Junction Sheep Range Provincial Park
Prescribed Fire Management Plan

Final Report

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Junction Sheep Range Provincial Park. Bunchgrass range near the Fraser River showing encroachment and in-ingrowth of Douglas-fir on cool aspects.

California Bighorn Sheep at Junction Sheep Range Provincial Park.

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Disclaimer

This prescribed fire management plan was prepared for Junction Sheep Range Provincial Park using the best available knowledge and local expertise within the limits of the time and funding constraints allowed for the project. While the prescribed burn parameters suggested in this report should not represent unacceptable risks to public safety or escapement from park borders, all prescribed burns carry some level of risk. The risk of prescribed burning to identified (Red and Blue-listed) plant and animal species with known or probable occurrence within the park has been examined and formed an important part of the development of burn prescriptions. Site specific field surveys to examine the occurrence of Red and Blue-listed species within suggested burn units should be performed prior to any prescribed burns being carried out.

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1. Background and Problem Analysis

Established in 1995 by the Cariboo-Chilcotin Land Use Plan, Junction Sheep Range Provincial Park (JSR) is a 4500 hectare park located at the confluence of the Chilcotin and Fraser Rivers within the Fraser River Basin Ecosection (Figure 1). JSR protects some of the most pristine grasslands in the Cariboo-Chilcotin including the BGxh3 and BGxw2 biogeoclimatic units. These landscapes provide important habitat for several wildlife species of concern including California bighorn sheep (*Ovis canadensis californiana*), Long-Billed Curlew (*Numenius americanus*), Flammulated Owl (*Otus flammeolus*) and the Rubber Boa snake (*Charina bottae*). A number of Red and Blue-listed plant species also occur or have probable distributions within the park. Until 1995, this park was managed as a Wildlife Management Area. The Wildlife Branch conducted prescribed burns in the 1970s and early 1980s with the objective of enhancing forage quality and availability for California bighorn sheep. Since this time, no subsequent burns have been performed.

Junction Sheep Range Provincial Park consists of grasslands and forested areas that have historically been subject to frequent, low intensity fires. Such a fire regime is characteristic of natural disturbance type 4 (NDT 4), a fire maintained ecosystem. The fire frequency for NDT 4 ecosystems historically is thought to have ranged from 4 to 50 years (FPC Biodiversity Guidebook 1995). Parminter (1978) calculated a fire frequency of 9.8 years for a study site close to JSR. These periodic surface fires would help maintain a specific vegetative and wildlife species composition and a forest stand structure characterized by open canopies and limited shrub growth. However, due to fire suppression throughout the 1900s, the frequency of fire has decreased dramatically. In many areas of the dry interior, fire has been excluded from the environment for 30 to 90 years (Daigle 1996).

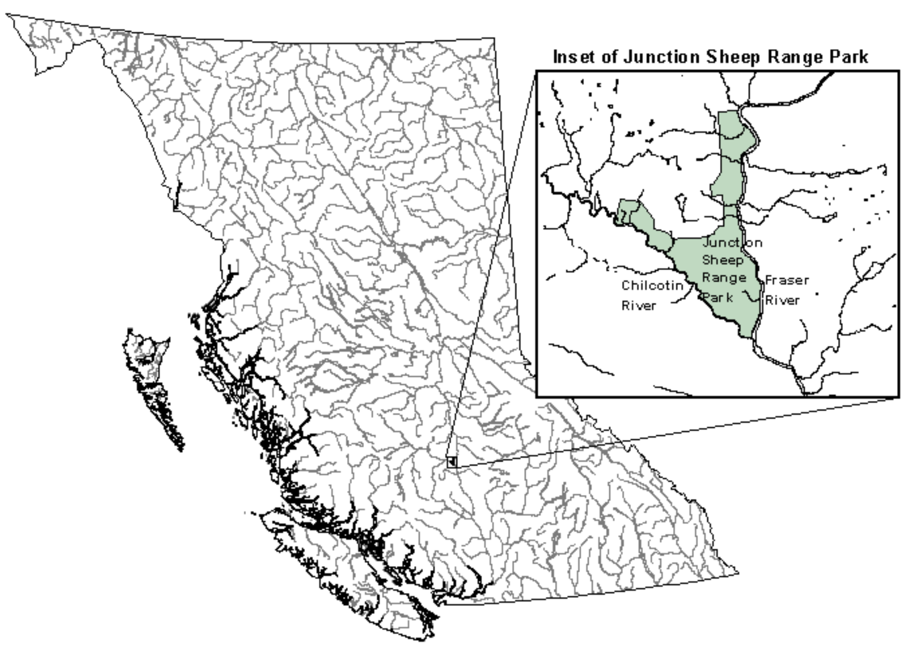


Figure 1. Location of Junction Sheep Range Provincial Park in BC.

A major issue affecting the management of grasslands within JSR and the entire Cariboo-Chilcotin region is the loss of grasslands due to forest encroachment and in-growth. At the regional scale, forest encroachment has significantly reduced the area of grasslands and open range over the past 100 years within the Cariboo-Chilcotin. It is estimated that more than 20 000 ha, or about 11 per cent of the total grasslands in the region, have experienced forest encroachment since the early 1960s (preliminary data from the DRAFT Cariboo-Chilcotin Grasslands Strategy Working Group 1999). Locally, documented grassland loss can range as high as 30 per cent (Ross 1997). The total grassland area lost to forest encroachment from the late 1800s to 1960s is currently unknown but is generally considered to be unacceptably high. The virtual elimination of grassland fires following European settlement is considered to be the primary cause of forest encroachment in the Cariboo-Chilcotin region (Braumandl 1995, Gayton 1996, Ross 1997).

The loss of grasslands within the Cariboo-Chilcotin has serious implications for the conservation of biodiversity and landscape-level patterns/processes. The Cariboo-Chilcotin grasslands support a major part of the biodiversity of British Columbia; grasslands comprise less than 2 per cent of the total regional land cover yet they support 36 per cent of the current provincial species of concern (Hooper and Pitt 1995). The conversion of grasslands to forested environments could also lead to a shift from a disturbance regime of NDT 4 to NDT 3 (frequent, stand initiating fire events). Such a shift in disturbance regimes would have major implications for landscape patterns, wildlife-habitat associations and fire management. Grassland loss also has implications for the ranching industry of the area, as historical herd numbers can not be maintained on a decreasing land base. Maintaining and restoring grassland environments such as JSR is therefore considered a priority.

The purpose of this prescribed fire management plan is to develop an ecosystem-based approach to re-introducing fire into the management of Junction Sheep Range Provincial Park. Some of the factors that have been considered in the development of this fire management plan include weather, fire behavior and fuel characteristics as well as plant, wildlife, fire and landscape ecology. Any prescribed fire management plan developed for JSR must consider potential negative effects on the variety of Red and Blue-listed plant and animal species that are known or are suspected to occur within the park. Habitat requirements and ecology of these species form an important component of this prescribed fire management plan.

2. Objectives

The objectives of this prescribed fire management plan are as follows:

- Document the state of forest encroachment and in-growth in JSR and recommend a prescribed fire management plan to restore or reclaim problem areas;

- Produce a prescribed fire management plan that will re-introduce fire to JSR in a manner that is ecologically-based and that does not cause significant negative impacts on identified plant and animal species of concern.

3. Ecological Setting and Disturbance History

JSR is located at the confluence of the Chilcotin and Fraser Rivers within the Fraser River Basin Ecosection (Figure 1). The park contains some of the most pristine grasslands in the Cariboo-Chilcotin including the BGxh3 and BGxw2 biogeoclimatic units (Map 1). These landscapes provide important habitat for several Red and Blue-listed plant and animal species. The park is comprised of a series of gently-sloping plateaus and benches dissected by steep, variable aspect slopes and gullies. Bunchgrass, primarily bluebunch wheat grass (*Agropyron spicatum*), needle-and-thread grass (*Stipa* spp.) and sage (*Artemesia* spp.), are found on the flat terrain and gentle slopes while various structural stages of Douglas-fir forests are contained mainly in depressions and on the cool aspect, sloping terrain. Small groves of deciduous forest are also scattered about JSR. Several depressions with shallow open water bodies create moist riparian areas in this arid landscape. Steep, active gullies and extreme slopes remain largely unvegetated or sparsely vegetated. Most identified species rely in some way on the grassland and sage habitat elements within the park.

JSR is considered to be a fire maintained system (NDT 4). The fire frequency for NDT 4 ecosystems is thought to have ranged historically from 4 to 50 years (FPC Biodiversity Guidebook 1995). Frequent, low intensity surface fires burning through the grassland areas and grassland-forest transitions assisted in limiting forest conditions to cool aspects and depressions. The cause of such fires was both natural, through lightning ignitions, and anthropogenic, through First Nation use of prescribed fire for forest and range management. This pattern of fire maintained a matrix of contiguous grasslands, transitional grassland-forest, and contiguous, open-canopy forest environments. The historical role of fire and general fire ecology of Cariboo-Chilcotin ecosystems is summarized by many documents (Parminter 1978, Strang and Parminter 1980, Wikeen and Strang 1983, Ross 1997).

The Wildlife Branch conducted prescribed burns in the 1970s and early 1980s with the objective of enhancing forage quality and availability for California bighorn sheep. Since this time, no subsequent burns have been performed and no natural fires have occurred within the park.

Insert Map 1 – Photo Mosaic of JSR with BEC zones

4. Methods

Most methods for this project necessitated remote sensing or desktop mapping. A limited field sampling program was completed in early October, 1999, to verify desktop mapping exercises and recommendations. An aerial overview flight was also performed during the field sampling portion of the project.

4.1 FOREST ENCROACHMENT AND IN-GROWTH

Detailed quantitative study of forest encroachment and in-growth was beyond the scope of this prescribed fire management plan. To provide a preliminary quantification of forest in-growth and encroachment conditions within JSR, a 50-year chrono-sequence of aerial photographs were selected for three general areas within the park. The photographs were taken at approximately 10-year intervals. The photographs represent a mix of color and black and white panchromatic, and were acquired at scales ranging from 1:15,000 to 1:30,000. The three locations were selected along an east-west transect across Ross Gulch, in the north section of the park, from the open range west of the JSR boundary to the Fraser River. These three areas represent a range of landscape conditions as outlined below (landscape conditions are described in Section 4.2.3):

Area 1. Ross Gulch to Fraser River

(a) cool aspect-steep slopes
(b) cool aspect-moderate slopes, warm aspect-moderate slopes
(c) cool aspect-steep slopes

Area 2. Upper Ross Gulch (outside park)

(a) warm aspect-moderate slopes
(b) cool aspect-moderate slopes
(c) warm aspect-moderate slopes, cool aspect-moderate slopes

Area 3. Prairie edge west of Ross Gulch

(a) cool aspect-moderate slopes
(b) cool aspect-moderate slopes, warm aspect-moderate slopes.

Within each of the three areas, the same two or three groups of stands and stand edges were selected on each of the photos to examine forest in-growth and encroachment changes throughout the 45-year period and by decade. Site visits helped to verify the interpretation of the aerial photographs. Table 1 lists the airphoto sets used in this analysis.

Table 1. Airphoto sets used to examine and quantify forest in-growth and encroachment near Ross Gulch in the north section of JSR.

YEAR	AIRPHOTO JOB	FRAMES
1950	BC1133	38, 69, 86
1962	BC4042	77, 79, 81
1974	BC7616	181, 183, 185
1986	BCC513	38, 40, 42
1995	BCC95075	19, 21, 23

4.2 DISTURBANCE HISTORY AND LANDSCAPE STRATIFICATION

4.2.1 Disturbance History

The limited duration and budget available for the development of this prescribed fire management plan precluded the development of a detailed fire history analysis of JSR. The general fire ecology of the NDT 4 Cariboo-Chilcotin grasslands is well documented and is directly applicable to the development of prescribed burn prescriptions for the park. Due to the geographic proximity of the study area, Parminter (1978) and Parminter (pers. commun., Oct. 07, 1999) formed the primary references for developing fire frequency parameters within JSR. Determining historical fire size distributions for grassland areas is extremely difficult due to the low intensity of the burns and the near absence of datable fire evidence following the event. Even in grassland-forest transition areas, surface fires may not always leave a scar on veteran trees. Parminter (1978) was not able to determine fire size distributions on the Dester Ridge study area. A near absence of historical fire size information exists for grassland areas. However, given the close association between abiotic site conditions and the historical fire ecology of grassland ecosystems, fire size may not be as important of a consideration in the development of prescribed burn parameters for NDT 4 BG biogeoclimatic units as in stand initiating forest ecosystems. To provide a regional context for fire history within the JSR region, the BC Fire Atlas and Lightning database were consulted. The Carrier Chilcotin Tribal Council was also consulted to discuss First Nations historic and current use of fire in the region.

4.2.2 Documenting Previous Prescribed Burns

Historical hardcopy prescribed burn reports and maps provided by the BC Ministry of Environment, Lands and Parks formed the primary source of prescribed burn documentation. Several prescribed burns were performed in JSR during the 1970s and early 1980s. Hand drawn fire sketch maps displayed on various scales of topographic base maps and on an uncorrected aerial photomosaic of JSR were heads-up digitized to allow merging with other digital information. Field surveys of old prescribed burn sites were conducted to examine current vegetation conditions.

4.2.3 Landscape Characteristics

Digital base map coverage for JSR is provided by TRIM 092.078, .079, .088 and .089. Using 1:20,000 TRIM base mapping, a digital elevation model (DEM) of the project area was created. Two sources of vegetation information exist for JSR: 1) BC MoF 1:20,000 scale forest cover mapping and 2) Biophysical Habitat Mapping produced by Fenger and Demarchi (1992); a third source was created specifically for this project. Forest cover mapping was found to be of limited use within JSR due to the non-stand initiating nature of fire within the park. Age-class estimates determined through forest cover mapping are intended mainly for forested landscapes characterized by stand initiating disturbances. In a NDT 4 disturbance regime like JSR, there is no way to determine/represent the potentially numerous surface fires that have affected the forest and grassland communities. While of a detailed nature, the mapping of Fenger and Demarchi (1992) is currently unavailable in a digital format. This situation limits the utility of this detailed vegetation community mapping to be incorporated with other data sources. However, this mapping was useful as a visual interpretive data source for the major vegetation conditions within the park. An uncorrected digital airphoto mosaic was also created for the park by scanning individual 1:15,000 scale color photographs (BCC95075). These photos were mosaic-ed in a graphics program and registered to the TRIM base. This airphoto mosaic was used as a product for visual display and was useful for general mapping purposes within JSR.

Similar to most other mid-high latitude arid landscapes, one of the most important controls over the distribution of vegetation communities within the Cariboo-Chilcotin area are slope and aspect conditions. Differences in slope and aspect conditions create large soil moisture differences between cool and warm aspects. These differences are one of the primary determinants of vegetation pattern within JSR. Given the generally strong correlation between slope and aspect conditions and vegetation communities and the absence of a detailed vegetation map that could be incorporated with other digital information sources, JSR was stratified into the major slope and aspect units to produce a landscape stratification based on physiographic characteristics. The physiographic conditions listed below (Table 2) appeared to influence the pattern of vegetation to a large degree within the park, as determined on a visual examination of aerial photographs and the Biophysical Habitat Units (Fenger and Demarchi 1992). Table 2 describes the five physiographic classes used to represent landscape characteristics within JSR. Due to the strong correlation between slope and aspect conditions and vegetation communities within JSR, it is probable that fire patterns and patterns of forest in-growth and encroachment will also show some correlation to these terrain classes. Some fire ecology studies have found strong linkages between fire history and landscape characteristics (Francis 1996, AEM 1998). In many ways, the current Natural Disturbance Type (NDT) stratification for the Province of British Columbia reflects these principles, but on a more generalized, regional basis (FPC Biodiversity Guidebook 1995). The landscape units suggested within this report reflect the fine-scale variability that would be created by local terrain features.

Such an approach has a number of advantages over the use of traditional vegetation mapping for park planning units or fire management units:

- Physiographic conditions are relatively static and are well suited to map-based applications. Vegetation communities can change over time, as evidenced by the current in-growth and encroachment observed in JSR.
- The use of physiographic units (landscape units) allows for park planning units and fire management units to be integrated. Such integration will ultimately be necessary to achieve long-term, ecologically-based park management goals.

Table 2. Physiographic parameters used to stratify the JSR landscape into its major slope and aspect conditions.

LANDSCAPE UNIT	ASPECT CONDITION	SLOPE CONDITION	DESCRIPTION
1	Flat (none)	Flat (0^o-10^o) or (0%-22%)	Flat plateaus, benches, terraces and gentle slopes mainly occurring along the interior of JSR. This unit contains the most extensive cover of bunchgrass vegetation.
2	Cool	Moderate – Steep (10^o-40^o) or (22%-89%)	North and easterly (cool) aspects on moderate (10^o-40^o) slopes. This landscape unit contains the most heavily forested areas in JSR and is situated mainly along the Fraser River.
3	Cool	Extreme (>40^o) or (>89%)	North and easterly (cool) aspects on very steep (>40^o) slopes. These units contain sparse forest cover and in some cases are non-vegetated due to active slope processes.
4	Warm	Moderate – Steep (10^o-40^o) or (22%-89%)	South and westerly (warm) aspects on moderate (10^o-40^o) slopes. This landscape unit generally contains sporadic bunchgrass-sage-shrub and open forest.
5	Warm	Extreme (>40^o) or (>89%)	South and westerly (warm) aspects on very steep (>40^o) slopes. These units contain sparse vegetation cover and in some cases are non-vegetated due to active slope processes.

4.3 WILDLIFE SPECIES OF CONCERN

Several animal species of provincial concern (Red and Blue-listed species) have a documented or probable occurrence within JSR. These species rely primarily on the grassland and sage habitats contained within the park and adjacent landscapes. Both provincially and regionally, grasslands comprise a very small percentage of the total land cover yet contribute to a large proportion of the provincial biodiversity. The loss of grasslands through forest encroachment is therefore an important conservation issue for these species. Habitat requirements and general ecology of each identified species were reviewed from existing literature with input from regional species specialists. Potential prescribed fire effects for each species were summarized and recommendations made to mitigate potential significant negative impacts of a prescribed fire program for JSR.

4.4 PLANT SPECIES OF CONCERN

Several plant species of provincial concern (Red and Blue-listed species) have a documented or probably occurrence within JSR. Some of these plant species occur in both the grassland and sage environments but many are found along steep bluffs and rock outcrops of the Chilcotin and Fraser River canyons. To address potential fire effects on these plant species, habitat requirements and general ecology of identified plant species were reviewed by regional plant specialists. Potential prescribed fire effects for each species were summarized and recommendations made to mitigate potential significant negative impacts of a prescribed fire program for JSR.

4.5 FIRE WEATHER CLIMATOLOGY

The BCFS Fire Weather Network of stations archived by the BCFS Protection Program was investigated for a suitable benchmark station to represent JSR. Historical fire weather climatologies and Canadian Forest Fire Weather Index (FWI) System climatologies were calculated by month. Probability of ignition climatologies for four benchmark fuel types and fire behavior climatologies for thresholds of potential crown fire behavior in the most representative benchmark fuel type for JSR were calculated by month.

Lightning occurrence trends were examined using BCFS Protection Program archived lightning data for the period 1982-1995. Lightning activity was quantified for a 460.5 km^2 area bounded by 51.70°N - 51.90°N and 122.30°W - 122.55°W.

4.6 FIRE PRESCRIPTIONS AND RECOMMENDATIONS

In order to make recommendations for an ecologically-based prescribed fire management plan, it was necessary to review the documentation concerning objectives, accomplishment and assessment of the past burning program on JSR. In addition, current prescribed burning research and operational programs in similar ecosystems were reviewed, experts consulted, and operationally tested prescriptions tailored to the vegetation conditions and management objectives recommended for JSR. Identified wildlife species ecology and habitat requirements were also considered. Fire prescription planning tools in current use were consulted and fire weather and FWI climatologies used to determine historical occurrence of suitable burn days by month and year.

5. Results and Discussion

5.1. FOREST ENCROACHMENT AND IN-GROWTH

Observations during the October field reconnaissance gave the impression that forest encroachment and in-growth was significant on cool (north and east) aspects of all mid-and-upper slopes in JSR. Airphoto interpretation of the three selected areas along the east-west transect at the north-end of JSR confirmed these field observations (Figure 2).

The 45- year record of changes can be summarized as follows:

Area 1. Ross Gulch to Fraser River:

(a) East-facing slopes north of Ross Gulch from ridge at 1000 m to Fraser River breaks at 600 m has changed from open forest to closed (Douglas-fir) forest, including some encroachment down slope at mid-slope elevations, and significant in-growth. The west-facing (warm aspect) slopes of this ridge have not changed significantly from open range with scattered trees.
(b) South of Ross Gulch, from west park boundary at 760 m elevation to bench at 550 m. Northeast aspects have changed from mostly open forest to mostly closed forest, primarily by in-growth, plus some encroachment down slope. Southwest aspects of these draws have not changed significantly from open range and very open forest.
(c) South of (b) from west park boundary at 975 m elevation, east aspects to 450 m elevation at breaks above Fraser River. These slopes have changed from very open forest to closed forest with some narrow open forest stringers. Some limited encroachment onto prairie west of park boundary; little or no encroachment down slope towards Fraser River.

Area 2. Upper Ross Gulch:

(a) Upper Ross Gulch, north and south aspects. Southeast aspects at 760 m elevation above Ross Gulch have changed from open forest to closed forest.
(b) North aspects from 1070 m elevation down to Ross Gulch at 760 m show significant encroachment into previously large open range patches with scattered trees, changing them to closed forest, and to dense forest in some areas.
(c) Southwest of (b), hilltop at 1130 m. Some encroachment up west and north aspects, as open range is changing to open forest on warm aspects and from open forest to closed forest on cool aspects.

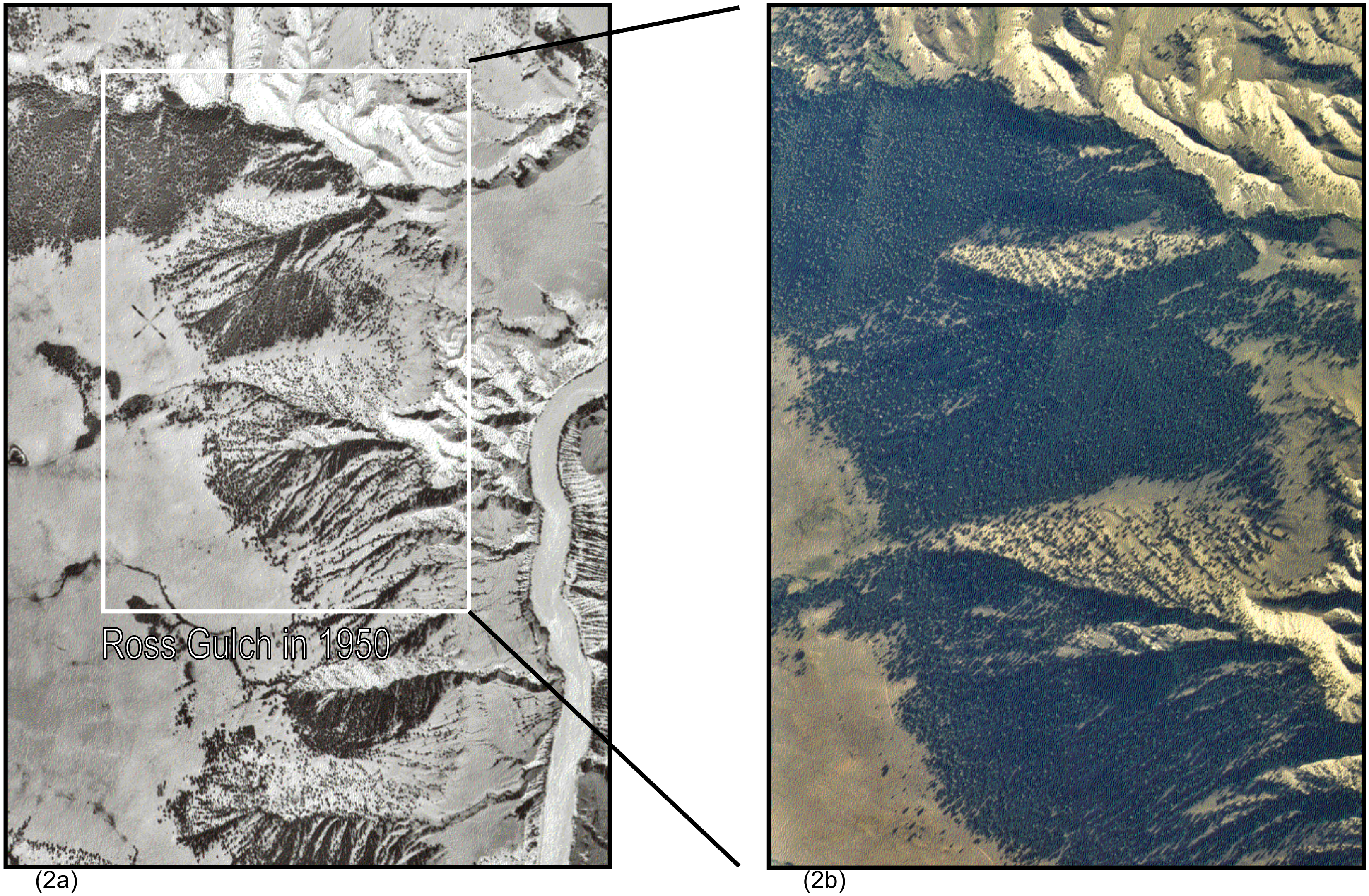


Figure 2. North Fraser Unit, Ross Gulch area, Junction Sheep Range Provincial Park, showing encroachment and in-growth of Douglas-fir on cool aspects between 1950 (2a) and 1995 (2b) aerial photographs.

Area 3. Prairie edge west of Ross Gulch

(a) Prairie with scattered trees at 950 m elevation has changed to open forest due to both encroachment and in-growth.
(b) Low, round hill on prairie shows significant encroachment and in-growth on cool aspects, which have changed open range to open forest and open forest to closed forest. Little change has occurred on warm aspects.

On an interval basis, no significant in-growth or encroachment was observed at any of the visual sample plates between 1950 and 1962. In-growth was noticeable between 1962 and 1974 at Area 1b and 1c, and both in-growth and encroachment were visible at Area 2b, 2c and 3b. Further significant in-growth was evident at Area 1b and 1c, Area 2a, b and c, while noticeable in-growth and encroachment was present at Area 3a and b between 1974 and 1986. Finally, between 1986 and 1995, very significant in-growth was noted at Areas 1a, b and c, and significant in-growth at Area 2a, b and c and Area 3a.

Based on the interpretation of a 45-year airphoto record and site reconnaissance, the following statements summarize our qualitative observations of forest/range dynamics in JSR:

- It is clear that during the last 25 years, both in-growth and encroachment of Douglas-fir are significantly reducing the area of open forest and range with scattered trees, while areas of closed forest and dense forest are increasing.
- Limited change is evident on warm aspects, but on cool (north and east) aspects at mid and upper elevations, even very minor topographic features (shallow draws and depressions) show significant tree encroachment and in-growth. These ecotones highlight the pattern of vegetation change at the grassland/forest interface but equally significant is the closing of the Douglas fir forest canopy over large areas of cool aspect slopes.

The implications of these vegetative changes are discussed within the context of recommended fire prescriptions and objectives in Section 5.5 below.

5.2 DISTURBANCE HISTORY AND LANDSCAPE STRATIFICATION

5.2.1 Disturbance History

5.2.1.1 Recent Fire History

The BC Forest Service Fire Protection fire history database records only three fires in the JSR area for the period 1950-1995. One lightning fire and two person-caused fires are recorded during this interval. All fires were relatively small although a 600 ha person-caused fire burned west of the park, south of Ross Gulch, in 1980.

In order to facilitate the calculation of recent fire occurrence densities in the JSR area, a 460.5 km^2 area centered on JSR and bounded by 51.70^{o}N - 51.90^{o}N and 122.30^{o}W - 122.55^{o}W, was examined. The BCFS Protection fire database records a total of 119 fires within this area for the period 1950-94. Almost twice as many of the fires were people-caused as lightning-caused, and about one-third of the people-caused fires were recreation-oriented. People-caused fire occurrence density for the JSR area is 1.87 fires/25km^2/20 years, rated medium by the *BC Forest Practices Code Fire Management Guidebook*. Lightning fire occurrence, at 1.06 fires/25km^2/20 years, is also rated medium.

5.2.1.2 First Nations Use of Fire

First Nations generally carried out “prescribed burns” to improve hunting through wildlife habitat enhancement (grass and shrubs) and to stalk and drive game, to enhance food plants (berry bushes) as well as special-purpose and medicinal plants. They also burned horse grazing areas, cleared campsites with fire to reduce fire hazard and enemy cover, and burned open forests to reduce fire hazard and to facilitate travel. A detailed cultural heritage overview has been prepared specifically for the Cariboo Forest Region by Alexander (1997). However, according to this report, there is little information available on First Nations use of grasslands. The Carrier Chilcotin Tribal Council still practice annual early spring burns in this region (pers. commun. Bert Groenenberg, Nov. 25, 1999). The major aims of the spring burning are to enhance grass production for horses and to keep forests open for human and animal travel. A reported increase in fire activity in the region was associated with the gold rush in the 1850’s and 60’s.

5.2.1.3. Fire History Reconstruction

The collection and reconstruction of detailed fire history information for JSR was beyond the scope of this study. A number of relevant sources of historical fire disturbance information exist for JSR and the Cariboo-Chilcotin grasslands region. Parminter (pers. commun. Oct. 7, 1999) provided several sources for mean fire return intervals at various locations surrounding JSR, including his own study of forest in-growth and encroachment at Dester Ridge (Parminter 1978). For the Dester Ridge study area, 28 km northwest of JSR, a mean fire return interval of 10.4 years was calculated for the period 1759-1926. At the time of the 1977 Dester Ridge study, the project area had not experienced a fire since 1926, or 51 years. This 51 year fire-free interval was well beyond any historical fire-free period detected during the previous 167 years. For the Gang Ranch study area, 25 km southeast of JSR, a mean fire return interval of 14.0 years was calculated for the period 1678-1958. Similarly, mean fire return intervals of 21 years were found for two locations in the Dog Creek area, approximately 23 km to the southeast of JSR. These studies spanned the intervals of 1758-1968 and 1717-1968. All of these studies examined fire history on the upper benches and plateaus of the grasslands through the use of fire scar analysis.

Parminter concludes that fire frequency of the upper elevations and plateaus of JSR should be similar to the above studies, averaging between 10-20 years. This is generally verified by the numerous, multiply-fire scarred veteran trees scattered about the benches and upper forested slopes of the park. Many of these Douglas fir veterans were observed to contain at least five visible fire scars and many more would probably have been detected if the trees were felled and disks collected. It is also possible that many more fires may have actually occurred than are recorded by the fire scar record, as very light surface fires probably did not leave scars on the thick, fire-resistant bark of the mature Douglas Fir trees. No record of their occurrence is therefore available.

While these studies provide mean fire return intervals for the respective study areas, spatially explicit fire frequency by landscape unit is currently not known. While the mean fire return intervals are probably adequate to describe the frequency of fire on the upper plateaus, it is not currently known if the 10-20 year mean fire return interval applies to all landscape units of JSR. It would be expected that the steep slopes leading down to the Chilcotin and Fraser Rivers would probably limit fire occurrence and fire size. Lightning fire ignitions in the lower Chilcotin and Fraser River canyons would be rare and fuel discontinuities due to very steep slopes and irregular topography would limit fire size and the down slope movement of fire. Human use of the lower canyons and steep side slopes would also be expected to be less. Differences in relative humidity, thermal heating and the resultant vegetation changes would also create a situation where cool aspect slopes would probably have a lower fire frequency than warm aspect slopes.

The likely occurrence of differential fire history by landscape unit provides the ecological rationale for stratifying the park into the major physiographic conditions discussed in Section 5.2.3. Basing prescribed fire and fire management planning on these units has an ecological basis as different rates and extents of fire would be expected.

5.2.2 Prescribed Burn History

Documented prescribed burns in JSR were carried out in seven different years. Table 3 provides a summary of the years and area burned. Map 2 shows the location of the different treatments. A 282 ha undocumented (unmapped) burn was apparently conducted in 1977. The total area prescribed and actually burned in these eight years of treatments between 1975 and 1986, including documented and undocumented burns, is 1505 ha (approximately 35 per cent of the total park). All burns were conducted in the spring, between March 17 and April 23. Most of the burns were conducted on the steep east and northeast slopes above the Fraser River, and the moderate slopes and benches above the junction of the Fraser and Chilcotin Rivers. In addition to these areas, an area above the Chilcotin River near the west park boundary was partially burned in 1978.

Table 3. Documented prescribed burns within JSR.

DATE	AREA BURNED (ha)*	PERCENTAGE of TOTAL PARK
1975	4.45	0.10
1976	11.74	0.26
1977	282.19	6.17
1978	457.49	10.00
1979	133.60	2.92
1980	495.95	10.85
1983	100.00	2.19
1986	20.00	0.43
TOTAL	1505.42	34.26

*Burn areas obtained from prescribed burn reports and may not correspond to GIS calculated areas due to difference in map base and scale. Areas burned should be viewed as approximate.

A review of the prescribed burn reports can be summarized by the following statements:

- The early spring burning window (mid-March to mid-April) that has been used for all JSR burns to date has produced fires too low in intensity to accomplish vegetation management objectives related to encroachment and in-growth of Douglas-fir on cool aspects.
- Burn objectives related to increasing quality and yield of key bunchgrass species, important to California bighorn sheep and mule deer populations, on cool and warm aspects and on flat to rolling benches of JSR, have generally been met by the early spring burns carried out to date.
- On-site documentation of the pre-burn and burn day weather conditions has generally been insufficient to provide adequate feedback to the prescription development process. However, it does appear that light to moderate winds from the prevailing south or southeast direction during ignition are essential to achieving fire spread and coverage on the steep slope cool aspects. This appears to be especially important during the early spring window when fuel moisture (fine, medium and heavy fuel) is still high, snow patches are still present in cool aspect draws, and solar radiation received on cool aspects is minimal.
- While aerial ignition using the Premo/PFC Aerial Ignition Device (AID) system ("ping-pong balls") has produced satisfactory burn coverage on grass-covered benches and moderate slopes, the AID system is not suited to lighting steep slopes on cool aspects where fuels are not continuous. The helitorch is more cost effective for ignition under these conditions. Pre-burn preparation for fireguards, such as black lining along roads, trails, topographic breaks such as gullies can be done effectively and cheaply with hand-held ignition devices such as drip torches.
- Quantitative sample plot measurements of prescribed burn effects on vegetation and soils were carried out in 1976, and confirmed that the highest impact burn was associated with the achievement of burn objectives related to improving grass quality and yield, eradication of Big Sage, and no significant impact on soil chemistry. The only significant change in forage quality measured was that grass on burned plots contained significantly less undigestible fibre (% Acid Digestible Fibre (ADF)) than unburned plots. Forb production decreased and pasture sage increased. Impacts on trees were not well documented with quantitative sample plots, but photographs suggest that flame heights were generally too low to consistently torch and/or cambium kill Douglas-fir trees of any significant size (>2m height).
- Attempted burning on the "Chilcotin Unit" sage and cactus-dominated steep slopes and benches above the Chilcotin River did not cover well due to sparse grass and fuel discontinuities.

Insert Map 2. Prescribed Burn History.

5.2.3 Landscape Units

Map 3 demonstrates the location and extent of the five different landscape units identified within JSR. Table 4 reports the distribution of the different landscape units. Vegetation patterns appear to be strongly correlated with the different landscape units recognized in this prescribed fire management plan. The central grassland portion of JSR is composed of relatively flat plateaus and gentle slopes; bunchgrass prairie is the most prevalent vegetation cover. The “Chilcotin Unit” along the Chilcotin River canyon is comprised of moderate-steep and extreme warm aspect slopes, broken only by localized, flat benches. These warm aspect slopes provide mixed bunchgrass, sage, cactus and non-vegetated areas. Small pockets and individual Douglas fir trees are scattered across the slope. The “Fraser Unit”, occurring along the east slopes of the park, is comprised predominantly of moderate-steep and extreme cool aspect slopes. The highest percentage of forest cover is found on cool aspect slopes along the Fraser Canyon. Forest encroachment and in-growth was also observed to be the most advanced within this landscape unit.

Table 4. The distribution of major landscape units within JSR.

LANDSCAPE UNIT	LANDSCAPE CONDITIONS	AREA (ha)	PERCENTAGE of TOTAL PARK
1	flat	904	19.76
2	cool aspect – moderate-steep slopes	1059	23.15
3	cool aspect – extreme slopes	767	16.77
4	warm aspect – moderate-steep slopes	1076	23.52
5	warm aspect – extreme slopes	768	16.80
	TOTAL	4574	100.00

Insert Map 3. Landscape Units.

5.3 WILDLIFE SPECIES OF CONCERN

The Cariboo-Chilcotin region contains a substantial portion of the biodiversity of British Columbia. Table 5 lists the nine provincial wildlife species of concern with known or probable occurrence in JSR. The following sections present a summary of the ecology and known habitat requirements of the wildlife species as they relate to the objectives of this prescribed fire management plan. Unless otherwise stated, much of this discussion has been adapted from the BC Forest Practices Code Accounts for Identified Wildlife.

Table 5. BC wildlife species of concern with known or probable occurrence in JSR.

Taxonomic Name	Common Name	List
Spizella breweri	Brewer's Sparrow	Red
Ovis candensis californiana	California Bighorn Sheep	Blue
Otus flammeolus	Flammulated Owl	Blue
Numenius americanus	Long-Billed Curlew	Blue
Charina bottae	Rubber Boa	Blue
Tympanuchus phasianellus	Sharp-Tailed Grouse	Blue
Asio flammeus	Short-Eared Owl	Blue
Bartramia longicauda	Upland Sandpiper	Red
Ictera virens	Yellow-Breasted Chat	Red

Three general habitat types, related strongly to the major landscape units, occur within JSR:

a) The steep, cool aspect slopes of the Fraser River Canyon are largely wooded with various structural stages of Douglas-fir forests.

b) The flat to gently-sloping interior plateaus and terraces of the park are largely grassland habitat.

c) The steep, warm aspect slopes of the Chilcotin contain grassland-sage-cactus habitats.

Very steep, sparsely vegetated bluffs, gullies and rock outcrops occur along both river canyons. A generalized wildlife habitat map can therefore be created for JSR illustrating the potential distribution of species of concern within the park (Figure 3). These habitat classes are a more generalized version of the Biophysical Habitat Map produced by Fenger and Demarchi (1992). Potential species distributions reflect the known habitat requirements of the nine Red and Blue-listed wildlife species discussed below.

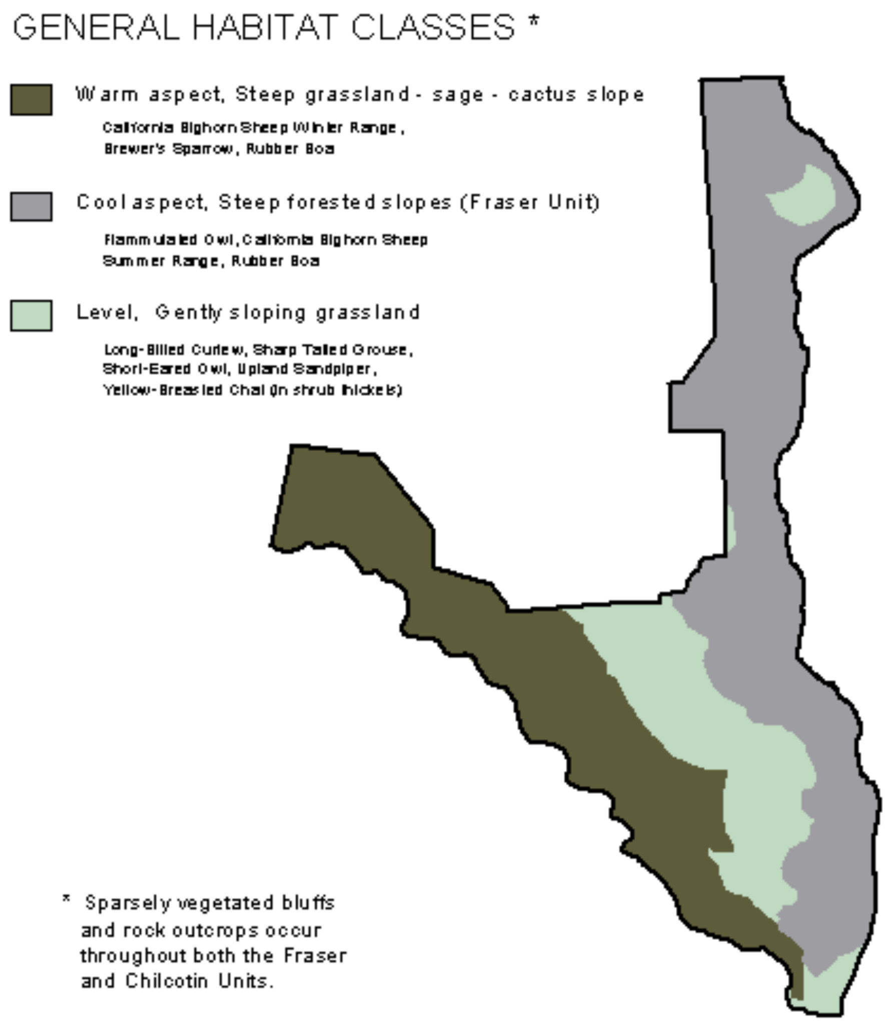


Figure 3. Related strongly to the landscape units described in Section 5.2.3., three general habitat types occur within JSR. Potential wildlife-habitat associations are listed.

5.3.1. Brewer's Sparrow (*Spizella breweri breweri)*

Sarell and McGuinness (1996) form the primary reference for the Brewer's Sparrow in British Columbia. The Brewer's Sparrow is a nondescript Spizellid known for the male birds' elaborate breeding vocalizations. This bird species breeds in arid sagebrush-grasslands throughout western North America but is Red-listed in British Columbia. Brewer's Sparrow breeds in only 14 confirmed sites within BC, none of which are currently protected. Brewer's Sparrow is an opportunistic open-ground forager, with diet composition determined by seasonal availability. They migrate to BC in late April to early May, and depart on fall migration in late August or early September. In BC, Brewer's Sparrow lays a single clutch of 2-5 eggs in early May to mid-June; fledging begins in late June to late August. This bird has been known to use the same breeding areas annually. Protection of existing breeding sites is therefore important to the provincial conservation of this species.

Changes in sagebrush plant density appear to have the greatest impact on habitat use. Brewer's Sparrows have been known to nest in half their former numbers during the breeding season following sagebrush destruction by herbicides. Also, short-term nesting declines have been observed following wildfire in tall sagebrush habitats as a result of decreased nesting opportunities. However, it should be noted that the loss of sagebrush-grasslands through forest encroachment or development would represent a permanent habitat loss.

5.3.2. California Bighorn Sheep (*Ovis canadensis californiana*)

Wild sheep are threatened by past overgrazing, competition with domestic stock and other ungulates, land alienation and human encroachment. They are also threatened by disease, particularly those transmitted by domestic sheep. California Bighorn Sheep are currently Blue-listed in BC. Bighorn sheep are predominately grazers, relying on grassland habitats. Grasses, sedges and forbs comprise the majority of bighorn food but up to 25% of the diet may be shrubs such as sage, saskatoon, bearberry, juniper and willow. Breeding occurs in November. Ewes give birth to lambs from April-May on steep, rugged escape terrain adjoining the winter range grasslands. The limiting habitat for bighorn sheep is adequate winter range. Two types of winter range are recognized - normal winter range and severe winter range. In the occasional severe winter, the priority for sheep is relief from the energy drain of pushing through snow. Large canopied trees may provide this relief. In normal winters, the priority for sheep is access to food in areas that provide predator escape terrain. Most herds winter on low-elevation, south- and west facing slopes where relatively warm temperatures and a lack of persistent snow permit sheep to locate food. In the Cariboo-Chilcotin, south- and west-facing (warm aspect) grassland slopes with scattered Douglas-fir forests provide the majority of winter habitat. Escape terrain is critical on winter ranges and is usually provided by steep rock bluffs and canyons with narrow ledges, rugged rocky slopes, talus slopes, and dense timber patches bordering the winter foraging sites.

Low-elevation bunchgrass ranges on south- and west-facing slopes (warm aspects), adjacent to suitable escape terrain and water, provide winter habitat for all ages of sheep and spring lambing areas. A mixture of conifers of varying age classes, either in clumps within the grasslands, or bordering the grasslands, provide some cover, but adjacent rock bluffs, ledges, canyons and steep slopes are critical. Visibility is an important factor for wild sheep: they select ranges where their view is unrestricted by standing timber, high shrubs, brush or other obstructions.

Given these known requirements, the highest capability sheep habitat within JSR would be the warm aspect slopes along the Chilcotin River canyon. This area would also represent critical winter habitat. Sheep would obviously use the entire park at various times of the year, but the critical winter periods would probably be spent foraging along the slopes leading down to the Chilcotin River. Given the mobility of these large ungulates and their reliance on the Chilcotin River canyon slopes as critical winter habitat, limited prescribed burning on the upper plateaus and cool aspect, Fraser River canyon forested slopes would probably be generally positive for sheep, as fire can maintain grassland communities and improve forage availability.

5.3.3. Flammulated Owl (*Otus flammeolus*)

van Woudenberg (1999) forms the primary reference for the Flammulated Owl in British Columbia. The Flammulated Owl is a small, secondary cavity-nester that breeds in dry, old-growth Douglas fir-ponderosa pine forests in southern and central BC. These areas represent the most northern-extent of their North American range. Provincially, the Flammulated Owl is Blue-listed. This owl species is insectivorous and is dependent on structured old-growth IDF forests. They are a long-lived species with low fecundity. The Flammulated Owl migrates southward between early September and mid-October. Spring migrants tend to arrive in BC early in May. This owl lays 2-3 eggs, which it incubates for approximately 24 days. Depending on spring weather conditions and the location of the nest, fledging can range from mid-July to late-August.

The Flammulated Owl requires critical foraging, security, and nesting features to meet its life requisites during the nesting period. Flammulated Owls require a heterogeneous forest structure with a multi-layered canopy and old-growth structural elements including snags with cavities for nesting. The understory component of these forest habitats is generally comprised of grasses and low shrubs. Flammulated Owls require an open forest canopy and appear to avoid dense stands of small diameter Douglas-fir.

Prescribed fire may be a management option to maintain Flammulated Owl habitat as an open forest canopy with mixed-diameter classes. Retaining adjacent mature-veteran trees that range in diameter from 30 to 80 cm as well as existing patches of thickets should be a component of the Flammulated Owl fire prescription. Some authors have advocated mechanical fuel reduction and thinning in closed-canopy Douglas-fir stands, and then reintroducing low-intensity fire cycles as a management tool for Flammulated Owls (Covington and Moore 1992).

5.3.4. Long-Billed Curlew (*Numenius americanus*)

The Long-Billed Curlew is a Blue-listed grassland bird with sandy brown plumage, long legs, and a long decurved bill for capturing insect prey. It nests in dry, open grasslands with low profile vegetation, including severely grazed areas. Nests are shallow scrapes on the ground, often placed beside an object like a stone or pile of animal dung. Incubating birds depend on their cryptic plumage to camouflage their presence. The breeding season extends from late March through late July. After this time, broods are moved to moister sites where young chicks can forage on smaller, more abundant insects. Breeding pairs return year after year to traditional nesting sites. The long-billed curlew requires large contiguous openings of native grassland with a low vegetative profile for nesting. Openings used for nesting should be at least 250 m wide, and preferably wider. Disturbance from humans or livestock should be limited during the breeding season.

Potential curlew habitat within JSR is confined primarily to major patches of landscape unit 1, flat to gently-sloping areas of the park with bunchgrass prairie. Similar to other ground nesting grassland birds, the Long-Billed Curlew would potentially be a concern during prescribed burns. Wildlife Habitat Area planning objectives clearly state that fire should not be used in nesting areas. This identified species would be most at risk from prescribed burning in the spring (mid-March) to mid-summer (July), when the curlew is breeding and nesting in the bunchgrass prairie. Prior to the development of detailed prescribed burn boundaries, detailed field surveys should probably be performed to identify Curlew nesting areas.

5.3.5. Rubber Boa (*Charina bottae*)

The rubber boa is secretive and semi-fossorial, usually occurring in rotting logs or under rocks, logs or bark. Like other species of snakes, it is active between April and November. Mating occurs in late spring and live young are born in the fall. During the rest of the year, it hibernates in dens that may be communal but rarely contain other species of snakes. When the snakes leave the dens in spring, they disperse to summer foraging sites, which are usually riparian areas. It preys primarily on rodents, which it kills by constriction. Home ranges may be smaller than those of other snake species.

This species burrows in wildlife trees (upright or on the ground) and lives under loose bark or between the soil-tree interface of fallen trees. Coarse woody debris between decay classes 6 and 9, and larger debris pieces (>10 cm diameter) are particularly important. It appears to require plenty of low cover (e.g., coarse woody debris) or soil suitable for burrowing. Rock outcrops provide hibernating and nest sites, sunning areas and support prey species.

The habitat requirements for the Rubber Boa indicate that the forested areas and limited riparian zones of JSR would be the most important habitats. However, rocky outcrops and non-vegetated, steep slopes are probably also used. This species appears to use a wide range of habitats within JSR but the forested ecotones and wooded slopes of the Fraser River canyon perhaps have the highest capability. The burrowing ability of this species and the scattered distribution of the snake within the park would probably result in limited direct prescribed burn impacts on the Rubber Boa. However, maintaining adequate levels of standing and downed coarse woody debris in areas where the Rubber Boa may be present should be an operational goal during the implementation of prescribed fires in JSR.

5.3.6. Sharp-Tailed Grouse (*Tympanuchus phasianellus*)

The Sharp-Tailed Grouse is a Blue-listed grassland bird species that is at risk in BC from habitat loss due to intensive livestock grazing and grassland conversion. The Sharp-Tailed Grouse is dependent on grasslands with some brush cover. This grouse is a true lek species; males defend small territories on traditional "dancing grounds" where they compete for mating opportunities. Leks are usually located in low, sparse vegetation allowing good visibility and unrestricted movement (i.e grasslands). Grouse nest on the ground among tall grasses or in brushy, wooded areas among the grasslands. This species generally lays 12 eggs which are incubated for 24 days. Nesting and fledging occurs in late May to mid-June. Chicks are fully independent within 6 to 8 weeks.

Fire is considered to be an important factor in creating and maintaining Sharp-Tailed Grouse habitat (Kruse and Piehl 1986, Fire Effects Information System 1996). Being a grassland species, grouse have existed with periodic grass fires and nests and eggs have been known to survive these events. Recently burned areas appear to be used by Sharp-Tailed Grouse as active lek sites have been recorded in recently burned grasslands. Some researchers believe that Sharp-Tailed Grouse increase in density in burned versus unburned areas. Fires may result in negative impacts however. Severe fires in autumn may eliminate the entire winter food and cover resource, making winter survival in that area nearly impossible. Other researchers advocate that prescribed fire should not be used during the spring breeding and summer fledging periods due to the potential destruction of nests, eggs or chicks. To mitigate these negative impacts, the location of known lek sites should be confirmed with the Wildlife Officer, MELP, Williams Lake, prior to any detailed prescribed burn planning.

5.3.7. Short-Eared Owl (*Asio flammeus*)

The Short-Eared Owl is a Blue-listed species in decline due to habitat loss. This owl is primarily a grassland species that depends on open meadows and grasslands for its primary prey species, the meadow vole, which comprises 90% of its diet. The Short-Eared Owl is weakly migratory meaning that nesting, hunting, and wintering habitats are generally the same. This owl nests on dry ground in open areas with dense herbaceous (grass) cover. Eggs are generally layed between early March and mid-June, with incubation requiring approximately 25 days. The young owls fledge after about 30 days.

Although much of the Short-Eared Owl decline can be attributed to urbanization, at least some is probably due to the succession of open plant communities to closed ones as a result of fire suppression (Fire Effects Information System 1996). The Short-Eared Owl has existed in the grassland fire environment for thousands of years and periodic fire is therefore considered to be an important agent of habitat maintenance for this species. The use of prescribed fire after the nesting and fledging stage, so that young owls are not lost to fire, would represent the least direct impacts to Short-Eared Owls. However, similar to most other ground-nesting bird species, Short-Eared Owl nests and eggs have been recorded to survive light grass fires (Kruse and Piehl 1986). Burning during the nesting season, therefore, does not totally eliminate reproduction of ground-nesting birds such as the Short-Eared Owl. If burning is to occur during the nesting season (spring and early summer), partial burning is recommended in order to create a patchy mosaic of burned and unburned habitat elements (Fire Effects Information System 1996).

5.3.8. Upland Sandpiper (*Bartramia longicauda*)

Hooper (1997) forms the primary reference for the Upland Sandpiper. The Upland Sandpiper is an inland-nesting shorebird with a confirmed presence in the Cariboo-Chilcotin. However, within the region, the Upland Sandpiper is rare and should be considered threatened. The species is Red-listed in BC due to low population numbers and localized distribution patterns. This bird is a local breeding summer visitant in the Cariboo-Chilcotin. The middle grasslands of JSR may provide suitable habitat for Upland Sandpipers but this bird species has not been recorded in the park. The Upland Sandpiper is largely insectivorous and similar to the Long-Billed Curlew, requires areas with flat topography and low vegetation profile. It nests in large, open, flat grasslands along grassland-woodland ecotones. In the Cariboo-Chilcotin, egg laying probably occurs in the last week in May or the first week of June. The Upland Sandpiper will incubate its eggs for 24 days but the chicks leave the nest only 24 hours after hatching. The chicks fledge five weeks after leaving the nest. Some Upland Sandpipers have been known to show philopatry, where they return annually to previous nesting sites. Important causes of nesting failure are egg infertility, livestock trampling and predation.

Upland Sandpiper nesting densities have sometimes been found to be highest on grasslands managed by prescribed fires. However, there appears to be little difference in mean hatching success between undisturbed and burned grasslands. Some studies have reported short-term post-burn declines that may be related to reduced protective cover for nesting and decreased available invertebrate food resources. Hooper and Pitt (1995) recommend that the use of prescribed fire should not be used for maintaining Upland Sandpiper habitat in the Cariboo-Chilcotin region due to potential short-term impacts on habitat and food resources. However, these authors also note that potential Upland Sandpiper habitat in the Caribou-Chilcotin may be declining due to forest encroachment into the grasslands.

5.3.9 Yellow-Breasted Chat (*Icteria virens*)

The Yellow-Breasted Chat is a large insectivorous neotropical migrant warbler. This species is Red-listed in BC due to a very small breeding population and its dependence on dense riparian thickets in arid, open landscapes. The BC breeding population of Yellow-Breasted Chats is probably less than 50 breeding pairs. The current known BC distribution of Yellow-Breasted Chats is restricted to south Okanagan and Similkameen valleys. The Cariboo-Chilcotin IDF and BG ecosystems contains similar habitat features as the Okanagan landscapes but it is not currently known if the Yellow-Breasted Chat occurs in JSR.

Spring migrants arrive in BC in mid-May with nesting and egg-laying occurring in early to mid-June. The Chat generally produces three-four eggs. The young fledge by mid-July and soon after begin their migration back south to Central American wintering areas. The Chat builds its nest low to the ground in dense riparian thickets with tall shrubs and a multi-storied forest canopy. Early-successional shrub thickets near ponds or streams are also preferred nesting habitat in the Okanagan. Wild rose thickets appear to be especially important. The role of fire in the ecology of the Yellow-Breasted Chat is not known.

5.3.10. General Wildlife Considerations

As illustrated in Figure 3, three general wildlife - habitat associations exist in JSR: those species that are dependent on the variety of forest structural elements, those species that require non-forested grasslands, and species that require a variety of different habitat types. Most sources state that the loss of native grassland habitat is one of the major risks to the identified grassland species described above. As discussed in Section 5.1, forest encroachment and in-growth was observed to be at an advanced stage in some locations within the park, primarily on cool aspect slopes of the Fraser River canyon. The grasslands of the Cariboo-Chilcotin are considered to be fire maintained, or NDT 4, ecosystems, and that the eradication of fire from the system is one of the primary reasons for grassland loss. However, some ground nesting species of concern including the Long-Billed Curlew, Sharp-Tailed Grouse, Short-Eared Owl and Upland Sandpiper could be negatively impacted by prescribed fires, especially during the spring and early summer nesting and fledging seasons. Given some species use of traditional nesting sites, it may be possible to perform a survey of nesting areas at locations identified for burn treatments. Such an activity would allow for site-specific pre-burn planning to be developed, or may result in burn unit boundary modification. However, it should be noted that these grassland species have existed with fire for thousands of years. Considering the long-term viability of the JSR grassland ecosystems, limited prescribed burning in potential grassland ground nesting bird habitat may therefore be required to maintain necessary bunchgrass ecosystems for these species. The long-term maintenance of the native grassland ecosystems should be viewed as the highest management priority within JSR.

For species that require forested environments or downed and standing woody material such as the Flammulated Owl and Rubber Boa, light surface fires in the forest and forest-grassland ecotones would be beneficial and present relatively few immediate risks to individual animals. Light spring surface fires which kill a moderate number of live trees, create standing snags to later become wildlife trees, and maintain an open forest canopy, would be best achieved with low-moderate intensity spring fires.

5.4 PLANT SPECIES OF CONCERN

In addition to the identified wildlife described in Section 5.3., several Red and Blue-listed plant species occur or have a probable occurrence within JSR (Table 6). This plant list and the habitats in which they are found was developed through personal correspondence with Ray Coupe, Research Ecologist, BC Forest Service, Cariboo Region (per. comm. Feb/2000).

Table 6. BC plant species of concern with known or probable occurrence in JSR.

Taxonomic Name	Common Name	List
Silene drummondii var. *drummondii*	Drummond's campion	Blue
Crepis atrabarba spp. *atrabarba*	slender hawksbeard	Red
Chamaerhodos erecta spp. *nuttallii*		Blue
Potentilla quiquefolia	five-leaved cinquefoil	Blue
Draba reptans	Carolina draba	Blue
Arabis holboellii var. *pinetorum*	Holboell's rockcress	Blue
Apocynum sibincum var. *salignum*		Blue
Carex xerantica		Blue
Arnica chamissonis spp. *inarca*	meadow arnica	Blue
Atriplex argentea spp. *argentea*		Red
Carex hystericina	porcupine sedge	Blue
Castilleja tenuis		Red
Chenopodium leptophyllum var. *oblongifolium*		Red
Pellaea atropurpurea		Blue

Similar to the general wildlife – habitat associations described in Section 5.3, associations exist between plant species and the general habitat classes contained within JSR. Drummond's campion (*Silene drummondii* var. *drummondii*) and slender hawksbeard (*Crepis atrabarba* spp. *atrabarba*) grow solitarily and are distributed sparsely throughout the flat to gently-sloping grassland-sage habitats in the interior of the park. *Chamaerhodos erecta* spp. *Nuttallii* and five-leaved cinquefoil (*Potentilla quiquefolia*) are known to grow in shallow soil over bedrock on slopes and terraces above the Fraser River. Carolina draba (*Draba reptans)* is a Blue-listed species that is confirmed on nearby Doc English Bluff Ecological Reserve, and likely occurs within JSR on limestone outcrops above the Fraser River. The remaining species listed in Table 6 occur either on rock outcrops or on sparsely-vegetated slopes. They would therefore not be at high risk from prescribed fire for the treatment of forest in-growth and encroachment in the middle grasslands or along the Fraser River canyon grassland-forest ecotone.

5.5 FIRE WEATHER CLIMATOLOGY

The BCFS Fire Weather Network station most representative of JSR is Riske Creek (1708) located 15 km north of the park at 900 m elevation. Other BCFS and AES Synoptic and Climate stations in the vicinity are Williams Lake Airport (1703), Big Creek (1729) and Gaspard Creek (1723). Data from all were examined, but Riske Creek is the most applicable weather benchmark, and has been archived by BCFS since 1980. All weather, FWI, ignition probability and fire behavior parameters are tabulated and graphed in Appendix One.

The Southerly portion of JSR is lower in elevation than the Riske Creek weather station, and the park's topography and position at the confluence of two major rivers would suggest that JSR is subject to earlier snow departure, higher peak daily wind speeds, warmer temperatures, lower minimum relative humidities and higher Buildup Indices than calculated at the reference weather station (Tom Matzen, BCFS, pers. Commun. Jan. 2000). The most important management implication of this situation is that preparation for prescribed burns will require an on-site weather station to be established at least a week in advance in order to ensure that prescription conditions are being met. A practical solution could be to deploy a portable remote automatic weather station (RAWS) near the prescribed burn site from the start of the fire season until mop-up has been completed.

Fire Danger (FWI System) starting conditions are typically met around April 1, and occasionally as early as mid-March, with a tendency towards earlier fire season startup in recent years. Early spring (March-May) temperatures stay cool (6-15°C at noon), while noon relative humidities average consistently in the mid-40s from March through September. Wind speeds are a little higher March through May than the summer months (average 9 vs. 7 km/h; 90th percentile 17 vs. 13 km/h), and wind direction predominantly south in the spring, while evenly split between south and north in the summer months.

March to May is quite dry (less than 33mm total precipitation per month), while the months of June and July each receives about 50mm of rainfall. August and September rainfall decreases from June-July values, but still exceed March-April values.

The six FWI System components are tabulated and graphed at their 50th, 90th and 100th percentile values by month at Riske Creek. There is no appreciable seasonal trend to the Fine Fuel Moisture Code (FFMC) at the 50th percentile, but 90th percentile values rise sharply from 90 for April to 93 for May. Duff Moisture Code (DMC) peaks in June and again in August, but more significantly from a prescribed burning standpoint, almost doubles from April to May, reflecting a rapid drying rate of the active duff layer. Deeper forest floor layers, typical of the closed and dense forests on the cool aspect slopes, and reflected by Drought Code (DC) dry slowly in March-April. Drying of these layers accelerates in May, reaching the threshold of moisture reversal with depth (i.e., the deeper the layer the drier the duff) in June when DC exceeds 400 10% of the days.

Substantial Initial Spread Index (ISI) values occur during 10% of March and April days, and increase only slightly in May-June, which creates good prescribed burning opportunities early in the spring. Buildup Index (BUI) shows a very strong seasonal trend, favoring light to moderate impact burns in spring, but much higher impact potential in late summer. Fire Weather Index (FWI) increases sharply each month March to May, then plateaus through September, again favoring spring burning for control considerations.

From an ignition probability standpoint, the guidelines of Lawson and Dalrymple (1996) show that near-certain ignition of fires from small firebrands like matches and campfires (>90% probability) occur in Douglas-fir with grass-dominated surface fuels on 12% of April days and 26% of May days. This would create favorable opportunities for spring prescribed burning. The spruce-balsam benchmark fuel type and moist pine benchmark fuel types that would represent the closed and dense Douglas-fir forests growing on the north slopes in JSR have much fewer ignition days in spring than Douglas-fir and grass. The spruce-balsam (deep duff) types increase in ignition probability through the summer, reflecting the seasonal trend in DC. This ignition probability differential among fuel types by season again favors spring prescribed burning over fall for the target fuel types, treed grassland, open and closed forest, but excluding dense forest on north slopes (cool aspects).

In addition to probability of ignition, the second most important fire characteristic from a risk management standpoint is the probability of crown fire spread. In order to present this fire behavior characteristic from a climatology standpoint, three levels of Crown Fraction Burned (CFB) were defined, as predicted by the Canadian Forest Fire Behavior Prediction (FBP) System, where the lowest two classes of CFB, <10% and 10-50%, constitute surface fire behavior, and the highest class of CFB, >50%, indicates the threshold of crown fire. CFB class is graphed in terms of percentage of days by month for FBP Fuel Type C-7 (Douglas-fir-ponderosa pine), comparing flat ground and 40% slopes on easterly aspect. For the Riske Creek benchmark station, very few days in any month are subject to crown fire in C-7 on flat ground, but on 40% east slopes, 4.5% of May days support crown fires, peaking at 6% of days in June.

Another commonly used fire behavior indicator, fire intensity class (FIC) is shown climatologically, as the percentage of days by month that each of the six FIC classes occurs at the benchmark weather station. Classes 5 and 6 constitute intermittent crown fire (4 000 – 10 000 kW/m) and continuous crown fire (>10 000 kW/m), respectively. On flat ground, about 5% of days May through August meet conditions for at least intermittent crown fire, while on 40% east slopes, crown fire intensities occur on 4% of April days, then jump to about 15% of days May through August.

Lightning occurrence, both positive strikes (the most strongly associated with fire starts) and negative strikes, peaks in July-August, is moderate in June, and low in March to May and September. The annual peak year was 1989 with 144 strikes and the lowest year was 1985 with only 16 strikes.

5.6 FIRE PRESCRIPTIONS AND RECOMMENDATIONS

Our review of the prescribed burning history on JSR (Section 5.2.2) suggests that the multiple objectives that have been established for these early spring burns have generally not been met, with respect to retarding conifer encroachment and in-growth. The burns have met objectives for increased yield and quality of grass, but the burns have generally not been of high enough intensity to kill established Douglas-fir trees of any significant size. It is clear that planning for future prescribed burns must start with more narrowly focussed objectives, so that prescriptions can be tailored to the most difficult objective, rather than the easiest one, as has been the case to date. In other words, you can't knock back forest encroachment with a light grass fire.

Further, it is clear from our preliminary examination of the last 50 years of conifer encroachment and in-growth on JSR (Section 5.1) that restoration of previously open range and open forest from the open forest and closed forest that has resulted from encroachment and in-growth of Douglas-fir is currently the main vegetation management concern on JSR. With domestic stock grazing now eliminated from the park, grass yield and quality on open ranges does not appear to be a significant problem. However, prescribed burning for forage yield and quality on open range should be retained as a management option when the need arises.

The conifer encroachment and in-growth is most significant on cool (north and east) aspects on mid and upper elevations, while warm aspects show little change over the past 25 years. We recommend that the vegetation management objectives for JSR reflect the need to restore the relative proportions of open range:open forest:closed forest as they were in the 1960's.

This objective can be achieved by conducting a series of prescribed burns over the next 10 years that will probably be smaller in area than the 1/3 of the park area prescribed burned in the decade 1975-1986, but higher in intensity. These burns should be focussed on the forest/grassland ecotones, rather than the steep Fraser River slopes and open grassland benches.

Analysis of encroachment and in-growth over the past 50 years in Okanagan Mountain Provincial Park (OMPP) near Summerland is instructive. Taylor and Hawkes (1997) reported that the area of dense forest (crown closure >55%) increased by 56%, while treed grassland (crown closure 6-15%) decreased 55% since 1938. Based on a Forest Vegetation Simulator (FVS) growth model, the next 50 years is expected to result in a further increase in cover classes 0-3 (grassland, treed grassland, open forest, crown closure 16-40%) while cover class 4 (dense forest) decreases due to natural mortality. Because OMPP, like JSR, contains significant area of relatively undisturbed native grassland and open ponderosa pine-Douglas-fir forests, restoration of pre-settlement vegetative distribution is considered to be a priority for BC Parks. For OMPP and its Okanagan dry forest neighbor, Kalamalka Lake Provincial Park (KLPP), current Fire Management Plans call for the use of prescribed burns in spring prescriptions to reduce canopy densities of both open and closed Douglas-fir-ponderosa pine forests, the target being a one-class reduction of canopy density.

For JSR, a quantitative study of area by canopy class was beyond the scope of this Prescribed Fire Management Plan, but such a study is recommended in order to firm up the targets for prescribed burning over the next decade. Ross (1997) estimated that the area of grassland has been reduced by more than 30% since 1962 in areas such as Bald Mountain and Becher's Prairie, west of JSR, mainly by encroachment. After cattle grazing on JSR ceased in 1973, the condition of grasslands improved with respect to improved forage carryover and species composition, and, according to Peek, Demarchi et al. (1984) this improvement may have been hampered, rather than improved by the program of spring burning conducted between 1975 and '86. These authors felt that the low cation exchange capacity (CEC) of the grassland soils leave little capability to produce a plant nutrient response to burning; however, they did agree that the burning program had no apparent negative effects on the Bighorn Sheep population. The sheep were probably encouraged to traverse the narrow bands of forest where canopy had been opened; however, these authors pointed out that the critical sheep habitats and winter range are permanent grasslands, not subject to forest encroachment. Further, the burning to eradicate big sage may have removed some hiding cover, and summer thermal cover, as well as a snow interceptor and possible forage source.

Youds and Hebert (1988) summarized the JSR prescribed burned area 1975-80 (1415 ha) as shrub-grassland, 1983 (100 ha) as forest and 1986 (20 ha) as grassland. They noted that the 1983 forest burn did kill young conifers encroaching onto grasslands, but did not kill larger diameter trees in closed forests to achieve the desired canopy reduction, because low winds kept fire intensity too low. The 1986 cool grassland burn on north slopes increased green grass availability and summer sheep use increased four-fold. The earlier monitored burn (1976) produced only transitory (12 month) increases in forage quality and an overall decrease in species diversity. Concern was expressed that repeat burns would result in a net loss of nutrients because of the near-100% base (cation) saturation of the JSR soils. Further, Youds and Hebert (1988) considered prescribed burning to have only limited potential to replace historic levels of fire in grasslands and open forests, due to restrictive forest protection policies, and approving prescribed burns only for less than optimal conditions, assuring failure to achieve burn objectives.

However, we present here tested prescriptions, as developed for similar objectives and landscapes in OMPP and KLPP. The prescriptions were adapted from prescriptions developed and tested with operational research-based ecosystem maintenance burns conducted in the Rocky Mountain Trench under the multi-agency EMBER (Ecosystem Maintenance Burning Evaluation and Research) Project (Braumandl et al. 1995). A more narrowly focussed prescribed burning program for JSR than conducted during the 1975-86 period would concentrate on conifer encroachment and in-growth at forest/grassland ecotones in which canopy cover ranges from treed grassland (crown closure 6-15%), open forest (crown closure 16-40%) and closed forest (crown closure 40-55%). Permanent grassland (crown closure 0-5%) and dense forest (crown closure >55%) areas would not be burned. This is justified by the findings that the permanent grasslands are not at risk from encroachment, and burning them does not appear to produce significant and lasting benefits. Excluding dense forests from the prescribed burning program is justifiable from the point of view that such forests are found primarily on north aspects and are not crucial to the resource management priorities of JSR. These cool aspect forests are also not readily treatable with prescribed fire during the spring when prescribed fires can be conducted at reasonable cost and risk.

The concerns expressed by Youds and Hebert (1998) about restrictive BCFS protection policies dooming prescribed fire to failure are no longer valid, according to BCFS Cariboo Fire Centre (Tom Matzen, Pers. Commun. Jan 2000), who assures that Park burn plans developed to deliver prescriptions documented here would be supported. Specific prescribed burn plans are required under Forest Fire Prevention and Suppression Regulations, and require on-site weather monitoring and consulting fire weather forecasts, as well as taking adequate measures to contain the fire to the prescribed area and carrying out sufficient mop up to prevent future escape. BCFS Protection Program specialists are available at the regional level to help BC Parks with the burn planning process. It should be noted that the prescriptions presented here are intended to use on-site weather and FWI System components measured at JSR, not at the Riske Creek weather station.

Conversion of closed forest to open forest is possible using prescribed fire alone, although a combination of mechanical thinning followed by burning is the preferred treatment, outside of protected areas. Recent prescribed burns conducted in the east Kootenay under the EMBER Program have demonstrated the feasibility of under-burning closed Douglas-fir-ponderosa pine-lodgepole pine stands without mechanically controlling stocking, fuel load and fuel distribution first (Braumandl et al. 1995).

The treatment objective is to reduce stand density by killing smaller diameter trees with low-intensity surface fire. Fire intensity can be best controlled using strip headfire ignition pattern, which, through careful monitoring of the relationship between fire behavior and ignition strip spacing, can generally keep the fire from crowning. Crown fire is undesirable, from the standpoint of controllability and the likelihood of achieving excessive tree mortality over a wide range of diameters. The objective of stand restoration using fire is to ensure the older larger trees survive.

It is important for BC Parks to be confident that ecosystem restoration burns as proposed here will contribute to re-establishment of native grasslands under open-canopied forest without the undesirable side effect of helping to establish non-native species, particularly noxious weeds.

A study of a July 1993 wildfire that burned the ungrazed Haynes Lease Ecoreserve and adjacent grazed grasslands with varying intensities determined that fire intensity did affect plants differently under grazed and ungrazed conditions (Krannitz 1997). In this antelope bitterbrush ecosystem, perennial species like sand dropseed grass and Arrow-leaved Balsam root immediate post-burn responses were similar four years after the burn. Annual weed species like cheatgrass showed initial density reductions related to fire intensity under both grazed and ungrazed conditions, but four years later, the differences were no longer apparent. Another invasive non-native species Dalmation Toadflax, also increased in numbers after fire, and remained two years later. The burn affected species distribution, and fire intensity and grazing had different effects. For example, Needle and Thread Bunchgrass (*Stipa comata*) was more abundant, as was *Phlox longifolia*, another perennial, after fire, while the annual cheatgrass was found mostly in unburned plots, and Red Three-Awn was associated with grazed plots. Further, *Stipa* and *Phox* were more abundant on higher intensity burn plots, while Downy Brome was more abundant in unburned plots. Prickly Pear cactus was reduced by fire and this pattern remained the same after four years.

While the post-burn response pattern held for two years, by four years later, there wasn't much evidence of the fire's effects on annuals. For example, cheatgrass was virtually eliminated in burned plots the first year, but by four years there was little difference with unburned areas. Unlike the annuals, however, the perennials retained their post-fire responses four years later, a result that favors fire as a positive effect on native grasses. The author acknowledges that, while fire may be a suitable tool for restoration of these ecosystems, based on these results, the fire was a mid-summer fire, while prescribed burning is normally applied in spring.

The author suggests from this study and others that while fire in the long term has turned shrub-steppe communities (further south) into annual grasslands, it initially burns cheatgrass seeds in the seed bank.

Other current B.C. studies (east Kootenay's EMBER, Kamloops near Tranquille, Kalamalka Lake Prov. Park) of prescribed fire effects on open canopied forest grassland response will add regional knowledge to what has been learned. Nicholson (1992) investigated prescribed fire and knapweed at Kalamalka Lake Prov. Park, finding that neither spring nor fall burning reduced knapweed seedlings or total knapweed biomass where it was already established, nor did either burning treatment result in knapweed establishment during the first growing season after burning on sites free of knapweed. However, as knapweed spread is known to favor bare soil and the amount of bare soil increases with fire intensity, it would seem prudent to target JSR prescriptions to the season and range of conditions that will likely minimize undesirable fire effects that may be associated with excessive fire intensity.

A review of the prescriptions, actual burning conditions and results and impacts achieved on three EMBER burns as reported in Braumandl et al. (1995) suggests a modified prescription for JSR:

Fire Weather Indices

FFMC	DMC	DC	ISI	BUI	FWI
87-90	16-30	50-250	4-10	16-45	6-20

Fire Weather

T (°C)	RH (%)	WS (km/h)
6-22	18-60	5-15

Season**:** Spring, April 1 – May 15

Table 7 lists the months and days when fire prescription weather conditions have occurred during the last 20 years (1980 - 1999), as recorded by the BC Fire Weather Database.

This prescription should meet the stand treatment objectives:

- reduce crown closure by 1 class;
- remove >=50% of small-diameter Douglas-fir;
- limit mortality of large trees (>30cm) to 10%;
- reduce surface fuels <10cm diameter by >=50%;
- reduce surface fuels >20cm diameter by 5-10%.

The EMBER burns conducted within this prescription range generally met the objectives for tree mortality, surface fuel consumption, and confining fire behavior to surface fire. The fires spread well in open areas, especially on south aspects, but coverage was incomplete in thickets and on north slopes generally.

A fire behavior and impact predictive model for surface fires in ponderosa pine-Douglas-fir called SCORCH is available to test prescriptions (Taylor and Armitage 1998). This model couples fire spread and intensity as predicted by the Canadian Forest Fire Behavior Prediction (FBP) System, with single tree mortality equations based on diameter and scorch height. Applying a single tree-based model of mortality at a stand level assumes complete fire spread, which is unrealistic in underburns. Fuel consumption was over-predicted for the EMBER burns, as was the related variable fire intensity. Rate of spread was over-predicted, because the FBP System predicts a free-burning equilibrium spread rate, while prescribed underburns restrict spread rate by using narrowly spaced ignition strips which do not allow the fire to reach its potential equilibrium spread rate.

Extensive experience with underburning in open ponderosa pine – Douglas fir for wildlife habitat enhancement over a 30 year period in Montana's Kootenai National Forest was reported by Curtis (1997), in which he makes several observations worth repeating here:

- Underburning is best accomplished in early spring prior to greenup, on sunny days with < 30% cloud cover.
- Ignition should generally start at the top of the unit, working across the slope, controlling fire intensity by ignition line spacing.
- Winds should be in the range of 5-8 km/hr, temperatures above 10° C.
- No fire lines are constructed, fires being allowed to spread into steep rock cliffs or snow, in order to minimize mop up requirements and holdover fires.
- These fires killed considerable conifer seedlings and some saplings and pole-size trees, depending on amount (if any) of selective logging slash present.
- Aesthetically, the result was not pleasing in the first year, but greened up and was attractive by the second year.
- Browse species sprout vigorously under the open canopy.
- Air quality not adversely affected by spring burning, as smoke dispersal conditions are generally favorable and inversions rare (unlike fall).
- Fuel moisture conditions should range from 7-11% for fine fuels (0.0 – 0.5cm) and 9-14% for medium (0.5-2.5 cm) fuels.

Table 7. Months and days when fire prescription weather conditions have occurred during the last 20 years (1980 - 1999). Data from BC Fire Weather Database.

YEAR	MONTH	DAY	TEMP (°C)	RH	WIND DIR	WIND SPEED	PRECIP (mm)	FFMC	DMC	DC	ISI	BUI	FWI	DANGER RATING
1987	4	13	11.6	42	140	11.0	0.0	89.4	29.9	112.5	6.8	36.0	14.0	2
1988	5	11	21.3	31	90	6.0	0.0	89.6	18.1	232.3	5.5	30.0	10.7	2
1989	4	25	13.2	21	360	12.0	0.0	88.1	24.4	151.8	5.9	34.8	12.4	2
1990	5	7	7.8	59	320	8.0	0.0	87.4	20.6	118.2	4.4	28.6	8.7	2
1992	4	2	15.7	52	90	12.0	0.0	88.0	18.6	112.6	5.9	26.3	10.5	2
1992	4	5	6.3	35	180	6.0	0.0	89.0	22.8	119.5	5.0	30.9	10.1	2
1992	4	7	6.4	37	230	14.0	0.0	87.1	24.4	123.3	5.7	32.7	11.5	2
1992	4	12	12.9	37	90	11.0	0.0	89.1	29.6	133.1	6.6	38.1	14.1	2
1993	4	9	10.9	48	180	12.0	0.0	87.3	17.3	164.3	5.4	27.2	9.9	2
1993	4	10	14.7	35	90	8.0	0.0	88.7	19.7	167.9	5.3	30.4	10.5	2
1993	4	11	14.3	42	360	12.0	0.0	88.8	21.9	171.5	6.6	33.1	13.0	2
1993	4	12	12.8	37	140	8.0	0.0	88.8	24.0	174.7	5.4	35.7	11.6	2
1993	4	17	18.4	37	90	8.0	0.0	88.5	30.0	190.5	5.2	43.0	12.5	2
1994	4	16	18.9	31	140	10.0	0.0	89.9	23.0	118.4	7.0	30.9	13.2	2
1994	4	17	14.8	44	0	8.0	0.0	89.4	25.1	122.1	5.9	33.2	11.9	2
1994	4	18	14.1	48	90	5.0	0.0	88.7	27.1	125.5	4.6	35.2	10.1	2
1994	4	19	16.6	45	270	12.0	0.0	88.8	29.4	129.5	6.6	37.6	13.9	2
1995	4	17	9.5	38	140	8.0	0.0	87.4	20.2	155.5	4.4	30.3	9.0	2
1995	4	22	14.0	32	320	8.0	0.0	87.9	24.8	168.4	4.8	36.2	10.5	2
1995	5	7	16.4	26	50	6.0	0.0	90.0	21.0	196.0	5.8	33.0	11.8	2
1997	4	28	10.0	36	180	10.0	0.0	87.8	26.3	75.8	5.2	28.3	9.8	2
1998	4	19	10.8	26	270	10.0	0.0	89.3	17.6	51.4	6.5	18.9	9.6	2
1998	4	20	13.2	37	180	11.6	0.0	89.4	19.8	54.7	7.0	20.8	10.8	2
1998	4	21	15.6	31	135	6.2	0.0	90.0	22.5	58.5	5.9	23.0	9.8	2
1998	4	28	16.3	38	225	5.2	0.0	88.2	29.0	79.7	4.3	30.4	8.8	2
1999	4	23	16.7	25	270	5.7	0.0	89.9	23.1	79.2	5.7	26.7	10.3	2
1999	4	24	18.6	35	225	13.1	0.0	90.0	26.2	83.5	8.3	29.3	14.7	2
1999	4	30	16.2	23	135	5.1	0.0	89.3	24.6	97.3	5.0	30.1	10.0	2
1999	5	1	10.7	54	270	12.2	0.0	87.6	26.0	101.6	5.6	31.7	11.3	2
1999	5	2	9.4	40	135	12.1	0.0	87.7	27.7	105.7	5.6	33.4	11.7	2

5.6.1. Proposed Prescribed Burn Units

Map 4 shows the location of the following proposed prescribed burn units. These burn units will have very limited impacts on the California Bighorn Sheep critical winter range habitat (the warm aspect slopes along the Chilcotin River canyon) and by focussing on the forest-grassland ecotone, impacts will be minimized on potential Long-Billed Curlew nesting areas.

It is important to tie the parks prescribed burn program objectives into the landscape on which these objectives will be implemented. Since the park boundaries do not follow topographical and landform boundaries, it is desirable from both an ecological and a fire containment standpoint to define prescribed burn units on a landscape basis. However, while proposed Burn Units 1 & 2 extend beyond park boundaries, no burning on private land would be prescribed and carried out without the express written consent of the land owner.

- **<u>North Fraser Unit</u> (Air Photo 30BCC93029-149)**

  Extends from Erosion Gulch in the south to unnamed gulch 1.5 km south of Ross Gulch in the north; from the 500 m (1700 ft) contour above the Fraser River in the east to a north-south line between upper Erosion Gulch and unnamed lake, upper end of unnamed gulch, in the west. Unit is bisected north-south by road just west of park boundary at approximately 900 m elevation, hence approximately half the unit is west of the park boundary (Unit 1a).

  The east half of the unit (Unit 1b) is largely within the park, and is composed mostly of east aspect open Douglas-fir forest, with closed Douglas-fir forest on north aspects of the three gulches that run from the road to the Fraser River. The west half of the unit is largely outside the park, and contains much of the forest/grassland ecotone along the road, and some large expanses of rolling grassland that rises to a low height of land at 1160 m (3800 ft).

  Because of the elevation range and variation in aspects, Unit 1a could be burned in two separate burns, within the suggested prescription range. The upper elevation grasslands would probably be ready to burn two weeks or so before the cool aspect slopes and north-facing gulches. This sequence of burning helps to create a significant “black line” fuel break to assist in containment of the second burn.

- **<u>North Relict Unit</u> (Air Photo 30BCC93079-052)**

  The North Relict Unit extends from Erosion Gulch in the north to an unnamed gulch 800 m south of Erosion Gulch; from the 500 m (1700 ft) contour above the Fraser River in the east to a north-south line between upper Erosion Gulch and unnamed lake at top of unnamed gulch and road, in the west. The road to Ram Flats on the park boundary forms part of the west and south burn boundary, but approximately two thirds of the burn unit lies outside the park boundary.

  The east third of the unit (Unit 2b - within the park) below Ram Flats consists of steep gullies with open and closed Douglas-fir forests on the north aspects and scattered treed grass and shrubs on the south aspects. The western two-thirds of the unit (Unit 2a - west of the park boundary) is mostly rolling forest/grassland ecotone and open to closed Douglas-fir forest, extending to 750 m elevation (2500 ft) on mainly south-east aspects.

As with Fraser Unit 1, this unit would probably come into prescription over an approximate two-week period, in which the west portion should be ready to burn first, followed by the north-facing gully slopes east of the Ram Flats. This sequential burning, in which Relict Unit "A" and "B" blocks would follow Fraser Unit "A" and "B" blocks would assist not only containment within the units, but reduce risk of escape from one unit to the next, considering the prevailing southerly wind direction.

- **<u>Trap Unit</u> (Air Photo 30BCC93046-170)**

The Trap Unit extends from the east-west park boundary in the north to Cairn/Lookout in the south; from the 600 m (1950 ft) contour above the Fraser River in the east, to the west loop road in the west. This unit is entirely inside the park, and parts of it were prescribed burned in 1979, 1983 and 1986.

The east slopes to the Fraser River are bounded on the north by a steep gulch, but the remainder of these east aspects, south to the burn boundary at a topographic change to dense forest on north east aspects, are mostly treed grassland and open forest on moderate slopes. The east loop road to the Cairn/Lookout follows the ecotone between forest to the east and grassland to the west. The west half of the unit is mostly grassland benchland at 900 m elevation with scattered trees and a few areas of open forest.

Slightly lower elevations and flat to rolling topography without steep gulches with north slopes suggests that this unit would come into prescription earlier than Units 1 and 2. The unit has been divided into a north block (3A) and south block (3B) across an east-west shallow draw containing a band of open forest. The A block should be burned a year before the B block, in order to provide a fuel-reduced buffer to windward, and to reduce potential impact on Long-Billed Curlew nesting habitat, which includes the large open grassland benches on the west half of this unit.

- **Optional Burn Unit**

While it does not appear necessary to burn the large grassland bench south of the Trap Unit that was last burned in 1978, this area should be monitored over the next decade for bunchgrass yield and quality decline, and a light spring burn applied before greenup if warranted. Potential impacts on the Long-Billed Curlew will have to be considered carefully prior to this unit being burned. The lower slopes to the junction of the Fraser and Chilcotin Rivers that was also burned in 1978 should not require burning, nor should any of the Chilcotin Unit to the west park boundary. Previous burns in 1978 along the Chilcotin River slopes were generally not beneficial, and killed sagebrush that is now considered a useful forage and cover species. Grass, shrubs and forbs are generally too sparse on these steep, warm aspect slopes to require or even support continuous spreading fire.

Inset Map 4. Proposed Prescribed Burn Units.

5.6.2 Prescribed Burn Rotation

The new focus of the JSR prescribed fire program is on the forest/grassland ecotones. In order to address the encroachment and in-growth issue, rather than grass yield and quality, the frequency of conducting burns should now be determined on the basis of regular monitoring of impacts of burning on encroachment and in-growth. Previous burn monitoring in JSR has not documented this aspect very well, so a more focussed approach to forest dynamics will be needed. In addition, there are still significant areas of true grassland within the proposed burn units, and monitoring plots should be established to quantify fire effects on all grassland ecosystem species, including lichens. Pre-burn planning and monitoring the effects of prescribed burning on the grassland ground-nesting bird species should receive special emphasis.

5.6.3. Other Prescribed Fire Considerations

Spring burning is recommended rather than fall burning, even though spring burning requires mitigating conflicts with ground-nesting birds such as the Long-Billed Curlew and Sharp-Tailed Grouse. Spring burns are less subject to escape problems, as much of the JSR area to be burned should be drier in spring than adjacent forest areas, following the spring snowmelt pattern that would progress from the BG to IDF zones. The low prescribed BUI range better suits the spring window, and would avoid high impact burns on sensitive forest floors and soils that could be associated with September burns at the high Drought Codes typical in the area, even though Duff Moisture Codes have typically dropped to spring-like levels by September (Appendix 1). Prescribed fire requires risk assessment before deciding on burn objectives and prescriptions, and in our judgment, spring burning is more likely to achieve resource management and conservation objectives at lower risk of damage and escape to private property than fall burning.

While aerial ignition is the norm today for landscape-scale prescribed burning, past experience at JSR, and the steep slopes on parts of the proposed burn blocks suggest that the helitorch is preferred for the most effective ignition pattern and rate, and maintenance of control over the fire behavior.

In order to minimize mechanized equipment needs for fire guards, pre-burn black lining with hand drip torches will generally be required, in some cases, following snow departure.

JSR fencing programs have added significant investment to fence lines along much of the north-south park boundary. All fences will need protection by fuel clearing and/or pre-burn black lining along areas within proposed burn blocks. The location of two cabins and major roads/trails within the park is shown in Figure 4.

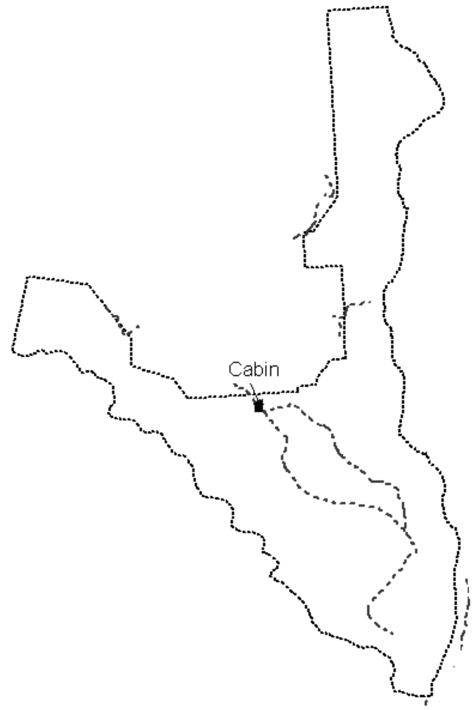


Figure 4. Park values – cabins and major roads/trails. The park has limited infrastructure; two cabins are located within JSR and only a limited number of rough trails traverse the park.

6. Recommendations

- **Forest Encroachment and In-Growth**

  The authors of this plan consider the primary vegetation management issue currently facing JSR to be forest encroachment and in-growth. The removal of cattle from the park eliminates the immediate need for prescribed burning to increase grassland forage production and quality. The most advanced areas of encroachment and in-growth were observed to be on the cool aspect slopes along the Fraser River canyon. Figure 2 demonstrated the extent of encroachment and in-growth during a 45-year period at Ross Gulch. The proposed prescribed burn units are focussed directly on the forest/grassland ecotone of these areas.

- **Proposed Burn Units and Prescribed Fire Treatments**

  Given the current forest encroachment and in-growth issues, prescribed fire treatments have been prepared to deal specifically with this issue. Previous prescribed burns focused primarily on grassland forage production and quality, with limited effectiveness in knocking back forest encroachment and in-growth. Three burn units have been proposed, all on the east-side of JSR where forest encroachment and in-growth was most advanced: the North Fraser Unit, the North

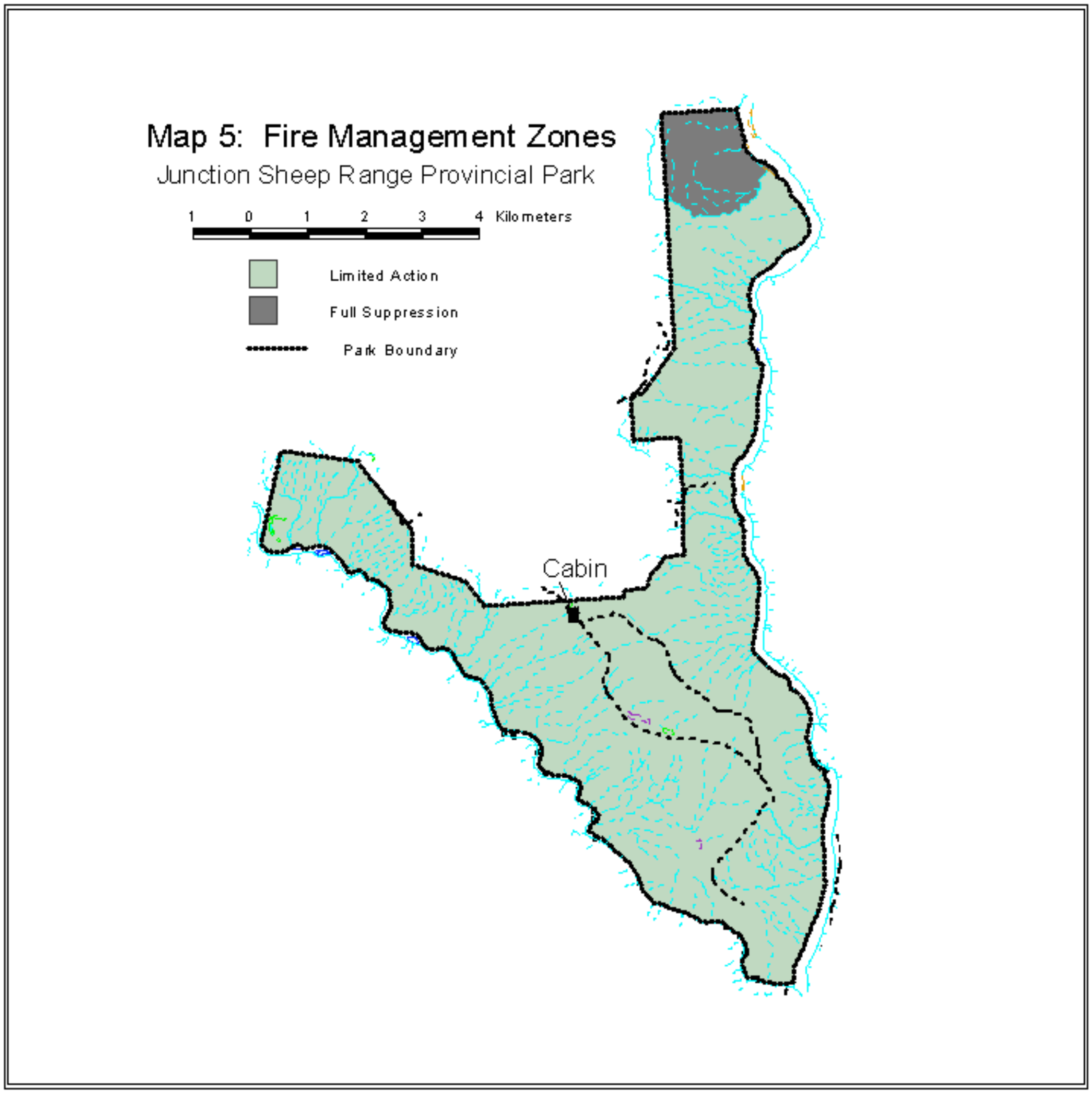
Relict Unit and the Trap Unit (Section 5.6.1). One optional burn unit is also proposed.

- **Fire Management Zones**

The 1999 Pre-Attack Plan for JSR designates two Fire Management Zones within the park (Map 5). A full suppression zone is identified for the area north of Ross Gulch with a limited suppression zone covering the rest of JSR. The specified suppression responses in the current Pre-Attack Plan appear to be appropriate for any reported fires, both natural and human-caused. Initial attack should occur on all fires and if initial attack fails, the level of additional suppression would be decided jointly by BC Parks and the BC Forest Service Cariboo Fire Centre District Manager. Additional suppression activities would be based on forecast fire behavior, evaluation of expected fire growth, adjacent land values, and limitations on the use of mechanized equipment within the park. Off-road mechanized equipment is not authorized within JSR but can be authorized by the BC Parks District Manager.

- **Landscape Units**

Five general landscape units, based on physiographic characteristics, were recognized in the development of this plan. The slope and aspect conditions appear to be the primary determinant of vegetation patterns within the park. These units, unlike some vegetation communities, are relatively static and therefore lend themselves to map-based applications. It is recommended that these general landscape units be adopted as the primary landscape management units for JSR. The integration of fire management units and park management units will be necessary to meet long-term ecosystem-based management goals.



- **Vegetation/Habitat Mapping**

The current lack of a GIS-based vegetation map is a limitation to ecosystem-based management goals for JSR. It is recommended that either the biophysical habitat mapping of Fenger and Demarchi (1992) be updated and a digital coverage created or a new GIS-ready, 1:20 000 scale TEM-based habitat map be produced. The creation of a GIS-based vegetation map for the park will allow efficient monitoring of long-term encroachment issues and proper examination of landscape unit – vegetation community relationships. Wildlife habitat values can be linked directly to the ecosystem units, allowing more effective planning and impact assessment of park management activities. This was not possible in the development of the prescribed fire management plan. JSR is also small enough to allow for a selected set of current stand boundaries to be mapped by GPS for very accurate forest encroachment monitoring.

- **Wildlife Species of Concern**

The management of wildlife within JSR requires a long-term approach. Over the long term, grassland loss through forest encroachment and the in-growth of open canopy forests are probably the primary threats to identified species. The recommended prescribed burn treatments were developed with consideration of the general habitat requirements and ecology of the identified wildlife species known to occur or with probable occurrences in JSR. However, to minimize short-term negative impacts to wildlife, a detailed walk-through should occur prior to the development of any operational burn plans. The following statements summarize prescribed fire considerations for the identified species discussed in this plan:

Brewer's Sparrow. This species requires tall sagebrush habitats, which in JSR occur mainly along the steep warm aspect slopes of the Chicotin River canyon. The destruction of these tall sage brush areas through burning would have a short-term negative impact on nesting sites for the Brewer's Sparrow. Prescribed burn units suggested by this plan do not impact the Chilcotin potential Brewer's Sparrow habitats.

California Bighorn Sheep. The mobility and wide-ranging use of the park by the native wild sheep probably allow them to escape from any active prescribed fire. Critical winter sheep habitat occurs on the warm aspect slopes above the Chilcotin River. These areas have not been recommended for prescribed burns as the rates of in-growth and encroachment in these areas appeared minimal and the previous prescribed burns on this landscape unit did not appear to be effective. However, the current decline of the sheep population (possibly due to lung worm and pneumonia bacteria (John Youds, pers. comm. Jan/2000)) suggests retaining the option to explore whether habitat enhancement through burning might help to mitigate these particular problems. In addition to the recommended burns in the Trap Unit, burns in the 'Optional Unit', south of the Trap Unit, a natural grassland bench, could be used to study specific fire effects on sheep habitat issues, including forage quality, species composition, lichen abundance and recovery.

Flammulated Owl. These small owls require a heterogeneous Douglas-fir forest structure with a multi-layered canopy and old-growth structural elements including snags with cavities for nesting. Flammulated Owls appear to avoid dense stands of small diameter Douglas-fir. Low intensity, prescribed fire may therefore be a management option to maintain Flammulated Owl forest habitat in an open canopy with mixed-diameter classes and standing dead trees. Retaining adjacent mature-veteran trees that range in diameter from 30 to 80 cm as well as existing patches of thickets should be a component of a Flammulated Owl fire prescription. Fire prescriptions as contained in this report should create these desired forest conditions along the grassland-forest ecotone.

Long-Billed Curlew. The Long-Billed Curlew is a ground-nesting grassland bird. The spring burning window suggested in this prescribed fire plan occurs during the breeding season when birds are on nest. However, the burn units proposed in this report do not occur within the largest areas of potential Curlew habitat, the relatively expansive flat grasslands. Also, to further mitigate potential negative fire impacts it is suggested that a detailed field assessment be conducted to locate nesting areas and plan appropriate fuel modification where required. While the potential for negative fire impacts do occur, long-term grassland loss and a potential shift in grassland species composition could be a greater long-term risk to the Long-Billed Curlew than the immediate effects of prescribed fires.

Rubber Boa. The Rubber Boa snake uses are range of habitats in JSR and is probably at limited risk from prescribed burning within JSR due to its burrowing habitats and foraging behavior in riparian areas/moist depressions. However, the species is dependent on large diameter standing and downed coarse woody material and efforts should be made to maintain an adequate amount of this material during the implementation of a prescribed burn.

Sharp-Tailed Grouse. Similar to the Long-Billed Curlew, the Sharp-Tailed Grouse is a ground-nesting grassland bird that could be negatively impacted by fire. The Grouse is a true lek species, allowing traditional lek sites to be located and mapped prior to the development of detailed burn plans. The location of known lek sites should be confirmed with the Wildlife Officer, MELP, Williams Lake, prior to any detailed prescribed burn planning.

Short-Eared Owl. The Short-Eared Owl is another grassland-dependent ground-nesting bird species of concern in JSR. Short-Eared Owls depend on meadow voles for the majority of their energetic requirements. If burning is to occur during the nesting season (spring and early summer), partial burning is recommended in order to create a patchy mosaic of burned and unburned habitat elements. This could also be achieved by locating Owl nests through field surveys and taking appropriate fuel modification measures where required.

Upland Sandpiper. The Upland Sandpiper is the fourth of the grassland-dependent ground nesting bird species of concern considered in this report. The interior grasslands of JSR may provide suitable habitat for Upland Sandpipers but this species has not been confirmed in the park. Upland Sandpipers require areas with flat topography and low vegetation profile; it nests in large, open, flat grasslands along grassland-woodland ecotones. Sandpipers have been known to return annually to previous nesting sites. Due to its ground-nesting habits, this species may be negatively impacted by the use of prescribed fire in JSR. Similar to other grassland ground-nesters, nesting sites should be identified prior to detailed burn planning and mitigated for as appropriate.

Yellow-Breasted Chat. The Yellow-Breasted Chat is very rare in BC and its presence has only been confirmed in the south Okanagan and Similkameen valleys. The species is dependent on dense riparian thickets in arid, open landscapes for foraging and breeding. The role of fire in the ecology of this neotropical migrant warbler is currently not known. Given the low probability that the Chat may occur in JSR, and considering its riparian habitat requirements, the Chat is probably a low priority for fire planning in the park. However, future bird census work should try and determine if this species does in fact use JSR.

- **Plant Species of Concern**

  Most Red and Blue-listed plant species that have a confirmed presence or a probable occurrence in JSR occupy steep, shallow soil units or occur among rock outcrops of the Fraser and Chilcotin River canyons. These areas have not been recommend for prescribed burns in this plan. Two species do occur sporadically in the interior grasslands of the park, Drummond's campion and slender hawksbeard, but the total area of the interior grasslands recommended for prescribed burns is very small.

- **Research and Monitoring**

  Standard methodology should be used to establish pre- and post-burn monitoring plots in JSR prescribed burns. BC Resource Inventory Committee Procedures for Environmental Monitoring in Range and Wildlife Habitat Management are contained at http://www.for.gov.bc.ca/ric/pubs/teecolo/habitat/. This will be required to evaluate the effectiveness of various prescriptions and provide feedback to the development of future prescriptions and objectives. The change in prescribed fire objectives from range quality to forest encroachment and in-growth issues should not result in grassland fire effects being ignored in future monitoring programs. Fire effects on all affected values including forest conditions, range quality and floristic composition, wildlife response and soil parameters, should be monitored by encouraging resource management and research agencies, as well as universities and colleges, to become involved in fire effects monitoring and research design, in partnership with BC Parks. A list of current researchers with interests in prescribed fire research can be obtained from Steve Taylor, Fire Research Group, Canadian Forest Service, Victoria, BC. Enough recent monitoring of similar prescribed burns has occurred, that there is now a strong knowledge base on which the JSR prescribed fire program can be added. Important projects for this effort will be the EMBER program in the Rocky Mountain Trench and planned burn monitoring at Okanagan Mountain and Kalamalka Lake Provincial Parks in the dry interior.

7. References

Alexander, D. 1997. A Cultural Heritage Overview of the Cariboo Forest Region. Report prepared for the Cariboo Forest Region, Ministry of Forests, Williams Lake, B.C.

Applied Ecosystem Management Ltd. 1998. Fire History of the Little Rancheria Caribou Herd Winter Range. Unpublished report prepared for Yukon Territorial Government Department of Renewable Resources and DIAND Forest Resources.

BC Forest Practices Code. 1999. Accounts for Identified Wildlife. BC Ministry of Forests and Environment, Lands and Parks.

BC Forest Practices Code. 1995. Biodiversity Guidebook. BC Ministry of Forests and Environment, Lands and Parks.

BC Forest Practices Code. 1995. Fire Management Guidebook. BC Ministry of Forests and Environment, Lands and Parks.

Braumandl, T. 1995. Forest in-growth in the ponderosa pine (PP) and Interior Douglas-fir (IDF) biogeoclimatic zones of the southern Rocky Mountain Trench. Research Section, BC Ministry of Forests, Nelson Forest Region, Nelson, BC. 12 pp.

Braumandl, T.F., S. Taylor, C.F. Thompson, A.J. Stock, D. Gayton. 1995. Ecosystem maintenance demonstration burns monitoring project. General work plan and establishment rep. for Picture Valley and Findlay Creek sites. EMBER Project, Nelson For. Reg., Nelson, BC.

Cariboo-Chilcotin Grasslands Strategy Working Group. 1999. DRAFT (internal review) Cariboo-Chilcotin Grasslands Strategy. Interim Report on Grassland Encroachment and In-growth. August, 1999.

Coupe, R. 2000. Personal Communication, Ray Coupe, Research Associate Ecologist, Cariboo Forest Region. February, 2000.

Covington, W.W., and M.M. Moore. 1992. Post-settlement changes in natural fire regimes: implications for restoration of old-growth ponderosa pine forests. *In* W.R. Kaufmann, W.H. Moir, and R.L. Bassett (Eds.). Old-growth forests in the Southwest and Rocky Mountain Regions: proceedings of a workshop. U.S. Dep. Agric. For. Ser. Gen. Tech. Rep. RM-213. Portal AZ.

Curtis, G. 1997. Planning and implementing a prescribed burning program in the Kootenai National Forest. Abstract and summary in Report on the Symposium Fire and Ecosystem Restoration in dry southern interior forests, Sept. 29 – Oct. 2, 1997, Fort Steele, B.C. S.W. Taylor, editor (in prep.).

Daigle, P. 1996. Fire in the dry interior forests of British Columbia. British Columbia Ministry of Forests Research Program Extension Note 08:5pp.

Fenger, M.A. and Demarchi, D.A. 1992. Biophysical Habitat Units of the Junction Wildlife Management Area and the Deer Park Wildlife Reserve. 1:20,000 scale map prepared by

BC Ministry of Environment, Lands and Parks, Wildlife Branch, Habitat Inventory Section.

Fire Effects Information System (Online). 1996, September. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer). Available: www.fs.fed.us/database/feis/ (1998, March 12).

Forest Practices Code of British Columbia. 1995. Biodiversity Guidebook. Prepared by BC Ministry of Forests and BC Environment, Lands and Parks.

Francis, S.R. 1996. Linking Landscape Pattern and Forest Disturbance: Fire History of the Shakwak Trench, Southwest Yukon Territory, M.Sc. Thesis, Dept. of Biological Sciences, University of Alberta, Edmonton, 130pp.

Gayton, D. 1996. Fires-maintained ecosystems and the effects of forest in-growth. BC Ministry of Forests and Government of Canada Forest Resources Development Agreement Report, Nelson, BC. 4 pp.

Habitat Monitoring Committee. 1996. Procedures for environmental monitoring in range and wildlife habitat management. Version 5.0. British Columbia, Ministry of Environment, Lands and Parks and British Columbia Ministry of Forests, Victoria, B.C. 225pp.

Hooper, T.D. 1997. Status of the Upland Sandpiper in the Chilcotin-Cariboo region, British Columbia. Wildlife Working Report No. WR-86. B.C. Ministry of Environment, Lands and Parks, Williams Lake, B.C. 13 pp.

Hooper, T.D. and Pitt, M.D. 1995. Problem Analysis for Chilcotin-Cariboo Grassland Biodiversity. BC Ministry of Environment, Lands and Parks Wildlife Bulletin No. B-82, March, 1995. 106 pp.

Krannitz, P. 1997. Fire and livestock grazing in the antelope bitterbrush ecosystem of the south Okanagan. Abstract and summary in Report on the Symposium Fire and Ecosystem Restoration in dry southern interior forests, Sept. 29 – Oct. 2, 1997, Fort Steele, B.C. S.W. Taylor, editor (in prep.).

Kruse, A.D., and J.L. Piehl. 1986. The impact of prescribed burning on ground-nesting birds. *In*: Clambey, G.K. and Pemble, R.H. (Eds). The prairie: past, present and future: Proceedings, 9th North American prairie conference; 1984 July 29 – August 1; Moorhead, MN. Fargo, ND: Tri-College University Center for Environmental Studies: 153-156.

Lawson, B.D. and G.N. Dalrymple. 1996. Probabilities of sustained ignition in lodgepole pine, interior Douglas-fir and white spruce-subalpine fir forest types. Suppl. 1 to Field Guide to the Can. FBP System. Can/BC Partnership Agreement on For. Res. Dev. – FRDA II. Hdbk. 012, Can. For. Serv., Victoria, B.C.

Matzen, T. 2000. Personal communication, Tom Matzen, Williams Lake Fire Zone, Williams Lake, January 2000.

Nicholson, R. 1992. Impact of prescribed burning on diffuse knapweed (*Centaura diffusa*) infestations and floral diversity in Kalamalka Lake Prov. Park. M.Sc. Thesis, University of B.C. Dept. of Plant Science.

Parminter, J. 1978. Forest encroachment upon grassland range in the Chilcotin Region of British Columbia. Unpublished Master of Forestry Thesis, Department of Forestry, University of British Columbia.

Parminter, J. 1999. Personal communication, John Parminter, British Columbia Ministry of Forests Research Branch, October 07, 1999.

Peek, J.M., Dearchi, D.A., Demarchi, R.A. and D.E. Strucker. 1984. Bighorn Sheep and Fire: Seven Case Histories. In Fire's Effects on Wildlife Habitat Symposium Proceedings. Missoula Montana March 21, 1984. USDA Forest Service Gen. Tech. Rep. INT-186

Ross, T. 1997. Forest in-growth and forest encroachment on Balk Mountain and Becher Prairie: 1962 and 1993/95. Report submitted to BC Ministry of Agriculture and Cariboo-Chilcotin Grazing Enhancement Fund, Williams Lake, BC by Ross Range and Reclamation Services. Cranbrook, BC.

Sarell, M.J., and K.P. McGuinness. 1996. Status of the Brewer's Sparrow in British Columbia. Wildlife Working Report No. WR-77. B.C. Ministry of Environment, Lands and Parks, Wildlife Branch, Victoria, B.C. 12 pp.

Strang, R.M. and Parminter, J. 1980. Conifer encroachment on the Chilcotin Grasslands of British Columbia. Forestry Chronicle.

Taylor, S.W. and O.B. Armitage. 1996. SCORCH: A fire-induced tree-mortality prediction model for Canadian forests. pp. 137-138 in: Integrated forest vegetation management options and applications. Proc. 5th BC For. Mgt. Workshop, November 29-30, 1993, Richmond, B.C. (P.G. Comeau et al., eds.) Can/BC FRDA Rep. No. 251.

Taylor, S.W. and B.C. Hawkes. 1997. A stand and landscape level fire and successional modeling system for ponderosa pine and interior Douglas-fir forests. FRBC Ann. Rep. – Project #FR-96/97-392.

van Woudenberg, A.M. 1999. Status of the Flammulated Owl in British Columbia. Wildlife Working Report No. WR-95. B.C. Ministry of Environment, Lands and Parks, Wildlife Branch, Victoria, B.C. 29 pp.

Wikeem, B.M. and Strang, R.M. 1983. Prescribed Burning on BC Rangelands: the State of the Art. *Journal of Range Management* (36): 3-8.

Youds, J.A. and D.M. Hebert. 1988. Prescribed burning for wildlife in the Cariboo. pp.78-83 in Proc. Wildlife and range prescribed burning workshop, Richmond, B.C., October 27-28, 1997, M.C. Feller and S.M. Thomson, eds., UBC Faculty of Forestry.

Appendix One

Weather Station (1708) Riske Creek:
Fire Weather Climatology (1980-1999)

Junction Sheep Range Provincial Park
Prescribed Fire Management Plan

Weather Stn. (1708) Riske Creek:
Location and Historical Weather

Latitude	Longitude	Elevation (m)	Period of Record
51º 57.60´N	122º 30.60´W	884	1980 – 1999

Historical Weather Climatology

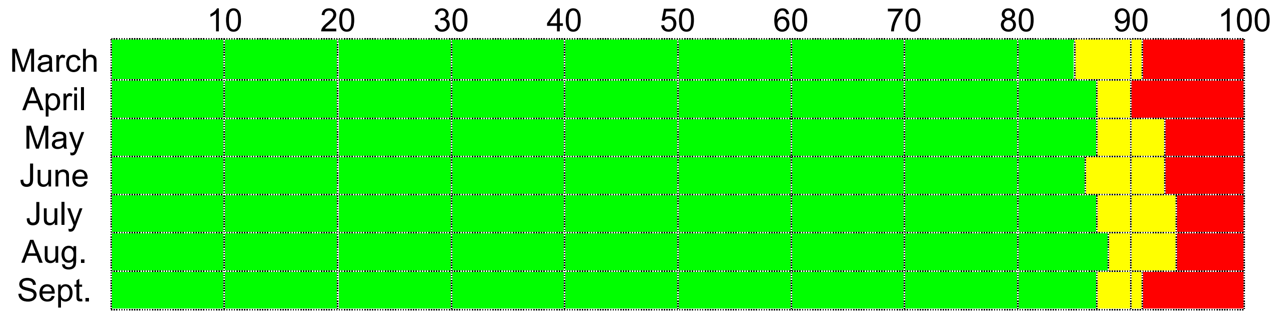
	Temp.(ºC)	RH (%)	Precipitation (mm)
	Avg.	Avg.	Avg.
March*	6	46	7.0
APRIL*	10	44	12.9
May	15	45	32.0
June	18	48	51.2
July	20	46	50.8
Aug.	20	46	38.7
Sept.	16	47	26.9

* Estimated based on incomplete weather records

	Windspeed (km/hr)		Wind Direction Frequency (%)				
	Avg.	90th %	calm	90	180	270	360
March	9	17	6	27	27	27	13
April	9	17	3	24	33	22	18
May	9	16	3	17	36	19	25
June	8	14	3	18	33	17	29
July	7	13	8	15	30	16	31
Aug.	7	13	7	14	30	17	32
Sept.	6	14	11	14	34	17	23

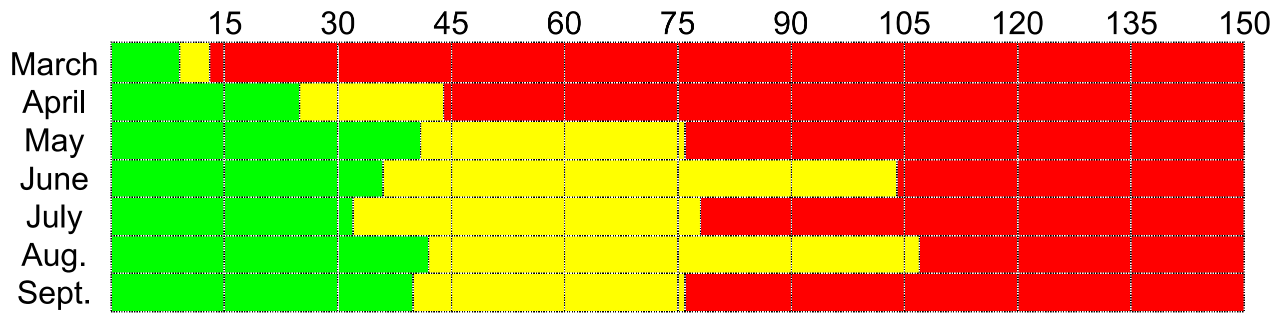
FUEL MOISTURE CODES

FFMC



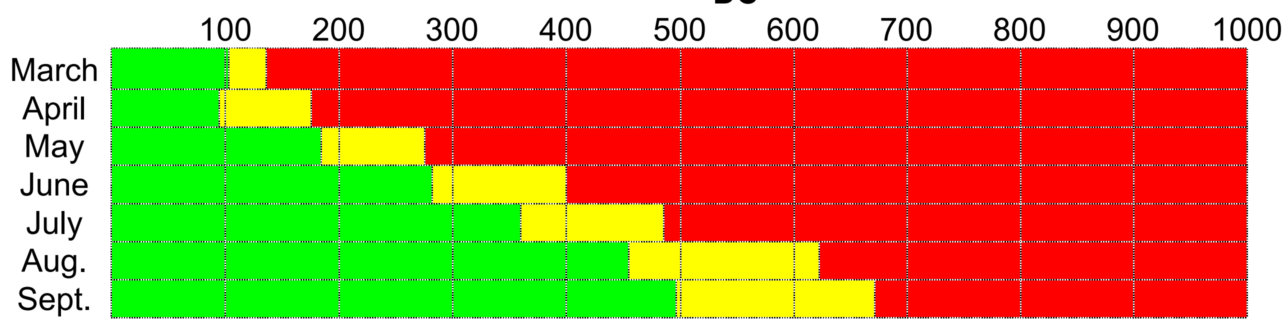
Month	Percentile 50th	90th	100th
March	85	91	93
April	87	90	95
May	87	93	97
June	86	93	97
July	87	94	97
Aug.	88	94	98
Sept.	87	91	96

DMC



Month	Percentile 50th	90th	100th
March	9	13	17
April	25	44	64
May	41	76	131
June	36	104	178
July	32	78	187
Aug.	42	107	146
Sept.	40	76	151

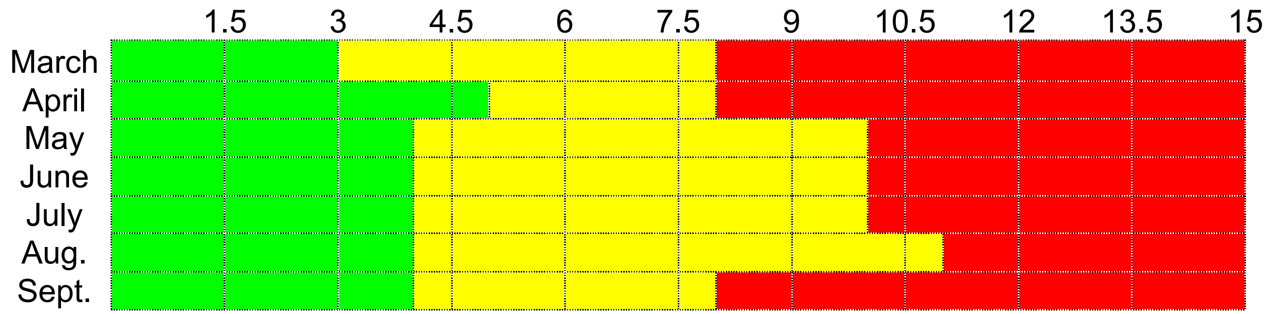
DC



Month	Percentile 50th	90th	100th
March	102	135	154
April	95	175	238
May	184	275	394
June	282	400	524
July	360	486	635
Aug.	455	622	809
Sept.	499	671	798

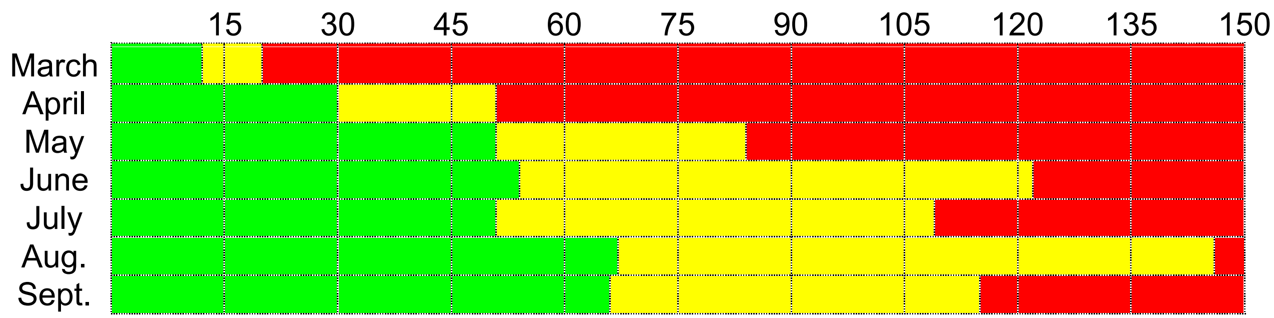
Fire Weather Indices

ISI



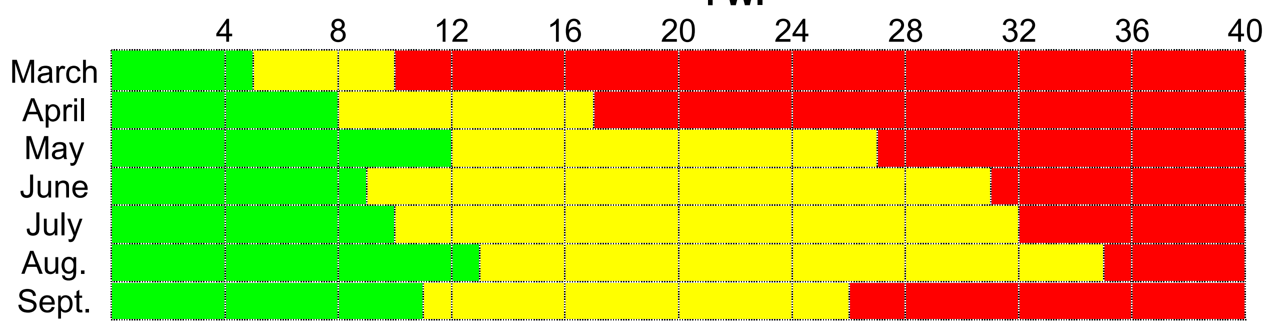
Percentile		
50th	90th	100th
3	8	17
5	8	41
4	10	25
4	10	21
4	10	24
4	11	27
4	8	26

BUI



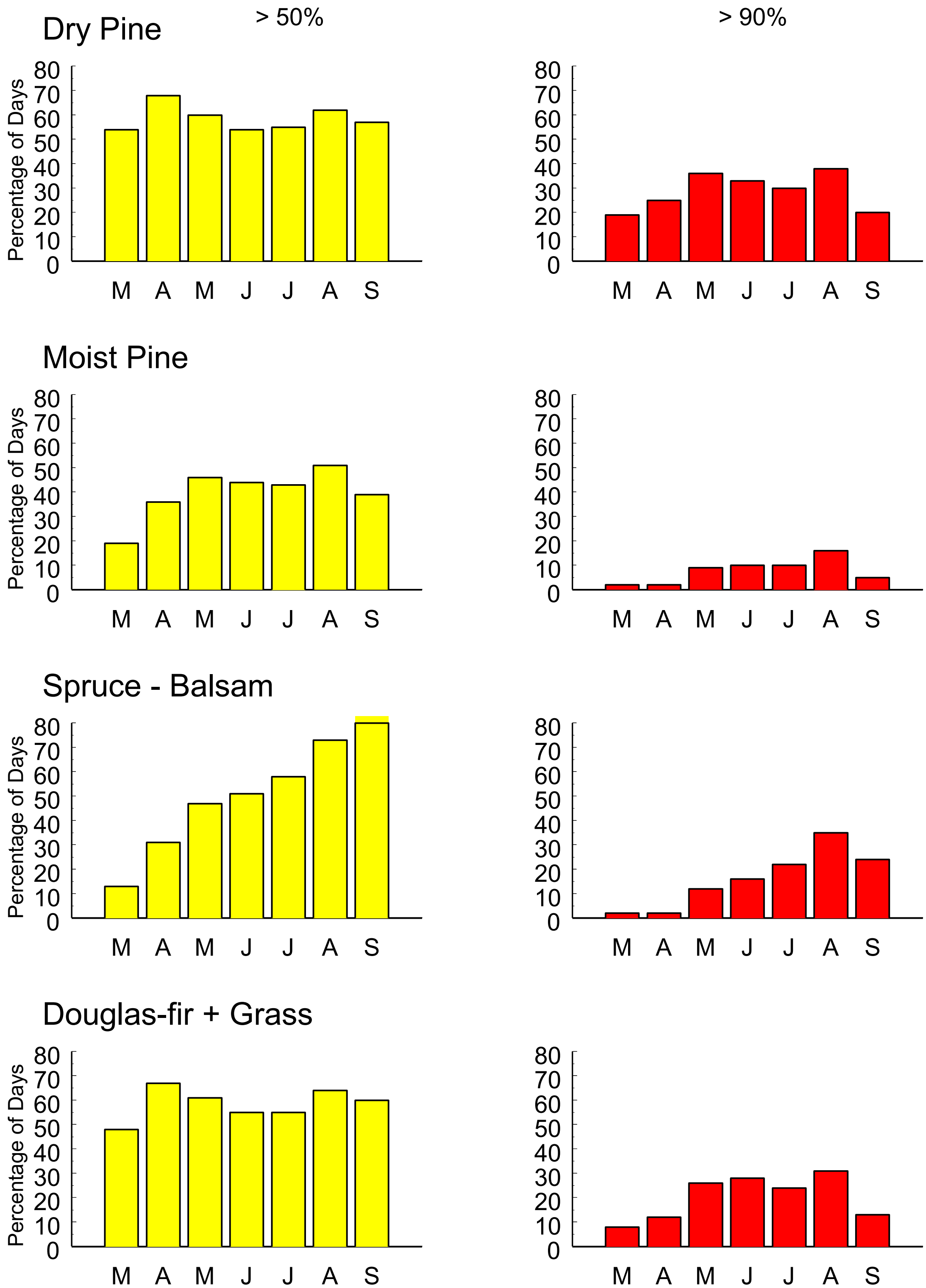
Percentile		
50th	90th	100th
12	20	24
30	51	70
51	84	136
54	122	187
51	109	196
67	146	199
66	115	197

FWI



Percentile		
50th	90th	100th
5	10	16
8	17	47
12	27	50
9	31	55
10	32	54
13	35	65
11	26	60

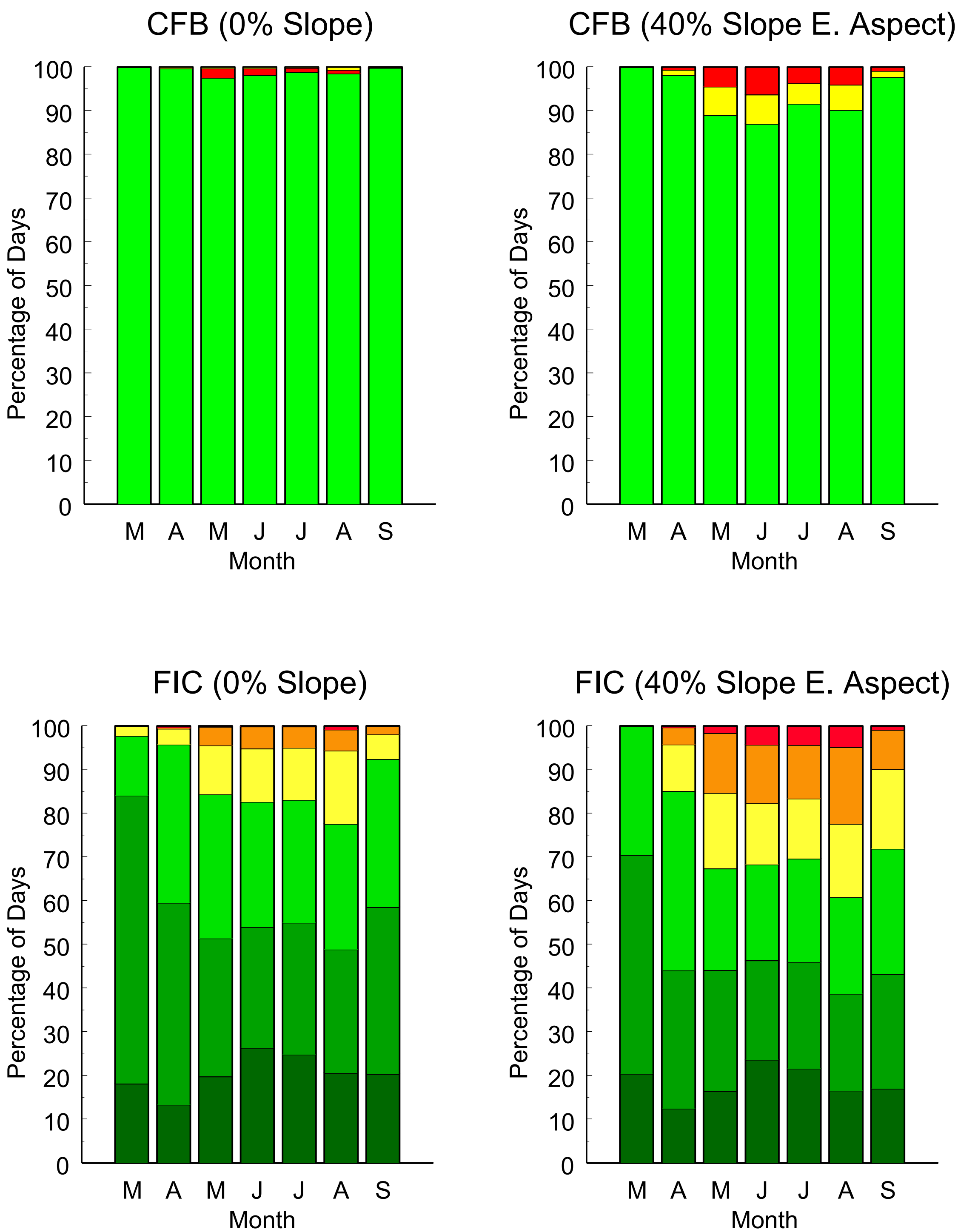
NUMBER OF DAYS THAT PROBABILITY OF IGNITION EXCEEDS 50% AND 90%



Number of days that probability of ignition exceeds 50% and 90%

	Ignition Probability > 50% Percentage of Days	Ignition Probability **> 90% Percentage of Days**
Dry Pine		
March	54	19
April	68	25
May	60	36
June	54	33
July	55	30
August	62	38
September	57	20
Moist Pine		
March	19	2
April	36	2
May	46	9
June	44	10
July	43	10
August	51	16
September	39	5
Spruce Balsam		
March	13	2
April	31	2
May	47	12
June	51	16
July	58	22
August	73	35
September	83	24
D. fir + grass		
March	48	8
April	67	12
May	61	26
June	55	28
July	55	24
August	64	31
September	60	13

Percentage of Days for Crown Fraction Burned (CFB) and Fire Intensity Classes (FIC) for benchmark fueltype C-7.



Percentage of Days for Crown Fraction Burned (CFB) and Fire Intensity Classes (FIC) for C-7 Fueltype

	Crown Fraction Burned (CFB) Class			Fire Intensity Class (FIC)					
	1	**2**	**3**	**1**	**2**	**3**	**4**	**5**	**6**
0% slope									
March	100.00	0.00	0.00	18.18	65.91	13.64	2.27	0.00	0.00
April	99.70	0.00	0.30	13.37	46.20	36.17	3.65	0.30	0.30
May	97.53	2.14	0.33	19.77	31.63	32.95	11.20	4.28	0.16
June	98.17	1.50	0.33	26.33	27.67	28.67	12.17	5.00	0.17
July	98.87	0.97	0.16	24.84	30.16	28.06	11.94	4.84	0.16
August	98.55	0.81	0.65	20.65	28.23	28.71	16.77	4.84	0.81
September	99.82	0.18	0.00	20.39	38.14	33.92	5.62	1.93	0.00
40% slope E. aspect									
March	100.00	0.00	0.00	20.45	50.00	29.55	0.00	0.00	0.00
April	98.18	1.22	0.61	12.46	31.61	41.03	10.64	3.95	0.30
May	88.96	6.59	4.45	16.47	27.68	23.23	17.30	13.67	1.65
June	87.00	6.67	6.33	23.67	22.67	22.00	14.00	13.33	4.33
July	91.61	4.68	3.71	21.61	24.35	23.71	13.71	12.26	4.35
August	90.16	5.81	4.03	16.61	22.10	22.10	16.77	17.58	4.84
September	97.72	1.41	0.88	17.05	26.19	28.65	18.28	8.96	0.88