs to be assessed during prescription development. Only those trees that will likely release and grow rapidly should be retained. These trees will provide recruitment of large trees over time,
3. Promote a diverse understory vegetation community. Deer utilize a wide range of food types when they are available. Many of the understory plants that are valuable as forage for deer respond to fire with increased palatability and productivity (Peek *et al.* 1979, Willms *et al.* 1980).

Since these treatments are untried in south-central British Columbia and the resulting habitat quality during all winter conditions is unproven, monitoring of habitat use is required.

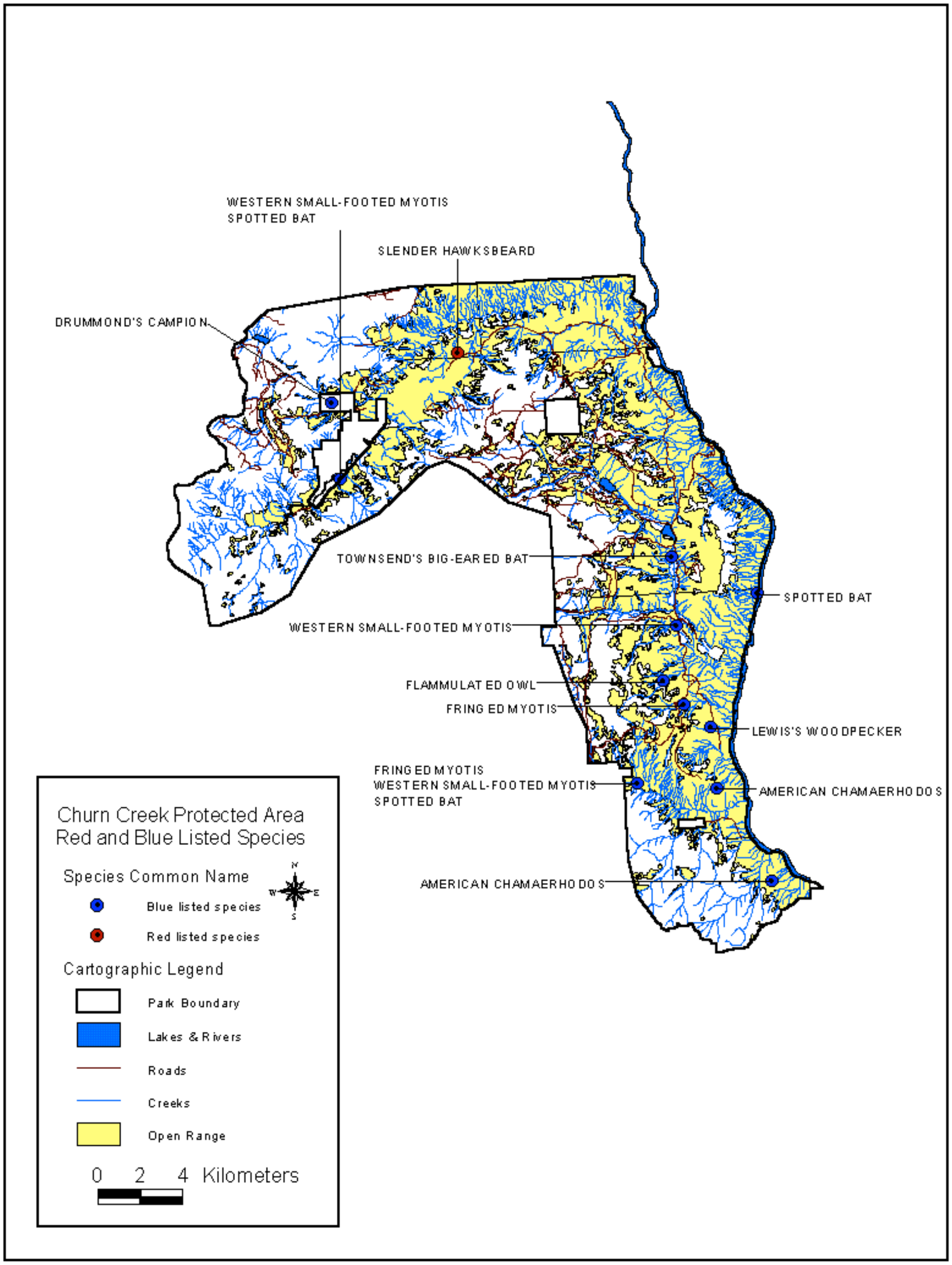


Figure 8. Red and blue listed species in Churn Creek.

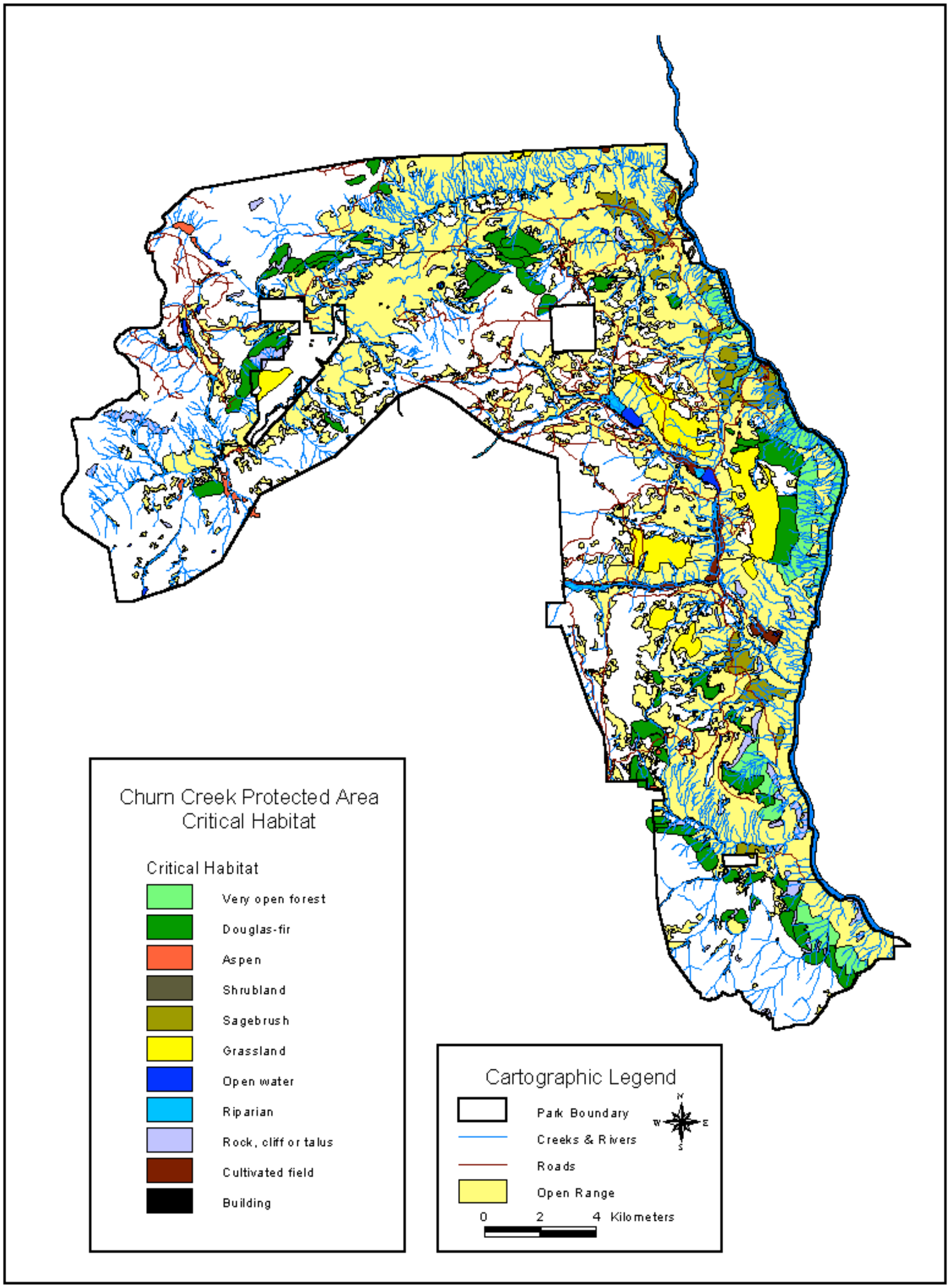


Figure 9. Critical habitats in Churn Creek.

4.5 Enhancement and maintenance of California bighorn sheep

Both resident and migratory sub-populations of California bighorn sheep use Churn Creek Protected Area. As illustrated in Figure 10, it is primarily the grassland slopes and benches along the Fraser River and Churn Creek that are used. Bighorn sheep are adapted to open grasslands usually associated with steep rocky terrain which they use as escape terrain (Shakleton *et al.* 1999). The sheep populations using the CCPA have declined in recent years probably due to a number of stressors (Legg *et al.* 1996).

One of these factors is loss of grassland habitat due to forest encroachment. Forest encroachment has occurred in many areas of important winter habitat and along migration routes of the migrant sub-populations. This encroachment has implications for sheep populations beyond reducing habitat supply. Decreased availability of habitat has the effect of concentrating sheep in a smaller area which may lead to increased predation risk from cougars, coyotes and other predators (Haas 1989, Wehausen 1996).

Decreased visibility distances along migration routes may also subject the sheep to greater predation rates. The increased densities that result from loss of grasslands may also lead to increased risk to diseases such as pneumonia and lungworm infestation (Festa-Bianchet 1991, Fougere-Tower and Onderka 1988). Forage supply is also affected by fire exclusion. Vegetation regrowing following fire has a higher protein content and produces more forage than unburned vegetation (McWhirter *et al.* 1992).

Because there are a number of cumulative impacts affecting bighorn sheep, monitoring the effects of prescribed fire on sheep population health is difficult. Monitoring and management recommendations will be proposed in a research project being prepared under another contract and these should be included in the monitoring program suggested here.

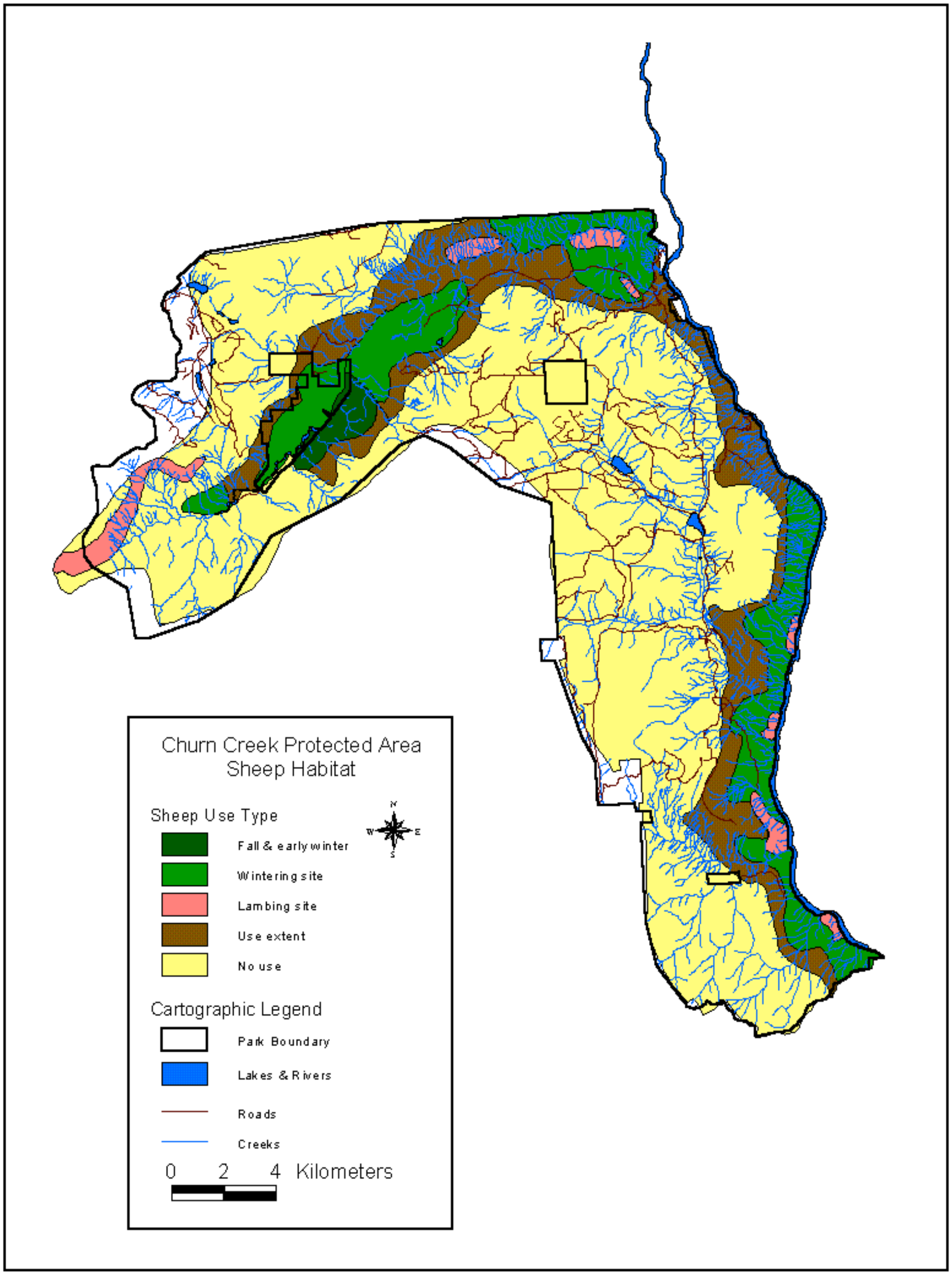


Figure 10. California bighorn sheep habitat in Churn Creek.

5.0 VEGETATION AND FOREST STRUCTURE MONITORING

For each prescribed burn, permanent plots should be established within each major vegetation type, within each treatment type and within unburned, untreated control areas adjacent to the burn area. Plots should photographed and established with rebar stakes. Wildlife monitoring is described in section 6.0.

There are four generalized sets of objectives for forested areas:

1. plant community response to burning,
2. understory and overstory tree mortality,
3. physical damage to range improvements, and
4. response of mule deer and red- and blue-listed species to burning.

There are four generalized sets of objectives for grassland encroachment areas:

1. plant community response to burning,
2. encroachment mortality,
3. physical damage to range improvements, and
4. response of mule deer and red- and blue-listed species to burning.

There are three generalized sets objectives for grassland areas:

1. plant community response to burning,
2. physical damage to range improvements, and
3. response of mule deer and red- and blue-listed species to burning.

5.1 General Monitoring for all areas

5.1.1 Response of red and blue listed plants

A rare plant survey should be conducted by walking the burn area. Voucher specimens should collected (unless there is a very limited number of specimens), and the position of rare plants located using a GPS. If any rare plants are located that are sensitive to burning, strategies for maintaining these rare species should be developed within the burn plan.

5.1.2 Damage to Range Improvements

Physical damage to range improvements can be assessed immediately post-burn and an estimate of replacement costs established. Long-term consequences of the burn on range improvements could involve the damage to fencelines resulting from the falldown of fire-killed trees.

5.2 Monitoring for specific areas

5.2.1 Forested Area (Types 1b, 2b, 6, and 7)

<u>Plot establishment</u>
For each of 3 monitoring locations:

- establish one 50m long transect,
- establish 30m triangle (using a random starting bearing),
- establish three fixed radius plots at the apices of the triangle.

<u>Burn pins</u>
Establish 40 plots (using random grid locations) within the burn area only.

<u>Photopoints</u>
Establish photopoints for each transect and each triangle.

Plant community response
Plant community response should be measured by establishing ten 20cm X 50cm plots at systematic locations (one every 5m starting at 1m) on each 50m long transect (for a total of 30 plots) prior to burn operations. For these plots, all plants and canopy cover would be recorded. Additionally, the number of seed culms for large bunchgrasses (bluebunch wheatgrass and *Stipa* spp.) would be recorded (as a measure to correlate to productivity). These plots would then be re-measured the first summer post-burn, and again 1, 3 and 5 years following the first re-measurement. Shrub intercept should be recorded along transects (this would include measuring the intercept of trees less than 10m tall). For all sites, starting one meter from the start and end of each transect, the first 5 individual bunchgrasses that are intercepted will have basal diameter measurements recorded (along with the location of the bunch along the transect). This will give a total of 20 bunches at each monitoring site.

The results of the monitoring should be tied in with re-introduction of domestic livestock grazing on the site. Grazing should not be re-introduced until seed stalk production, cover and basal diameter data meets or exceeds pre-treatment levels for bluebunch wheatgrass and *Stipa* spp.

Forest structure
At each of the three triangles, three fixed radius plots are established at the apices of the triangle for a total of nine plots. For each of these plots stand density, crown closure, mineral soil exposure, and height to live crown should be measured. These plots should be re-measured 1-2 weeks post-burn in order to let scorched needles completely lose their chlorophyll and turn red.

Fuels
Along each leg of the triangle, < 1cm and > 1cm fuel loading should be measured. Post-burn, depth of burn should be measured. At each of the 40 rebar pins, eight duff pins should be installed.

5.2.2 Grassland Encroachment Areas (Types 1a, 2a, 4, and 5)

Plot establishment
For each of 3 monitoring locations:
- establish one 50m long transect,
- establish 30m triangle (using a random starting bearing),

Plant community response
Plant community response should be measured by establishing ten 20cm X 50cm plots at systematic intervals (one every 5m starting at 1m) on each 50m long transect (for a total of 20 plots) prior to burn operations. For these plots, all plants and canopy cover would be recorded. Additionally, the number of seed culms for large bunchgrasses (bluebunch wheatgrass and *Stipa* spp.) should be recorded as a measure to correlate to productivity. Shrub intercept should be recorded along transects (this would include measuring the intercept of trees less than 10 m tall). For all sites, starting one meter from the start and end of each transect, the first 5 individual bunchgrasses that are intercepted will have basal diameter measurements recorded (along with the location of the bunch along the transect). This will give a total of 20 bunches at each monitoring site.

The results of the monitoring should be tied in with re-introduction of domestic livestock grazing on the site. Grazing should not be re-introduced until seed stalk production, cover and basal diameter data meets or exceeds pre-treatment levels for bluebunch wheatgrass and *Stipa* spp.

Fuels
Along each leg of the triangle, < 1cm and > 1cm fuel loading should be measured. Additionally, the 20cm X 50cm plot frame should be randomly tossed 6 times and the vegetation within the plot should be clipped to 1cm height to measure grass and forb fuel loading.

5.2.3 Grassland Areas (Type 3 and all other grassland areas)

Plot establishment
For each of 3 monitoring locations:

- establish one 50m long transect,
- establish 30m triangle (using a random starting bearing),

Plant community response
Plant community response should be measured by establishing ten 20cm X 50cm plots at systematic locations (one every 5m starting at 1m) on each 50m long transect (for a total of 20 plots) prior to burn operations. For these plots, all plants and canopy cover would be recorded. Additionally, the number of seed culms for large bunchgrasses (bluebunch wheatgrass and *Stipa* spp.) would be recorded (as a measure to correlate to productivity). Shrub intercept should be recorded along transects (this would include measuring the intercept of trees less than 10 m tall). For all sites, starting one meter from the start and end of each transect, the first 5 individual bunchgrasses that are intercepted will have basal diameter measurements recorded (along with the location of the bunch along the transect). This will give a total of 20 bunches at each monitoring site.

The results of the monitoring should be tied in with re-introduction of domestic livestock grazing on the site. Grazing should not be re-introduced until seed stalk production, cover and basal diameter data meets or exceeds pre-treatment levels for bluebunch wheatgrass and *Stipa* spp.

Fuels
The 20cm X 50cm plot frame should be randomly tossed 6 times and the vegetation within the plot should be clipped to 1cm height to measure grass and forb fuel loading.

5.3 Timing of Measurement

All plots should be established and measured prior to the burn. Vegetation should be re-measured the first summer post-burn and again 1, 3, and 5 years later. Forest structure plots and fuel transects should be measured 1-2 weeks post burn once scorched needles have completely lost their chlorophyll and turned red. Forest structure plots should be re-measured again 1 and 5 years later. Duff pins should be remeasured once following the burn.

6.0 WILDLIFE MONITORING

Monitoring recommendations for wildlife species found in each critical habitat type are given both pre-treatment to assess the use of the habitat by red- or blue-listed species and following prescribed fire treatments to ensure that management objectives are met.

6.1 Douglas-fir habitats (along slopes and crests of hills)

When burns are planned between early May and August in these habitat types, surveys to determine flammulated owl presence should be conducted in the prior field season. If owls are found nesting in the site, burns should be planned for before of after this nesting period or a 50m no burn buffer should be maintained around the nest tree. Townsend's big-eared bats forage in these habitats from late June and August and they may roost in snags during the same time period. It is unlikely that prescribed fires will be conducted during this period, but if so, extra care must be taken to protect snags and live trees with cavities to ensure that no bats are injured. Post-treatment monitoring of flammulated owl re-occupancy is required to ensure treatments did not affect flammjulated owl habitat use.

6.2 Very open forest

Surveys for Lewis' woodpecker should be conducted in these habitat types prior to prescribed burning if burning is planned between early May and late July. Any nest trees found should be removed from the treatment areas or timing of fire should be changed.

Western-small-footed myotis and Townsend's big-eared bat may nest in cavities in these habitats so if burining is planned in July or August extra care must be taken to protect snags and cavity trees from fire. Fire retardant or fire shelter material can be used to protect scarred trees that are particularly prone to damage from fire.

Monitoring the retention of snags and wildlife trees in these areas should be conducted to ensure adequate snag retention was achieved.

6.3 Grasslands

Any areas with a big-sage component should be surveyed for Brewer's sparrow and sage thrasher prior to any burns being conducted. Areas occupied by sage thrashers should be removed from the burn area. Areas occupied by Brewer's sparrow should be treated to retain some sage cover by spot burning or removing from the treatment area.

Open grasslands should be surveyed for sharp-tailed grouse, long-billed curlews and upland sandpipers so that they can be accommodated in the burn prescription. Sharp-tailed grouse begin appearing at the open grassland lek sites in mid-March and continue into early May. They are unlikely affected by prescribed fire during this period and should quickly re-occupy the lek after the fire has passed. Burning after about 9:00 am will ensure that grouse are not present on the lek during the burn. Sharp-tailed grouse may begin nesting as early as mid-April so fires should not be conducted within 1km of known lek sites between then and late August. Long-billed curlew nest in grasslands between early April and mid-August and upland sandpipers nest between May and September. If these species are confirmed in an area, burn timing should be planned outside of those times.

Other species using these habitats are generally mobile enough to avoid fire, only use them as foraging habitat and are not at risk from prescribed fire.

Surveys in occupied sites should be conducted for each of these species following treatment to evaluate the effectiveness of the treatment and the species response. Prescriptions can then be modified as required.

6.4 Cultivated field

If cultivated fields are considered for prescribed burning, they should be surveyed for bobolinks before prescriptions are developed. Presently bobolinks have not been recorded in the area and there are no implications for managing hay fields. However, if they are recorded, burning should be conducted outside of the nesting season for bobolinks, late May to early August.

6.5 Aspen copses, Aspen forest, Open Water, Vernal Ponds and Rock or Talus

These habitat types will generally not be treated.

6.6 Shrubland

Yellow-breasted chat surveys should be conducted in shrublands in riparian areas and should not be treated if occupancy is confirmed. This habitat type is primarily used for foraging by other species of interest and no pre- or post-treatment monitoring is required.

6.7 Monitoring for mule deer

<u>Snow Depth</u>
Since snow depth can limit the availability of habitat for deer, snow depth transects are suggested. Snow depth should be measured after snowfall events (when track counts are conducted) as well as other times to measure snow persistence. Snow depths can be related to stand and site characteristics and to deer use patterns. Prescriptions can then be adjusted to specific site conditions. Snow depths should be taken concurrently in areas with no tree cover to evaluate the snow-reducing effect of tree canopies.

Deer use of treated and untreated sites.
Winter track counts are relatively inexpensive to conduct and give will give strong evidence of deer use patterns. Track counts should be conducted a few days after significant snow events (greater than 6 cm accumulations) so that only recent tracks are tallied. These use patterns can be related to forage abundance data and to snow depths to adapt prescriptions to better meet deer winter habitat requirements.

Deer diets can be evaluated by fecal analysis.
This information will help guide longer term management plans for deer in the protected area. Diet of deer when a range of forage sources is available will enable managers to assess the frequency of various forage types in the diet and plan to maintain the appropriate proportion of the habitat types over the landscape.

6.8 Monitoring for California bighorn sheep

The population declines seen in bighorn sheep in CCPA are due to a number of small cumulative impacts which may include fire suppression, cattle grazing, forest encroachment, cougar predation, human-caused mortality and harassment, disease, and displacement by livestock and other wild ungulates. Any benefits to sheep populations from prescribed fire may not be apparent if other of the impacts have an equivalent negative effect on population recruitment or martality. Habitat increases from reduced forest encroachment and improved forage quality through fire will certainly have a beneficial effect on sheep populations but that effect may take some time to manifest and may be difficult to attribute solely to fire.

A proposal is currently being prepared to identify a monitoring methodology that will identify the magnitude of various stressors to bighorn sheep populations in the CCPA. Monitoring recommendations from that report should be included in the fire management monitoring. Monitoring recommendations for wildlife species found in each critical habitat type are given both pre-treatment, to assess the use of the habitat by red- or blue-listed species, and following prescribed fire treatments to ensure that management objectives are met.

PART B- BACKGROUND

7.0 TOPOGRAPHY

This section was adapted from the Churn Creek Terrestrial Ecosystem Mapping – Volume 1 Bioterrain and ecosystem mapping project report (Sinclair et al. 1999).

Physiographically, the Churn Creek study area encompasses a portion of the Fraser Plateau, a subdivision of the Interior Plateau region of British Columbia (Lavkulich and Valentine, 1978). The Fraser River bisects the project area from north to south along the eastern edge of the study area. In addition to the Fraser, there are several major creeks that have incised their way through post-glacial deposits down to the Fraser River. These include, Churn, Koster, Grinder, Porcupine, Lone Cabin, and French Bar Creeks. At the height of the Fraser Glaciation, the Cordillerian Ice Sheet was approximately 2000 m thick over the montane areas to 1000 m along major valleys and 600 m over the plateau (Huntely and Broster, 1997).

7.1 Fraser Plateau

The Fraser Plateau extends to the west and east of the Fraser River; however, the West Fraser Plateau, and its associated foothills, constitute the majority of the project area. The rounded ridges and summits of the rolling plateau topography suggest that the Cordilleran Ice-Sheet covered all of the study area (Huntely and Broster, 1997). Meltwater channels dissect the plateau and long sinuous esker ridges are also evident on the landscape. A compact matrix-supported till, that has an undulating or hummocky surface expression, comprises a large portion of the plateau surficial material. On the plateau, lacustrine and organic veneer and blanket deposits typically occur in depressional sites often associated with shrinking stagnant waterbodies or seasonal ponds (Plate 2).

Glaciolacustrine deposits are found on the side slopes of minor valleys within the plateau. These deposits can be linked to post-glacial lakes that formed, in tributary valleys, due to blockage by ice-dams and glaciers in the more significant valleys. Upon down-wasting of the ice, these deposits were down-cut by creeks striving to achieve a new equilibrium with creeks at lower elevations. Thus, narrow glaciolaustrine terraces have been left along some valley side slopes in the project area. Some areas of the plateau have salt precipitates that indicate saline soils and have been classified as a subtype of lacustrine deposits for the purposes of bioterrain mapping (L1).

Isolated grassland pockets occur amongst forested areas throughout the Fraser Plateau. The undulating till deposits in these areas are usually capped with eolian veneers from less than 10 cm thick along convex knolls to greater than 20 cm thick in gentle swales and along forest edges (Plate 2).

7.2 River and Creek Valleys

Surficial deposits become increasingly complex in the river and creek valleys of the project area, when compared with those deposits of the plateau. Multiple episodes of glaciation (large and small) and subsequent down cutting action by rivers and creeks have resulted in the layering of deposits. These layers combined with ongoing geomorphic activity in these valleys, only adds to the complexity of the deposits.

The upper slopes of the Fraser River and tributary valleys are steep with complex terraced topography below. The surficial deposits are a mixture of colluvial cones and fans, kame terraces, deltas, meltwater channels, glaciofluvial and glaciolacustrine terraces, and till deposits (Plate 1). These deposits are often accompanied with a capping of windblown silts (eolian) (Lord and Valentine, 1979). Moderate to very steeply sloping terrain including terraces and gullies and is underlain by gravelly, coarse loamy till deposits and sandy-skeletal mixed fluvial, glaciofluvial and till material. The steeply sloping terrain also includes outcrops of columnar flood basalts and other volcanic origin rocks.

Sandy-skeletal glaciofluvial material occurs on level to moderately sloping terraces that support grassland ecosystems on valley sides and bottoms. These deposits have an eolian capping that ranges in depth from

20 to approximately 50 cm and has a loamy texture (Plate 3). There has been evidence to suggest that the Fraser River was once blocked, and thus, the occurrence of glaciolaustrine terraces and hummocks can be found along the Fraser River within the Churn Creek study area (Huntely and Broster, 1997). These deposits may or may not have an eolian capping and are silty in texture.

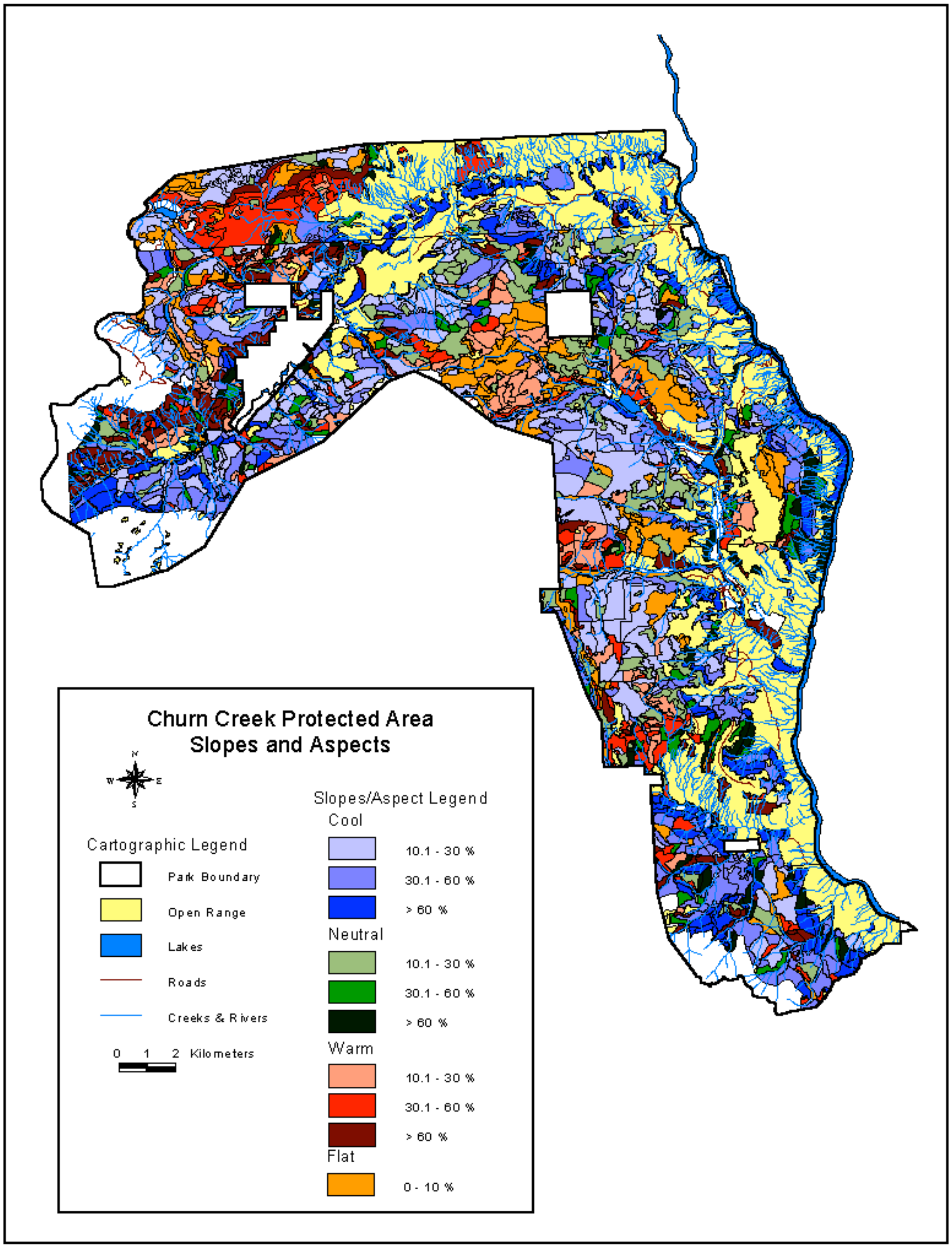


Figure 11. Slope and aspects in Churn Creek.

Note that slope and aspect (Figure 12) has only been interpreted for forested polygons and polygons with ingrowth or encroachment. Additionally, areas within the SBPS and MS have not been mapped.

8.0 FIRE HISTORY AND DISTURBANCE PATTERNS

8.1 Fire History –Regional Perspective

The maintenance and promotion of biodiversity is key to natural areas management (B.C. Ministry of Environment, Lands and Parks 1996). Biodiversity includes three component parts: composition, structure, and function (Perry 1994; Pregitzer *et al*. 2001). The composition component describes the organisms found in the area; the structural elements include the arrangement of organisms within an area; and, function is expressed as processes and mechanisms such as nutrient cycling, decomposition, and energy flows (Perry 1994; Pregitzer *et al.* 2001). Central to the maintenance and promotion of biodiversity in Churn Creek Protected Area (CCPA) is the process of fire, defined by the local fire regime, and the effect that fire regime had, and will have, on ecosystem composition, structure, and function.

Fire regimes change over time as fire frequency and fire severity change due to fire exclusion. The use of the “historic” fire regime, as defined through rigorous data collection and analysis, is thought by many natural resource managers and the public, to best describe the dominant process that maintained naturally functioning ecosystems (Tolle and Williams 2001). The “historic” fire regime, however, is not a single number or static point in time but a range of conditions that provide variability within the occurrence and effect of the process. This concept is referred to as “historic”, or natural range of variability (Morgan *et al*. 1994; Swanson *et al*. 1994; Swetnam *et al.* 1999), and can be used to describe not only the variability in a process such as fire, but also in structures and species.

9.0 FIRE REGIMES

There are several definitions of fire regimes available in the literature. The most recent comes from Brown (2000), and refers to the nature of fire occurring over long periods and the prominent immediate effects of fire that generally characterize an ecosystem. The use of the historic fire regime in ecosystem management planning is tied to the recognition of ecological reference conditions that maintain these systems over long periods of time (Forest Ecosystem Management Assessment Team 1993; Cissel *et al*. 1998; Hemstrom *et al*. 1998; Holt 2000). Fire regimes can be described using the following factors: fire frequency, fire periodicity, fire intensity, size of fire, pattern on the landscape, season of burn, and depth of burn (Kilgore 1987; Martin and Sapsis 1992; Agee 1993). In this analysis, fire regimes is described using the frequency statistics: mean, minimum, and maximum intervals; seasonality; intensity, and extent.

Two separate, spatial fire regimes are defined for CCPA, then further described in their historic context followed by their contemporary context. The first is located in the bunchgrass very dry hot subzone Fraser variant (BGxh3), while the second is found in the interior Douglas-fir very dry mild subzone (IDFxm) (Figure 13 fire regime sampling site map). Other fire regimes are likely evident in CCPA in cooler, more mesic ecosystems and at higher elevations. These areas were not sampled in this project due to a focus on encroachment and in-growth areas at lower elevations. In the future, historic fire regime and biodiversity data for the IDFdk4 can be extrapolated from research in the IDFdk3 carried out by Feller *et al*. (1998) and ongoing research funded by Lignum Ltd. involving the authors of this report.

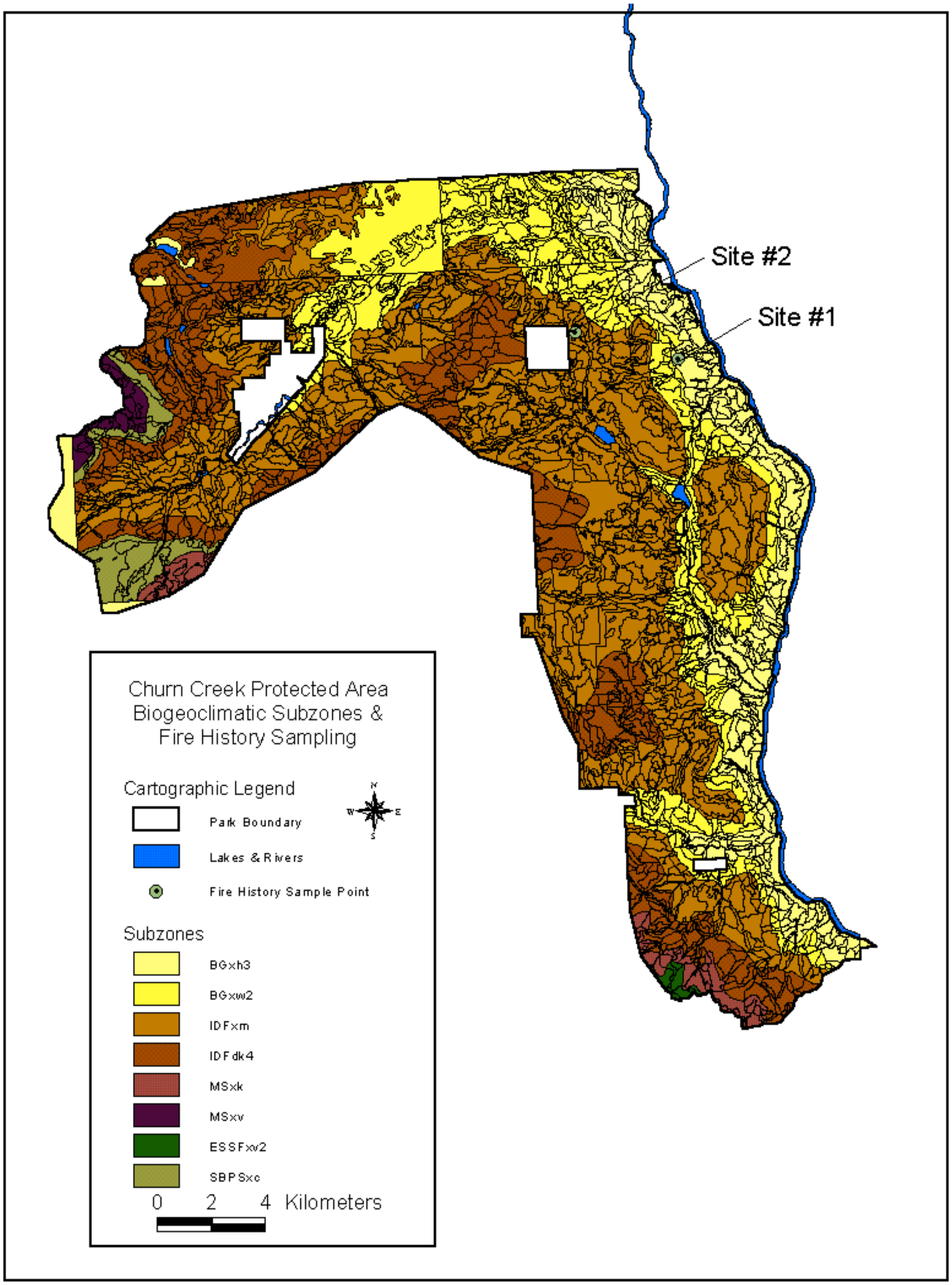


Figure 12. Biogeoclimatic zones and fire sampling locations in Churn Creek.

9.1 Historic Fire Regime in BGxh3

The first stage in determining the historic fire regime for an area is the development of a historic dendrochronological record. Increment cores were collected from 10 Douglas-fir trees in the vicinity of the fire scar sampling area. This data was used to produce a master chronology of ring-widths, which is then used to cross-date fire scar samples that are on dead wood (Stokes and Smiley 1968).

Collecting dendrochronological data entails collecting 2 core samples from each of 10 sample trees. Cores are collected from opposing sides of the tree along the contour in order to minimize the effects of slope (expansion/compression wood) on the ring pattern. Sample areas and trees are chosen from very harsh growing sites, which are likely to express extreme environmental variation in growth rings (Stokes and Smiley 1968).

Each increment on each core is then measured using a Velmex - Quick Chek sliding stage system and the MEDIR measuring program (Grissino-Mayer *et al.* 1996). The measurement files are run in COFECHA (Grissino-Mayer *et al.* 1996) which is a software program that verifies cross-dating among measured tree ring series. The program flags possible cross-dating errors, which are then checked by the researcher. Positive standard deviation units indicate wider than average growth rings while negative standard deviation units indicate narrower than average growth rings. Extreme spikes, either positive or negative, are used as “marker” years (Yamaguchi 1991) to help cross-date fire scars on dead wood samples.

Fire scar samples were collected from seven Douglas-fir trees (4 live, 3 dead) in a 10 hectare area at the upper edge of the BGxh3 subzone in the CCPA. Topography and physiography consisted of a flat to gently sloping terrace above the Fraser River on a southeast aspect. Most Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) trees growing in the area were found in narrow, shallow draws bisecting the terrace. In order to determine area-wide fire regimes, certain assumptions must be made concerning the probability of historic fire spread over the sample area and the resultant scarring of trees. Sampling areas, therefore, focus on locations where all sample trees have an equal probability of being exposed to the same fires. If significant topographic firebreaks or fuel barriers bisect the sample area, probabilities are lower that all sample trees are exposed to the same fires. The terrain features found in the sample area are not considered to constitute significant topographic fuelbreaks.

Fire scar sample collection was carried out according to accepted methods in short-interval fire-maintained ecosystems (Arno and Sneck 1977; Kilgore and Taylor 1979; Brown and Swetnam 1994; Grissino-Mayer 1995; Swetnam and Baisan 1996; Gray and Riccius 1999). Sampling was carried out over a small area and sample trees had to have external evidence of several fires before they were chosen for collection. Small-diameter trees were felled and sectioned to find the most visible scars, while cross-sections were removed from larger-diameter trees. It’s often the case that a higher number of scars become evident once the cross-section has been taken; this is attributed to growth over the wound. In areas where fires have been excluded for a long period of time a large proportion of the wound area and its scars become over-grown. Samples were labeled, stored and air-dried for two months before sanding and analysis.

Prepared samples were analyzed at the Resource and Environmental Management Program lab at Simon Fraser University. Scars from live trees are cross-dated by working from the bark year (2000) to the pith, and using the list of “marker” years. Samples obtained from dead wood (snags, stumps or logs) are measured using the Velmex and MEDIR. The undated ring width series from the sample was run in COFECHA against the master chronology to determine the inside or pith date of the sample. This date was verified by visually cross-dating the sample with the master chronology prior to cross-dating the fire scars on the sample (Gray and Riccius 1999).

Scars that were a definite result of fire were distinguished from scars that may have resulted from other causes such as frost kill, or sun-scalding. This phenomena is more of a problem with Douglas-fir than any other species we’ve encountered in fire history studies. It’s unclear why this occurs in Douglas-fir and what the related physiology is. As a result the fire history for the 2 sites may be somewhat conservative, in that some fires which did not leave very distinctive scars were noted as a minor injury (Wright 1996; Gray and Riccius 1999). Most of the fire scars collected were cross-dated a second time to ensure accuracy in the dates.

The dates for fire scars were entered into a statistical analysis package for fire history known as FHX2 (Grissino-Mayer 1995). This package aids in statistical and graphical analysis of fire history data.

The composite fire history graph (Figure 13 Churn Plot 1 FHX2 Graph) shows the following details for each sample tree: the pith date, death date, and years in which fires occurred. The bottom axis of the graph provides the composite of all fires and samples. A total of 13 intervals were recorded (Table 7) resulting in a mean fire interval (MFI) of 19.1 years, a median of 9 years, and a minimum and maximum interval of 3 and 81 years respectively. Three other injuries, one occurring on a single tree (Tree # 7) in 1809, and one scarring Trees # 4 and 6 in 1870, are recorded on the composite graph but are not included in the frequency statistics. These injuries could be attributed to any number of biotic or abiotic factors including sun scald, frost, or wildlife. Fire-scarred Douglas-fir trees in the interior often exhibit this type of scarring pattern (Gray and Riccius 1999).

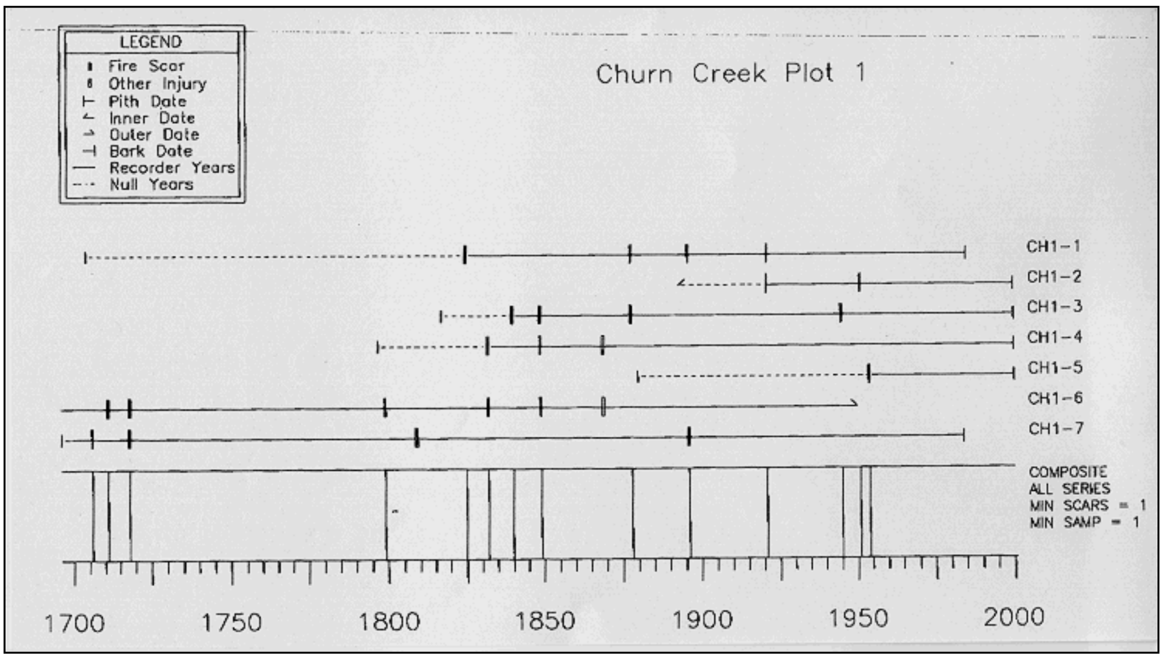


Figure 13. Composite fire history graph for the BGxh3 site.

Table 7. Fire years and frequency statistics for the BGxh3 site.

No. Intervals	MFI	Median	Min.	Max.	Fire years
13	19.1	9	3	81	1706, 1711, 1718, 1799, 1825, 1832, 1840, 1849, 1878, 1896, 1921, 1945, 1951, 1954

Fire occurrence data is limited for bunchgrass ecosystems in British Columbia. Similarly, in the western United States, few published studies exist for grassland ecosystems due to the lack of recording trees (Agee 1994). Studies from pure grassland types indicate a MFI <35 years (Paysen *et al*. 2000). Frequency data has also been extrapolated from forests having grassland understories, such as ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) (Wright and Bailey 1982), reducing the MFI to 2 to 15 years (Paysen *et al*. 2000). In neighboring sagebrush-grass ecosystems, Houston (1973), found a frequency of 32 to 70 years in Yellowstone National Park, Wyoming, while Harniss and Murray (1973), in eastern Idaho, speculate that the frequency there would be closer to 50 years. In western juniper (*Juniperus occidentalis* Hook.)

woodlands, MFI's of 15-20 years in Nevada (Young and Evans 1981), 7-17 years in northern California (Martin and Johnson 1979), and 25 years in southwest Idaho (Burkhardt and Tisdale 1976), kept juniper out of grasslands and limited older juniper to refugia sites such as rocky outcrops (Agee 1994).

The fire scar record, especially in grassland or low fuel loading ecosystems, is very conservative (Houston 1973). The threshold temperature necessary to kill cell tissue, such as cambium tissue in the case of fire scars, is >60° C (Hungerford 1989). Douglas-fir trees growing in harsh environments, such as bunchgrass ecosystems, tend to produce very thick bark at a young age. This bark insulates the cambium from heat damage (Crane 1991). Grass fuels can produce very high heat output but only for a very short period of time due to the size of fuel and the rapid combustion process (Wright and Bailey 1982; Paysen *et al*. 2000). Scarring a tree under this scenario, therefore, is a difficult proposition and one that does not occur with the passage of every fire or even every other fire. There were very few trees within the 10 ha sampling area and a low proportion of these trees was actually scarred.

In examining the composite fire chronology for the BGxh3 area in CCPA the minimum fire interval is likely to be fairly accurate while the mean and maximum intervals are likely skewed to the conservative side. The maximum, at 81 years, is the product more of missing data than any kind of lapse in fire activity. Only three samples extend back to the early 1700's and only two of them recorded any fires (the third tree was over 100 years old before it recorded its first fire).

Seasonality of fires was difficult to determine due to the small size of the wound area and the very narrow growth rings. Two fire dates, 1832 and 1869, however, yielded mid-growing season scars. Without knowing the normal growing pattern of Douglas-fir in the area it's difficult to speculate on the months that would apply.

Another approach to use in assessing seasonality is to look at the phenological patterns of plants in the bunchgrass zone that contribute to the annual fuel load. Bunchgrasses inhabiting the BGxh3 are perennials with an early summer growing season. This is the primary fuel source in this zone. Due to green-up constrictions over several weeks in the early summer, natural fires are limited to occurrence in early spring, mid- to late-summer, and early fall.

Intensity and extent of fires in the sample area is difficult to accurately determine from just fire scar data. In order to make a prediction of how large a historic fire was or what type of intensity it burned under, the fire behaviour elements of fuel, topography, and weather must be brought in to the equation.

Fire size is only limited by the availability of fuel: its horizontal continuity and moisture content. The historic bunchgrass ecosystem in the sample area was grazed by native ungulates; specifically mule deer and California bighorn sheep. The availability of grass fuels was only limited by herd size and use. The numbers of these animals and the potential carrying capacity of the larger landscape means a lower level of grazing intensity than that experienced under pasture livestock management. Fuels were therefore very abundant, both loading and extent.

Fire intensity, while also limited by fuel (loading), is also affected by topography and weather (windspeed). Topography in the sample area is conducive to fire spread with an increasing slope gradient and a southeast aspect. Windspeed along the Fraser River would be constant and moderate (gradient and diurnal valley funneling). The evidence available for reconstructing fire extent and intensity, therefore, is the fire scarred trees, the historic fuel type in the sample area, and the local topography and weather patterns.

Fire scar data indicates many single-tree scars as well as several fires that scarred more than one tree. Considering how hot a fire must be to scar a mature Douglas-fir tree the fire in 1849 may have been of fairly high intensity. Several other fires in the record scarred two trees. Many combinations of fuels, weather, and topography in the sample area could lead to low- to moderate-intensity fires occurring on a frequent basis.

Historic fires in the sample area could be of large extent owing to the lack of natural fuel/firebreaks and conditions of weather, fuels, and topography conducive to large-scale fire spread. The only limiting factors to fire spread were natural barriers, such as the Fraser River and Churn Creek, and fire-stopping precipitation.

A second fire regime can be found in the bunchgrass zone in areas that, for a number of reasons, did not burn as frequently as the sample area. These areas are termed "fire refugia" and are made up of talus slopes, cliffs, and some steep, south-facing aspects overlooking the Fraser River. Fire frequency in these areas is measured in the hundreds of years due to a lack of fuels in which to carry a fire. A number of refugia areas are found throughout the bunchgrass zone in CCPA.

Riparian systems are often assumed to be wildfire refugia (Biodiversity Guidebook 1995). Based on recent high fire severity observations (S. Arno pers. comm. 1999), and research data (Arno 1996; Camp 1997; Arno 2000, Agee 2001), many riparian systems historically experienced fire at the same frequency as the adjacent, dry, upland sites.

9.2 Contemporary Fire Regime in BGxh3

Fire activity is recorded in the fire scar record up to the early 1950's on 3 separate trees. The record of fire exclusion on the site is therefore set at 46 years; from 1954 to 2000. The debate then centers on whether or not the current 46-year exclusion of fire is outside the historic range of variability (HRV) (Morgan *et al*. 1994; Swanson *et al*. 1994; Swetnam *et al.* 1999) considering the 81 year gap that is recorded from the early 1700's to the early 1800's. It is unlikely that there was a cessation of fire activity for the 81-year period from 1718 to 1799. A host of reasons for this gap in fire information are presented above. If the area has not experienced a large temporal gap in fire activity in the past, we need to examine the significance of the current 46-year gap. Assessments of fire severity, biodiversity, and succession may provide some direction.

9.3 Historic Fire Regime in IDFxm

A total of 8 fire scar samples were collected from 5 live and 3 dead Douglas-fir trees. Sampling took place over a 5 ha area in the IDFxm subzone in CCPA. The composite fire history graph (Figure 14 Churn Plot 2 FHX2 Graph) shows the following details for each sample: the pith date, death date, and years in which fires occurred. The bottom axis of the graph provides the composite of all fires and samples.

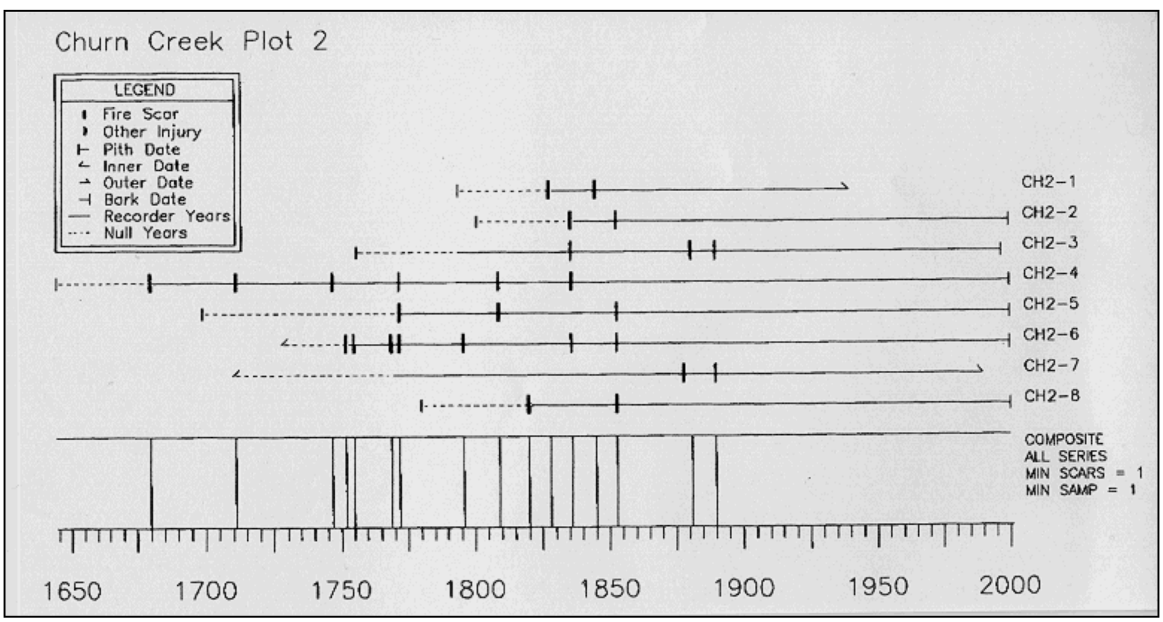


Figure 14. Composite fire history graph for the IDFxm site.

A total of 15 intervals were recorded (Table 8) resulting in an MFI of 14 years, a median of 9 years, and a minimum and maximum interval of 3 and 36 years respectively. Unlike the bunchgrass zone samples, no unknown scars were recorded in the IDFxm zone.

Table 8. Fire years and frequency statistics for the IDFxm site.

No. Intervals	MFI	Median	Min.	Max.	Fire years
15	14	9	3	36	1680, 1711, 1747, 1752, 1755, 1769, 1772, 1796, 1809, 1820, 1828, 1836, 1845, 1853, 1881, 1890

The fire frequency found at CCPA in the IDF is very similar to statistics found in other IDF ecosystems in British Columbia and the western U.S. In B.C., a range of MFI's have been recorded for IDF ecosystems, including: 9 to 22 years in the IDFdk3 subzone across the Cariboo Region (calculated from Feller *et al*. 1998 data); 13 years in the IDFdk1 outside Merritt (Gray and Riccius 1999); 14 and 18 years in IDFdm2 ecosystems in the Rocky Mountain Trench (Gray *et al*. 2001); and, 6.2 to 17 years in the IDFww in the north end of the Squamish Forest District (Gray and Riccius 2000).

In the western U.S., similar ranges in frequency have been found in IDF forest types, including: 7 to 24 years in eastern Washington and northeastern Oregon (Agee 1994); 18.8 years (Wright 1996), 13 years (Everett *et al*. 1992), 6.6 to 7 years (Everett *et al*. 2000), and, 7.5 to 7.7 years (Ohlson 1996), all in the eastern Cascades of Washington.

The relative accuracy of the frequency statistics follows the same issues presented in the BGxh3 section. With a historic landscape composed of scattered Douglas-fir and an understory of bunchgrasses and pinegrass (*Calamagrostis rubescens*), fires would not be very intense, resulting in few scars and a conservative fire scar record. With the maximum interval recorded occurring very early in the composite record, 1711 to 1747, it is highly probable that this interval is attributed to missing data and not a lack of fire activity.

Determining seasonality of fires was just as difficult with the upland samples as it was with the samples from the BGxh3. Most fires were undetermined for seasonality except fire dates: 1747, 1769, 1772, and 1853. These four fires were recorded in the latewood of the active growing portion of the ring. This indicates fires prior to the onset of annual translocation shut down (Gray and Riccius 1999), and could be associated with the month of June or early July, depending on the growing season cycle of Douglas-fir at this elevation in CCPA.

Other fires are associated with the seasonal availability of fuels, which in the case of the IDFxm, is cured grasses. These fires could have occurred during the dormant periods in late spring, late summer, and early fall.

The intensity of historic fires in the IDFxm was the product of available fuels, and weather and topographic conditions under which these fires burned. Fuel loading in this type was likely to be heavier than in the bunchgrass type owing to an increase in site productivity. A higher number of overstory trees with their attendant litter accumulations, coupled with thickets of seedlings and saplings, provided a higher quantity of larger fuels that, once ignited, released higher quantities of heat energy than grass fuels.

Fire weather in the IDFxm is variable, with historic fires likely to have occurred under a wide range of wind, temperature, and relative humidity conditions. Topography is also highly variable with significant, small-scale changes in slope and aspect that can have pronounced effects on fire intensity. Fire intensity in the IDFxm, therefore, was highly variable. This is reflected in the fire scar record by many single-tree scars and many multiple-tree scars; several scarring at least 50% of the samples. Fire intensity, while highly variable, did not result in high levels of overstory mortality. The evidence for this is in the density of older trees (>200 years) available to sample for fire history (see Figure 13 – fire history graph).

The extent of historic fires in the IDFxm, like the BGxh3, was limited only by available surface fuels and fire-stopping weather events. A great deal of professional debate centers on the size of historic fires in the interior Douglas-fir plant associations. At the root of the problem is the difficulty in establishing historic fire boundaries. These difficulties range from the cost of sampling large areas to concerns over attributing far-flung fire dates to the same fire. In ponderosa pine/bunchgrass plant associations in the U.S. southwest, historic fires were likely capable of burning for long periods of time and eventually covering several thousand hectares (Swetnam and Dieterich 1983; Baisan and Swetnam 1990). In the eastern Cascades of Washington, Everett *et al*. (2000), working in ponderosa pine/Douglas-fir plant associations, found 50% (1652 ha) of the Nile Creek watershed, and 60% (9312 ha) of the Mud Creek watershed burned within a 6-7 year period. From the 1700s to the 1900s there were only three decades where fires greater than 810 ha in size did not occur in the Nile Creek watershed (Everett *et al*. 2000).

9.4 Contemporary Fire Regime in IDFxm

The contemporary fire regime in the IDFxm in CCPA is marked by the lack of fire activity since 1890 (see Figure 14 - fire history graph). This is not to say that small fires that did not scar any trees in the sample area did not occur. These types of fires could have occurred early in the century and left no evidence of their occurrence. The lack of fire has shifted the regime from one characterized by low-intensity, frequent, stand-maintaining fires to a less frequent, and potentially higher intensity fire regime that results in large-scale stand mortality.

The seasonality of the contemporary fire regime is affected by ignition sources and fuel moisture condition. Historic ignition sources included First Nations people as well as lightning. Lightning ignitions were relegated to favorable lightning-producing weather and fuel conditions, while First Nations people were known to burn during different seasons to favour specific plants (Barrett and Arno 1982; Turner 1999). Lightning is still a source of ignitions today while human-caused fires have been narrowed to summer and fall. The "window" in which fuels are available to burn has been narrowed due to increased stand density, increased crown closure, and a shift in understory composition from bunchgrasses to pinegrass and moss.

The potential fire intensity associated with the contemporary fire regime is characterized as high to extreme. The historic fire regime resulted in minor levels of ecosystem reorganization with patch changes measured in the tenths to tens of hectares (Cooper 1960; White 1985; Everett *et al*. 2000). As a result of a century of fire exclusion, the potential for large-scale, catastrophic fire has increased dramatically. This condition is prevalent throughout vast areas of western North America in dry Douglas-fir/ponderosa pine forests (Society of American Foresters 1997; United States Congress 1997; Natural Resources Canada 1999). The ability of organisms adapted to frequent, low-intensity fire to survive and recover quickly to pre-burn levels is significantly affected.

Differences in the extent of fires between the historic landscape and the contemporary landscape centers on changes in fuelbed characteristics and man-made fuel barriers. Stand structure conditions have altered surface fuels from bunchgrasses, with a wide burning "window", to pinegrass and moss, with a much narrower burning "window." Fires burning on hot, dry aspects historically could have spread through open, northerly aspects because of contiguous grass fuels. The same fire today would encounter moss on northerly aspects, where it would be extinguished.

While the characteristics of surface fuels have become more heterogeneous over the landscape, aerial fuels, consisting of overstory and understory tree crowns, have become more homogeneous. This condition is a reversal from historic conditions. Contemporary stands are now at high to extreme risk of wide-spread crown fire, whereas historic stands rarely supported small-scale crown fire.

Historic fires were impeded by natural fuelbreaks such as talus slopes, wide riparian systems, and exposed rock. On the contemporary landscape a great many man-made fuel/firebreaks exist, including dirt roads, well-grazed pastures, and livestock trails.

9.5 Recent Fire History For Churn Creek (Post Fire Exclusion Period)

The Ministry of Forests fire reporting system was used to compile a database of fires back to 1950 (see Figure 15 – Churn Creek fire history). Numbers of fires have ranged from 0 to 4 per year. The average number of fires per year by decade are as follows: 1950-59 – 0.2; 1960-69 – 0.2; 1970-79 – 0.7; 1980-89 – 0.7; 1990-99 –0.6. The most significant fire year in recent history was 1975 when a total of 4 fires were reported for the Park. Given the dry biogeoclimatic zones and human activities that have occurred in the Park, the number of fires is considered low. Given the encroachment and ingrowth that has occurred over the past 100 years many of the forested sites within the park are at risk of fires of high severity that could negatively effect Park resources.

Table 10 summarizes fires that have occurred between 1950 and 1994 in the Park by size class and cause (lightning and human caused). The total number of fires during this period was 24, of which 46% were the result of human causes and 41% lightning caused while the remaining causes were undetermined. Eighty three percent of all fires that burned between 1950-1994 were smaller than 4 ha, while only no fires were greater than 40 ha. The largest fire within the Park since 1950 occurred in 1959, and was 24.2 ha in size.

Table 9 summarizes fire cause by decade and provides some interesting insight into the nature of fire within the Park. Through the 1950s all of the fires within the Park were classified as industrial (100%). From the beginning of the sixties to present human caused fires have decreased substantially. Through the 1970's and 80's human related ignitions (6 fires) accounted for 43% of the fires compared with (7 fires) 36% for lightning. Approximately 21% of the fires reported in the 70's and 80's were classified as cause undetermined. In the nineties human caused ignitions decreased to 33% while lightning fires have accounted for 67% of all fires. The total number of fires by decade has varied for the 50 years recorded averaging 2 in the 1950's and 60's and increasing to between 6 and 7 in the 70's, 80's, and 90's.

Table 9. Fire history summary for Churn Creek Protected Area from 1950 - 1994.

Decade	Lightning	Recreation	Industrial	Undetermined	Total
1950-59	0	0	2(100)	0	2
1960-69	0	1(50)	1(50)	0	2
1970-79	3(43)	3(43)	0	1(14)	7
1980-89	3(43)	2(29)	0	2(29)	7
1990-99	4(67)	1(17)	1(17)	0	6
Total All Years	10(41)	7(29)	4(17)	3(13)	24

Note: Numbers in parenthesis ( ) indicate percentage of total fires for a given decade.

Table 10. Summary of fire cause in Churn Creek Provincial Park.

Size Class (ha)	Total Number of Fires	Percent of Total	Lightning Caused	Human Caused
0.1-3.9	20	83%	10	9
> 3.9	4	17%	0	2
Total	24	100%	10	11

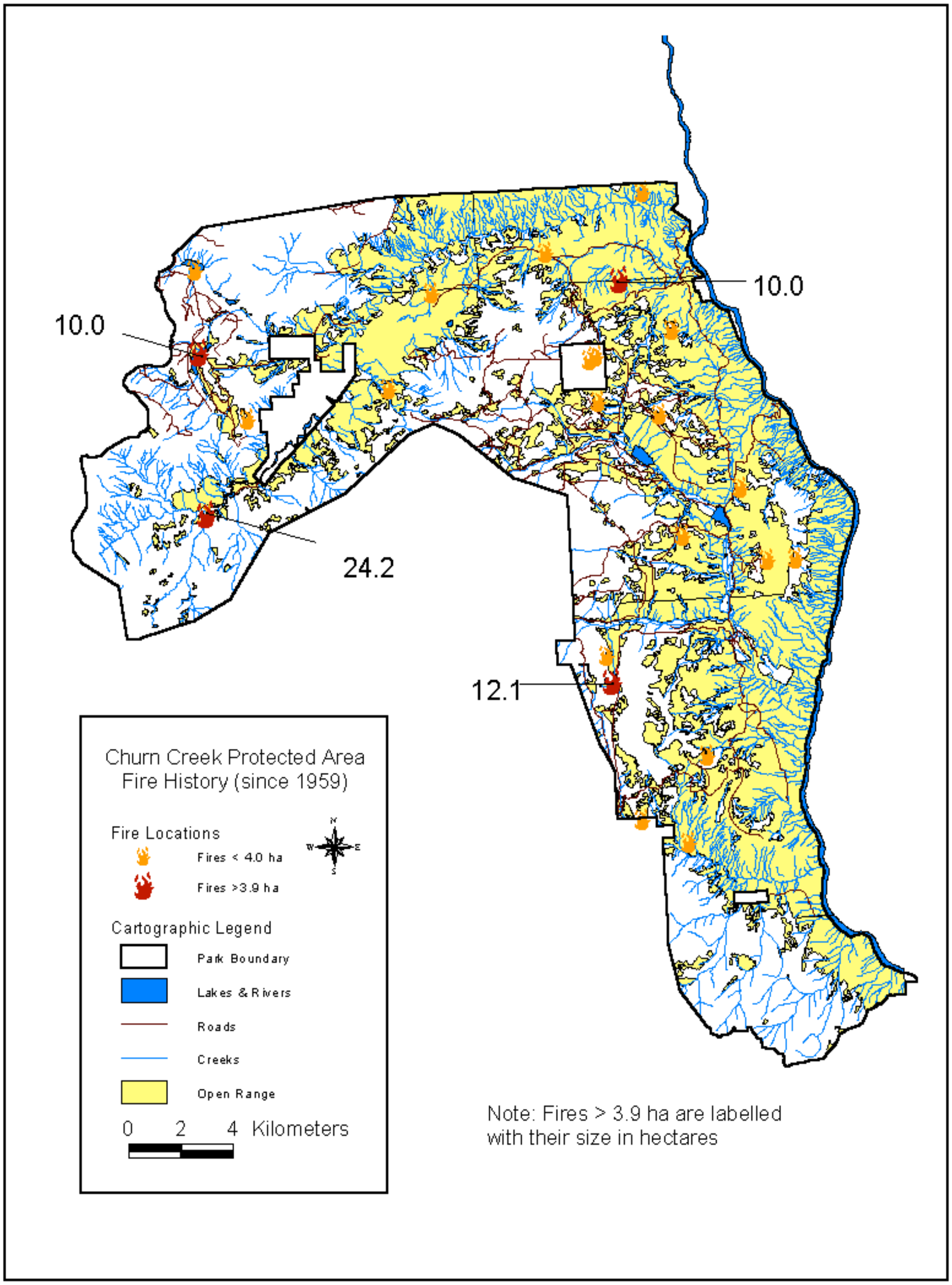


Figure 15. Churn Creek fire history.

10.0 FOREST SUCCESSION IN THE ABSENCE OF FIRE

Succession theory deals with the science of predicting how plant and animal community composition changes as a result of natural disturbances over various lengths of time (Waring and Schlesinger 1985; Kaufmann *et al*. 1994). Classical succession theory, is defined as the replacement of the biological community over a period of time, involving associated plants as well as animals, and is determined mainly by the climate (Chandler *et al*. 1983; Zwolinski 1994). Classical succession theorizes that there is an orderly process of community change that is directional and predictable. One community in succession modifies the physical environment, creating conditions suitable for the establishment of another set of organisms in the next community along the path of succession. This step-wise progression of succession has been referred to as "relay floristics," or "linear" succession. The end of community succession is the biologically stable monoclimax community (Chandler *et al*. 1983; Agee 1993; Zwolinski 1994; Oliver and Larsen 1996).

The greatest concern with classical succession theory, and with a host of refinement theories and models that followed Clement's theory, is that little or no attention has been given to the impacts of natural and human-caused disturbances, and that not all successional sequences proceed stepwise through to a climax community (Heinselman 1978; Zwolinski 1994). The term climax community loses meaning when a natural and frequent disturbance factor such as fire is considered because all the species from the community that persist are climax species (Heinselman 1978; Zwolinski 1994). In other words, following fire there is not a wholesale replacement of species from the pre-fire community with an entirely new community. In most post-fire situations, elements of the pre-fire community survive the fire. In situations where fire is a rare event, to which organisms in the community are not adapted, fire can result in the destruction of these organisms requiring the immigration of new organisms from elsewhere for restocking (Zwolinski 1994). In situations where fire is a frequent event, to which most species in the community are adapted, a fire seldom results in the loss of a species from the community. The fact that these resident, fire-adapted species re-occupy the disturbed area shortly after the disturbance has led to the succession theory of "initial floristics," or "cyclic" succession (Oliver and Larsen 1996).

Even in fire-adapted communities, however, adaptation is specific to the particular fire regime. A change in this fire regime can result in the elimination of a species from the community or the invasion of new species. Some species could become locally extinct if fires occur more frequently than they're adapted to; and conversely, other species could become extinct if they are adapted to frequent fires but the period between fires becomes too long (Zwolinski 1994).

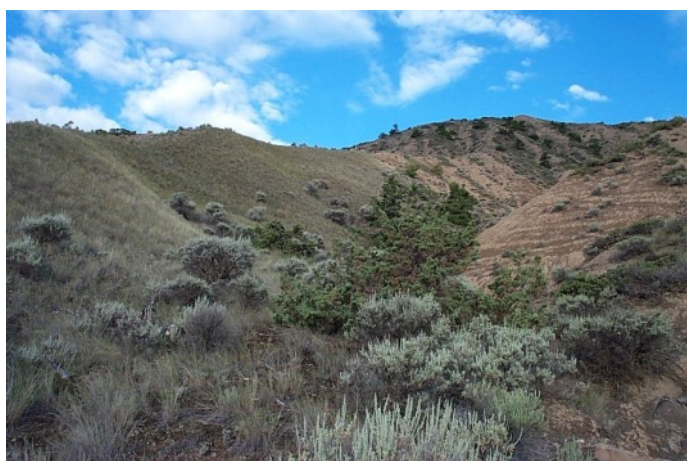


Figure 16. Grassland ecosystem containing areas of consistent fuels (left) that historically experienced frequent fire, and fire "refugia" areas (right), where fires occurred less frequently. These fire "refugia" areas are often inhabited by species with little physiological adaptation to frequent fire.

10.1 Historic Bunchgrass Succession

Historic ecosystem succession in the bunchgrass zone would be defined as "cyclic" in nature. Natural disturbance processes such as fire occur frequently and result in little re-organization of component species and structures (Brown 2000). Most organisms inhabiting the bunchgrass zone have developed adaptations to fire through the process of evolution. Examples of adaptations include underground culms in balsamroot (*Balsamorhiza sagittata*), and bulbs in nodding onion and Mariposa lily (*Allium cernuum*, *Calochortus macrocarpus*), rhframeizomes in saskatoon (*Amelanchier alnifolia*), and tussocks in bluebunch wheatgrass (*Elymus spicatum*). Individuals that are not adapted to the frequent fire regime inhabit areas where this process occurs less frequently, such as fire refugia (Figure 16 grassland photo), and typically regenerate through seed (*Juniperus scopulorum, J. horizontalis, and J.communis*) or vegetative dispersal from refugia as occurs in prickly pear cactus (*Opuntia fragilis*) (Figure 17 Cactus photo). Following disturbance in a "cyclic" pathway ecosystem species respond by re-growing; there is not a turn-over of plant and animal communities. Structures, such as snags and mature trees, are affected as individuals but are not affected as populations (Brown 2000).

Figure 17. Prickly pear cactus, a non-fire adapted species, has invaded the grasslands from refugia sites.

10.2 Contemporary Bunchgrass Succession

The fairly simplistic successional pathways of the historic bunchgrass ecosystem are significantly more complex in the current time period. In the absence of fire, several native plants, including Rocky Mountain juniper, common juniper, and prickly pear cactus, that are not adapted to fire, have proliferated. Douglas-fir, which has been present throughout the BG zone for centuries as scattered individuals or small clumps, has now expanded its range in the form of closed, even-aged waves of seedling-, sapling-, and pole-sized stands. The current distributions of Douglas-fir encroachment and ingrowth are illustrated in Figures 21 and 22 respectively. In addition, the ability of the native plant community to sustain itself following a fire disturbance is exacerbated by introduced species such as cheatgrass (*Bromus tectorum*) (Figure 18 cheatgrass photo). With continued fire exclusion and grazing the refugia species and Douglas-fir will continue to encroach onto the bunchgrass ecosystem. Cheatgrass can continue to expand its range with any soil disturbance, fire or grazing.

Figure 18. Cheatgrass has invaded millions of hectares of grasslands in western North America since its introduction in the late-1800s. This aggressive annual grass can alter a natural fire regime to the detriment of native grasses.

Cheatgrass is a highly significant problem that plays a substantial role in all potential future successional pathways. This species is very adaptable and easily invades disturbed sites (Bradley 1986). Since its arrival in the new world in the late 1800's, cheatgrass has occupied millions of hectares of perennial grasslands, sage-shrublands, and open coniferous forests in the western U.S., Canada, and Mexico (Billings 1994). Cheatgrass can effectively outcompete native grasses and shrubs when the cover of these species is reduced by fire or grazing. The rapid, early growth of this species and its ability to utilize most of the available upper soil moisture enables it to exclude seedlings of other species (Bradley 1986).

Cheatgrass reaches annual maturity early in the year, typically by May to June, then rapidly dries out. The production of large amounts of light, flammable litter early in the growing season places native perennials at a distinct disadvantage when fires occur. The frequency of fire in areas now occupied by cheatgrass has increased substantially. Cheatgrass, therefore, alters the frequency, intensity, extent, and seasonality of fires, resulting in a new fire regime that many native plants are not adapted to (Bradley 1986; Billings 1994; Monsen 1994; Peters and Bunting 1994).

Fire exclusion has also been beneficial to the spread of big sagebrush in the BGxh3. Fire frequency in big sagebrush communities in the Great Basin of eastern Oregon, southern Idaho, and northern Nevada and Utah, is estimated to fluctuate around a 40-year mean. Most sagebrush species produce large quantities of light seed; allowing them to re-invade a site following fire from remnant plants and plants adjacent to the burn. If fires are frequent, prior to the plant's sexual maturity, the species can be eradicated from a site for a fairly long time (Wright and Bailey 1982). On the historic landscape, sagebrush could be found in refugia areas where a diversity of ages and vertical structures were likely available.

Following prolonged fire exclusion periods, sagebrush sites can become less flammable. High density sagebrush plants can successfully rob surface soil moisture to the point where grass cover, and subsequently, surface fuels, are diminished. The restoration of these sites once surface fuels are unavailable to carry a fire, is dependent on promulgating a crown fire through the crowns of sagebrush (Wright and Bailey 1982).

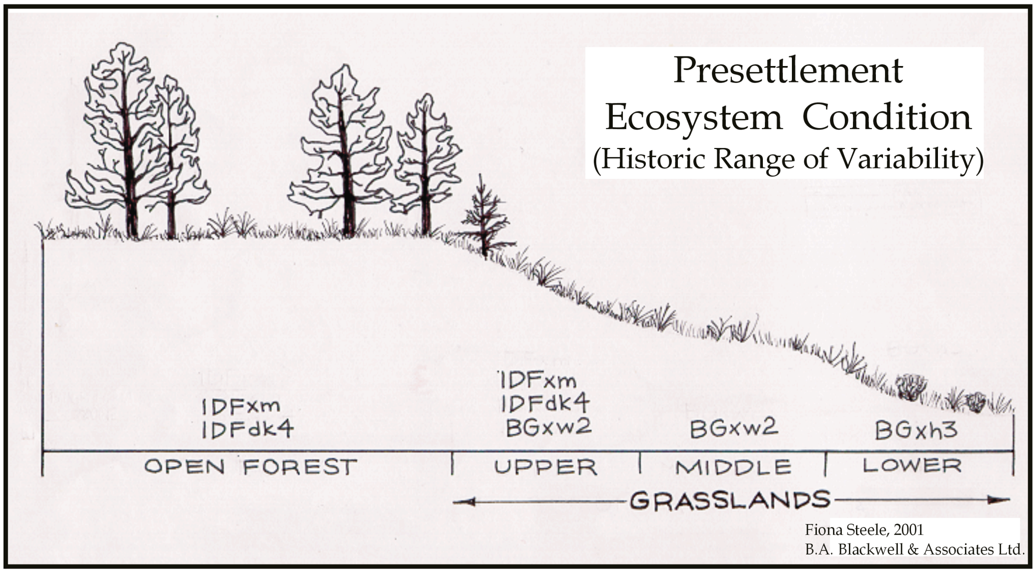
10.3 Historic IDF Succession

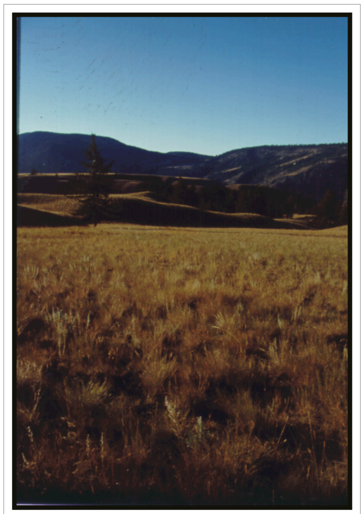
Interior Douglas-fir ecosystems followed a similar "cyclic" succession pathway to that described for the historic bunchgrass ecosystems. Figure 19 illustrates a schematic drawing of presettlement ecosystem conditions. These open, multi-aged Douglas-fir forest communities were perpetuated by the recurrence of frequent, low-intensity fire events (Wenatchee National Forest 1997). At the stand level, disturbance-related patch sizes tended to be small (<1 ha), and associated with the death of single trees or small clumps of t7rees (Agee 1994; 1998). Regeneration of a new age cohort took place in these openings as Douglas-fir in this ecosystem is marginally shade-tolerant. Successive fires thinned the regenerating layer while possibly creating new, small gaps in the forest canopy. Occupancy by multiple ages of trees was always maintained on the site and following disturbance (fire) the pre-fire plant community quickly recovered to pre-fire levels.

Figure 19. Area of dense ingrowth in the IDFxm. Large, old Douglas-fir (center of photo) are historic structures while the high-density, small-diameter Douglas-fir are the product of close to a century of fire exclusion.

10.4 Contemporary IDF succession

A wide range of successional pathways are possible within the contemporary IDFxm, depending on temporal scales and types of disturbance. The current trajectory for these ecosystems leaves them highly susceptible to insect attack and catastrophic fire. Figure 20 illustrates a schematic drawing of fire exclusion conditions. The budworm is currently epidemic while the bark beetle, likely still endemic, has the potential to reach epidemic levels as well. Crown fire hazard conditions are high to extreme with no possible reduction in this rating without some form of human intervention (Figure 19 ingrowth photo). When the fire occurs, succession is more likely to resemble the classical "linear" model as opposed to the "cyclic" model of the historic regime. If, however, exotic species such as cheatgrass invade, succession can get caught in a "closed loop" of fire = cheatgrass = fire = cheatgrass, etc. This "new" ecosystem is a complete type conversion.





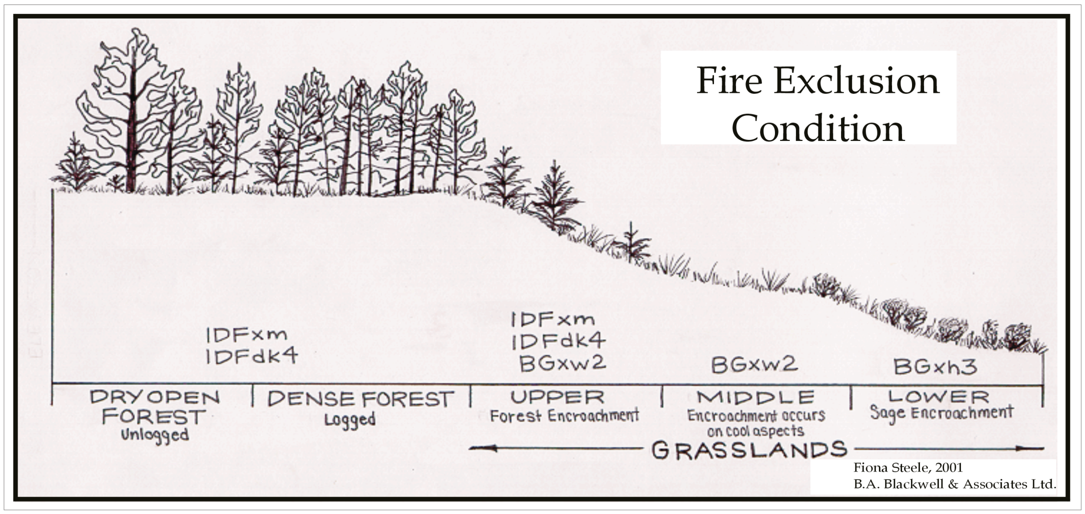
Middle Grassland

Lower Grassland
(Center of photo)

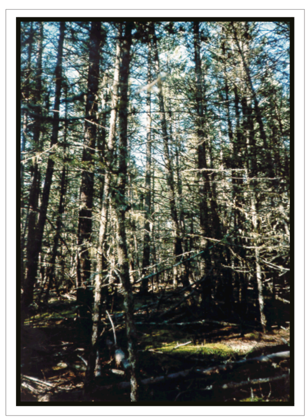
Figure 20. Illustration of presettlement ecosystem conditions

Middle grassland

Lower grassland



Dry open forest



Dense Forest
(logged)

Upper grassland
(Forest encroachment)

Figure 21. Illustration of fire exclusion conditions.

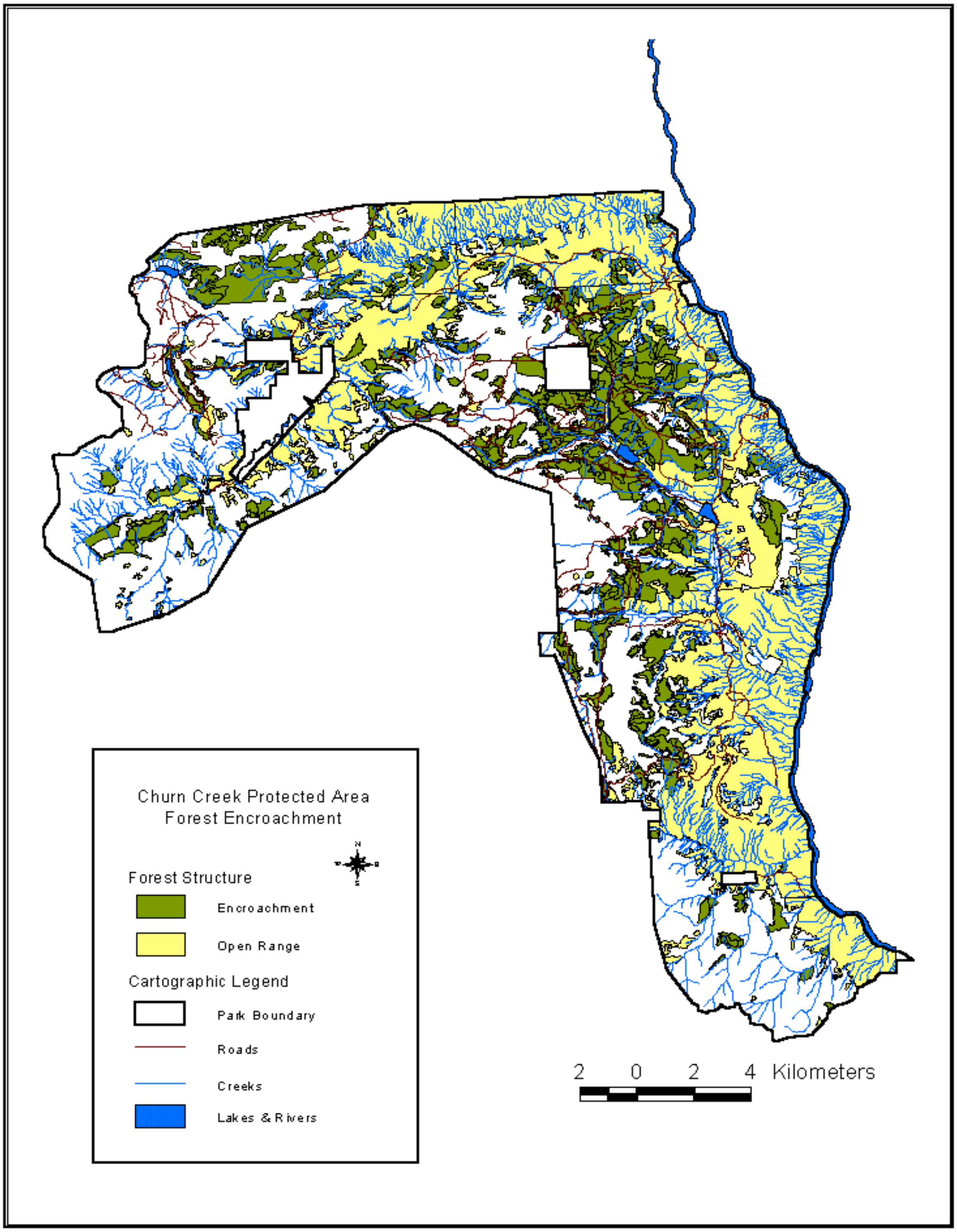


Figure 22. Encroachment in Churn Creek.

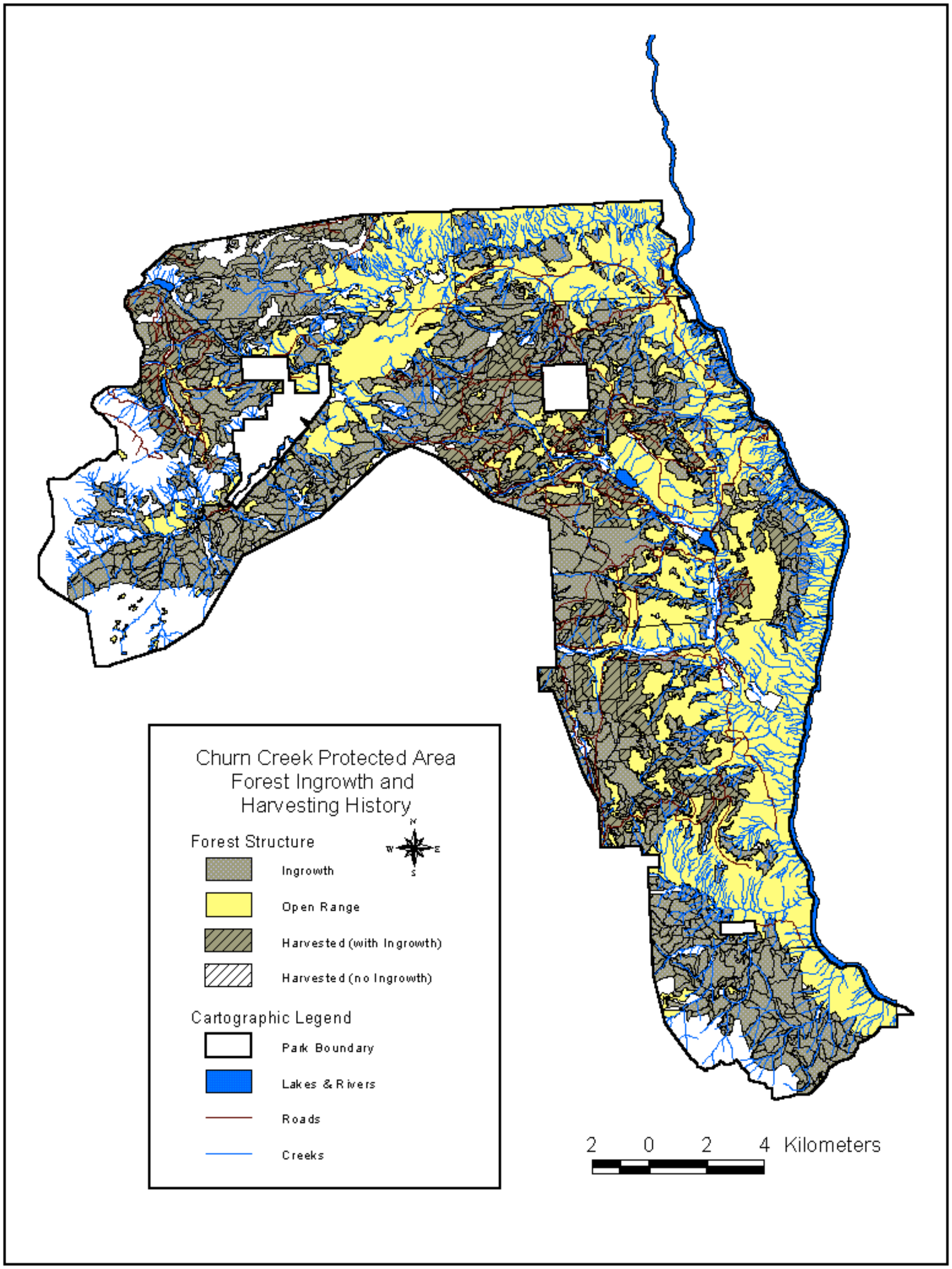


Figure 23. Ingrowth and harvesting history in Churn Creek.

11.0 FIRE SEVERITY AND BIODIVERSITY

The core building blocks for terrestrial ecosystems are soils and the processes that occur in the soil. Maintenance of plant life on a site is depended on the physical, chemical, and biological processes in the soil. The long-term sustainability, therefore, is tied to root dynamics, and physiology, biogeochemical cycling, microbial, hydrologic, and thermal processes that regulate nutrient storage and flux and the soil's ability to hold water and nutrients. These critical below ground processes, functions, and organisms are necessary to maintain aboveground biodiversity (Neary *et al*. 2000).

The effect of the historic fire regime, and the predicted effect of the contemporary fire regime, on biodiversity centers on fire severity. Fire severity is a measure of the effects of fire on soil and site resources, including: mineral resources (Mroz *et al.* 1980; Jurgenson *et al*. 1981; Little *et al*. 1982; Little and Klock 1985; Baird *et al.* 1999), soil porosity and soil moisture holding capacity (Hungerford *et al*. 1991), microbial populations (Harvey *et al*. 1979; Frandsen 1989; Hungerford 1989; Fritze *et al*. 1992), fungal populations (Harvey *et al*. 1981), and underground plant life (Harvey *et al*. 1989). Fire severity is a function of fire intensity, which is an integration of fuel and climatic conditions that precede ignition, and duration, or the amount of residence time of the fire (Little *et al*. 1982; Little and Klock 1985; Neary *et al*. 2000). In fire effects modeling fire severity is expressed as the reaction intensity and carries measures of heat energy release per area per time (Rothermel 1983). The level of severity exerts a strong influence on plant survivorship, regeneration, soil fertility, wildlife habitat, and hydrologic processes (Harvey *et al*. 1989; Ryan 2000).

> "Fire exerts selective pressure both at the individual plant and community level. Short fire cycles favour species that endure fire by juvenile sprouting or evade fire by storing seed in the soil; invading from offsite, and having short life cycles. Intermediate fire cycles favour species that resist fires when mature or evade fire by storing seed in canopy, but sprouting and invasion by offsite colonizers also occur. Long fire cycles favour species that typically avoid fire. Such species exhibit low resistance to fire injury and regenerate predominantly by seed. If the fire return interval is reduced to a period less than the time to sexual maturity, then a species will no longer be able to complete its life cycle on the site and could be lost from the site. The ensuing rate of reseeding will depend largely on the size of the area burned and the mobility of seed." (Ryan 2000)

This definition assumes natural, historic fire regimes and ecosystem responses. The effect of fire exclusion (defined as the contemporary fire regime) on biodiversity, can be predicted by combining potential fire severity with individual plant adaptations to fire, structure adaptations to combustion, and ecosystem process responses.

11.1 Fire Severity and Biodiversity in the BGxh3

Historic fire severity in the BGxh3 subzone would have been low due to a lack of accumulated fuels and the rapid burn-out of existing fuels. With a conservative mean fire interval of 19 years, grass and shrub fuel accumulations would be low. Under the few, well-spaced Douglas-fir in this zone, the loading of needles and small-diameter branchwood could be moderate over a twenty-year period; however, it still wouldn't be sufficient to cause significant site productivity damage when burned.

As fire severity was historically low, the effect on site biodiversity would be equally low. Important ecological processes such as nutrient cycling, and nitrification would not be significantly impacted by frequent, low-severity fires. Plant and animal community composition would likewise be minimally impacted with most plant species exhibiting a high degree of adaptation to fire (Appendix B). Wildlife species adapted to the frequent occurrence of fire would favour this zone while less adapted species would be in a constant state of habitat flux and under stress. Numbers of structural components such as live trees, snags, and logs, and vertically diverse shrub, herb, and grass assemblages, would be maintained in a somewhat static state temporally, but in a dynamic state spatially. Animal species dependent on these structures for some or all of their life needs would be able to find them in the local area.

Figure 24. Successive waves of Douglas-fir encroachment on grasslands.

Contemporary fuel loading in the bunchgrass zone is highly variable owing to livestock grazing and Douglas-fir encroachment patterns (Figure 24 Fir encroachment). In some areas grass fuels are significantly augmented by shrub (sagebrush (*Artemisia tridentata*)), and tree (Douglas-fir, and Rocky Mountain juniper) fuels. The incorporation of larger fuel size classes, shrub stems, tree boles and branchwood, and large duff accumulations, provides for longer fire duration and an increased likelihood of site productivity impacts. The tree and shrub fuels are also an increase in fuel loading in the vertical plane (crown bulk density). Fires burning in the crowns of these fuels will have higher fireline intensity (flame length) leading to increased mortality in overstory structures. The spatial continuity of these fuels over large areas could lead to large-scale impacts on overstory structures such as large-diameter trees and snags and the wildlife species depended on them.

11.2 Fire Severity and Biodiversity in the IDF

Fire severity affects the productivity of the site by delivering high levels of heat energy, for long periods of time, to the upper layers of the soil matrix. Specific effects are listed previously in this report. Fire severity also impacts site biodiversity by altering structures, species, and processes that are adapted to the site and leaving the site open to a conversion in biodiversity elements.

The conditions that can result in high fire severity are currently present in the IDF in the CCPA, and will be present in larger volume in the future under certain management scenarios. These conditions are surface and ground fuel loading and stand density. Surface fuels, consisting of logs, branches, and needles, and ground fuels, consisting of duff, are well outside the HRV for these structures in this ecosystem. The potential energy release from these fuel accumulations in a fire is well above threshold levels for ecosystem structures (snags, large old trees) and constituents (plant and animal species) to survive. Biotic disturbances, such as the recent western spruce budworm *(Choristoneura occidentalis* Freeman), and impending Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins) epidemics, will add to the surface fuel loading problem. Resource management in the Protected Area, if it centers on fire exclusion or prescribed fire with no prior density reduction, will only exacerbate the problem. In the initial fire some accumulated fuels will be combusted, while others will remain and be highly augmented by all the dead trees that fall within 10 years of being killed. A fire at this point, with an extremely high surface fuel loading, has the potential to sterilize the soil.

12.0 FIRE ENVIRONMENT

12.1 Climate

Fire weather data was obtained from the Gaspard climate station (1723) located in the vicinity of the Park. The weather record for the station is short, <10 years. The daily historical record of 13:00 temperature, precipitation, relative humidity, wind speed and all Canadian Fire Weather Codes and Indices were obtained. The digital file for each station was imported into an Excel spreadsheet where variables could be summarized by month and year. The total number of days in which recorded fire weather conditions would promote ignition and spread of fires in the spruce/abies fuel type were compiled by month (June, July, August and September). The fire weather conditions for this analysis were defined as:

1. Fine fuel moisture code (FFMC) $\geq$ 88
2. Duff moisture code (DMC) $\geq$ 40
3. Drought code (DC)_ 250-500 and >500
4. Initial Spread index (ISI) = 8

Summary graphs were also produced for the number of days, by year that the DC was < 500 or > 500 (Figure 27), for the average August maximum (Figure 25) and mean DC by year (Figure 26).

Some general observations from the summary include:

- Few periods where the mean and maximum drought code exceed 500
- Burning windows are generally short with few good opportunities between May and October
- Not every year provides a burning window within the prescription criteria outlined above

Figure 25. Mean and maximum August drought codes for Gaspard station 1723.

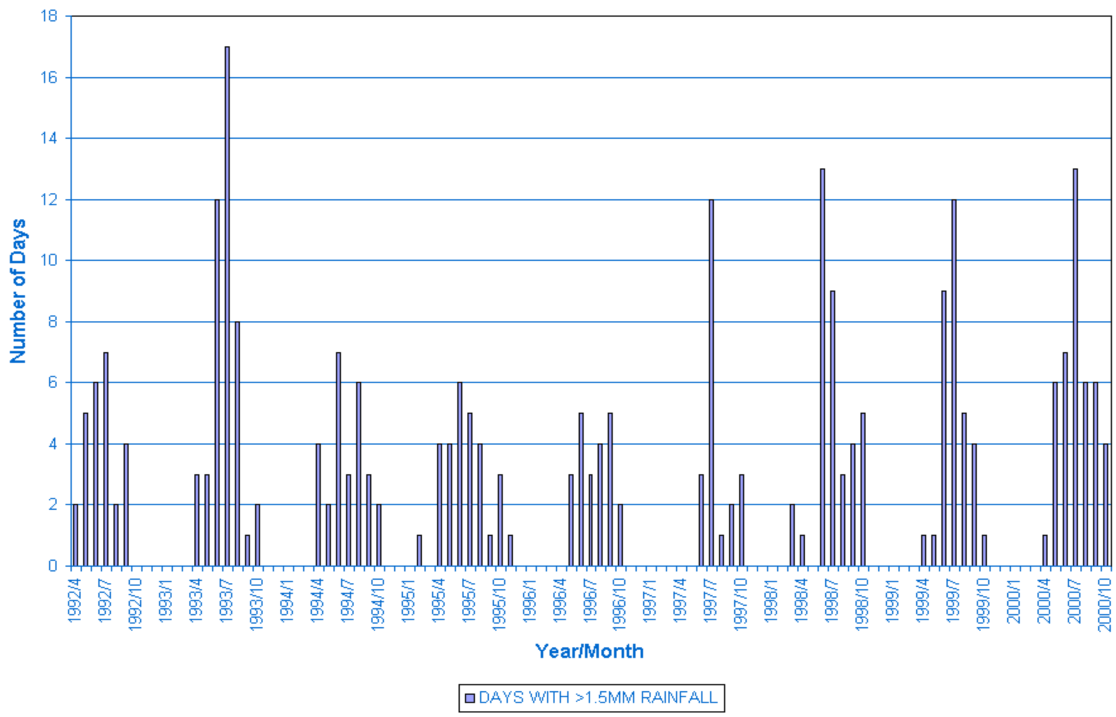


Figure 26. Number of days/month with rainfall >1.5mm for Gaspard station 1723.

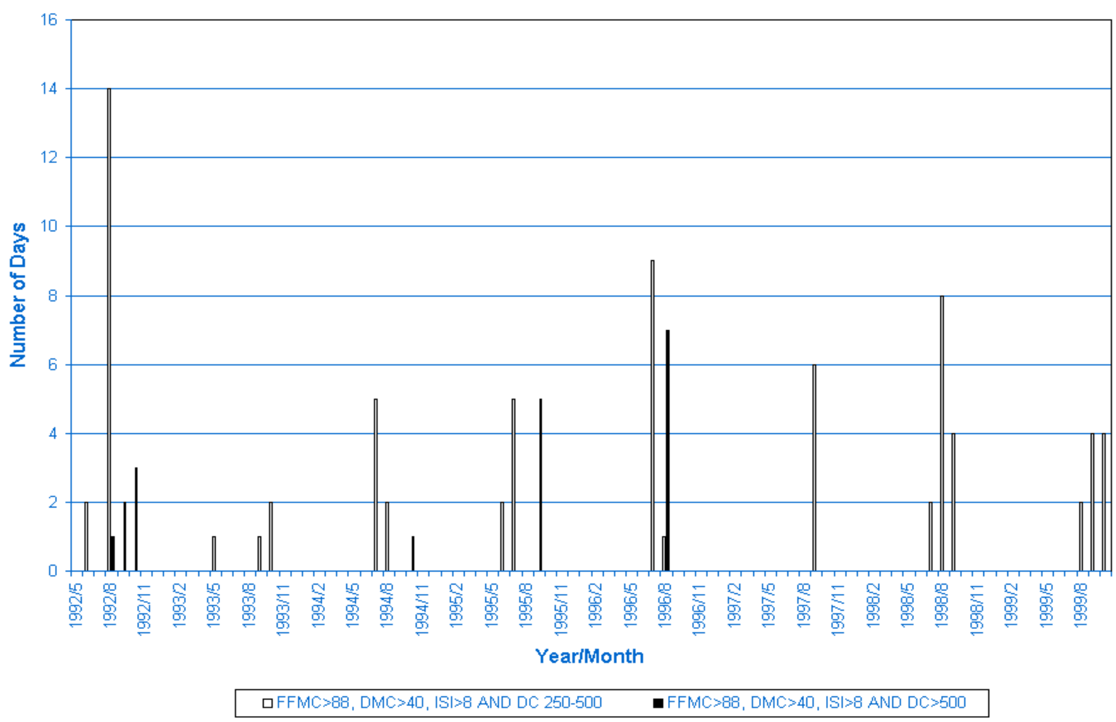


Figure 27. Days/month with high risk of significant ignition and rate of spread for Gaspard station 1723.

13.0 FUELS

Fuel classification was based on the Canadian Forest Fire Danger Rating System (CFFDRS) and a summary of fuel type attributes. Typically the CFFDRS fuel types at best only adequately describe the variation in fuels present in the Protected Area. For each type identified we have attempted to best approximate the CFFDRS classification and have substantiated this classification with a summary of detailed attributes. This typing is not meant to be definitive in that it represents all the variation in fuels types in the PA but more importantly it provides a reference point on which to make recommendations. Figure 29 shows fuel types in Churn Creek.

13.1 Description of each fuel type/treatment type in Churn Creek

13.1.1 Ingrowth and Encroachment Type 1 – South aspect a) encroachment and b) ingrowth

Fuels within this type are classified as CFFDRS fuel type C3 varying to open grass. Stands are dominated by *Psuedotsuga menziesii* (Douglas-fir). Average stand age is approximately 89 years old. Stand density in this type is highly variable ranging from 0 to 3400 stems/ha. Average tree heights range from 10 to 15 m with crown closure ranging from 0-45%; averages 20-25%. The average height of live crown is 0m with crowns occupying the entire bole length. Surface fuel loading is less than 1 kg/m^2 and the duff depth ranges from 1 to 3 cm. Within the stand grass fuels are low while in treeless opening grass fuel is sufficient to burn. Burning difficulty is considered moderate. Pre-burn site preparation will require pruning to create surface fuels sufficient to carry a crown fire. Figure 28 shows Type 1 fuels.

- Stand density: 0 – 20 – 3400 stems/ha (highly variable; sample site was an encroachment site)
- Woody fuels - <1kg/ m^2
- Height to live crown – 0m
- Crown closure – ranges from 0-45%; averages 20-25%
- Vegetation: dominated by bluebunch wheatgrass (*Elymus spicatus*) (about 25% cover)
- sample site – 25% slope, 165º
- Within stand grass fuel is low; opening grass cover is sufficient to burn
- burn difficulty = moderate; burning will require some pruning to create surface fuel to initiate crown fire

Figure 28. Ingrowth and Encroachment Type 1 fuels.

12.1.2 Ingrowth and Encroachment Type 2 – North aspect a) encroachment and b) ingrowth

a) as per Type 1 but crown closure is highly variable 0-80% with dense vegetation bluebunch wheatgrass (*Elymus spicatus*) on open sites to moss on closed sites. Grass fuel loading is high on open sites but low on closed sites.

b) Fuels within this type are classified as CFFDRS fuel type C3-4. Stands are dominated by *Psuedotsuga menziesii* (Douglas-fir). Average stand age is approximately 98 years old. Stand density in this type is ranges from 1400 to 1500 stems/ha. Average tree heights range from 10 to 15 m with crown closure averaging 50%. The average height of live crown is 3m. Surface fuel loading is less than 1 kg/m^2 and the duff depth ranges from 1 to 3 cm. Vegetation is dominated by patches of moss (approximately 50% cover)

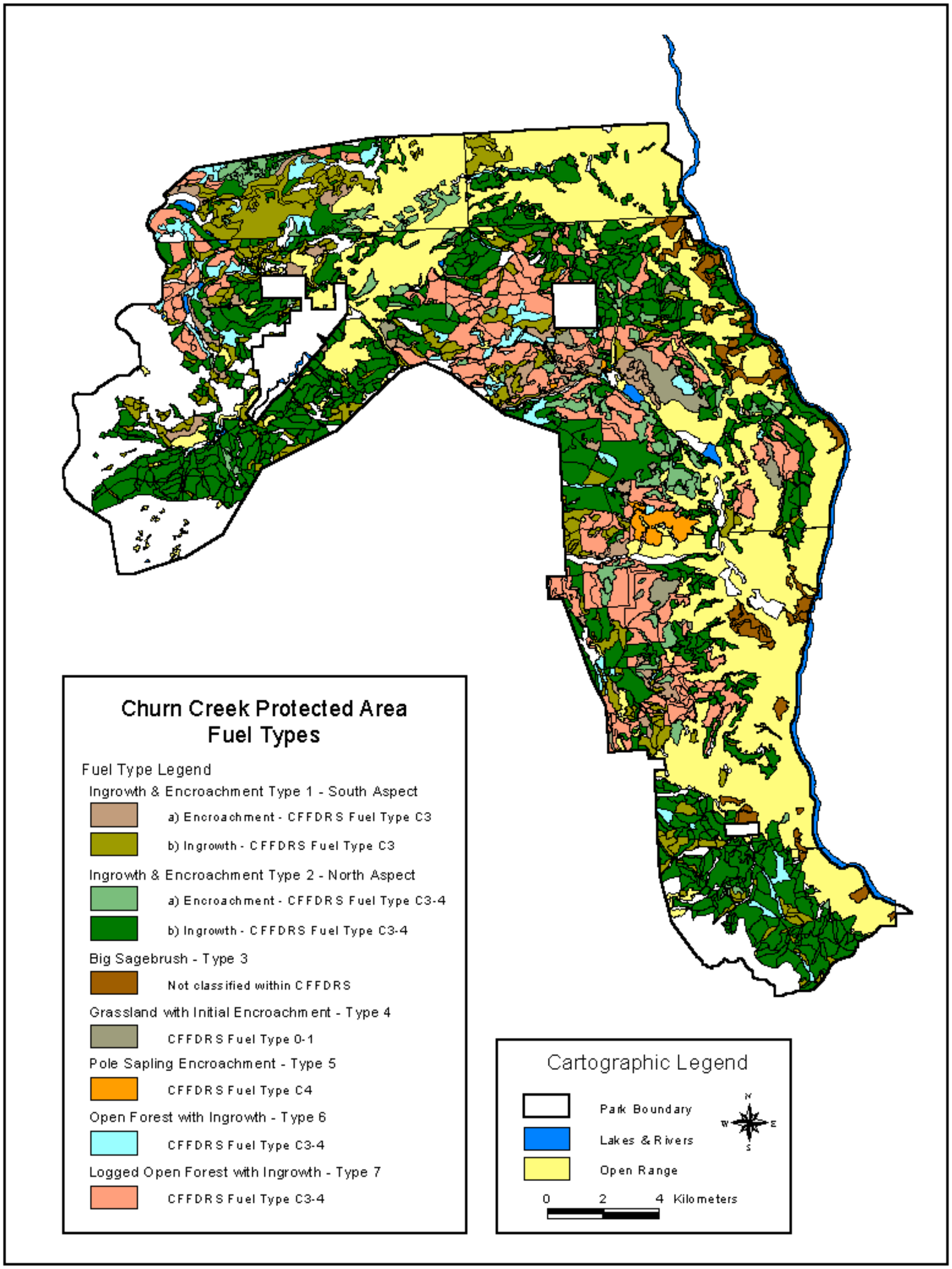


Figure 29. Fuel types in Churn Creek.

with scattered Rockt Mountain Juniper (*Juniper scopulorum*) and Rocky Mountain Fescue (*Festaca saximontana*). Within the stand grass fuels are low while in treeless openings grass fuel is sufficient to burn. Burning difficulty is considered moderate. Pre-burn site preparation will require pruning to create surface fuels sufficient to carry a crown fire.

- Stand density: 1400-1500 stems/ha (density will be higher on steeper slopes); was about 5-10 stems/ha prior to encroachment
- Woody fuels - <1kg/ m^2
- Height to live crown – 3m
- Crown closure – 50%
- Vegetation: dominated by moss patches (about 50% cover) with scattered Junisco and Festsax
- sample site – 30% slope, 360º
- Within stand grass fuel is low; opening grass cover is sufficient to burn
- burn difficulty = moderate; burning will require some pruning to create surface fuel to initiate crown fire

13.1.3 Big Sagebrush Type 3 – Big sagebrush in lower grasslands

This vegetation type is not currently classified within the CFFDRS. Vegetation cover is dominated by dense big sagebrush (*Artemisia tridentata*; 50%+ cover) with bluebunch wheatgrass (*Elymus spicatus*) in most areas. It appears that fire suppression has reduced the grass component of these ecosystems and allowed big sagebrush to occupy larger proportions of the site. In the absence of fire the component of sage will likely increase while the component of grass will decrease. There are no trees within this fuel type. Burning difficulty is low. Under the right conditions is expected that these sites burn to meet prescribed objectives. Figure 30 shows Type 3 fuels.

Figure 30. Big Sagebrush Type 3 fuels.

- dense big sagebrush (50%+ cover) with bluebunch wheatgrass (*Elymus spicatus*)

13.1.4 Grasslands with Initial Encroachment Type 4

Fuels within this type are classified as CFFDRS fuel type 0-1. These are level open grasslands with initial encroachment of *Pseudotsuga menziesii* (Douglas-fir). Average tree age is approximately 12-23 years old. Tree density ranges from 0-1600 stems/ha. Average tree heights range from 0.5 to 1.0m. The average height of live crown is 0m as crowns are present from the ground surface up. Surface fuel loading is less than 0.5 kg/m^2 and the duff depth ranges from 0.5 to 1cm. Vegetation is dominated by Kentucky bluegrass (*Poa pratensis*) with scattered Sandberg's bluegrass (*Poa secunda*), junegrass (*Koeleria macrantha*), porcupine grass (*Stipa curtiseta*), spreading needlegrass (*Stipa ridrardsonii*), and bluebunch wheatgrass (*Elymus spicatus*). Bluebunch wheatgrass is more abundant on warmer aspects, with abundant pussytoes (*Antennaria spp*.). Grassland condition improves adjacent to bordering forest. Currently these areas do not have sufficient fuels to burn and need to be rested from grazing to develop enough fuels for burning encroachment. In some areas reduction of Kentucky bluegrass litter may be required to allow for germination and establishment of more native grasses. Additionally, increased tree growth would increase fuel loading to improve burning conditions. Pre-burn site preparation should include knockdown of encroachment to create surface fuel. Expect burning to be difficult. Figure 31 shows Type 4 fuels.

- Tree ages are about 12-23 yrs old
- Stand density: 0-1600 stems/ha
- Fuel loading low – likely not sufficient to burn
- Requires time to grow sufficient grass fuels to burn; may need to reduce Kentucky bluegrass litter to allow germination and establishment of more native grasses; let trees grow taller for a few years then fall and allow to dry to produce surface fuels
- difficult burn

Figure 31. Grassland with initial encroachment Type 4 fuels.

13.1.5 Pole Sapling Encroachment Type 5

Fuels within this type are classified as CFFDRS fuel type C4. Stands are dominated by *Psuedotsuga menziesii* (Douglas-fir). Average stand age is approximately 70-93 years old. Stand density in this type is ranges from 3800 to 4800 stems/ha. Average tree height ranges from 10 to 15 m with crown closure averaging 60% to 65%. The average height of live crown is 5m. Surface fuel loading is 3 to 5 kg/m^2 and the duff depth ranges from 2 to 3 cm. Of the total fuel load the fine fuel (< 1 cm) component exceeds 1.0 kg/m^2. Vegetation is dominated by Kentucky bluegrass (*Poa pratensis*) with scattered Sandberg's bluegrass (*Poa secunda*), Junegrass (*Koeleria macrantha*), porcupine grass (*Stipa curtiseta*), and abundant Pussytoes (*Antennaria spp*.). Expect burning of these sites to be difficult. Treatment of these sites will require a crown fire or removal of trees. Crown fire initiation on these sites will require a significant wind (>20 km/hr), given the lack of ladder fuels, resulting in a control hazard that may not be acceptable. Figure 32 shows Type 5 fuels.

- Stand density: about 3800 – 4800 stems/ha
- Crown closure – 60 to 65%
- Woody surface fuel – 3-5 kg/m^2
- Fine fuel – 1 kg/m^2
- Height to live crown – about 5m
- Height of codominant and dominant tree about 15m (age core taken)
- Requires a crown fire to treat; probably not enough ladders and surface fuels to easily burn; intensity of burn required would present a control hazard
- difficult burn

Figure 32. Pole sapling encroachment Type 5 fuels.

13.1.6 Open Forest with Ingrowth Type 6

Fuels within this type are classified as CFFDRS fuel type C3-4. Stands are dominated by *Pseudotsuga menziesii* (Douglas-fir). These stands were previously dominated by open forest. Current stand structure is composed of veterans from the open forest layer and a dense pole sapling layer resulting from fire suppression and encroachment. Stand density in this type is approximately 3200 stems/ha with scattered standing veterans (approximately 10 stems/ha). Ages range from 75-124 in pole sapling stage ingrowth to >370 for veteran Douglas-fir trees. Average tree height ranges from 10 to 15 m with crown closure averaging 50%. The average height of live crown is 5m. Surface fuel loading is <3 kg/m^2 and the duff depth ranges from 2 to 3 cm. Of the total fuel load the fine fuel (< 1 cm) component is < 0.5 kg/m^2. Vegetation is dominated by litter with patches of moss and scattered pinegrass, some remnant species from when the stand was open Rocky Mountain fescue (*Festuca saximontana*). Expect burning of these sites to be difficult. Treatment of these sites will require a crown fire. Crown fire initiation on these sites will require a significant wind (>20 km/hr), given the lack of ladder fuels, resulting in a control hazard that may not be acceptable. A more effective and lower risk treatment of these sites would require fuel removal prior to burning. Figure 33 shows Type 6 fuels.

Figure 33. Open forest with ingrowth Type 6 fuels.

- Surface fuel <3 kg/ m^2
- Fine fuels <0.5 kg m^2
- Crown closure – 50%
- Height to live crown – 5m
- difficult burn
- Stand density: about 3200 stems/ha; encroachment and ingrowth appear to be part of same cohort
- Scattered standing vets (about 10 stems/ha but higher in other areas)

13.1.7 Logged Open Forest with Ingrowth Type 7

Figure 34. Logged forest with ingrowth Type 7 fuels.

Fuels within this type are classified as CFFDRS fuel type C3-4. Stands are dominated by *Pseudotsuga menziesii* (Douglas-fir). These stands were previously dominated by open forest. Logging within these stands in two passes (pre 1965 to remove hi-graded fir vets and mid-1990's to remove larger dominant pole sapling) has removed most or all of the large trees. Current stand structure is composed of a dense pole sapling layer resulting from fire suppression and encroachment. Stand density in this type ranges from 0-5000 stems/ha. Average tree height ranges from 10 to 15m with crown closure averaging 60 to 65%. The average height of live crown is 5m. Surface fuel loading is <3 kg/m^2 and the duff depth ranges from 2 to 3 cm. Of the total fuel load the fine fuel (< 1 cm) component is < 0.5 kg/m^2. Vegetation is dominated by litter with patches of moss and scattered pinegrass (*Calamagrostis rubescens*) and some remnant species from when the stand was open including Rocky Mountain fescue (*Festuca saximontana*). Expect burning of these sites to be difficult due to the variability and discontinuity of forest and fuels.

Treatment of these sites will require a crown fire. Crown fire initiation on these sites will require a significant wind (>20 km/hr), given the lack of ladder fuels, resulting in a control hazard that may not be acceptable. A more effective and lower risk treatment of these sites would require fuel removal prior to burning. Figure 34 shows Type 7 fuels.

- Was previously an open forest; now dominated by pole sapling trees; identified by presence of large stumps (two passes of logging: both pre-1965 hi-graded large vets and in mid-1990's to take out larger pole sapling dominants)
- Vegetation: dominated by litter and patches of moss with scattered pinegrass; pinegrass is more abundant in openings; remnant Rocky Mountain. fescue and other plants reflect previous open understory
- Burning will be difficult because of variability and discontinuity of forest/fuels
- Height to live crown about 5m

14.0 SOCIAL CONCERNS

14.1 Historic Land Use

There is an extensive history of human habitation in the Churn Creek area including a long history of First Nations' use including hunting, fishing, plant gathering, and habitation (BC Parks 2000). It also likely included both intentional and accidental burning of grasslands and forests. Contact with non-natives introduced disease and eventually resulted in the movement of most people onto reserves although they still continue to use the area.

The first non-native residents of the area were likely pack train operators associated with the gold rush that likely wintered their pack animals on the grasslands (BC Parks 2000). Shortly thereafter, Chinese miners occupied the area and European settlers established a number of homesteads. There have been numerous homesteads and associated ranches in the Churn area. The primary uses of the area were grazing and some cultivation of hay fields. These uses continue today. Discovery of gold on Blackdome Mountain (west of the CCPA) eventually resulted in the building of the Blackdome Mine Road around 1960. Numerous other roads associated with ranching and placer mining have also been established in the CCPA.

14.2 Values at Risk - Facilities & Structures

In the CCPA there are numerous fences (Figure 35) and several water hole developments associated with the historic and present ranching operation. There are several buildings at the Empire Valley Ranch headquarters and the Calving Barn just north of the ranch. Additionally, there are many historical buildings, many of which provide some cultural and wildlife habitat values.

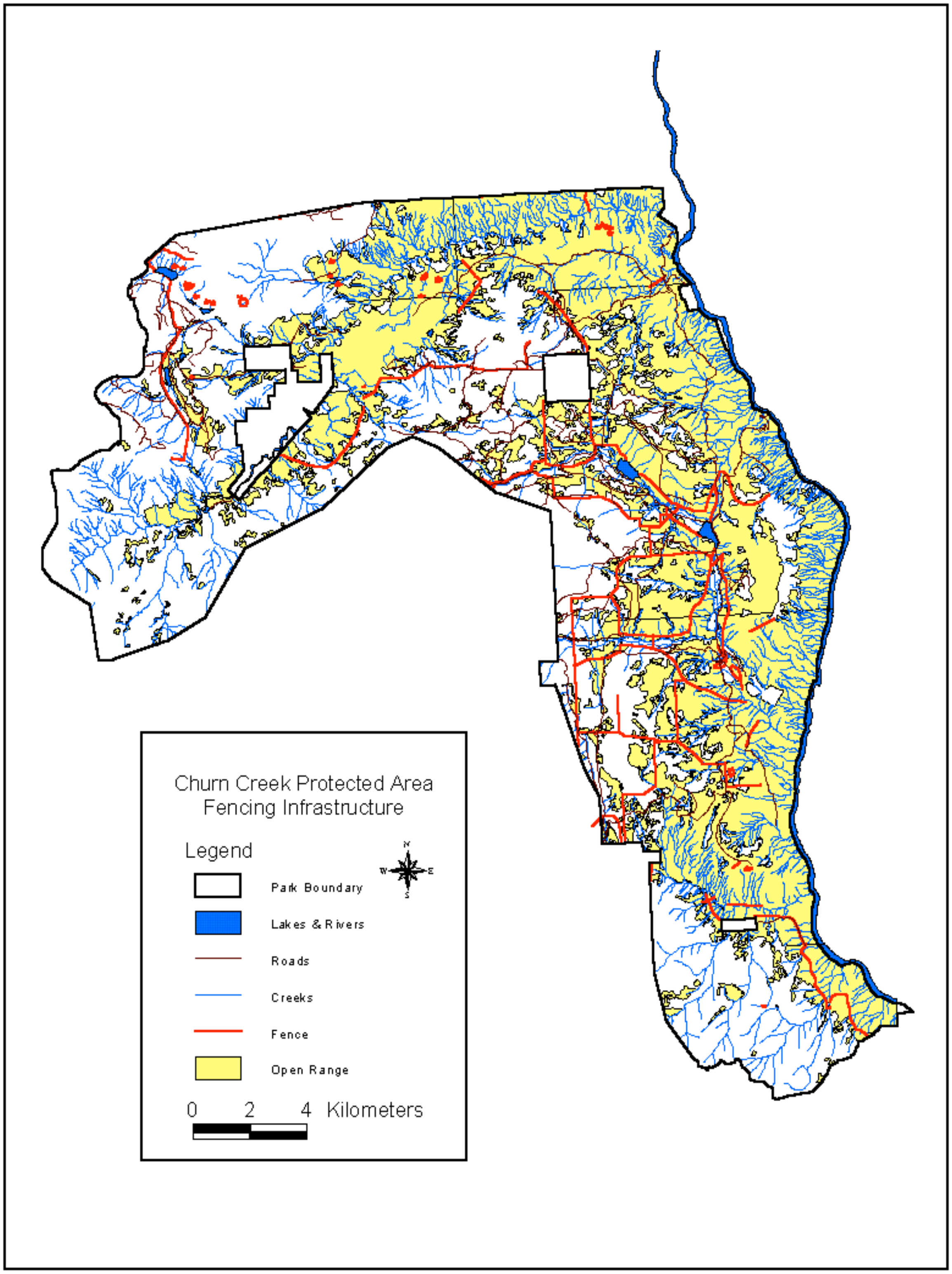


Figure 35. Infrastructure (fencing) in Churn Creek.

14.3 Policy Discussion

The two primary issues driving this prescribed fire management plan are forest encroachment on grasslands and the steady in-growth of trees in what was once open forest. Both of these issues have been thoroughly described in their historic and contemporary ecological context in several preceding sections. The focus of problem resolution is on the applicability of a variety of vegetation management strategies including prescribed fire, and stand thinning.

Within the open bunchgrass areas this is not a significant policy issue as the use of prescribed fire to reduce small clumps of young, encroaching trees in areas of light surface fuel is well established in several program policy statements. In areas where the use of prescribed fire alone as a vegetation management tool threatens to result in unacceptable collateral damage to other ecosystem values, such as areas of dense in-growth or encroachment around large old trees, large-scale areas of continuous aerial fuels, and areas of deep surface fuels, the current conservation policy does not provide clear direction on what other strategies are acceptable. In these areas, the use of prescribed fire alone will not result in ecosystem conditions that meet the intent of BC Parks Conservation Program Policies. Consideration of the combination of prescribed fire and mechanical and manual thinning should be incorporated into policy to address some of the issues identified above. The recognition that in areas where prescribed fire severity may result in unacceptable consequences to the ecosystem being restored or managed, needs to be added to the fire management policy. Where potential high fire severity has been identified through planning removal of excess fuels should be conducted using mechanical/manual methods prior to use of prescribed fire.

Under *Ecosystem Manipulation of Vegetation*, the associated policy areas: “vegetation removal or modification”, and “habitat manipulation parameters”, describe the test of vegetation removal; while the areas: “disposal of timber” and “Forest Practices Code”, describe the process of vegetation removal (BC Parks Conservation Policy 1996). While this policy area provides clear direction to the use of thinning and removal of wood to restore and maintain ecosystems, the policy area of “insect and disease control actions” is prohibitive in the strategies available in those situations. These inconsistencies in BC Parks Conservation Policy need to be cleared up. In the end, the widest range of vegetation management strategies are needed in order to maintain and restore successional stages, critical species, and critical habitat attributes in the dry ecosystems of the CCPA. The issue of vegetation removal should be presented to the Local Advisory Group (LAG) for the Churn Creek Protected Area for discussion and potential approval. This group has representation from a wide cross-section of local interest groups and individuals.

Given the high fuel loading associated with many of the ingrowth areas prescribed natural fires should not be considered as a management tool at this time. Such fires may result in unacceptable ecological impacts that have the potential to reduce site productivity, biodiversity, and wildlife habitat.

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Appendix A: Prescribed Burn Plan Outline

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Appendix B: Hat Creek Burn Plan

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Prescribed Burn Plan

HARRY LAKE (HAT CREEK)

Prepared by:

R.W. Gray Consulting Ltd.
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and

Iverson and MacKenzie Biological Consulting Ltd.

December, 2000

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1.0 Project Location

The 470 ha Harry Lake Burn Area is located in the east-central part of the Kamloops Forest District. Access to the site is via Highway 99 to the Hat Creek Road and approximately 4 km up the road to the McLean Lake Road. A series of primitive dirt roads provide access to the south, east, and north perimeters of the burn unit.

The latitude of the unit is 50° 46', while the longitude is 121° 33'.

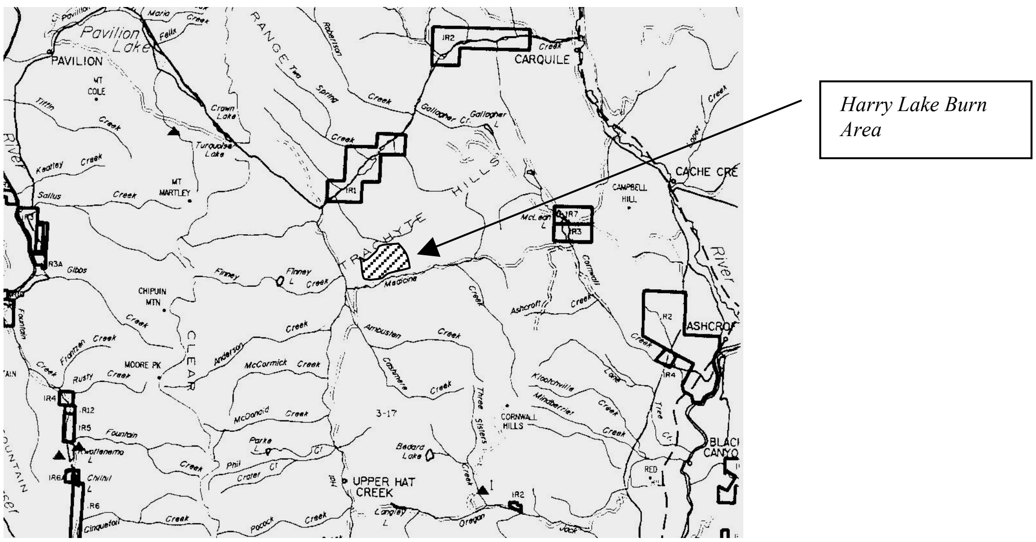

Figure 1. Location of Harry Lake Burn Area.

2.0 Burn Schedule

Historic weather data records from the McLean Lake weather station were analyzed for diurnal temperature, relative humidity, windspeed and wind direction, daily and monthly precipitation, and daily Fire Weather Index values. Based on the data analysis and the stated burn objectives, the schedule of the burn extends from late March to mid- to late-April. Ignition operations will occur throughout the day and be constrained by wind direction.

A list of activities to be completed leading up to the burn operations is provided in Appendix 1.

3.0 Burn Objectives

Treatment Goals (Desired Future Condition)

The objective of this burn is to achieve 20% to 50% canopy mortality resulting in a mosaic of downed woody debris, standing dead snags, and remnant patches of living trees. Utilizing individual tree "torching", crown scorching, and subsequent bark beetle attack will attain this level of canopy reduction. It is expected that remnant unburned patches will be retained throughout the burn area with higher densities retained in the northeast corner and along the east flank of the unit. Fire severity will be variable ranging from low to high across all portions of the burn. The upper northeast corner of the unit dominated by high-density encroachment will likely experience the highest fire severity and retain the greatest number of standing snags and woody debris accumulations.

Removal of canopy trees will stimulate increased growth of the bluebunch wheatgrass and rough fescue, improving forage production throughout the burn area. The extensive patches of pinegrass associated with high crown closure will likely be reduced in area. Long-term tree encroachment has provided conditions suitable for juniper (common and Rocky Mountain) invasion. The fire prescribed in this plan should remove a large percentage of the juniper currently present on the site.

Although the fire effects documented in this plan and accompanying Environmental Assessment will be beneficial to the site they will not provide all necessary changes to fully mitigate ecosystem properties degraded through long-term fire exclusion. Given that the fire will likely result in a greater number of standing dead trees, and volume of downed woody debris in portions of the unit, it is recognized that a second fire will be required to consume additional fuels on the site. This will likely be required within five to seven years following implementation of this burn. Pre- and post-burn monitoring will provide the required data to establish this timeline and to measure the attainment of management objectives.

Quantifiable Burn Objectives

General prescribed fire objectives for rangeland in the Kamloops Forest District are found in the document "*A Process for Reintroduction of Prescribed Fire into the Kamloops Forest District*." From this District-wide direction a set of specific burn objectives were identified for the Harry Lake area of Hat Creek. These objectives are:

- increase rangeland productivity by reducing the coarse, dead grass component in the bunchgrass tussocks and stimulating tiller production,
- reducing the spatial extent and crown closure of overstory and understory Douglas-fir, ponderosa pine, common juniper, and Rocky Mountain juniper,
- stimulate mule deer browse,
- stimulate traditional-use plants,
- protect range improvements,
- maintain/create a spatial distribution of large old Douglas-fir and ponderosa pine, Douglas-fir and ponderosa pine snags, and large pieces of coarse woody debris that is closer to the HRV.

The most constraining objective is the reduction of fine fuels in and around the bunchgrass tussocks without adversely affecting the plants themselves. Both bluebunch wheatgrass and rough fescue are highly adapted to frequent fire in low fuel loading conditions (McMurray 1987; Redmann *et al*. 1995; Archibold *et al*. 1998; Zlatnik 1999). When fuels accumulate and burn under high-severity individual plants can be significantly damaged or killed. Under the historic fire regime bunchgrass ecosystems burned frequently enough to control fine fuel build-ups and limit plant damage.

Rough fescue is the more susceptible of the two major bunchgrass species found at Harry Lake to adverse heat effects (McMurray 1987; Zlatnik 1999). Over much of the area fuel accumulations around the tussocks are high, limiting their combustion and removal to a time of year when the plant is still dormant, fine fuel moisture is high, and the prospect of the site receiving timely precipitation is good. An additional operational strategy will be the use of rapid flaming combustion through the use of headfire as opposed to slow, smoldering combustion associated with backing fire. Minimizing the exposure of bunchgrass plants to lethal temperatures for extended periods of time[1] (Archibold *et al.* 1998) is better met through headfire than backing fire.

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[1] The lethal temperature for plant cell material is 60°C (Brown and Davis 1973) with increasing damage associated with increasing exposure time (Archibold *et al*. 1998). It is impossible to keep heat output at such a low temperature when burning grassland fuels; however, exposure time can be significantly mitigated through fuel moisture, windspeed, and ignition strategy.

Meeting an overstory crown closure reduction objective is compatible with the bunchgrass maintenance objective, especially considering the ignition strategy. Burning during the early spring, prior to grass growth, also insures that foliar moisture content is low. Coupling the consumption of grass fuels through headfire, with burning encroached conifer trees with low crowns, and foliage containing highly flammable volatile extractives and low moisture content, will enable the burn team to meet their objective. The typical structure of the encroached conifers, especially the junipers, is dense, low crowns, or dense thickets of trees. Both conditions facilitate the condensing of hot convective gas into the crown as opposed to dispersing it. It is expected that most overstory conifer mortality will be attributed to crown scorch and not crown consumption (torching or "candling").

The mule deer browse and traditional-use plant objectives are positive benefits of meeting the two primary objectives. Important forage, ungulate and ethnic plants found at Harry Lake are listed in Appendix 1 of the EA; all are highly adapted to fire and are expected to be stimulated by the treatment.

Two consequences of the prescribed fire treatment are the loss of some range improvements (fence posts and stays), and the loss of some large old trees, snags, and CWD. The fenceline along the west boundary of the unit will be actively protected during the operation (see Holding Plan). The fenceline running east to west through the middle of the unit cannot be protected without jeopardizing crew safety and will therefore be left to random chance. The replacement cost of this range improvement is built into the burn budget.

Concern over the loss of biodiversity attributes is covered at length in the accompanying Environmental Assessment. During burn operations attempts will be made through ignition tactics to limit the loss of some of these attributes. It should be recognized, however, that the current number of these attributes is well outside the HRV for this ecosystem.

4.0 Burn Prescription

Historically burn prescriptions in B.C. have relied on the use of either Fire Weather Indices input into the Canadian Fire Behavior Prediction System or, simply tracking relative humidity and coupling that with fuel moisture sticks. Recently, the use of the U.S. time-lag fuel moisture tracking system input into the BEHAVE suite of fire behavior prediction models has gained some use in the province[2]. Both systems have merits depending on season of burning, fuelbed characteristics, and burn objectives. Spring 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 behavior prediction model. Difficulties were experienced in developing a safe, reliable prescription that would deliver the kind of fire effect outputs needed to meet the burn objectives using FWI and FBPS. The best range of values as both input and output are provided in Table 2. The FWI values are from 5 years of data from the McLean Lake weather station while fire behaviour outputs are from FBP '97. The collection of absolute fuel moisture values directly input to BEHAVE FIRE1 (Appendix 2) will be concurrent with the collection of FWI values. The Harry Lake burn project affords a good opportunity to track both systems in order to objectively quantify and assess strengths and weaknesses of both systems. The tracking of fire behavior outputs, used to compare predicted with actual values for both systems, is part of the monitoring regime.

4.1 Fuels Description

Surface fuels in the project area consist of cured grass, small branches, and large, old logs (Appendix 3). Aerial fuels consist of conifer foliage and branchwood and bark associated with snags. Cured grass makes up approximately 90% of all surface fuels with the remaining 10% of fuels by coverage consisting of duff/litter, branchwood, and large logs.

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[2] It is the recommendation of several Provincial Prescribed Fire Task Team members that practitioners familiar with the use of this system be encouraged to use whatever tools are necessary to carry out safe and effective prescribed burns.

Stand structure attributes that will contribute to fire behaviour, aerial fuel consumption, and prescribed fire emissions include height to live crown, stand density, and crown closure (Table 1). Detailed fuelbed inventory will be conducted as part of the fire effects monitoring (see Monitoring Plan).

4.2 FWI parameters and predicted fire behaviour

The range of fuel moisture parameters are outlined in Table 2, and divided into two types: the C-3 conifer plantation fuel type and C-7, the dry Douglas-fir, ponderosa pine type. This range of values was developed from the McLean Lake weather station. The predicted rate of spread and crown fraction burned indicate a very low intensity surface fire based on the input FWI values. These input values will be used primarily to determine when the project area is approaching the prescription window. The use of a test fire will determine whether or not the fire effects needed to meet the objectives can be achieved.

4.3 Weather parameters

Relative humidity, windspeed, and wind direction are the three critical weather parameters in the prescription. Hourly diurnal relative humidity data for March and April was analyzed in order to determine the likely burn schedule. Minimum RH's for March don't provide for too many burn windows while April greatly improves. Both months show adequate RH recovery overnight to retard fire spread (in the case of an escape) and to aid in mop-up.

Table 1. Stand structure and crown fuel attributes.

Location	**Density (t/ha)**	**Tree Layer Coverages (%)**	**Understory Layer Coverages (%)**	**Ht. Live Cr. (m)**	**Cr. Closure (%)**
IDFxh2/03 south aspect, majority of burn area	**5-2000**	**Douglas-fir 5-10** Ponderosa pine 5-10	**Wood rose 0-1** Saskatoon 0-1 b. wheatgrass 10-15 r. fescue 0-15 junegrass 0-5 needlegrass 0-2 balsamroot 15-20 pussytoes 0.2-2 onion 0.2-0.5 moss/lichen 2-25	**2 - 10**	**15 - 20**
IDFxh2/01 upper area of burn	**400-500**	**Douglas-fir 20-25** Ponderosa pine 0-5	**Pinegrass 30-50** r. fescue 0-20 b. wheatgrass 0-5 balsamroot 5-15 pussytoes 0.2-2 onion 0.2-0.5 moss/lichen 5-15	**2 - 3**	**25**
IDFxh2/01 dense encroachment	**3500-4500**	**Douglas-fir 65-75**	**Pinegrass 15-25** r. fescue 0-0.5 moss/lichen 5	**5 - 6**	**70**
IDFxh2/91 rough fescue grasslands			r. fescue 30-50 R. needlegrass 5-15 b. wheatgrass 0-3 balsamroot 10-20 pussytoes 0.5 onion 0-0.2 m. lily 0-0.1		

Table 2. Fuel moisture and fire behaviour outputs using FBPS.

Fuel Type	FFMC Range		BUI Range		Head fire ROS (m/min)		HFCFB*	
C-3	75	89	20	60	0	1.4	0	0
C-7	75	89	20	60	0	1.3	0	0

* Head fire crown fraction burned.

Recorded windspeed and wind direction in the lower Hat Creek valley appears to be heavily influenced by local topography. The weather station is located at the confluence of three significant topographic gaps, to the east, west, and south. Diurnal wind patterns are somewhat predictable with late afternoon and overnight winds coming out of the north, northwest, and late morning and afternoon winds coming down Hat Creek from the south. These local wind characteristics are considered in the Ignition Plan.

A remote automated weather station (RAWS) needs to be in place on the upper road one month prior to the proposed burn operation. During the burn operation hourly weather indices will be collected at this station.

5.0 Ignition Plan

Ignition operations will begin late in the afternoon of the first day and under a general northwest wind. The initial ignition sequence will occur in the extreme northeast corner of the unit (Figure 2) at the transition between open grassland and closed forest. At this point one ignition team will proceed north (downhill) along a wet line[3] to a deep riparian draw, and ultimately to the upper road. The east flank ignition team will slowly bring the ignition line down the east flank intermittently along a wet line and an aspen coppice. Occasionally a line will extend along the contour into the unit in order to steer a headfire back uphill into the unit and toward the headfire coming from the north.

Ignitions will continue the first afternoon west along the upper road to the northwest corner at the junction of the upper road and west fenceline. This ignition team then slowly fires off a wetline in the slashed out fenceline proceeding to the south. Ignitions will proceed just beyond the break in the slope where they will terminate for the first day.

On day two the east and west flank ignition teams will intermittently bring the fire down the flanks and send ignition teams across the slope. Each team sent across the slope will consist of three ignition personnel and one lead ignition specialist. The role of the two ignition specialists will be to scout ahead of their respective teams for the best ignition sites and to rendezvous with their alternates coming from the opposite direction. Due to the highly heterogeneous nature of the fuels and forest structure within the unit these two ignition specialists will be tasked with the goal of meeting site specific fire effects objectives while insuring safe working conditions. Attention will be paid to the need to provide escape routes and communications for their crews while meeting the stated burn objectives. The most dangerous part of the operation will involve the meeting of the two internal crews. The burn boss in the helicopter and the lookout across Medicine Creek, in addition to the two ignition specialists scouting ahead of their teams, will help in this effort.

Once the internal teams have brought the ignition down close to the lower road, the final ignition sequence will involve the east flank ignition team tying into the lower road in the southeast corner of the unit and igniting along the road to the southwest corner of the unit where the lower road meets the west fenceline.

The entire ignition operation, including the blackline operation, is expected to take 2-2.5 days. Ignition teams will utilize a combination of handheld trip torches and fusees for firing.

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[3] A "wet line" is a wetted down line using water, foam, or retardant. Ignition operations are started against this line as a barrier. This strategy is often used in grassland fuels because of the rapid burn-out time of the fuels and the expense of building control lines down to bare mineral soil.

6.0 Burn Organization Chart

<u>Burn Boss</u>
Robert W. Gray

District Designated Forest Officer
Mike Dedels/Phil Youwe

Safety Officer

Fire Behavior/Weather Specialist

Ignition Specialist
Bruce Blackwell
Ralph Thevarge
Bruce Janning

Ignition Crew
Colin Templeton
Jacquie Rasmussen
Chris Runnals
Mike Dedels
Peter Falsetta

Holding Specialists
Jim Gilliam
Joe Clarke
Mark Fletcher

Holding Crew
10-person Humble (Lillooet) Crew

Engine Operators

EMT

Lookout/Radio Relay
Kristi Iverson

7.0 Holding/Contingency/Mop-up Plan

Pre-burn

Prior to ignition operations the fenceline along the west flank will need to be cleared of fallen trees, any snags close to the line will need to be felled, and the fence opened where the east-west fenceline takes off. On the east flank a section of the shallow draw just above the switchback (Figure 3) will need to be cleared of ladder fuels and a shallow firebreak constructed. Below the switchback, any snags located close to the riparian draw will need to be felled. Snags close to the lower road will also need to be felled.

Two 1500 gal. porta-tanks need to be set up and filled at the east flank switchback and in the northwest corner adjacent to the upper road and the west flank fenceline.

During the burn

At the onset of ignition operations holding resources will be split into three teams. The east flank team will consist of a five-person crew equipped with backpack pumps and handtools (pulaski's and MacLeods). This crew will assist the east flank ignition crew as they slowly fire-off the east flank along a wet line to the break in the slope. Assisting the second ignition crew as they work their way downhill to the north toward the riparian draw and the upper road will be an engine strike team (brush engine plus 3 crewmembers). This team will follow behind the ignition team as they work their way along the upper road to the northwest corner. Once at the northwest corner a second five person holding crew with backpack pumps and handtools will assist the west flank ignition team as they work their way down the west fenceline to the break in the slope. The engine strike team will then take up patrol duties along the entire north flank.

During the subsequent ignition operations the two, five-person holding crews along the east and west flanks will continue to work with the two flank ignition crews as they slowly bring fire down the two flanks. The holding crews will facilitate wet-lining and mop-up. During this same time period the engine strike team will continue to patrol the north flank of the unit. Once ignition operations on the east flank reach the switchback a second engine strike team (3,000 gal. engine plus 2 crew) will come into effect. This engine strike team will assist the east flank ignition crew as they tie in the southeast flank with the lower road and bring the fire down the lower road to the southwest corner.

Post-burn

Mop-up operations will commence as soon as ignition operations have ceased. Mop-up will need to be complete within 100 m of the burn perimeter. Any burning snags or fire-weakened trees or snags will need to be felled and extinguished within this zone. Within the greater burn perimeter any steep slopes that have experienced moderate-severity fire will require "contouring[4]" remediation. This will be undertaken as a precaution against a possible high-intensity rainfall event on potentially hydrophobic soils before the grass greens-up. Any firebreaks constructed by the holding crew will also need to be rehabilitated. The standard process involves constructing waterbars on steep sections and placing coarse woody debris in the trail. These areas should be inspected periodically for noxious weeds.

[4] "Contouring" involves the cross-slope felling and anchoring of small-diameter fire-killed trees as barriers to surface soil erosion.

8.0 Safety Plan

BRIEFING

All participants in the prescribed burn operation will be thoroughly briefed each morning of the operations, and attendance recorded at each daily or shift briefing. The briefing will cover the following key elements:

- fireline organization
- objectives – ignition plan/holding plan
- individual assignments
- expected fire weather/fire behavior
- additional safety concerns.

Only personnel identified in the burn organization chart will be permitted in the project area. All others will be required to remain outside the project area until the ignition component of the operation is complete. All personnel involved in the burn are to limit their exposure to smoke.

LOOKOUTS

A staged lookout will posted at the height of land on the south side of Medicine Creek during all stages of ignition. The lookout is located due south and across the main valley from the burn unit. The designated lookout personnel will be responsible for reporting fire escapes, spot fires, and any other observable hazards. Other responsibilities will include communications support and the maintenance of photographic and written fire behavior records and smoke characteristics. Additional lookouts will be posted as required.

COMMUNICATIONS

The location of communication "dead spots" will be investigated prior to operations and identified for crews. The lookout posted to the south of Medicine Creek will also function as a radio-relay. Approved radio frequencies are noted in section 9.0.

ESCAPE ROUTES

Escape routes will vary depending on individual position in or adjacent to the burn area. It will be the responsibility of the Burn Boss and Crew Supervisor to identify and ensure that appropriate escape routes are available at all times during the operations. Escape route strategies should be discussed during all briefing sessions.

SAFETY ZONES

The primary safety zone is located at the marshalling point in the northwest corner of the unit. Adjacent and within the unit there are a limited number of safety zones in the vicinity of the burn unit. These include the proposed black line area along the northern burn boundary, the lower road running along the southern boundary of the unit, short-grass meadows along the lower road, and the road flanking the eastern boundary that runs from the bottom to the top of the unit. Within the actual burn unit there are site specific areas with limited grass and tree cover (dead spots) that may serve as safety zones. The Burn Boss and Crew Supervisor should ensure that all personnel are aware of appropriate safety zones. In addition to designated safety zones all personnel working within the burn unit will be required to carry and be familiar with the use of a fire shelter.

EMERGENCY RESPONSE

A designated WCB first aid attendant will be onsite during all phases of burning operations and will provide initial emergency care for any medical incidents. All first aid incidents will be reported to the Burn Boss who will be responsible for allocating appropriate resources to deal with an emergency response. The nearest hospital is located in the Ashcroft and will be notified prior to ignition. A helicopter will be on standby during all phases of the operation to medevac any serious emergency victim to the Ashcroft hospital.

PERSONAL PROTECTIVE EQUIPMENT (P.P.E.)

All personnel involved in the operation are required to wear P.P.E.

Mandatory Equipment (*WCB 26.19 and 26.7*)

- long-sleeved shirt, pants, or coveralls made of cotton, wool, denim or flame resistant fabric
- high visibility orange or red hard hat
- headlamp that attaches to hardhat
- leather boots with either caulked or vibrum soles
- leather gloves

Recommended Equipment

- 100% cotton or wool undergarment
- cotton, wool, or nomex jacket or sweater
- cotton bandanas or Respro® mask and filter
- tight fitting swim goggles
- fireline pack
- canteens
- radio chestpack
- spare AA batteries
- fire shelter
- personal first aid kit
- wire cutters (for ignition crew)

ADDITIONAL SAFETY CONCERNS

Additional safety concerns include:

- a fenceline located within the burn unit boundary
- a number of danger trees within the burn unit
- moderate to high tick hazard during the seasonal burning window

A fenceline transects the burn unit, running across the middle of the area in an east/west direction. This fence poses a serious hazard for ignition crews working within the block. The fence line will be clearly marked with bright flagging tape prior to ignition. Additionally selected section of the line will be strategically cut to speed access across the line in the event of an emergency. The fenceline will be clearly marked on all maps used during ignition of the unit.

Dead snags and dead overhead branches can be found throughout the burn unit. These trees pose a significant safety hazard to anyone working within the block. All crews working within the burn boundary will be assisted by a designated certified Wildlife Danger Tree Assessor. This individual will be responsible for ensuring that all personnel avoid any significant overhead or snag hazard. In any areas where the densities of these types of hazard are high a no work zone will be established prior to ignition.

Prior to any ignition activity, crews will conduct a walkthrough of the area to review snags, danger trees and the location of the fenceline.

The location of the burn unit is within a moderate to high tick hazard area. Given the timing of the burn (March – April) there is a high probability of the presence of ticks. All personnel will be briefed on this hazard and the necessary precautions required to minimize tick bites will be reviewed.

To prevent access congestion on the limited, narrow roads in the unit designated parking and marshalling areas will be used. Access priority will be to the medical staff, the engines, and the fuel truck.

VALUES AT RISK

In addition to rangeland improvements, other local values at risk include the power line along the upper road and nearby private dwellings. The powerline will be under observation of the engine crew on the upper road for the time period when it is at high risk (blacklining operations). Private dwellings in the lower Hat Creek valley are not in danger of being impacted by the prescribed burn. Emissions and embers are being directed up valley and away from residences. Down-valley winds at night, however, are expected to send some emissions into the lower valley over night.

9.0 Communication Plan

The radio frequencies to be used on the prescribed burn are outlined in Table 3. All personnel are to be tuned into these frequencies at all times. Use of the radios must be kept to clear, concise communications; excess "chatter" will be discouraged.

Table 3. Approved radio frequencies.

Channel	Transmit Frequency	Receive Frequency
Line of site	163.99	163.99
Repeater (Green)	163.125	163.995
Repeater (Yellow)	163.335	164.205
Repeater (Purple)	163.095	163.965

10.0 Smoke Management Plan

Legislated requirements for the management of pollutants from smoke in B.C. are found in the *Open Burning Smoke Control Regulations* (B.C. Reg. 145/93) which are part of the *Waste Management Act*. Under the provisions of the regulation every effort must be made by the proponent of the burn to minimize the production of particulate matter and other harmful pollutants and to minimize the effects that these emissions will have on human health. To date, the only quantitative standard that is used in BC to measure the relative concentration of these emissions in a particular area is the 'ventilation index.' This standard is derived from the sum of the plume mixing height and the mean upper elevation windspeed, and as the name implies, is a measure of the ability of the atmosphere to disperse emissions. In prescribed burn planning a range of mixing heights and upper elevation windspeeds must be analyzed in order to develop a 'window' for smoke production that will insure that pollutants become sufficiently diluted in the atmosphere and don't become a human health threat. As per the Ministry of Environment regulations, the prescribed burn will not take place unless the "Ventilation Index" is indicated as "good" or better.

The most significant pollutant produced in prescribed burning is particulate matter; specifically particles <10 microns. This category of pollutant is referred to as PM-10. In BC the **air quality objective** for PM-10 is 50 $\mu g/m^3$ averaged over 24-hours (Ministry of Environment 1997; the US *Clean Air Act* short-term standard for PM-10 is 150 $\mu g/m^3$ averaged over 24-hours while the long-term standard is 50 $\mu g/m^3$ averaged over a year (Stoneman 1997)). This pollutant, plus carbon monoxide (CO), are also of concern to personnel working on forest fires and prescribed burns although there are as of yet no *Occupational Health and Safety Regulations* governing the exposure of personnel to these pollutants in the workplace (BC Regulation 296/97). Issues of prescribed fire emissions effects on the human environment are addressed in the accompanying EA.

To determine what particulate and CO levels were likely to be produced and what the impact would be on the nearest down-wind community, two smoke plume models from the US Forest Service were used in the analysis. The Emissions Production Model (EPM) was developed at the Pacific Northwest Research Station for use on slash burns in the Pacific Northwest. Outputs from this model can then be imported to SASEM which is a Gaussian smoke plume model (Breyfogle and Ferguson 1996). The inputs and outputs from both models appear below.

EPM

```
  1. Fire/site name ............. Hatcreek
  2. Date of the burn ...........  4/15/01
  3. Owner of the unit site ......  BC Forest Service
  4. Location of the site ........  Kamloops Forest District
```

5. Fire unit size .... 400 ha
6. Primary species .... Ponderosa Pine
7. Harvest type .... PARTIAL CUT
8. Ignition period .... 13.6 hours
9. Cured fuels .... Yes
10. Days since rain > 0.5 in. ... 5 days
11. 10-Hour fuel moisture .... 8.0 percent
12. 1000-Hour fuel moisture from ODS
13. 1000-Hour fuel moisture ..... 17.0 percent
14. Diameter largest fuel .... 20 cm
15. 100-Hour fuel loading .... 0.35 kg/m^2
16. 3 to 9 inch fuel loading .... 0.47 kg/m^2
17. 9+ inch fuel loading .... 0.22 kg/m^2
18. Rotten fuel loading .... 1.98 kg/m^2
19. Green fuel > 0.5 tons/acre .. No
20. Duff depth .... 4.2 cm
21. YUM Piles burned .... No
22. Used for firewood .... No

* * * * * * * * * * * * * * * * * Fire # 1 * * * * * * * * * * * * * * * ** *

Time Since Ignition (min)	Heat Release Rate (Btu/s)	TSP Emission Rate (g/s)	PM10 Emission Rate (g/s)	CO Emission Rate (g/s)
0	0.0	0.0	0.0	0.0
20	4194306.5	4005.0	3204.0	22943.4
40	5289678.5	5500.7	4400.6	32164.8
60	5745911.5	6144.1	4915.3	36152.1
80	5946045.0	6426.4	5141.1	37901.1
100	6033836.0	6550.2	5240.1	38668.4
120	6072347.0	6604.5	5283.6	39004.9
140	6089240.0	6628.3	5302.7	39152.6
160	6096650.5	6638.8	5311.0	39217.3
180	6099901.0	6643.3	5314.7	39245.8
200	6101327.0	6645.4	5316.3	39258.2
220	6101952.5	6646.2	5317.0	39263.7

240	6102227.0	6646.6	5317.3	39266.1
260	6102347.5	6646.8	5317.4	39267.1
280	6102400.0	6646.9	5317.5	39267.6
300	6102423.5	6646.9	5317.5	39267.8
320	6102433.5	6646.9	5317.5	39267.9
340	6102438.0	6646.9	5317.5	39267.9
360	6102440.0	6646.9	5317.5	39267.9
380	6102441.0	6646.9	5317.5	39268.0
400	6102441.0	6646.9	5317.5	39268.0
420	6102441.5	6646.9	5317.5	39268.0
440	6102441.5	6646.9	5317.5	39268.0
460	6102441.5	6646.9	5317.5	39268.0
480	6102441.5	6646.9	5317.5	39268.0
500	6102441.5	6646.9	5317.5	39268.0
520	6102441.5	6646.9	5317.5	39268.0
540	6102441.5	6646.9	5317.5	39268.0
560	6102441.5	6646.9	5317.5	39268.0
580	6102441.5	6646.9	5317.5	39268.0
600	6102441.5	6646.9	5317.5	39268.0
620	6102441.5	6646.9	5317.5	39268.0
640	6102441.5	6646.9	5317.5	39268.0
660	6102441.5	6646.9	5317.5	39268.0
680	6102441.5	6646.9	5317.5	39268.0
700	6102441.5	6646.9	5317.5	39268.0
720	6102441.5	6646.9	5317.5	39268.0
740	6102441.5	6646.9	5317.5	39268.0
760	6102441.5	6646.9	5317.5	39268.0

780	6102441.5	6646.9	5317.5	39268.0
800	6102441.5	6646.9	5317.5	39268.0
820	3186095.5	4493.2	3594.5	27844.9
840	1397624.6	1971.0	1576.8	12214.5
860	613087.2	864.6	691.7	5358.1
880	268939.2	379.3	303.4	2350.4
900	117973.9	166.4	133.1	1031.0
920	51750.9	73.0	58.4	452.3
940	22701.2	32.0	25.6	198.4
960	9958.2	14.0	11.2	87.0
980	4368.3	6.2	4.9	38.2
1000	1916.2	2.7	2.2	16.7
1020	9460407.0	4966.9	3973.5	22554.2
1040	31532256.0	16552.8	13242.2	75159.5
1060	53659692.0	28168.1	22534.5	127898.9
1080	75787240.0	39783.6	31826.9	180639.3
1100	97914840.0	51399.2	41119.4	233380.2
1120	120042456.0	63014.8	50411.8	286121.3
1140	142170080.0	74630.4	59704.3	338862.4
1160	164297744.0	86246.0	68996.8	391603.7
1180	186425376.0	97861.7	78289.3	444344.9
1200	208553008.0	109477.3	87581.8	497086.1
1220	230680656.0	121092.9	96874.3	549827.3
1240	252808304.0	132708.6	106166.9	602568.6
1260	274935904.0	144324.2	115459.3	655309.7
1280	297063584.0	155939.8	124751.9	708051.0
1300	319191168.0	167555.4	134044.3	760792.2

1320	341318848.0	179171.1	143336.9	813533.4
1340	363446496.0	190786.7	152629.4	866274.7
1360	385574112.0	202402.3	161921.9	919015.9
1380	407701792.0	214018.0	171214.4	971757.2
1400	429829376.0	225633.6	180506.9	1024498.3
1420	451957056.0	237249.2	189799.4	1077239.6
1440	474084672.0	248864.8	199091.9	1129980.7
1460	496212320.0	260480.5	208384.4	1182722.0
1480	518339968.0	272096.1	217676.9	1235463.2
1500	540467584.0	283711.7	226969.4	1288204.5
1520	562595328.0	295327.4	236261.9	1340946.0
1540	584722880.0	306942.9	245554.4	1393686.9
1560	606850560.0	318558.6	254846.9	1446428.2
1580	628978112.0	330174.2	264139.4	1499169.4
1600	651105856.0	341789.9	273431.9	1551910.7
1620	673233472.0	353405.5	282724.4	1604651.9
1640	695361088.0	365021.1	292016.9	1657393.1
1660	717488768.0	376636.7	301309.4	1710134.4
1680	739616384.0	388252.4	310601.9	1762875.6
1700	761744000.0	399868.0	319894.4	1815616.7
1720	783871616.0	411483.6	329186.9	1868358.0
1740	805999296.0	423099.2	338479.4	1921099.2
1760	828126976.0	434714.9	347771.9	1973840.5
1780	850254592.0	446330.5	357064.4	2026581.9
1800	872382144.0	457946.1	366356.9	2079322.9
1820	0.0	0.0	0.0	0.0

Fuelbed Component	Convective Period: Fuel Consumed Flaming (T/A)	Convective Period: Fuel Consumed Smolder (T/A)	Convective Period: TSP Emit (lb/A)	Non-Convective Period: Fuel Consumed Smoldering (T/A)	Non-Convective Period: TSP Emit (lb/A)	Total: Fuel Consumed (T)	Total: TSP Emitted (lb)
0-3" Woody	1.5	1.0	79.	0.0	0.	2550.	78531.
3"+ Woody	0.2	2.2	114.	0.1	3.	2510.	117714.
Rotten	0.4	6.8	348.	0.2	10.	7480.	358489.
Subtotal	2.2	10.1	541.	0.3	14.	12541.	554734.
Duff	4.6	0.0	86.	1.5	73.	6068.	159583.
Total	6.7	10.1	627.	1.8	87.	18608.	714317.
Total+Piles						18608.	714317.

Lighting time divided by smoldering rate decay constant 33.5
Proportion of fuel consumed after end of flaming 3.0 %
Maximum smoldering fuel consumption rate 14.59 T/min
Maximum smoldering TSP emission rate 5485. g/s
Time for smoldering rate to decay to 37% of its max. value 24.3 min
Fire duration 30.3 hours
Average heat release rate 49519947800. cal/s
Emission factor 19.19 g/kg
Average emission rate 1.47 g/s/m

```
 PM10 to TSP ratio
0.80

Your input values from SASEM are:
  1. Fire/site name ......................  Hatcreek
  2. Date of the burn ....................  4/15/01
  3. Burn type of the fire ...............  BROADCAST
  4. Fuel type of the fire ...............  GRASS
  5. Size of the fire ....................  400.0 ha
  6. Fuel loading of the fire site ........  12.0 tons/acre
  7. Fireline intensity ..................  145.0 Btu/ft/sec
  8. Burn duration .......................  14.00 hours
  9. Meteorology type ....................  SASEM
```

Sensitive Receptor Information

Receptor Number	Receptor Name	Receptor Distance	Receptor Direction
1	CARQUILE	8.4	SW
2	CACHE CREE	9.0	ENE
3	ASHCROFT	11.0	ESE

```
 The SASEM calculated emission statistics are:
     Pollutant of interest ...................... Particulates (TSP
and PM10)
     Emission factor ............................ 16.82 g/kg
     Emission rate .............................. 1.63 g/s/m
     Total particulates emitted ................. 181.7 tons
     Proportion of fuel consumed ................ 90. %
     Heat content of fuel specified ............. 5000. Btu/lb
     Residence time of fire front ............... 120. s
     Fire line rate of spread ................... 0.04 m/s
     Approximate fire line length ............... 2011.7 m
     Depth of the fire line ..................... 4.8 m
     Number of effective plumes in fire ......... 420.0
     Heat release rate for a plume .............. 1285714. cal/s
     Persistence factor for concentration ........ 0.29
     Proportion of smoke which rises ............ 60. %
     Proportion of total particulates in PM10 .... 90. %
```

					Exceedences of Standards

Disp Day	Wind Speed (MPH)	Maximum Concen (ug/m**3)	Distance to Maximum Concen (mi)	TSP* Distance Downwind From (mi)	TSP* To (mi)	PM10* From (mi)	PM10* To (mi)	Plume Rise (m)
EXC	2.0	742.4	1.52	0.59	11.22	0.59	9.97	431.
EXC	3.0	742.1	1.11	0.56	7.51	0.56	6.89	288.
EXC	4.0	742.0	0.81	0.56	6.03	0.56	5.47	216.
EXC	5.0	742.6	0.68	0.56	4.97	0.56	4.47	173.
EXC	6.0	741.8	0.56	0.56	4.16	0.56	3.79	144.
EXC	7.0	736.7	0.56	0.56	3.67	0.56	3.29	123.
EXC	8.0	715.9	0.56	0.56	3.23	0.56	2.92	108.
EXC	9.0	687.2	0.56	0.56	2.92	0.56	2.61	96.
EXC	10.0	655.2	0.56	0.56	2.61	0.56	2.36	86.
GOOD	5.0	740.8	1.22	0.59	14.33	0.59	12.46	173.
GOOD	6.0	725.8	0.87	0.56	11.81	0.56	9.94	144.
GOOD	7.0	692.7	1.31	0.57	9.95	0.57	8.71	123.
GOOD	8.0	742.2	0.81	0.56	8.08	0.56	7.46	108.
GOOD	9.0	742.6	0.68	0.56	7.46	0.56	6.21	96.
GOOD	10.0	742.5	0.62	0.56	6.21	0.56	5.97	86.
FAIR	7.0	742.6	2.94	0.57	62.15	0.57	62.15	123.
FAIR	8.0	742.6	2.41	0.61	62.19	0.61	62.19	108.
FAIR	9.0	742.6	2.04	0.61	62.19	0.61	62.19	96.
FAIR	10.0	742.5	1.76	0.58	62.16	0.58	62.16	86.
POOR	2.0	3335.8	4.70	0.60	62.68	0.60	62.68	96.

POOR	3.0	1942.8	6.19	0.60	62.18	0.60	62.18	110.
POOR	4.0	1323.9	7.50	0.60	62.18	0.60	62.18	121.
POOR	5.0	983.2	8.75	0.61	62.19	0.67	62.19	130.
POOR	6.0	771.0	9.96	0.83	62.16	0.83	62.16	138.
POOR	7.0	627.8	11.21	1.02	62.16	1.08	62.16	146.
POOR	8.0	525.4	12.43	1.19	62.14	1.31	62.14	152.
POOR	9.0	449.0	13.45	1.46	61.92	1.58	61.92	159.
POOR	10.0	390.2	14.57	1.71	62.42	1.83	62.42	164.

* The primary TSP standard is 150. micrograms per cubic meter.
The primary PM10 standard is 150. micrograms per cubic meter.

Receptor No.	Name	Dist (mi)	Dir	Disp Day	Wind Speed (MPH)	Range of Wind Dir	P&K* Visual Range (mi)	Kosh** Visual Range (mi)
1	CARQUILE	8.40	SW	EXC	2.0	N -NNW	0.8	0.7
1	CARQUILE	8.40	SW	EXC	3.0	N -NNW	1.2	1.0
1	CARQUILE	8.40	SW	EXC	4.0	N -NNW	1.6	1.3
1	CARQUILE	8.40	SW	EXC	5.0	N -NNW	2.0	1.6
1	CARQUILE	8.40	SW	EXC	6.0	N -NNW	2.5	2.0
1	CARQUILE	8.40	SW	EXC	7.0	N -NNW	2.9	2.3

1	CARQUILE	8.40	SW	EXC	8.0	N	-NNW	3.3	2.6
1	CARQUILE	8.40	SW	EXC	9.0	N	-NNW	3.7	2.9
1	CARQUILE	8.40	SW	EXC	10.0	N	-NNW	4.1	3.3
1	CARQUILE	8.40	SW	GOOD	5.0	N	-NNW	2.0	0.6
1	CARQUILE	8.40	SW	GOOD	6.0	N	-NNW	2.5	0.7
1	CARQUILE	8.40	SW	GOOD	7.0	N	-NNW	2.9	0.8
1	CARQUILE	8.40	SW	GOOD	8.0	N	-NNW	3.3	0.9
1	CARQUILE	8.40	SW	GOOD	9.0	N	-NNW	3.7	1.0
1	CARQUILE	8.40	SW	GOOD	10.0	N	-NNW	4.1	1.1
1	CARQUILE	8.40	SW	FAIR	7.0	N	-NNW	2.9	0.2
1	CARQUILE	8.40	SW	FAIR	8.0	N	-NNW	3.3	0.2
1	CARQUILE	8.40	SW	FAIR	9.0	N	-NNW	3.7	0.3
1	CARQUILE	8.40	SW	FAIR	10.0	N	-NNW	4.1	0.3
1	CARQUILE	8.40	SW	POOR	2.0	N	-NNW	0.8	0.0
1	CARQUILE	8.40	SW	POOR	3.0	N	-NNW	1.2	0.1
1	CARQUILE	8.40	SW	POOR	4.0	N	-NNW	1.6	0.1
1	CARQUILE	8.40	SW	POOR	5.0	N	-NNW	2.0	0.1
1	CARQUILE	8.40	SW	POOR	6.0	N	-NNW	2.5	0.2
1	CARQUILE	8.40	SW	POOR	7.0	N	-NNW	2.9	0.2
1	CARQUILE	8.40	SW	POOR	8.0	N	-NNW	3.3	0.3
1	CARQUILE	8.40	SW	POOR	9.0	N	-NNW	3.7	0.3
1	CARQUILE	8.40	SW	POOR	10.0	N	-NNW	4.1	0.4
2	CACHE CREE	9.00	ENE	EXC	2.0	N	-NNW	0.9	0.7
2	CACHE CREE	9.00	ENE	EXC	3.0	N	-NNW	1.3	1.1
2	CACHE CREE	9.00	ENE	EXC	4.0	N	-NNW	1.7	1.4
2	CACHE CREE	9.00	ENE	EXC	5.0	N	-NNW	2.1	1.8
2	CACHE CREE	9.00	ENE	EXC	6.0	N	-NNW	2.6	2.1

2	CACHE CREE	9.00	ENE	EXC	7.0	N	-NNW	3.0	2.5
2	CACHE CREE	9.00	ENE	EXC	8.0	N	-NNW	3.4	2.8
2	CACHE CREE	9.00	ENE	EXC	9.0	N	-NNW	3.8	3.2
2	CACHE CREE	9.00	ENE	EXC	10.0	N	-NNW	4.2	3.5
2	CACHE CREE	9.00	ENE	GOOD	5.0	N	-NNW	2.1	0.6
2	CACHE CREE	9.00	ENE	GOOD	6.0	N	-NNW	2.6	0.7
2	CACHE CREE	9.00	ENE	GOOD	7.0	N	-NNW	3.0	0.8
2	CACHE CREE	9.00	ENE	GOOD	8.0	N	-NNW	3.4	1.0
2	CACHE CREE	9.00	ENE	GOOD	9.0	N	-NNW	3.8	1.1
2	CACHE CREE	9.00	ENE	GOOD	10.0	N	-NNW	4.2	1.2
2	CACHE CREE	9.00	ENE	FAIR	7.0	N	-NNW	3.0	0.2
2	CACHE CREE	9.00	ENE	FAIR	8.0	N	-NNW	3.4	0.3
2	CACHE CREE	9.00	ENE	FAIR	9.0	N	-NNW	3.8	0.3
2	CACHE CREE	9.00	ENE	FAIR	10.0	N	-NNW	4.2	0.3
2	CACHE CREE	9.00	ENE	POOR	2.0	N	-NNW	0.9	0.0
2	CACHE CREE	9.00	ENE	POOR	3.0	N	-NNW	1.3	0.1
2	CACHE CREE	9.00	ENE	POOR	4.0	N	-NNW	1.7	0.1
2	CACHE CREE	9.00	ENE	POOR	5.0	N	-NNW	2.1	0.1
2	CACHE CREE	9.00	ENE	POOR	6.0	N	-NNW	2.6	0.2
2	CACHE CREE	9.00	ENE	POOR	7.0	N	-NNW	3.0	0.2
2	CACHE CREE	9.00	ENE	POOR	8.0	N	-NNW	3.4	0.3
2	CACHE CREE	9.00	ENE	POOR	9.0	N	-NNW	3.8	0.3
2	CACHE CREE	9.00	ENE	POOR	10.0	N	-NNW	4.2	0.4
3	ASHCROFT	11.00	ESE	EXC	2.0	N	-NNW	1.0	0.9
3	ASHCROFT	11.00	ESE	EXC	3.0	N	-NNW	1.5	1.3
3	ASHCROFT	11.00	ESE	EXC	4.0	N	-NNW	1.9	1.8
3	ASHCROFT	11.00	ESE	EXC	5.0	N	-NNW	2.4	2.2

3	ASHCROFT	11.00	ESE	EXC	6.0	N	-NNW	2.9	2.7
3	ASHCROFT	11.00	ESE	EXC	7.0	N	-NNW	3.4	3.1
3	ASHCROFT	11.00	ESE	EXC	8.0	N	-NNW	3.9	3.5
3	ASHCROFT	11.00	ESE	EXC	9.0	N	-NNW	4.3	4.0
3	ASHCROFT	11.00	ESE	EXC	10.0	N	-NNW	4.8	4.4
3	ASHCROFT	11.00	ESE	GOOD	5.0	N	-NNW	2.4	0.7
3	ASHCROFT	11.00	ESE	GOOD	6.0	N	-NNW	2.9	0.9
3	ASHCROFT	11.00	ESE	GOOD	7.0	N	-NNW	3.4	1.0
3	ASHCROFT	11.00	ESE	GOOD	8.0	N	-NNW	3.9	1.1
3	ASHCROFT	11.00	ESE	GOOD	9.0	N	-NNW	4.3	1.3
3	ASHCROFT	11.00	ESE	GOOD	10.0	N	-NNW	4.8	1.4
3	ASHCROFT	11.00	ESE	FAIR	7.0	N	-NNW	3.4	0.3
3	ASHCROFT	11.00	ESE	FAIR	8.0	N	-NNW	3.9	0.3
3	ASHCROFT	11.00	ESE	FAIR	9.0	N	-NNW	4.3	0.3
3	ASHCROFT	11.00	ESE	FAIR	10.0	N	-NNW	4.8	0.3
3	ASHCROFT	11.00	ESE	POOR	2.0	N	-NNW	1.0	0.0
3	ASHCROFT	11.00	ESE	POOR	3.0	N	-NNW	1.5	0.1
3	ASHCROFT	11.00	ESE	POOR	4.0	N	-NNW	1.9	0.1
3	ASHCROFT	11.00	ESE	POOR	5.0	N	-NNW	2.4	0.1
3	ASHCROFT	11.00	ESE	POOR	6.0	N	-NNW	2.9	0.2
3	ASHCROFT	11.00	ESE	POOR	7.0	N	-NNW	3.4	0.2
3	ASHCROFT	11.00	ESE	POOR	8.0	N	-NNW	3.9	0.3
3	ASHCROFT	11.00	ESE	POOR	9.0	N	-NNW	4.3	0.3
3	ASHCROFT	11.00	ESE	POOR	10.0	N	-NNW	4.8	0.4

* Packham, D. R. and R. G. Vines, 1978, JAPCA 28:790-795.
**Koshmieder, 1924, Beitr. Phys. Freien Atm., 12:33-54.

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    and EPA, 1979, EPA-450/5-79-008.
  Based on TSP emission rates.
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The EPM model (Emissions Prediction Model) is used to assess the ability of altering the prescription, namely fuel moisture, in order to reduce overall emissions of TSP (Total Suspended Particulate), PM10 (Particulate Matter >10 microns), and CO (carbon monoxide). Inputs to the model include total area, ignition time, fuel moisture, and fuel loading. Outputs include heat and particulate emissions over time plus fuelbed consumption by fuel size class. The modeled runs above were weighted heavily to woody fuels as opposed to grass fuels because the current version of EPM poorly predicts grass emissions (a newer version is due out this year). Therefore, estimates of total fuel consumed (18,608 tons) and TSP emitted (714,317 lb), are higher than they likely are.

The SASEM model is used to predict the impact of emissions at any number of sensitive receptor sites, i.e., areas of human habitation. The impacts measured are the legislated limits of particulate, both TSP and PM10, and the visual refraction of particulate (smog). SASEM, unlike EPM, accurately predicts grass emission rates which is why there is such a disparity in total particulate emitted between EPM (357 tons) and SASEM (182 tons). Regardless of the amount of particulate emitted the key outputs from the model are the exceedences of guidelines and the visual impact at receptor sites.

As can be seen in the dispersal day table, the best emission condition occurs with windspeeds greater than 2 mph on excellent dispersion days. This is found by looking at line 1 of the table. On an excellent dispersion day with a 2 mph wind the maximum concentration of particulate is 742.4 ug/m^3. The distance from the emission source (the burn area) to this maximum concentration is 1.52 miles. Lesser amounts, that still exceed the provincial guideline, occur from 0.59 to 11.22 miles (0.59 to 9.97 for PM10). Ashcroft, at 11 miles downwind from the burn, would be negatively affected by these emissions. However, when more wind is added on excellent dispersion days, the maximum concentration is reduced, the distance to the maximum is reduced, and the exceedence of standards is contracted back toward the burn site.

The visual impact of the emissions shows a similar pattern. The higher the windspeed and the better the dispersion conditions, the larger the visual range is. Weather station data from McLean Lake indicate average daily windspeeds in excess of 2 kmph during the prescription period. This minimal condition will greatly improve ventilation conditions.

A caveat to the outputs from these models is the very fact that they are simply models. Smoke emissions from prescribed fires are highly variable and very difficult to model. These models were used more for educational purposes than for producing a set of hard and fast numbers relating to prescribed fire emissions. Igniting 400 ha of grass and timber litter fuels is going to result in the conversion of solid carbon and other minerals into a wide array of gaseous compounds. Two of the largest components of the pyrolysis process are water vapor (90%) and particulate (<10%). The predicted emission total of 182 tons of particulate, while appearing to be a large number, is significantly less than wildfire emissions for the same area and fuel loading.

11.0 Public Information Plan

Upon completion of the draft burn plan a period of consultation is required to address stakeholder comments and questions. The Ministry of Forests will be responsible to advertise that the plan and EA are available for public viewing during a period prior to ignition (proposed January 2001). Additionally the Ministry of Forests will hold a local meeting (Hat Creek Community) to review the plan and answer questions related to any of the proposed burning activities. All local residents within the Hat Creek community, grazing leaseholders, and other appropriate government agencies should be invited to attend. This meeting will involve a brief presentation to describe the plan objectives, desired fire effects, implementation of the prescribed fire, smoke management and post fire effects.

Any questions or concerns identified at this meeting will be responded to in writing. Suggestions and recommendations provided by stakeholders will be integrated into the burn plan where it is deemed appropriate.

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12.0 Fire Effects Monitoring Plan

The fire effects monitoring plan sets out the methodology for quantitatively assessing whether or not the stated prescribed fire objectives were met. Some of these objectives can be assessed immediately post-burn, while others will need to be assessed over time. Permanent plots, photographed and referenced with rebar plot stakes, will be established in the burn area as well as in adjacent control areas.

There are three generalized sets of objectives: plant community response to burning, overstory tree mortality, and, physical damage to range improvements.

Measuring plant community response will entail establishing a series of plant transects and 20cm X 50cm plots prior to burn operations. These plots would then be re-measured at 6-months, and 18 months post-burn. Variables analyzed include: species diversity, frequency of species occurrence, and productivity. These variables will be measured for primary rangeland grasses, traditional-use plants, noxious weeds, and primary mule deer browse plants. Unfortunately, the timing of the pre-burn monitoring will make it difficult to identify smaller herbs on the plots, especially annuals, thus limiting the ability to fully analyze species diversity.

Placement of vegetation transects will be tied to the location of the overstory tree plots. At each overstory tree plot, two 50 m long vegetation transects will be established. Shrub intercept will be recorded along these transects. Starting one meter from the start and end of each transect, the first 5 bunches (bluebunch wheatgrass or rough fescue) that are intercepted will have basal diameter measurements recorded (along with the location of the bunch along the transect). This will give a total of 20 bunches at each monitoring site.

Ten 20cm X 50 cm plots will be established along each transect at systematic locations (one every 5m starting at 1m) for a total of 20 plots at each monitoring location. For these plots, all plants and canopy cover will be recorded. Additionally, the number of seed culms for bluebunch wheatgrass and rough fescue will be recorded (as a measure to correlate to productivity). One monitoring site will be established in each of the major vegetation types in the burn area. Additionally, one control site will be established in a site similar to the dominant vegetation type outside of the burn area.

The results of the monitoring should be tied in with re-introduction of domestic livestock grazing on the site and any mitigative strategies needed for controlling noxious weeds. Grazing should not be re-introduced until seed stalk production, cover and basal diameter data meets or exceeds pre-treatment levels for bluebunch wheatgrass and rough fescue. Additionally, it may be of interest to continue to monitor beyond 18 months to examine increases in forage production. Noxious weed control strategies need to be tied to specific plants. Once these species are identified control strategies can be recommended.

Overstory tree mortality will be analyzed using fixed plots and pre-burn crown closure measurements (using spherical densiometer). These plots will be re-measured 1-2 weeks post-burn in order to let scorched needles completely lose their chlorophyll and turn red. This variable should continue to be assessed (recommended the same time as plant re-measurements) in order to quantify the effect of post-burn insect attack.

Physical damage to range improvements can be assessed immediately post-burn and an estimate of replacement costs established. Long-term consequences of the burn on range improvements could involve the damage to fencelines resulting from the falldown of fire-killed trees.

The final objective stated in the burn plan involves the maintenance or creation of a spatial distribution of large old trees, snags, and large CWD. The initial post-burn spatial extent of these attributes can be assessed from a random set of fixed radius plots and simple attribute tallies. These plots will need to be assessed over an extended time period as overstory mortality will continue to occur, snags will be created and lost over time, and CWD will be in flux.

Appendix 1: Schedule of Activities

Month	Activity
January	• make determination on whether or not to proceed with project in spring 2001, • conduct public information session, request written feedback by February 15, • notify District staff involved in project to schedule availability,
February	• respond to public comments by amending burn plan, EA, mitigation of effects, etc., • submit burn plan to Protection Branch for Reference number, • set up weather station, • purchase equipment, • commit contract resources, i.e., ambulance and medic, First Nations crew, etc.,
March	• hold pre-burn logistics and planning meeting with District staff, Protection Branch, and other key individuals or organizations involved in operations, • establish pre-burn monitoring plots, • have flanks cleared of fallen trees, snags adjacent to line, slash out east flank, etc. • check unit for communication dead "spots", • check access to unit and lookout location, • check communications equipment, • purchase drip torch fuel, • pick up drip torches and spare parts from Protection Branch, • check drip torches for operability, • check engine functioning plus holding equipment,
April	• check area for livestock, people, prior to operations, • carry out operations, • re-measure overstory mortality, • analyze prescription accuracy, • return equipment to Protection Branch
September	• re-measure plant transects, vegetation plots, and overstory mortality, • write-up initial post-burn fire effects analysis.
September, 2002	• re-measure plant transects, vegetation plots, overstory mortality.

Appendix 2: BEHAVE FIRE1

The BEHAVE (Andrews 1986) submodel FIRE1 was used to derive a realistic range of fire behavior outputs. Inputs to the model are general, but slightly conservatively biased, conditions for the burn unit and include:

- NFFL fuel model 2 timber (grass and understory),
- 1-hr fuel moisture 6%
- 10-hr fuel moisture 6 to 12%
- 100-hr fuel moisture 10%
- live herbaceous 100%
- midflame windspeed 2 to 10 km/h
- terrain slope 30%
- wind direction upslope

The burn objectives can be safely met with a headfire rate of spread from 3 – 13 m/min (Table 1) and flame length from 1.0 – 2.0 m (Table 2). These values will result in crown scorch heights (5 – 10 m) (Table 3) and crown volume scorch (40 – 100%) (Table 4) within an acceptable range to meet the burn objective of overstory reduction.

Table 1. Rate of spread (m/min) with target range shaded in.

10-hr moisture (%)	Midflame windspeed (km/h)				
	2	4	6	8	10
6	3	6	9	13	19
8	3	6	9	13	19
10	3	6	9	13	19
12	3	5	9	13	19

Table 2. Flame length (m) with target range shaded in.

10-hr moisture (%)	Midflame windspeed (km/h)				
	2	4	6	8	10
6	1.1	1.3	1.7	2.0	2.4
8	1.1	1.3	1.7	2.0	2.4
10	1.1	1.3	1.7	2.0	2.4
12	1.1	1.3	1.7	2.0	2.4

Table 3. Crown scorch height (m) with target range shaded in. Additional input is ambient air temperature range from 14 to 24°C.

10-hr moisture (%)	Midflame windspeed (km/h)				
	2	4	6	8	10
6	1.1	1.3	1.7	2.0	2.4
8	1.1	1.3	1.7	2.0	2.4
10	1.1	1.3	1.7	2.0	2.4
12	1.1	1.3	1.7	2.0	2.4

Table 4. Crown volume scorch (%) with target range shaded in. Additional input is average tree height of 14 m.

10-hr moisture (%)	Midflame windspeed (km/h)				
	2	4	6	8	10
6	42	73	94	100	100
8	42	72	94	100	100
10	42	72	94	100	100
12	41	72	93	100	100

These fire behavior outputs and first order fire effects, still highly dependent on ignition strategies, will not be uniform over the treatment unit. Areas of shallow slope (<10%), light surface fuels, compacted fuels, or moist fuels will not exhibit these fire behavior output levels or first order fire effects.

Appendix 3: Fuelbed Descriptions

Figure 1. View of overstory and surface fuels that occur within the majority of burn area (highly variable).

Figure 2. View of some of the heaviest accumulations of grass fuels on the site.

Figure 3. View of some of the denser encroachment located in the northeast corner of the burn area.

Figure 4. Understory view of the dense encroachment located in the northeast corner of the burn area.

Appendix 4: Briefing Record

Project/Incident	Date	Name

Appendix 5: Budget

Item	No. Units	Cost/Unit ($)	Total Cost ($)
Equipment			
Fusees	4 cases	75.00/case	300.00
Drip torch fuel	400 gal. (1,400 litres)	0.5/litre diesel, 0.65/litre gas	800.00
Mileage for Lillooet engine	150 km	0.40/km	60.00
Industrial ambulance	1	257.00/day + 0.54/km	2,704.00
Fence repair	1,000 m	5,000/km	5,000.00
Equipment total			8,864.00
Personnel			
Rep. @ stakeholder mtg.	1 persons/2.5 days	420.00	1,050.00
Pre-burn planning	2 persons/2 days	840.00	1,680.00
Burn supervision	1 person/4 days	420.00	1,680.00
Fire effects monitoring 2001	2 persons/4 days	480.00	1,920.00
Fire effects monitoring 2002	2 persons/5.5 days	480.00	2,640.00
Holding specialist	1 person/4 days	180.00	720.00
Ignition specialist	1 person/4 days	420.00	1,680.00
Holding crew	10 persons/8 days	1,155.00	9,240.00
Mop-up supervisor	1 person/4 days	180.00	720.00
First aid attendant	1 person	300.00	2,400.00
Personnel total			23,730.00
"False-start" buffer 10%			2,373.00
Grand total			$34,967.00
Cost/ha			**$74.40**

Appendix 6: Equipment List

ITEM	ATTAINED BY	DATE ATTAINED
Fusees (4 cases)		
Drip torches (12)		
Drip torch fuel (400 gal.)		
Porta-tanks (2)		
Engines (2)		
Weather station (1)		
P.P.E. for District Staff: • nomex clothing • headlamp • batteries • fire shelter • goggles • bandannas • hardhats		
Radios		
Camera and film		

Appendix 7: Prescribed Fire Complexity Analysis*

COMPLEXITY ELEMENT	RATING VALUE	WEIGHTING FACTOR	TOTAL SCORE
1. Potential for escape	1	10	10
2. Values at risk	1	10	10
3. Smoke/air quality	3	7	21
4. Treatment objectives	5	7	35
5. Fuels/fire behaviour	3	5	15
6. Fire duration	3	5	15
7. Ignition methods	5	3	15
8. Management team size	5	3	15
Total Project Complexity Rating			**136****

* From USDI National Park Service NPS-18 manual. BC is developing a similar rating system but as of yet it is not completed.

****Complex burns typically score >338**.

Appendix 8: EFSA (Escaped Fire Situation Analysis)

Prescribed Fire
Name______________________________Date______________________________

Fire
situation____
____
____

Alternative Actions

Holding actions

A. No
action____
____
____
____

B. ____
____
____

C. ____
____
____

Suppression Alternative Actions

Alternative____.

____
____
____
____

Alternative____.

____
____
____
____

Alternative____.

____
____
____
____

Decision Matrix

Impacts on:	Alternative____ (no action)	Alternative_____	Alternative_____
Soil			
Air			
Water			
Red & Blue listed species			
Vegetation			
Developments			
Recreation			
Firefighter safety			
Public safety			
Cultural assets			
Private property			
Wildlife habitat			
Other			

Projected containment/suppression needs/costs:

Alternative____		Alternative_____		Alternative_____	
Item	Cost	Item	Cost	Item	Cost

Total Cost ____________ ____________ ____________

Alternative: ________ ________ ________

Est. completion time (days) ________ ________ ________
Est. fire size at completion (ha) ________ ________ ________
Remaining uncontained perimeter (%) ________ ________ ________

Preferred alternative and
rationale:____
____
____
____
____

Prepared by:____Date:____________________

Signature:____Date:____________________

Title:____

Approved
by:____Date:__________________________
District Manager

Works Cited

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Appendix C: Fire Effects Tables

In order to prescribed burn objectives it is necessary to document the fire ecology and fire effects of species of interest in the protected area. Species that were included in the following Fire Effects Tables were chosen as follows:

- all tree species
- dominant shrubs and shrubs that form important components of wildlife habitat
- dominant grasses and significant introduced grasses
- dominant grassland forbs and dwarf shrubs, significant introduced forbs, and noxious weeds (where information was available)
- dominant microbiotic crust species (where information was available)
- red- and blue-listed animals and Mule Deer

For red and blue listed species, a risk rating was also applied. The risk refers to the direct risk of injuring, killing animals or affecting nesting success. These ratings do not refer to the potential problem of smoke drift into adjacent habitats nor do they refer to detrimental effects of habitat loss.

Fire Effects On Trees

Tree Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Douglas-fir (Uchytil and Crane 1991)	• shoots start mid-March to mid-June and buds burst a few weeks later • cones open (seed dispersal) late August to early October • seedling establishment best on mineral soil and thin (<5cm) organic seedbeds	• 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 ground fire • open-grown trees with low-growing branches and flammable foliage make these trees susceptible to crown fires • species relies on wind-dispersal of seeds to colonize burned areas • mineral soil exposed by burning provides a good seedbed • establishes and grows best under overstory trees (open) where there is less frost and less moisture stress	• larger diameter trees and snags with cavities used for Flammulated Owl nesting • patches of regeneration near Flammulated Owl nest trees preferred for roosting • Swainson's Hawks use open forests adjacent to grasslands for nesting • Lewis' Woodpeckers nest in large diameter trees in open areas • Townsend's Big-eared Bat forage in mature forests • seeds provide food for various birds and small mammals • Large old trees provide food and snow interception for Mule Deer in winter range habitats
Lodgepole Pine (Uchytil 1992)	• cones flower in spring • buds burst in May & leaves are fully flushed by mid-June • most trees have both serotinous cones (require fire to open) and non-serotinous cones • cones are mature by August or September; seeds are shed in September & October & following a fire • seeds germinate best on mineral soil	• fire spread to the crown can be difficult because crown is elevated above the ground • thin-barked trees are readily killed by ground fires • fire usually creates favorable conditions for seedling establishment	• serotinous cones allow trees to regenerate by seed after fire • trees establish and grow best in areas without overstory trees (shade intolerant)	• seeds provide food for squirrels, chipmunks, some songbirds and blue and Spruce Grouse • many Northern Goshawks nest in open pine stands • some Great Blue Heron rookeries are in pine stands • grouse feed on dwarf mistletoe growing on pine trees
Hybrid White Spruce (Uchytil 1991)	• pollen shedding in June or July • cones ripen in August or September • seedfall in late August or September (December) • seedlings establish well on mineral soil and rotten wood • only occurs on moist sites in the IDF	• thin-barked trees are readily killed by surface fires • fires readily spread to spruce crowns • seeds (on the ground and in cones) are killed by fire	• relies on wind-dispersed seeds from adjacent areas to colonize burned sites • seeds are dispersed over relatively short distances except on snow where they can travel long distances depending on the topography	• needles provide winter food for Spruce Grouse and Blue Grouse • seeds provide food for squirrels, chipmunks, rodents and some birds • large spruce trees used for denning by Fishers

Fire Effects on Trees, cont.

Tree Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Trembling Aspen (Howard 1996)	• flowers from April to May • bud-break occurs from mid- to late April • seed ripening and dispersal late May to mid-June • species capable of vegetative regeneration through suckering, or root collar of stump sprouting • regeneration through seed uncommon but can occur when moist mineral seedbed free from competition is present • occurs on moist depressions, riparian sites and some logged areas	• 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	• winter forage and shelter for Sharp-tailed Grouse and other grouse • shrub-height thickets can provide foraging and breeding habitat for Yellow-breasted Chat • foraging habitat for Townsend's Big-eared Bat, Spotted bat and Fringed Myotis • foraging habitat for Gopher Snake • nesting sites for many woodpeckers, ducks and songbirds • browse for Mule Deer and cattle, particularly in the fall and winter
Black Cottonwood (Holifield 1990)	• flowers from late March to May • seed dispersal occurs from late May to early July • viability of fresh seed is high but of short duration • good germination on bare, moist mineral soil • sprouts readily from stumps, branches, roots and logs • occurs on floodplains of streams and rivers	• seedlings and saplings usually killed by fire of any intensity • mature trees may survive low-intensity fires • species can sprout from the stump following top-kill • fire can create favorable conditions for seedling establishment	• species is adapted to fire through seeding and vegetative regeneration • air-born and water-born seeds can travel great distances	• Lewis' Woodpeckers nest in large diameter trees • nesting sites for many woodpeckers and songbirds, fisher, bald eagle and osprey • large cottonwood trees in densely forested riparian sites (IDFxm and higher elevation subzones) can provide resting, foraging and denning habitat for fishers • provides moose browse at higher elevations (IDF and above)

Fire Effects on Shrubs

Shrub Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Big Sagebrush (McMurray 1989; Meyer 1992)	• native, 1 – 2 m tall erect shrub with thick trunk & multi-stems • flowers in September • seeds dispersed through the winter – seeds can travel by wind up to 30m) • only a few seeds remain in seed bank beyond one winter • common on lower grassland sites and warn aspects of middle grasslands	• easily killed by most fires	• re-establishes from seed of surviving plants or plants directly adjacent to the burn • sometimes a few plants will establish from the seed bank	• in general: occasionally browsed by deer and sheep, however, is heavily browsed on some winter ranges • breeding habitat for Brewer's Sparrows (particularly on steep slopes) • breeding habitat for Sage Thrasher
Chokecherry (McMurray 1987)	• native, deciduous, rhizomatous shrub with numerous stems • leaf buds burst in May • flowers in early June • fruits ripen in August • occurs in some shrublands	• aerial portions of plants are top-killed • rhizomes are buried deep enough to survive most fires	• sprouts from surviving root crowns and rhizomes • plants survive best when they are dormant • germinates from seed dispersed by birds and mammals • fire generally enhances cover and plant numbers for several years	• cover and nesting habitat for many songbirds • browse for Mule Deer and California Bighorn Sheep • berries provide food for grouse, other birds and small mammals • Yellow-breasted Chat may use these shrubs for nesting
Common and Western Snowberry (Esser 1995 and Snyder 1991)	• Native, deciduous, rhizomatous, perennial shrub • Buds develop late April to early May • Leaves fall by late September • Common in aspen copses, riparian sites and shrublands	• 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	• important cover component in riparian habitats and aspen copses • berries provide winter forage for Sharp-tailed Grouse and other birds in the winter
Douglas Maple (Uchytil 1989a)	• native, shade-tolerant deciduous shrub with multiple stems • flowering from April to June • leaf-out from early May to early June • seed fall begins in early September • common on riparian sites and in gullies	• fire top-kills shrubs • survives fire by producing numerous root crown sprouts • severe summer fire can kill below ground stems	• species is well-adapted to fire through vegetative regeneration	• important cover component of riparian habitats • provides browse for Mule Deer • buds provide food for grouse • seeds provide food for squirrels and chipmunks

Fire Effects on Shrubs, cont.

Shrub Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Juniper (Common, Creeping, & Rocky Mountain) (Tirmenstein 1988a and 1988b)	• native, evergreen shrubs • flowers in May or June • berries form in June to July • germination of seeds is poor • small mammals and birds serve as dispersal agents • scattered on warm aspects and sand dunes	• Creeping Juniper low-growing mats have decreased flammability • Upright branches of common juniper & Rocky Mt. Juniper 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	• Mule Deer browse during winter (except Common Juniper) • berries provide food for sharp-tailed grouse, other birds and small mammals • most important winter food for Townsend's Solotaire
Prickly Rose & Prairie Rose (Crane 1990 and Tesky 1992b)	• native, deciduous, rhizomatous shrubs armed with prickles • blooms in May to June • rose hips ripen during late summer and fall • common on riparian sites, aspen copses and shrublands	• 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	• rose hips provide food for songbirds and small mammals (particularly in the winter) • hips and buds provide food for grouse and black bears • nesting sites and cover for many songbirds • shelter for small mammals
Rabbit Brush (Bradley 1986b)	• native, short, erect shrub • flowers in August & September • fruit ripens in October • scattered in grasslands, more common on warm aspects	• top-killed by moderate fires; killed by more intense fires	• sprouts from root crown or from off-site seed	• generally is a minor browse species for Mule Deer and California Bighorn Sheep (flowers may also be grazed in fall) • heavily browsed in many parts of Churn
Red-osier Dogwood (Crane, 1989)	• native, deciduous, many-stemmed shrub • can reproduce vegetatively by layering • flowers in May to June • fruit ripens in August	• top-killed by most fires • roots survive all but the most severe fires • may increase in abundance after fire	• sprouts from surviving roots or stolons and the base of aerial stems • light fires that remove duff stimulate germination of buried seed	• important cover component of riparian habitats; provides nesting cover for many songbirds • provides browse for Mule Deer, moose and cattle • fruit provides food for grouse, songbirds and small mammals
Sandbar Willow (Uchytil 1989c)	• native deciduous shrub that spreads with root suckers • flowering and leaf expansion begin in May • flowering ends in July • seeds shed from June to late July • occurs on moist and wet sites only; most common on active floodplains but also found in moist basins in grasslands	• readily top-killed by fire	• sprouts from roots after fire • wind-dispersed seeds can revegetate burned sites with exposed mineral soil	• important cover component in riparian habitats and some shrublands • nesting sites for many songbirds

Fire Effects on Shrubs, cont.

Shrub Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Saskatoon (Howard and Hickerson 1997)	• native, deciduous, rhizomatous shrub (1 – 8 m tall) • intolerant of deep shade • bud burst and flowering occurs from mid-April to May • fruits ripen in July to August • occurs on riparian sites, shrublands, and talus slopes	• easily top-killed by fire but vigorously resprouts from rhizomes and root crowns • can survive severe fires if the soil is moist or rhizomes are deep	• moderately adapted to fire through vegetative regeneration • fire will lower shrub height	• important winter browse for Mule Deer and California Bighorn Sheep • ungulates may preferentially browse regrowth after fire • grouse eat buds and fruits • rodents and songbirds eat fruits • food for bears • taller shrubs provide nesting cover for songbirds (possibly including Yellow-breasted Chats)
Willows (other than sandbar willow)	• native deciduous shrubs • generally restricted to riparian sites	• readily top-killed by fire	• re-sprout from the root crown • seeds will establish on exposed, moist mineral soil	• important cover component in riparian habitats • nesting sites for many songbirds (possibly including Yellow-breasted Chats) • buds provide winter food for grouse
Wolf Willow (Esser 1994)	• native, deciduous, strongly rhizomatous shrub • shade intolerant • tolerant of alkaline soils • flowers in May – June • fruit ripens from August to September • common on riparian sites, shrublands and scattered on some steep, eroded slopes	• top-killed by most fires • cover decreased by fire and recovers slowly	• adapts to fire by sprouting from rhizomes • may establish from seeds if dispersed onto burned sites	• winter forage and shelter for Sharp-tailed Grouse • may provide foraging and breeding habitat for Yellow-breasted Chat • foraging habitat for Townsend's Big-eared Bat, Spotted bat and Fringed Myotis • browse for Mule Deer and California Bighorn Sheep • important cover component of riparian and shrubland habitiats; provides nesting cover for many songbirds
Water Birch (Uchytil 1989b)	• native, deciduous shrub, usually with many spreading trunks • flowers in April or May • female catkins ('cones') disintegrate on the tree in the fall and winter • common on riparian sites	• easily top-killed by fires (thin, flammable bark)	• occurs on riparian sites that are infrequently burned • sprouts from basal buds • wind dispersed seed may also establish new plants after a fire • not well fire adapted	• catkins, buds, and seeds provide food for grouse and many songbirds (seed mostly eaten in winter) • important cover component of riparian habitats; provides nesting cover for many songbirds • may be the most important shrub for sharp-tailed grouse in the winter

Fire Effects on Graminoids

Graminoid Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Bluebunch Wheatgrass (Bradley 1986c; Redmann et al. 1995)	• native, perennial, cool season bunchgrass • regeneration via seedlings is slow • flower stalks appear in May-June; seed ripe in late July-Aug • common throughout lower and middle grasslands, common moderate to steep warm aspects on upper grasslands	• 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)	• most important forage grass for Mule Deer, California Bighorn Sheep and livestock • plants with lower stubble height tend to be grazed more • tolerates grazing well during dormant season but is sensitive from 1-2 weeks before seed emergence until seeds are ripe
Baltic Rush (Snyder 1992)	• native, thick, mat-forming, rhizomatous graminoid • reproduces by seed and extensive rhizomes • common in wet meadows around wetlands	• fire usually only top-kills plants, leaving rhizomes unharmed	• can survive a fire by sprouting from its extensive rhizomes	• provides forage for livestock • provides cover and feeding cover for shorebirds and waterfowl
Cheatgrass (Bradley 1986)	• introduced, annual grass • germinates from fall through spring; roots are well-developed by spring and use soil moisture more effectively than native species • seeds ripen from late spring to early summer (plants are usually dry by early June) • scattered patches (sometimes forming nearly pure stands) in middle & lower grasslands (usually in disturbed areas; can out-compete native grasses once established)	• highly flammable but seeds in litter layer are usually not consumed • increases the fire hazard on a site (dense stands provide continuous fuel, cures early in the season & ignites readily) • earlier fires reduce cover of cheatgrass (spring or early summer) but increase seed production	• able to complete its lifecycle in the spring before dry summer weather begins • seeds survive in unburned organic material on the site • frequent fires favor cheatgrass by eliminating competing perennial vegetation	• can sometimes provide spring forage for livestock, Mule Deer and California Bighorn Sheep
Crested Wheatgrass (Ahlenslager 1988a)	• introduced, long-lived, tufted, perennial, cool-season, bunchgrass • regenerates by seeds & tillering • most growth completed by June, matures in early to mid summer and may regrow in the falls with adequate moisture • seeded into Dry Farm area in the early 1990's	• top-killed; tillers usually undamaged by fires	• tolerant of fire when dormant • forms new tillers after top-killing	• formerly thought to provide forage for livestock and Mule Deer, however recent studies indicate there may be little nutritive value for wildlife

Fire Effects on Graminoids, cont.

Graminoid Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Junegrass (Tirmenstein 1987)	• native, tufted, cool-season perennial; shallow root system • regenerates through seed • flowers May to June or July • seed ripens July – Sept. • common throughout all grasslands; most common on mesic sites • increases initially with grazing	• 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	• provides some forage for livestock and Mule Deer
Kentucky Bluegrass (Uchytil 1993)	• introduced, perennial, cool-season, sod-forming grass • produces abundant seed • flowers in June; seeds mature late-June to July; plants are nearly dormant by mid-summer • occurs in Aspen copses throughout & in moist swales & meadows in the middle & upper grasslands • increases with grazing and may permanently displace native grasses	• above-ground parts are consumed by fire • plants are injured most in late-spring when new foliage reaches full development and major food reserves have been depleted • dormant plants are little affected by fire	• rhizomes survive fires and initiate new growth • returns to preburn levels within 1 to 3 years (even after late spring burning) • frequent spring burning can decrease densities or eliminate it from the site after several years of burning	• forage for livestock and Mule Deer • habitat for small mammals • provides some cover for birds
Needle-and-thread Grass (Tirmenstein 1987c)	• native, long-lived, cool-season perennial bunchgrass • regenerates through seed; seeds mature in mid- to late summer and drop when ripe • seeds disperse by wind and bury themselves in the soil; seeds also attach to mammals and are dispersed by them • common on mesic and drier sites in the lower an d middle grasslands; common on steep warm aspects in the upper grasslands • often increases initially with overgrazing	• generally killed when above ground vegetation is consumed by fire • tufts may burn 2 to 3 hours after the fire passes and transfer heat below the surface • large plants with a high ratio of dead to living plant material are more susceptible to fire damage • can expect a 50% reduction of basal area after burning; can minimize damage by preventing buildup of high fuel loads prior to burning	• regenerates through seed after fire • fire is most injurious in mid-summer (when plant is in fruit) & least detrimental in spring or fall • burning after a fall rain can minimize damage • if plant is not killed by fire, recovery is relatively slow (3 to 8 years) • productivity generally reduced for 1 year & then increases gradually	• valuable forage for Mule Deer, California Bighorn Sheep and livestock (moderately palatable) • avoided for grazing when seeds are on the plant • cover for grassland nesting birds (Vesper Sparrow, Western Meadowlark) and small mammals • seeds eaten by many birds including Brewer's Sparrows

Fire Effects on Graminoids, cont.

Graminoid Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Pinegrass (Snyder 1991)	• native, perennial, rhizomatous grass • reproduces mostly from rhizomes; flowers & produces seed only in open areas • starts growth in late April or early May • summer dormancy from late August through September • most common grass in IDF forests	• top-killed by low intensity fires • fires that consume the duff layer can sometimes kill pinegrass	• regenerates by rhizomes • can reproduce by seed if the forest canopy is opened • often increases after fire	• moderate quality forage for Mule Deer and livestock (most palatable in spring and fall) • cover for small mammals
Porcupine Grass (Bailey & Murray 1978; Gerling et al. 1995; Redmann et al. 1993; Walkup 1991b)	• native, long-lived, cool-season perennial bunchgrass • regenerates through seed; seeds mature in mid- to late summer and drop when ripe • seeds disperse by wind and bury themselves in the soil; seeds also attach to mammals & are dispersed by them • common on level sites and gently sloping cool aspects of the upper grasslands; also found in swales in the middle grasslands	• 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	• low profile sites: Long-billed Curlew nesting and foraging habitat • dense, late seral and climax sites: probable habitat for Upland Sandpipers and Sprague's Pipit; possible nesting habitat for Sharp-tailed Grouse • cover for grassland nesting birds (Vesper Sparrow, Western Meadowlark) and small mammals • valuable forage for Mule Deer and livestock (moderately palatable; avoided for grazing when seeds are on the plant)
Sandberg Bluegrass (Howard & Bradley 1997)	• native, shallow-rooted, cool-season perennial bunchgrass • relatively short-lived • regenerates by tillering & seed • begins growing in very early spring; blooms in June; seeds ripen in late June-July; plants dormant by late July • common on mesic lower, middle and upper grasslands • increases with grazing	• usually unharmed or only slightly harmed by fire • fire may cause damage if there is litter buildup at the base of the plant	• generally unharmed by fire; sparse litter results in little transfer of heat to buds in the soil • matures rapidly and is dormant when most fires occur • cover often increases after fire when competition from other species is reduced by fire	• minor forage grass for Mule Deer, California Bighorn Sheep and livestock (during growing season of the grass)

Fire Effects on Graminoids, cont.

Graminoid Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Sand Dropseed (Ahlenslager 1988b)	• native, warm-season, non-rhizomatous, tufted, perennial bunchgrass • drought tolerant • reproduces by seed and expands vegetatively by tillering • prolific seed producer; seeds may lie dormant for many years • blooms in June-July & seed matures in July-August • common on warm aspects or sandy sites in the lower grasslands and steep warm aspects in the middle grasslands • increases with grazing	• tufts burn readily	• regeneration via on-site stored seed • spring fires tend to favor the growth of sand dropseed	• provides some forage for California Bighorn Sheep in the spring and winter
Spreading Needlegrass (Esser 1992)	• native, long-lived, cool-season perennial bunchgrass • regenerates through seed; seeds mature in mid- to late summer and drop when ripe • seeds disperse by wind and bury themselves in the soil • common at the forest edge and cool aspects in the upper grasslands; occasionally found in deeper swales/depressions in the middle grasslands	• top-killed by fire • moderate to severe fires may kill the plant • often displaced by tree encroachment in the absence of fire	• specific information on this needlegrass unavailable but probably susceptible to fire, especially during midsummer and when thick litter has built up	• cover for grassland nesting birds (Vesper Sparrow, Western Meadowlark) and small mammals • dense, late seral and climax sites: probable habitat for Upland Sandpipers and Sprague's Pipit; possible nesting habitat for Sharp-tailed Grouse • valuable forage for Mule Deer and livestock (moderately palatable in spring and early summer)
Timber Oatgrass (Holifield 1987a)	• native, cool-season, strongly caespitose, perennial bunchgrass • shallow, fibrous root system • reproduces by seeds and tillering or lateral spread • flowers from late June to Aug; seeds dispersed in Aug and Sept • scattered in grassland openings in the IDFdk4	• scant information available • moderate probability that at least 50% of the population will survive or reestablish after fire • may sometimes increase after fire	• moderately resistant to fire • 5 to 10 years to approximate preburn frequency or cover	• provides spring forage for livestock and Mule Deer

Fire Effects on Graminoids, cont.

Graminoid Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Water Sedge (Cope 1992)	• native, hydrophyte, long-lived perennial sedge • forms dense rhizome networks • regenerates primarily through spreading of underground rhizomes • seeds germinate on moist, exposed mineral substrates • common large water sedge found in wetlands	• only vunerable to fire during late summer and fall • low intensity fires top-kill vegetation with no damage to rhizomes & result in a temporary increase in productivity • severe fires that remove the soil organic layer may kill rhizomes of sedges	• recovers quickly from low intensity fires • rhizomes are well protected from the heat of fires • colonizes burned areas by seeds and rhizomes	• forage for Mule Deer and livestock in late summer • winter forage for horses • cover for waterfowl and other birds (Common Snipe, Common Yellowthroat, Red-winged Blackbird, Song Sparrow, Marsh Wren, Sora, Wilson's Phalarope) • cover for small mammals

Fire Effects on Herbs and Dwarf Shrubs

Herb Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Alfalfa (Sullivan 1992a)	• introduced, perennial herb with a deep taproot • grows in hay fields, road sides and areas with disturbed soils • flowers from mid-summer to early fall	• top-killed by most fires	• re-sprouts from root crowns • alfalfa seeds may be scarified by moderate-severity fires • can be spring burned prior to growth to reduce insect pests	• eaten by cattle; grown as hay • eaten by Mule Deer and California Bighorn Sheep • seeds eaten by grouse, other birds and small mammals • ducks may nest in some hayfields • Bobolinks may nest on some hay fields • Long-billed curlews may forage on fields in spring
Balsamroot (Fischer & Holifield 1987; Parish et al. 1996)	• native, cool-season perennial forb • large woody root • most common on cool aspect grasslands, most common in middle and upper grasslands • reproduces entirely from seed	• usually undamaged by fire • may occasionally be killed by unusually intense fires	• First People's used fire to increase balsamroot (Turner, 1999) • burned plants regrow from the thick caudex • increases in frequency and density after fire • following fire, plants initially produce more biomass & then produce more seed	• spring forage for cattle, Mule Deer and California Bighorn Sheep • roots, young shoots, bud-stems and seeds were important foods for First Peoples (Turner, 1997) • seeds are dispersed by animals
Blueweed (Parish et al. 1996)	• noxious weed, tap-rooted biennial forb • scattered in swales east of Churn Flats	• no information available; fire probably top-kills plants	• no information available; burning during blooming may reduce seed production	
Common Burdock (Parish et al. 1996)	• noxious weed, biennial forb • common in moist gullies and riparian areas	• no information available; fire probably top-kills plants	• no information available; burning during blooming may reduce seed production	• bristly seeds are distributed by livestock, Mule Deer and humans

Fire Effects on Herbs and Dwarf Shrubs, cont.

Herb Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Dandelion (Esser 1993)	• introduced, cool-season perennial forb with a thick taproot and rosette of leaves • flowers through spring and summer • occurs on moist, disturbed or heavily grazed sites and logged areas	• establishes during the first or second year post-fire	• recolonizes burned sites with wind-dispersed seed and seedbank seed • burning to decrease cover of dandelion should be done in the spring after growth initiation	• eaten by Sharp-tailed Grouse in the spring • provide forage for wild and domestic ungulates
Death Camas (Howard 1992)	• native, perennial, cool-season forb with grasslike leaves and bulb • growth starts in April or May; flowers in June; seed dispersal in August • reproduces by seed & bulb offsets • common on cool aspect grasslands and moist swales	• top-killed by fire	• regenerates from deep underground bulbs	• seeds, bulbs, leaves and stems are poisonous to livestock and wildlife
Diffuse Knapweed (Carey 1995)	• noxious weed; perennial forb • 1 erect, branched stem; stout taproot • prolific seed producer • in fall, plants break off at the ground and tumble along the ground spreading seeds • most seeds germinate in spring • does not occur on shaded sites • colonizes disturbed sites readily but will also colonize undisturbed grasslands • flowers in July & August • seeds mature in mid- to late-August	• low-severity fires only top kill plants • severe fires probably kill knapweed • seeds buried in the soil probably survive most fires	• probably resists low-severity fires because it has a stout taproot • may regenerate after fire from buried seeds or from off-site sources • strong seedbanker; seeds are viable for a long time	• rodents eat seeds
Kinnikinnick (Crane 1991)	• native, prostate, evergreen shrub with extensive trailing stems • leaf buds burst in June; flowers in May to June; fruit ripe in August • can spread by layering • common on some sandy sites, moist depressions and logged areas	• 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	• minor browse species for Mule Deer and California Bighorn Sheep • berries are eaten by grouse, songbirds and small mammals
Hound's Tongue (Parish et al. 1996)	• noxious weed; biennial forb • scattered in disturbed areas (roadsides) and moist areas (gullies)	• no information available, fire probably top-kills plants	• no information available; burning during blooming may reduce seed production	• hooked seeds are distributed by livestock, Mule Deer and humans

Fire Effects on Herbs and Dwarf Shrubs, cont.

Herb Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Leafy Spurge (Walkup 1991a)	• noxious weed; perennial forb • extensive root/rhizome system • seeds remain viable for as long as 8 years • invades areas with disturbed soils • flowers in May to June; seeds ripen a month later	• fire removes aboveground portions of the plant	• survives fire due to the presence of underground rhizomes • fall fires may control leafy spurge but is less effective than herbicide treatments	• seeds may be dispersed by ants, birds and rodents
Mariposa Lily (Parish et al. 1996)	• native, herbaceous perennial with a deep-seated bulb and grass-like leaves • scattered on mesic and cool aspect middle grasslands	• below-ground part of plant unlikely to be harmed by fire	• First People's used fire to increase Mariposa Lily (Turner, 1999) • likely resprouts from bulbs after fire and increases from seed production	• bulbs were an important food for First Peoples and were collected in the spring before flowering (Turner, 1997)
Nodding Onion** (Parish et al. 1996; Williams 1990)	• native, herbaceous perennial with an elongated bulb and grass-like leaves • flowers in June • common on cool aspect grasslands in lower and middle grasslands, scattered through-out the upper grasslands	• below-ground part of plant unlikely to be harmed by fire	• likely resprouts from bulbs after fire	• bulbs were an important food for First Peoples and were collected in the spring before flowering (Turner, 1997)
Pasture Sage or Prairie Sagewort (Tirmennstein 1986)	• native, low, mat-forming dwarf shrub 10-40cm tall • begins growth in April • flowers from June to September • dispersal of fruit in October • common on most mesic and drier grasslands; increases with grazing	• plants are usually killed or seriously damaged when above-ground foliage is consumed • may re-sprout after some fires	• small, wind-dispersed seeds readily reoccupy a burned site • may re-sprout after some fires	• minor forage species for Mule Deer and California Bighorn Sheep
Prickly Pear Cactus* (Holifield 1987b)	• native, perennial growing in low clumps or mats • regenerates from rooting stem segments • common in lower grasslands and warm aspects in other grasslands	• easily killed by fire • some pads and root crowns may survive in lower intensity fires	• relatively susceptible to fire; sprouts from surviving root crowns and adventitious rooting of remaining pads	
Pussytoes (Nuttall's & Rosy) (Matthews 1993a & 1993b)	• native, stoloniferous, mat-forming perennial forbs 4-30cm tall • reproduces from seed (wind-dispersed) or spreads vegetatively through stolons • common on nearly all grasslands; increases with grazing	• probably killed by most fires	• colonizes bare mineral soil from light, wind-dispersed seed	

Fire Effects on Herbs and Dwarf Shrubs, cont.

Herb Species	Silvics	Fire Effects	Fire Ecology	Value for R&B Species and Other Wildlife
Salsify (Yellow & Meadow) Clements et al. 1999	• introduced, biennial or perennial herbs with yellow flowers (dies after flowering) • grass-like leaves • extensive root system • prolific reproduction from seed • flowers in June and July • seeds germinate in the fall and spring • scattered throughout mesic and wetter grasslands	• probably top-killed by most fires	• probably re-grow from root crowns or re-establish from off-site seed • burning after bolting but before seed production may effectively be used to reduce seed production	• some birds eat seeds • minor forage species for Mule Deer and livestock
White and Yellow Sweetclover (Uchytil 1992; Sullivan 1992a)	• introduced, biennial herbs • grows in hay fields, road sides and areas with disturbed soils • flowers from mid-summer to early fall • prolific seed producer; seeds are wind-dispersed in fall	• may kill the plant or may re-grow from the tips of branches	• burning aids establishment of seed through scarification and reducing competitive cover • can reduce cover by burning annually after 2nd-year shoots are visible or during critical growing period (late summer when resources are directed to root growth)	• eaten by cattle; can be grown as hay • eaten by Mule Deer and California Bighorn Sheep when available • palatable during spring and early summer until plants become woody
Woolly Cinquefoil (Tirmenstein 1987b)	• native, perennial herb that grows from a stout caudex • flowers from June through August • common forb on mesic upper grasslands; increases with grazing	• not known if it is killed by fire	• likely re-establishes through seed	• cinquefoils are generally unpalatable to livestock and wildlife

*no information was available for *Opuntia fragilis*, thus information was used for the closely related *Opuntia polycantha*
**Fire Effects and Fire Ecology information was taken from *Allium collinum* which is presumed to respond similarly to fire
No Fire Effects information was available for Burdock, Hound's tongue, or Blueweed

Fire Effects on Lichens and Mosses

Lichen or Moss Species	Silvics	Fire Effects	Fire Ecology
Collema tenax (Matthews 1993c)	• foliose, terricolous lichen with a thick thallus; dark olive green or black • photosynthetic symbiont is capable of nitrogen fixation • drought and dessication tolerant • dominant component of microbiotic crusts in lower grasslands, very common on warm aspects and disturbed grasslands in the middle and upper grasslands	• generally destroyed by fire • patches are likely skipped over by fires in areas with patchy fuels	• dries quickly during periods of low humidity making lichens highly flammable when dry • rapidly invades burn sites by the dispersal of vegetative spores from nearby areas (tends to be the first lichen colonizer on burned sites)
Cladonia spp.	• slow-growing, long-lived ground lichens • dispersed mostly by thallus fragments • important component of microbiotic crusts on mesic and moister sites	• can survive cool fires but is almost always killed by severe fires • many grassland fires would likely skip over patches of the microbiotic crust	• highly flammable and slow to recolonize burned sites • may take 40 to 50 years for recovery where burning consumes lichens
Tortula ruralis (Matthews 1993d)	• short, erect moss that forms large, loose to dense tufts • common component of microbiotic crusts, particularly under shrubs	• severely damaged by fires	• assumed to be highly flammable under dry conditions

Fire Effects on Red and Blue Listed Plants

References: Douglas et al., 1998a & 1998b; Douglas et al., 1999; Hitchcock et al., 1969

Bold plant names are those known to occur or are very likely to occur in Churn Creek

Herb Species	Status	Silvics	Fire Effects	Fire Ecology
Allium geyeri var. *geyeri* Geyer's onion	• Red-listed • not recorded in Churn Creek	• native perennial with grass-like leaves and a bulb • may occur in lower grasslands	• below ground part of plant unlikely to be harmed by fire	• likely re-sprouts from bulb after fire
Apocynum medium Western dogbane	• Blue-listed • not recorded in Churn Creek	• perennial herb from a rhizome	• fire would likely consume above-ground parts of plants	• would likely re-sprout from rhizomes
Apocynum sibiricum* var. *salignum **Clasping-leaved dogbane**	• Blue-listed • not recorded in Churn Creek but likely to occur	• native perennial herb from a rhizome • may occur on some floodplains	• fire would likely consume above-ground parts of plants	• occurs in areas unlikely to burn; would likely re-sprout from rhizomes
Arabis holboellii* var. *pinetorum **Holboell's rockcress**	• Blue-listed • not recorded in Churn Creek but likely to occur	• likely occurs in grasslands • biennial herb, simple or branched stem-base	• would likely be consumed by fire	• would have to re-colonize from seed
Arnica chamissonis ssp. *incana* Meadow Arnica	• Blue-listed • not recorded in Churn Creek	• may occur in wet meadows in the IDF • perennial herb from a long rhizome	• fire would likely consume above-ground parts of plant	• would likely re-sprout from rhizomes
Atriplex argentea Silvery orache	• Red-listed • not recorded in Churn Creek	• may occur in saline or disturbed habitats • annual herb from a taproot		• occurs in areas unlikely to burn
Bouteloua gracilis Blue grama	• Red-listed • not recorded in Churn Creek	• perennial grass with short rhizomes	• fire would likely consume above-ground parts of plant	• would likely re-sprout from rhizomes
Catex hystricina Porcupine sedge	• Blue-listed • not recorded in Churn Creek	• may occur in wetlands • short-rhizomatous perennial	• fire would likely consume above-ground parts of plant	• occurs in areas unlikely to burn • would likely re-sprout from rhizomes
Carex saximontana var. *saximontana* Rocky Mountain sedge	• Blue-listed • not recorded in Churn Creek	• may occur in moist meadows in the IDF or MS • tufted perennial	• fire would likely consume whole plant	• would have to re-colonize site from seed
Carex simulata Short-beaked sedge	• Blue-listed • not recorded in Churn Creek	• may occur in fens in the IDF • rhizomatous perennial		• occurs in areas that would not be burned
Carex sychnocephala Many-headed sedge	• Blue-listed • not recorded in Churn Creek	• may occur in wet meadows • tufted perennial	• fire would likely consume whole plant	• occurs in areas unlikely to burn (except in fall) • would have to re-colonize site via seed
Carex xerantica **Dry-land sedge**	• Blue-listed • not recorded in Churn Creek but very likely present	• likely occurs in the grasslands • tufted perennial	• fire would likely consume whole plant	• would have to re-colonize site via seed
Castilleja tenuis Hairy owl-clover	• Red-listed • not recorded in Churn Creek	• may occur in wet meadows/vernal pools		• occurs in areas unlikely to burn

Fire Effects on Red and Blue Listed Plants, con't.

Herb Species	Status	Silvics	Fire Effects	Fire Ecology
***Chamaerhodos erecta ssp. nuttallii* American chamaerhodos**	• Blue-listed • observed in Churn Creek	• native perennial or biennial with strong taproot • common on rock shallow soils on rock outcrops in lower grasslands	• fire would likely consume above-ground parts of plants	• occurs in areas with very low fuels; very unlikely to burn • would likely re-sprout from taproot
Chenopodium leptophyllum var. *oblongifolium* Narrow-leaved goosefoot	• Red-listed • not recorded in Churn Creek	• may occur on saline or alkaline sites • annual herb from a taproot	• fire would likely consume plant	• occurs in areas unlikely to be affected by fire • would have to re-colonize site via seed
Crepis atrabarba ssp. *atrabarba* Slender hawksbeard	• Red-listed • not recorded in Churn Creek	• may occur in the grasslands • perennial herb from a taproot	• fire would consume above-ground parts of plant	• would likely re-sprout from taproot
Epilobium ciliatum ssp. *watsonii* Purple-leaved willowherb	• Blue-listed • not recorded in Churn Creek	• may occur in wet areas • perennial herb, basal rosettes	• would likely die if burned	• occurs in wet areas unlikely to burn except in fall
Euphorbia serpyllifolia Thyme-leaved spurge	• Blue-listed • not recorded in Churn Creek	• may occur on sandy or gravelly sites • annual herb that grows from a fibrous root		• occurs on sites unlikely to be affected by fire
Juncus regelii Regel's rush	• Blue-listed • not recorded in Churn Creek	• may occur in marshes or on stream banks • rhizomatous perennial	• fire would likely consume above-ground parts of plant	• occurs in areas unlikely to burn • would likely re-sprout from rhizomes
Potentilla quinquefolia Five-leaved cinquefoil	• Blue-listed • not recorded in Churn Creek	• may occur on gravelly slopes • perennial with small crown		• occurs in areas unlikely to burn
Scolochloa festucacea Sprangle-top	• Blue-listed • not recorded in Churn Creek	• may occur in ponds, marshes or streamsides • strongly rhizomatous grass	• fire would likely consume above-ground parts of plant	• occurs in areas unlikely to burn • would likely re-sprout from rhizomes
***Silene drummondii var. drummondii* Drummond's campion**	• Blue-listed • observed in Churn Creek	• native perennial herb from a taproot • commonly scattered throughout grasslands	• fire would consume above-ground parts of plant	• likely re-sprouts from taproot

Fire Effects and Prescribed Fire Objectives for Habitat of Red and Blue Listed Wildlife Species and Mule Deer

Species	Risk to individuals in critical habitats*	Timing of Critical Habitat Use	Habitat Related Fire Effect	Prescribed Fire Objectives	References
Great Basin Spadefoot	NIL: Unlikely to be affected by prescribed burning	Breed in mid- late April until July (in cool years); larvae develop in 6-8 weeks	• do not burn near breeding areas during dispersal • seems to prefer ponds with very little vegetation, thus burning is unlikely to affect breeding habitat	• none	Green & Campbell 1984; Ward and Bushey 1996b
Painted Turtle	NIL: Unlikely to be affected by prescribed burning	Females dig nests in May or June; eggs hatch in late summer; juveniles overwinter in the nest	• do not burn near nesting areas during nesting season • nesting areas are usually sparsely vegetated so little impact expected	• none	Cannings et al. 1999
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 • lack of fire could reduce area of optimal foraging habitat • do not burn adjacent to hibernacula/nesting sites from April – August	• maintain coarse woody debris • maintain forest cover in riparian areas	Cannings et al. 1999; Gregory & Campell, 1984; Province of B.C. 1997
Racer	LOW: likely to escape fires	Hibernate from Oct-Apr; disperse in Apr; mate in May; young hatch in late Aug – early Sept	• active during daylight • mostly nests in talus slopes which should be unaffected by fires • do not burn adjacent to hibernacula/nesting sites from April – August	• maintain coarse woody debris • maintain or increase area of open forested/ grassland	Cannings et al. 1999; Gregory & Campell, 1984; Province of B.C. 1997
Gopher Snake, *deserticola* subspecies	LOW: slow-moving but mostly found in hayfields and riparian areas	Emerge from hibernacula in April; mate in May; lay eggs in late June-July; young hatch in late Aug – early Sept	• mostly crepuscular (active at dawn and dusk), slow moving but burns in foraging areas (riparian areas and hayfields) are likely to be infrequent • do not burn adjacent to hibernacula/nesting sites during April or from June – September	• maintain coarse woody debris • maintain/increase open forested/ grassland area •	Cannings et al. 1999; Gregory & Campell, 1984; Province of B. C. 1997
Western Rattlesnake	LOW: not known from CCPA, likely to escape fires	Emerge from hibernacula in April; mate in Aug-Sept; fertilization occurs the next spring; young born between Aug and Oct	• mostly crepuscular; forage in grasslands near rock/talus but unlikely to be caught in a fire • do not burn adjacent to hibernacula/nesting sites from April to October	• maintain coarse woody debris • increase open forested/ grassland area	Cannings et al. 1999 Gregory & Campell, 1984

Fire Effects and Prescribed Fire Objectives for Habitat of Red and Blue Listed Wildlife Species and Mule Deer					
Species	**Risk to individuals in critical habitats***	**Timing of Critical Habitat Use**	**Habitat Related Fire Effect**	**Prescribed Fire Objectives**	**References**
American Bittern	NIL: Unlikely to be affected by prescribed burning	Breeding season ends Aug 15	• wetlands are unlikely to be burned during the breeding season (do not burn where wetlands may be burned before Aug 15)	• none	Fraser et al. 1999; Province of B.C. 1997 Province of B.C. 1999
Great Blue Heron	NIL: Unlikely to be affected by prescribed burning (unless it is a rookery site)	Nesting begins in mid-April; young fledge by mid-August	• survey forests for rookeries before burning • avoid burning around rookeries at any time	• none	Fraser et al. 1999; Province of B.C. 1997
Northern Goshawk, *atricapillus* subspecies	LOW: burning unlikely in areas used by goshawks	Lay eggs in May – June; young fledge by the end of August	• dense, ingrown forests targeted for burning are unlikely to provide Goshawk habitat • burning of ingrowth could improve quality of forests for hunting and nesting for goshawks • long-term development of understories after burning could increase prey base • continued lack of fire could reduce nesting/foraging habitat	• maintain/ promote open understory under high canopy closure in nesting areas	Campbell et al. 1990b; Fraser et al. 1999; Reynolds et al., 1992
Swainson's Hawk	LOW: unless very large areas of ingrowth are burned at one time, unlikely to affect nesting birds	Lay eggs in May – June; young fledge by mid-August; migrate south by late Aug – early Sept	• Reduction of ingrowth in forests adjacent to grasslands may improve/expand nesting habitat; continued ingrowth/encroachment could reduce nesting habitat • probably low occurrence in CCPA but burning before eggs are laid in May or in the fall would prevent loss of any young	• maintain/increase open grassland area	Campbell et al. 1990b; Cooper 1998; Fraser et al. 1999
Peregrine Falcon	NIL: nest in areas unaffected by burning	Lay eggs in April – June; young fledge by the end of July	• nests on cliffs that would be unaffected by burning (avoid burning adjacent to cliffs during nesting season) • reduction of ingrowth and encroachment may increase foraging habitat; continued ingrowth/encroachment could reduce nesting habitat	• maintain/increase open grassland area	Campbell et al. 1990b; Cooper 1998; Fraser et al. 1999
Gyrfalcon	NIL: would not be present during times of prescribed burning	Does not breed in this area; may winter in area from Nov – Mar	• continued ingrowth/encroachment could reduce winter foraging habitat	• maintain/increase open grassland area	Campbell et al. 1990b Fraser et al. 1999

Fire Effects and Prescribed Fire Objectives for Habitat of Red and Blue Listed Wildlife Species and Mule Deer					
Species	**Risk to individuals in critical habitats***	**Timing of Critical Habitat Use**	**Habitat Related Fire Effect**	**Prescribed Fire Objectives**	**References**
Prairie Falcon	NIL: nests would not be affected by prescribed burning	Return to breeding range in Mar; lay eggs in April; young fledge by early August	• nesting sites (cliffs) unlikely to be affected by burning • reduction of encroachment may increase foraging habitat; continued encroachment will reduce foraging habitat • allow intervals between grassland fires to maintain prey populations	• maintain/increase open grassland area	Campbell et al. 1990b; Cooper 1998; Fraser et al. 1999; Hooper 1997a; Tesky 1994a
Sharp-tailed Grouse, *columbainus* subspecies	LOW: avoid burning leks and breeding areas during breeding and nesting periods	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 • avoid burning Aspen copses and grassland riparian and grassland nesting areas from April to the end of August (also, do not burn too many of these sites at one time) • fire may stimulate shrub production in Aspen copses and grassland riparian areas (this could improve winter habitat) • continued encroachment could reduce summer habitat	• maintain/increase open grassland area • promote shrub and aspen cover in 2 km radius around lek sites	Campbell et al. 1990b; Connelly et al. 1998; Fraser et al. 1999; Ritcey 1995; Tesky 1994b; van Rossum 1992
Sandhill Crane	NIL: Unlikely to be affected by prescribed burning	Eggs are laid from mid-Apr to May and young are fledged by Aug	• do not burn adjacent to or in wetlands until fall (after Aug 15)	• maintain moderate density forest adjacent to occupied wetlands	Campbell et al. 1990b; Cooper 1996; Fraser et al. 1999
Upland Sandpiper	LOW: rare bird	Breeding times unknown; adults or most vocal and visible at nest sites form mid-May to mid-July	• reduction of grass cover on nesting areas could be detrimental – avoid burning in areas that birds frequent (if any are found) • studies report variable response to burning – can be positive or negative • reduction of encroachment could increase potential habitat; continued encroachment could reduce potential habitat	• maintain grass cover in occupied areas • increase area of open grassland	Campbell et al. 1990b; Fraser et al. 1999; Hooper 1997b
Long-billed Curlew	LOW-MODERATE: burning would only be detrimental if done on breeding ranges during breeding season	Arrive late Mar – early April; lay eggs from April – May; young are fledged by the end of July	• prefer low-profile vegetation on breeding range; reduction of cover using prescribed burning could be beneficial • burn potential habitats before March 15^{th} or after July 15^{th} to avoid any risk of killing birds	• maintain/increase open grassland areas	Campbell et al. 1990b; Fraser et al. 1999; Province of B.C. 1999

Fire Effects and Prescribed Fire Objectives for Habitat of Red and Blue Listed Wildlife Species and Mule Deer					
Species	**Risk to individuals in critical habitats***	**Timing of Critical Habitat Use**	**Habitat Related Fire Effect**	**Prescribed Fire Objectives**	**References**
Flammulated Owl	MODERATE: Mature Douglas-fir forests on ridge-lines and valley slopes should not be burned during nesting season	Lay eggs from May 1st – July; young fledge by mid-August	• burning during breeding season could kill birds &/or reduce nesting success • increased understory development (resulting from reduced ingrowth) should improve insect prey base • reduction of crown closure (<30%) & snag creation could expand habitat • continued lack of burning in ingrown stands could reduce breeding & foraging habitat	• maintain/create open Douglas-fir forests with thickets of small trees on slopes • retain all large trees and snags in occupied territories	Bull and Wright 1990; Campbell et al. 1990b; Fraser et al. 1999; Goggans 1986; McCallum 1994; Roberts and Roberts 1995; St. John 1991; van Woudenberg 1992; van Woudenberg 1999
Burrowing Owl	NIL: Unlikely to occur, consider fire effects only if owls are found	Arrive on breeding range in Apr; lay eggs in late Apr – early May; eggs hatch a month later; young can hunt 2 months later (early Aug)	• if a nest is located, do not burn near it during breeding season • reducing/controlling encroachment will maintain potential habitat	• maintain/increase area of open grassland	Fraser et al. 1999
Short-eared Owl	LOW: Most adults will escape fire	Lay eggs from April to June; young fledge by mid-September	• nest on grasslands with tall grasses • most adult birds escape fire; fire before fledging probably kills some juveniles • reduction of ingrowth may increase owl habitat • fires in dense grass may temporarily reduce nesting habitat • continued lack of burning could reduce foraging/nesting habitat	• maintain/increase area of open grassland with vigorous graminoid cover	Campbell et al. 1990b; Fraser et al. 1999; Hold & Leasure 1993; Howard & Griffith 1994
White-throated Swift	NIL: Inhabit areas that would be unaffected by burning	Breeding times not known; likely lay eggs in late May and fledge in late August		• none	Fraser et al. 1999

Fire Effects and Prescribed Fire Objectives for Habitat of Red and Blue Listed Wildlife Species and Mule Deer					
Species	**Risk to individuals in critical habitats***	**Timing of Critical Habitat Use**	**Habitat Related Fire Effect**	**Prescribed Fire Objectives**	**References**
Lewis' Woodpecker	MODERATE: do not burn cottonwood; avoid burning large trees &snags in open grassland areas	Arrive in early May; lay eggs from May to June; young fledge by the end of July; migrate in late August	• reduction of ingrowth in stands adjacent to lower /middle grasslands could improve habitat • avoid burning large trees and snags in open areas and forests adjacent to lower/ middle grasslands • do not burn grassland riparian areas with cottonwood trees (these are the most important nest trees) • continued lack of burning in open Douglas-fir that are becoming ingrown could reduce nesting/foraging habitat	• maintain all large trees and snags • promote berry producing shrub abundance	Campbell et al. 1990b; Cooper et al. 1998; Fraser et al. 1999; Tobalske 1997
Sage Thrasher	LOW: burning of sage in early spring or fall would not affect any individuals	Arrive in May; lays eggs from June – July; young fledge by mid-August; migrate in late Aug – September	• requires dense, tall Big Sage for nesting (>70% cover) • fires that kill tall Big Sage and extensive areas of Big Sage would destroy nesting habitat • do not burn sage in areas Sage Thrashers are observed (if they are observed) • burning small patches of sage infrequently should not adversely affect Sage Thrashers	• retain large dense sage in occupied areas	Campbell et al. 1997; Cannings 1995a; Fraser et al. 1999; Reynolds et al. 1999
Yellow-breasted Chat	LOW: burning shrubby areas in early spring or fall would not affect any individuals	Arrive in late May; eggs are laid shortly after; depart in mid-July to early August after young fledge	• there is unlikely any need to burn dense shrubby areas (riparian and shrubland sites) that Chats nest in • incidental burning of nesting sites could increase shrub density and improve nesting habitat a few years after burning	• maintain/enhance shrub cover in riparian areas	Campbell et al. 1997; Cannings 1995b; Fraser et al. 1999

Fire Effects and Prescribed Fire Objectives for Habitat of Red and Blue Listed Wildlife Species and Mule Deer					
Species	**Risk to individuals in critical habitats***	**Timing of Critical Habitat Use**	**Habitat Related Fire Effect**	**Prescribed Fire Objectives**	**References**
Brewer's Sparrow, *breweri* subspecies	LOW: burning sage in early spring or after mid-September should not affect any individuals	Arrive in early May; young fledge by mid-July; depart in September	• use moderately open sage for nesting (~30% cover) • usually do not nest in sage areas with >50% cover • local observations suggest that these sparrows may prefer moderate to steep sage slopes – such slopes are unlikely to carry fires • fires in sage (particularly sage >50% cover) that result in partial kills could improve nesting habitat • severe fires that burn sage might destroy some nesting habitat • burning small patches of sage infrequently should not adversely affect Brewer's sparrows • continued lack of burning could result in areas of big sage that become too dense for breeding habitat	• maintain/enhance areas of moderately dense sage areas	Campbell et al. 1997; Fraser et al. 1999; Rotenberry et al. 1999; Sarell & McGuinness 1996
Lark Sparrow	LOW: burning sage in early spring or fall should not affect any individuals	Arrive in late May; depart in late August	• nest in open sage • probably quite rare; breeding requirements not well known • do not burn areas that individuals are seen using	• maintain/enhance areas of moderately dense sage areas	Campbell et al. 1997; Fraser et al. 1999
Bobolink	NIL: Inhabit areas that would not be burned during their breeding season	Arrive in late May; depart in August	• breeds in hayfields • unlikely to be affected by fire – if there is a need to burn hayfields it should be done in early spring or fall	• none	Campbell et al. 1997; Fraser et al. 1999
Pallid Bat	LOW: not known from CCPA	Breed from Oct to Dec; implantation delayed until spring; young born in early summer & are weaned 2 months later	• roosts in areas unlikely to be affected by burning • prefer to forage in areas with sparse vegetation; these areas are unlikely to carry a fire	• none	Cannings et al. 1999; Chapman et al. 1994; Holroy et al. 1994; Nagorsen & Brigham 1993
Townsend's Big-eared Bat	LOW-MODERATE: mostly roots in areas unlikely to be affected by burning but sometimes roosts in snags and old buildings	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; continued ingrowth in Douglas-fir stands could reduce foraging habitat	• retain all large trees and snags • promote open Douglas fir forests with thickets of smaller trees	Cannings et al. 1999; Holroy et al. 1994; Nagorsen & Brigham 1993

Fire Effects and Prescribed Fire Objectives for Habitat of Red and Blue Listed Wildlife Species and Mule Deer

Species	Risk to individuals in critical habitats*	Timing of Critical Habitat Use	Habitat Related Fire Effect	Prescribed Fire Objectives	References
Spotted Bat	LOW: roosts in areas unlikely to be affected by burning	Probably mate in fall; young born in July	• roost in cliffs unlikely to be affected by burning • forage in a wide variety of habitats (usually within 2 km of their roosting cliff and with some water nearby); unlikely to be affected by patch burns	• none	Cannings et al. 1999; Garcia et al. 1995; Holroy et al. 1994; Nagorsen & Brigham 1993
Fringed Myotis	LOW-MODERATE: mostly roots in areas unlikely to be affected by burning but sometimes roosts in snags and old buildings	Breed in fall; implantation in April – May; 1 young born in late June – mid-July; young remain in nursery colonies until October	• avoid extensive burning of riparian areas & aspen copses • do not burn old buildings • avoid burning snags near grasslands	• retain all snags and large trees	Cannings et al. 1999; Holroy et al. 1994; Nagorsen & Brigham 1993; Rasheed et al. 1995
Western Small-footed Myotis	LOW: roots in areas unlikely to be affected by burning (except that it sometimes roosts in old buidlings)	Probably mate in fall; implantation is delayed and young born from mid June to mid July	• avoid extensive burning of sagebrush and riparian areas (foraging areas) • do not burn old buildings	•	Cannings et al. 1999; Holroy et al. 1994; Nagorsen & Brigham 1993
Great Basin Pocket Mouse	LOW: usually in burrows during the day	One to two litters are born in the summer	• fire has little direct effect on fossorial mammals in their burrows (they are mostly active at night) • tend to converge on recent burns	• increase open grassland area	Cannings et al. 1999 Howard & Bushey 1996a
Fisher	NIL: unlikely to be affected by burning		• large spruce and cottonwood in forested areas unlikely to be targeted for prescribed burns	• retain all large trees and snags in riparian areas •	Cannings et al. 1999
California Bighorn Sheep	LOW-MODERATE: burning should be avoided near lambing areas during the lambing season	Mate in Oct-Nov; lambing in April-May; young are weaned 4-6 months later	• fire exclusion has allowed conifers to establish on grasslands, has decreased the forage & security values on many ranges • burning ingrowth & encroachment adjacent to large grassland areas can increase visibility, allowing sheep to see predators and potentially expand habitat • burning can be used to improve areas with old, unpalatable bluebunch wheatgrass • continued ingrowth and increased areas of 'iron' bluebunch wheatgrass could reduce the area of optimal habitat	• increase quantity and palatability of forage species adjacent to escape terrain • reduce encroachment in potential forage areas	Cannings et al. 1999 Tesky 1993

Fire Effects and Prescribed Fire Objectives for Habitat of Red and Blue Listed Wildlife Species and Mule Deer

Species	Risk to individuals in critical habitats*	Timing of Critical Habitat Use	Habitat Related Fire Effect	Prescribed Fire Objectives	References
Mule Deer	LOW-MODERATE:	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 small-diameter ingrowth could improve quality/amount of spring & winter forage • reduction of encroachment could increase spring foraging areas • continued lack of burning on encroachment could reduce spring range	• increase quantity and palatability of forage species • reduce forest ingrowth • maintain Douglas-fir canopy closure in accordance with Mule Deer Management Committee	
Badger	NIL: unlikely to occur in CCPA, unlikely to be affected by burning	Breed in summer; implantation delayed until Dec-Feb; young born in March-May; young disperse in summer	• hunt nocturnally and are protected from fire in the day by staying in burrows	• maintain/increase open grassland area	Cannings et al. 1999
Grizzly Bear	NIL: unlikey to be affected by burning	Hibernate from Oct-Nov to April-May; mate in spring – early summer; cubs usually born in the den	• burning in forests may increase cover of some forage species	• promote cover of berry producing shrubs and succulent vegetation	Cannings et al. 1999

*Risk refers to the direct possibility of an animal being killed in a fire or harmed by a fire; indirect effects are noted in 'Habitat Related Fire Effects'
Other: avoid burning wetlands and wet meadows adjacent to water bodies during spring and summer
avoid burning Aspen copses, Aspen stands and riparian areas from May to mid-August (breeding season of most birds that would be affected)

Critical Times for Red and Blue Listed Species in Churn Creek Protected Area

critical times for species

species present

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
AMPHIBIANS												
Great Basin Spadefoot	*Dispersal times may potentially be critical - surveys are required*											
REPTILES												
Painted Turtle					*breeding*				*juveniles overwinter*			
Rubber Boa			*dispersal*	*breeding*								
Racer				*dispersal*	*breeding*							
Gopher Snake, *deserticola* subspecies				*dispersal*	*breeding*							
Western Rattlesnake				*dispersal*				*breeding*				
BIRDS												
American Bittern					*breeding*							
Great Blue Heron					*breeding*							
Northern Goshawk, *atricapillus* subspecies				*breeding*								
Swainson's Hawk					*breeding*							
Peregrine Falcon				*breeding*								
Gyrfalcon												
Prairie Falcon				*breeding*								
Sharp-tailed Grouse, *columbainus* subspecies			*leks*	*breeding*								
Sandhill Crane					*breeding*							
Upland Sandpiper					*?breeding?*							
Long-billed Curlew				*breeding*								
Flammulated Owl					*breeding*							
Burrowing Owl				*breeding*								
Short-eared Owl				*breeding*								
White-throated Swift					*?breeding?*							
Lewis' Woodpecker					*breeding*							
Sage Thrasher						*breeding*						
Yellow-breasted Chat					*breeding*							
Brewer's Sparrow, *breweri* subspecies					*breeding*							
Lark Sparrow					*?breeding?*							
Bobolink					*?breeding?*							
MAMMALS												
Pallid Bat	? ?	? ?	? ?			*young*					? ?	? ?
Townsend's Big-eared Bat							*young*					
Spotted Bat	? ?	? ?	? ?				*?young?*				? ?	? ?
Fringed Myotis	? ?	? ?	? ?				*?young?*				? ?	? ?
Western Small-footed Myotis							*young*					
Great Basin Pocket Mouse						*?young?*						
Fisher												

California Bighorn Sheep	*lambing*
Badger	*young*
Grizzly Bear	

Fire Effects on Critical Habitats

Habitat*	Dominant Vegetation Species in Habitat	Possible Red and Blue Listed Using Habitat**	Timing to Avoid Burning	Fire Effects & Ecology	Prescribed Fire Recommendatio
Aspen copse (in grassland areas)	Trembling Aspen Prickly & Prairie Roses Common & Western Snowberry Kentucky Bluegrass	(Flammulated Owl) Fringed Myotis Gopher Snake (Lewis' Woodpecker) Racer Rubber Boa Sharp-tailed Grouse Spotted Bat Townsend's Big-eared Bat Western Small-footed Myotis	May – mid-August; winter for Sharp-tailed grouse	• Shrubs and trees would be top-killed by fire • Most trees and shrubs would re-sprout after fire • Cover would be reduced for several years; aspen height/trunk size would be reduced for at least 10 years	• Avoid burning snags, large diameter trees and any trees with cavities • Avoid consuming large coarse wood debris • Not particularly desirable to burn but would recover shrub structure after a number of years • Stagnant stands that are not regenerat may be stimulated to sucker by burning
Aspen forest (IDF and higher elevations)	Trembling Aspen Douglas Maple Prickly & Prairie Roses Red-osier Dogwood Water Birch	Fisher Fringed Myotis Gopher Snake (Lewis' Woodpecker) Racer Rubber Boa Sharp-tailed Grouse Spotted Bat Townsend's Big-eared Bat Western Small-footed Myotis	May – July; winter for Sharp-tailed Grouse	• Shrubs and trees would be top-killed by fire • Most trees and shrubs would re-sprout after fire • Cover would be reduced for several years; aspen height/trunk size would be reduced for at least 10 years	• Avoid burning snags, large diameter trees and any trees with cavities • Avoid consuming large coarse wood debris • Not particularly desirable to burn but would recover shrub structure after a number of years
Buildings	n/a	Fringed Myotis Townsend's Big-eared Bat Western Small-footed Myotis		• Buildings would generally be consumed by most fires	• Do not burn buildings designated as critical habitats
Cultivated field	Alfalfa	Bobolink Fringed Myotis Gopher Snake Long-billed Curlew Racer Rubber Boa Short-eared Owl Spotted Bat Townsend's Big-eared Bat Western Small-footed Myotis	Late May to late August	• Alfalfa is top-killed by fires and generally re-sprouts after fire • would only be likely to burn in spring before growth or in late fall if field was not hayed	• Avoid burning only if bird surveys indicate presence of bobolinks
Douglas-fir slope, crest of hill, base of hill	Douglas-fir Pinegrass Bluebunch Wheatgrass	Flammulated Owl Lewis' Woodpecker Townsend's Big-eared Bat	Late April to mid-August	• Larger trees usually survive fire, small trees may be killed • Grasses will mostly regenerate vegetatively after fire • May be some increase in shrub production (e.g. snowberry)	• Burn prescriptions should be designe reduce ingrowth but maintain large trees snags and some patches of small trees

Fire Effects on Critical Habitats, cont.

Grassland Lower	Big Sage Bluebunch Wheatgrass Junegrass Needle-and-thread Grass	Brewer's Sparrow Lewis' Woodpecker Racer Rubber Boa Western Small-footed Myotis California Bighorn Sheep Mule Deer	Early May to late August	• Big sage usually killed by fire • Bluebunch wheatgrass will usually regenerate vegtatively after fire; Junegrass and Needle-and-thread grass are often killed but regenerate readily from seed	• Fires should be small and patchy in tl habitat type • Avoid burning areas where Brewer's sparrows nest (surveys will be needed to determine this)
Middle	Bluebunch Wheatgrass Junegrass Needle-and-thread Grass	Long-billed Curlew Western Small-footed Myotis California Bighorn Sheep Mule Deer	April – July	• Bluebunch wheatgrass will usually regenerate vegetatively after fire; Junegrass and Needle-and-thread grass are often killed but regenerate readily from seed	• Fire may improve curlew habitat; avo burning during nesting season
Upper	Porcupine Grass Bluebunch Wheatgrass Spreading Needlegrass Timber Oatgrass	Long-billed Curlew Rubber Boa Short-eared Owl Spotted Bat Swainson's Hawk Upland Sandpiper Western Small-footed Myotis California Bighorn Sheep Mule Deer	April – July for Curlew April – mid-September for Short-eared Owl	• Majority of grasses will likely re-sprout vegetatively after fire; seed production may be increased • Cover would be reduced for several years	• Fire may improve curlew habitat; avo burning during nesting season • Some patches of denser grass should retained (not burned) to provide habitat f other birds
Open water	floating aquatics algae	Fringed Myotis Gopher Snake Great Basin Spadefoot Gyrfalcon Lark Sparrow Northern Goshawk Painted Turtle Peregrine Falcon Racer Spotted Bat Townsend's Big-eared Bat Western Small-footed Myotis	N/A	• Will not burn	N/A
Open water (marsh)	Sedges (eg Water Sedge) Rushes (eg Baltic Rush)	Great Basin Spadefoot Racer Gopher Snake Painted Turtle Peregrine Falcon Fringed Myotis Spotted Bat Townsend's Big-eared Bat Western Small-footed Myotis	N/A	• Unlikely to be dry enough or have enough fuel to carry a fire (except in exceptionally dry years) • Most rushes and sedges would re-sprout from rhizomes	• Unlikely to be affected by burning

Fire Effects on Critical Habitats, cont.

Riparian Riparian (marsh) Riparian + vernal ponds	Trembling Aspen Black Cottonwood Hybrid White Spruce Common & Western Snowberry Douglas Maple Prickly Rose & Prairie Rose Red-osier Dogwood Sandbar Willow Willows Water Birch Baltic rush Other rushes Sedges Saltgrass Cattails	Great Basin Spadefoot Gopher Snake Racer Rubber Boa Western Rattlesnake American Bittern Flammulated Owl Lewis' Woodpecker Sharp-tailed Grouse Yellow-breasted Chat Fisher Fringed Myotis Spotted Bat Townsend's Big-eared Bat Western Small-footed Myotis	May – August for nesting birds; winter for Sharp-tailed Grouse	• Shrubs and trees would be top-killed by fire • Most trees and shrubs would re-sprout after fire • Cover would be reduced for several years • Higher elevation riparian sites with Hybrid White Spruce likely would not have burned historically and the spruce trees would be killed by fire • Most rushes and sedges would re-sprout from rhizomes	• Avoid burning riparian sites, especial those with large diameter cottonwood, spruce or aspen • Avoid burning snags, large diameter trees and any trees with cavities • Avoid consuming large coarse wood debris • Not desirable to burn these sites unde most circumstances but would recover shrub structure after a few years; tree structure would take many decades to recover
Rock, cliff, or talus	minimal vegetation aside from rock lichens	Gopher Snake Racer Rubber Boa Western Rattlesnake Lewis' Woodpecker Peregrine Falcon Prairie Falcon White-throated Swift Fringed Myotis Pallid Bat Spotted Bat Townsend's Big-eared Bat	March – April dispersal; breeding during May to mid-September	• Unlikely to have enough fuel to carry a fire • Avoid burning adjacent to these sites during dispersal and breeding	• Nesting birds might be affected by smoke of adjacent fires • Avoid burning large Douglas-fir trees present
Shrubland	Prickly Rose & Prairie Rose Common & Western Snowberry Sandbar Willow Wolf Willow	Gopher Snake Racer Rubber Boa Lewis' Woodpecker Sharp-tailed Grouse Yellow-breasted Chat Fringed Myotis Spotted Bat Townsend's Big-eared Bat Western Small-footed Myotis	May – August; winter for Sharp-tailed Grouse	• Most shrubs would be top-killed by fire • Most shrubs would re-sprout after fire • Shrub cover would be reduced for several years	• Not particularly desirable to burn but would recover shrub structure after a number of years
Vernal Pond	Baltic Rush Saltgrass	Great Basin Spadefoot Townsend's Big-eared Bat	N/A	• Unlikely to be dry enough or have enough fuel to carry a fire except possibly in late fall	• Unlikely to be affected by burning
Very open forest (= scattered trees in grassland)	Douglas-fir Ponderosa Pine Bluebunch Wheatgrass Junegrass	Lewis' Woodpecker Western Small-footed Myotis	May – July	• Larger trees usually survive fire, small trees may be killed • Grasses generally regenerate vegetatively after fire	• Efforts should be made to retain larg older trees and snags especially those wi cavities

*Definitions of habitat types can be found in the document 'Churn Creek Protected Area Critical Habitat Maps' (Iverson and Roberts, 1999); species lists are specific to the particular sites Churn Creek that were mapped as critical habitats
**Species lists are derived directly from the Critical Habitat Map databases