Carpenter Lake/Bridge River Prescribed Fire Planning

September 2000

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1 Introduction

The goal of this project is to improve and expand the winter range habitat for ungulates in the Carpenter Lake drainage area. This can be accomplished through the proper application of prescribed fire.

The northern slopes above Carpenter Lake are very important winter range habitat for Mule Deer, California Bighorn Sheep, and Mountain Goat. The dry, open ecosystems that cover the steep south facing slopes support the local ungulate populations in the late Winter and early Spring when snow loads are high elsewhere. With the reduction in wildfire activity due to fire suppression and the reduction of traditional burning in the area, these open grassland areas are heavily encroached with Douglas fir. The coniferous encroachment reduces the forage available to ungulates during the critical late winter period. Winter range habitat has been recognized as the limiting factor for both deer and sheep populations in the area.

Reintroduction of fire, in a controlled and planned manner, will open the forest canopy and provide for more forage opportunities. By returning part of this area to earlier seral stages, winter forage can be increased.

There are few other competing values in this area which makes it a good candidate for prescribed fire. Ainsworth Lumber Co in Lillooet has a Five Year Development Plan approved in the same general area. This complicates, but does not eliminate the use of prescribed fire in the area.

Nine areas covering over 1100 hectares were identified as suitable for prescribed fire. Four of the highest value sites had prescribed fire plans prepared. The six low elevation sites can be a mixture of Spring anf Fall burns. The three high elevation sites will have to be ignited in the Fall. The first opportunity for prescribed fires in this area will be in the Fall of 2001. Four of the areas will have to wait until adjacent planned harvesting is completed, the timetable for this harvesting has not been finalized. Further work involving weather data collection, photo ties and vegetation plots will be required before prescribed fires are ignitied. In addition, concerns brought forward by the Ministry of Forests and First Nations will have to be addressed.

2 Study Area

The entire Carpenter Lake area, and side drainages to the reservoir, were reviewed for potential prescribed burning sites. The review covered topography, fuel types, natural barriers, and other conflicting resources uses. The area identified for further assessment covers the northeast side of Carpenter Lake, from the east end dam, west to Jones Creek. The study area includes all land from the reservoir to the height of land (Shulaps Range). Approximately 3000 hectares of suitable land was identified in the initial survey, not including alpine areas.

Smaller, more specific areas were then defined based on practical burn sizes, suitable forest types, natural boundaries and proximity to other values, most specifically planned forest development for harvesting operations. A helicopter flight on August 2, 2000 assisted in identifying the most suitable sites for prescribed burning. A total of six areas at lower elevations totaling 905 hectares were identified as good deer/sheep winter range sites that were suitable for burning. These are shown as areas one through seven (excluding three) on the attached 1:15 000 scale map (Appendix F). Three alpine sites with a combined area of 205 hectares were also identified. These areas are specifically for goat winter range but would provide summer areas for deer and sheep as well. The high elevation sites are patches of conifers adjacent to escape terrain. The nine areas total approximately 1110 hectares. The selected areas were reached at independently but coincide very closely with locations selected for prescribed fire in the *Prescribed Fire for Wildlife Habitat Improvement - 5 Year Program, Lillooet Forest District August 1989 (Appendix A).*

3 Local Fire History

A 1977 study of tree fire scars showed this area had a mean fire interval as low as 17.33 years (Low 1987). This regular fire occurrence created a mosaic of different aged forests, open areas, and varying stand densities that offered more forage opportunities than today's Douglas fir dominated multi-layered, largely mature forests. The fire interval has become significantly longer over the last fifty years because of aggressive fire suppression policies.

At least three prescribed burns have been completed in this area in the last three decades. All prescribed burn activity was planned and implemented with improving ungulate habitat as its main objective. Two burns occurred in the Cedarvale Creek in 1986 and one burn in the Viera Creek drainage in 1985. The Viera Creek burn was the largest and most intense, covering approximately 280 hectares.

The attached pictures show the impacts of the 1985 prescribed fire in upper Viera Creek. This burn was very intense, causing mortality in the entire coniferous overstorey. Very little brush or grass production has occurred in the fifteen years since this prescribed fire. Lodgepole Pine are just starting to re-establish themselves on the site. The intention for adjacent prescribed burns is lighter site impacts, where only a portion of the canopy is removed and a majority of the prescribed fire stays on the ground.

Winter Range Enhancement Burn in Veira Creek Burn in 1985.

4 Wildlife Habitat and Use

This project is directed towards improving ungulate winter range habitat. The three ungulates most common in the area are Mule Deer, California Bighorn Sheep and Mountain Goats. Deer and sheep are the most populous species in the area. The central portion of this study area has been recognized as the 'principle winter range' for the Shulap California Bighorn Sheep population (Sudgen 1961). It is also recognized as one of the major mule deer areas within the Thompson/Nicola Region (Low 1980). The limiting factor for both deer and sheep populations is wintering range. A 50% decline in sheep populations in the first half of the 1900's was speculated to be due to tree regeneration on grassy areas (Sudgen 1961).

Winter habitat for deer and sheep in this area is typically on steep, south facing, wind blown areas below 1500 meters in elevation, These areas have low snow cover and allow for foraging during the late Winter and early Spring. Most of these areas are experiencing a longer fire interval than in the past, due mostly to wildfire suppression efforts and a reduction in traditional burning activities. Encroachment of coniferous trees species, mostly Douglas fir, have reduced the size of these important forage areas, and reduced the amount of winter forage available. The area has become very homogenous, with little variation that would promote wildlife use.

4.1 Mule Deer *

The effects of fire on Mule Deer habitat are widely varied. In general, fires that create mosaics of forage and cover are beneficial. Deer seem to prefer foraging in burned compared to unburned areas. This preference may indicate an increase in plant nutrients which usually occurs following fire. Another study suggests there is an 'increase in the quality of deer diets due to changes in forage selection' after fire (multiple references, Fire Effects Information System).

4.2 Bighorn Sheep

Many bighorn sheep populations originally occurred in areas with frequent fire intervals. Fire exclusion for over 50 years has allowed plant succession to alter and reduce many bighorn sheep habitats throughout North America. Fire exclusion, which has allowed conifers to establish on grasslands, has decreased both the forage and security values on many bighorn sheep ranges. Fire is an important factor in creating habitats that are heavily used by bighorn sheep. Prescribed fire can be a useful tool in managing sheep habitat (multiple references, FEIS).

4.3 Mountain Goat

The effects of fire on Mountain Goat habitat has not been well studied. Some grasslands used by mountain goats are the results of past fires, and effective fire suppression in recent years has resulted in the lack of new grassland development in some areas. Periodic burning keeps seral grasslands from becoming dominated by climax coniferous tree cover (multiple references, FEIS). Fire can increase the diversity and quality of herbaceous and deciduous forage for goats.

** Additional information on fire effects on ungulates found in Appendix C.*

5 Prescribed Fire Objectives

1. Promote the growth of locally important browse and grazing plants, including; maple, willow, false box, birch leaved spirea, bluebunch wheatgrass, fescue grasses, saskatoon, ceanothus, and kinnikinnick. *
2. Remove dried surface fuels, immature conifers and dead, down material. This will return much of the impacted area to an earlier seral stage, dominated more by shrubs and grasses than conifers.
3. Remove a portion of the Douglas fir understorey to open the stand.
4. Raise crown height of overstorey.
5. Less than 20% overstorey mortality.
6. No impacts on accessible merchantable timber.
7. Impact a minimum of 60% of the planned burn area. This will create a mosaic of open areas combined with mature tree cover.
8. Keep burn within planned area.
9. Create a fire rank of 1 to 3, with the occasional Rank 4. A majority of the area should be impacted with a Rank 2 fire, a low to medium intensity surface fire.
10. Utilize natural barriers and low fuel areas to minimize the potential for escape and the preparation work required.
11. Reduce the potential for large, catastrophic wildfires in the area by reducing fuel loading

and stand densities.

** Being more specific about individual plants that will be promoted is very difficult. All plants react differently to varying fire intensities. Also, there are a large number of microsites within each burn area. The same plant will react differently on the same fire site depending on fire intensity, slope, aspect, soil moisture and numerous other variables.*

6 Priority Areas for Prescribed Fire Planning

Areas within the Dam to Jones Creek area were identified for treatment. They were selected based largely on suitability for ungulate winter range, the natural boundaries surrounding them, the fuel type and the topography.

Identified Areas Suitable for Prescribed Fire Activities

Number	Area (ha)	Elevation (m)	Deer/Sheep or Goat Range	Geographic	Conflicts
1	90	1200-1900	Deer/Sheep	North of Dam	Merchantable Timber
2	300	700-1800	Deer/Sheep	East of Viera Ck	Cabin at top end
4	40	700-1500	Deer/Sheep	Between Sebring and Cedarvale Creeks	Post-Harvest
5	70	700-1200	Deer/Sheep	Between Sebring and Cedarvale Creeks	Post-Harvest
6	170	700-1300	Deer/Sheep	Bighorn to Cedarvale Creeks	Post-Harvest
7	200	700-1300	Deer/Sheep	Jones to Bighorn Creeks	House west of Jones Creek Post Harvest
8	35	1800-2100	Goat/Deer	Head of Sebring Ck	None
10	90	1400-2200	Goat/Deer	Head of Bighorn Ck	None
11	115	1200-2000	Goat/Deer	Head of West Fork Jones Ck	None
	1110				

A total of nine different areas totalling approximately 1110 hectares were identified. They were then priorized based on the following criteria.

1. Suitability for winter range for local ungulates.
2. The quality of the natural boundaries for fire control and spread.

3. Proximity of other values (i.e. merchantable timber and powerlines)
4. Total potential burn size (in hectares). Larger areas were given preference.
5. Timber (Fuel) type - enough surface fuel for easy fire spread but not accessible merchantable timber
6. Elevation - a variety of elevations but concentrating on areas below 1500 meters for deer winter range
7. Topography - areas with low winter snow loads, steep south facing slopes
8. Access for layout/planning/crew work/plots.

Priority Areas for Prescribed Fire

Winter Range	Priorities	Area (ha)
Deer/Sheep	2, 7, 6, 5, 4, 1	905
Goat/Deer	11, 10, 8	205

7 Prescribed Fire Plans

Four complete prescribed fire plans were developed. Plans were developed for Areas 2, 7, 10, and 11. These areas were determined as the highest priority. All four plans can be found in Appendix D. The final burn plans might change slightly, after field layout and review by Ministry of Forests personnel. The remaining five sites do not have complete prescribed fire plans, but site pictures are also in Appendix D.

8 Prescribed Fire Techniques

Prescribed burning in this area will be completed by a combination of helicopter ignition with an Aerial Ignition Device (AID) Machine and hand ignition. Due to poor access and difficult terrain, a majority of the ignition will be completed from the air. The AID system allows for heavy application of ignition devices that land on the ground before igniting. Hand lighting will be used to strengthen control lines when possible and to 'touch up' areas that require additional ignition. Experienced ground crews will be essential for this activity.

Three AID Machines are available for loan from Dave Marek at the Ministry of Forests' Northwest Fire Center in Smithers, B.C. They also have a large supply of ignition devices that can be used and replaced afterwards.

Natural boundaries will be used whenever possible to reduce or eliminate the need for manmade control line construction. When required, blackline type control lines are preferred to mechanical guards. These blacklines can be installed under moist conditions before the prescribed fire with the hand application of fuel to the control line locations.

Accurate weather data will be required to properly monitor burn conditions. An automated weather station with daily reporting will be required in a representative site within the study area.

Both Spring and Fall prescribed fires will be considered. Spring burns are typically light surface fires that do not impact the main canopy or the soil to any extent. These are usually carried out shortly after the snow has left the site. This low intensity type of burn usually promotes grass production. The Ministry of Forests requires that all Spring burns be completely extinguished, usually within two weeks of ignition. This can result in very high mop up costs, especially in this type of inaccessible area.

Fall burns are usually more intense and have a higher impact on the site. A larger amount of fuel is dry after the summer period and more fuel becomes involved in the burn, creating more heat and more site impact. This type of burn usually promotes brush production. These fires can have large impacts on the soil and main forest canopy. The Ministry of Forests is far more flexible with Fall prescribed burns. They will often allow monitoring only and allow the weather to extinguish the fire. This will greatly reduce the prescribed fire costs.

9 Prescribed Fire Scheduling

The scheduling of prescribed fires in this area will depend on numerous factors. The availability of areas 4, 5, 6 and 7 for prescribed fire will depend largely on the harvesting plans of Ainsworth Lumber Co. These areas can not be burned until after harvesting on the adjacent blocks of CP 175 is completed. Areas 1, 2, 8, 10, and 11 do not have other direct resource conflicts. These areas can progress once all stakeholders are satisfied with the process.

10 Planned Harvesting in Study Area

Ainsworth Lumber Co has a development planned in the study area. Cutting Permit 175 development is planned for year 2000. The plans calls for 876 hectares to be harvested. Twenty kilometers of road will be constructed and 82,000 cubic meters of timber will be removed over a three pass system. The planned harvesting is located between Sebring and Bighorn Creeks, in the middle of the planned prescribed fire area. This development, while limiting and complicating the prescribed burn process, will have some positive benefits. The new access will permit better planning and control lines for prescribed fire. The openings from the harvesting process will be some improvement for winter range habitat, especially if the openings are burned.

Ainsworth has also suggested some partial cut options on areas where planned prescribed fire will occur. This would provide some timber from sites that might not normally be considered for harvesting, and could improve the surface fuel loading (limbing and topping in the bush) to carry a prescribed fire. A flight of the area on September 6th with Darren Blom, an Ainsworth Lumber Co Representative, showed little opportunity for this due to accessability and steep slopes of selected prescribed fire areas. Ainsworth is exploring this further.

Ainsworth is already considering prescribed fire as a site preparation treatment on many of the blocks in CP 175. They are reviewing and may adjust the present block boundaries to make them easier to broadcast burn.

The Small Business Forest Enterprise Program does not have any areas of interest in the study area. Their closest area is north of Marshall Creek and will not be impacted by these prescribed fire activities.

11 Study Area Limitations

1. Ainsworth Lumber Co has a five year development plan for this area that will commence in 2000. They will not support any plans that impact on accessible merchantable timber.
2. Water quality impacts - Campers at Bighorn Creek use creek water for cooking and drinking.
3. Visual impacts, much of the planned area is designated for full or partial retention.
4. Very steep rough terrain makes site access very difficult.
5. Prescribed fire escape is always a possibility as fire spread is partially controlled by weather.
6. Douglas Fir Bark Beetle infestations are a possibility after the prescribed fire has stressed many of the larger trees on site.
7. A lack of really accurate historical weather data for this area to predict the best burning conditions.
8. Creation of danger trees along the Carpenter Lake Road. Intense fire activity directly above the Road may kill and damage trees that could reach the road if they fail.
9. Powerlines are located inside or adjacent to many of the proposed prescribed fire areas.
10. Slope stability issues above Highway 40 need to be looked at.

12 Study Area Benefits

1. Numerous cliffs and rock outcrops provide natural barriers to slow or stop the spread of prescribed fires.
2. Ainsworth Lumber's development will improve access into the area, and its lowest openings may improve forage for ungulates.
3. Few other values are identified here which will reduce conflicts for prescribed fire.
4. Area is recognized as important winter range for deer, sheep and goat.
5. Wildfire is a natural part of the ecosystems in this area.

13 Local Biogeoclimatic Zones and Plant Communities

The planned prescribed burns cover a variety of biogeoclimatic zones and plant communities. The north side of Carpenter Lake is in the Northern Dry climate region. The low elevation burns, including sites 7, 6, 5, 4, and 2, are in the IDF dk2 biogeoclimatic zone.* The coniferous cover consists of;

Common Name	Scientific Name
Douglas fir	Pseudotsuga menziesii
Ponderosa Pine	Pinus Ponderosa
Lodgepole Pine	Pinus contorta

The most common shrubs include;

Common Name	Scientific Name
common juniper	Juniperus communis
saskatoon	Amelanchier alnifolia
birch-leaved spirea	Spiraea betulifolia
soopolallie	Shepherdia canadensis
false box	Paxistima myrsinites
tall oregon grape	Mahonia aquifolium

The most common herbs include;

Common Name	Scientific Name
bluebunch wheatgrass	Agropyron spicatum
pinegrass	Calamagrostis rubescens
kinnikinnick	Arctostaphylos uva-ursi
twinflower	Linnaea borealis

Prescribed fire area number 1 in in the MS dc biogeoclimatic zone. The conifers in the area include;

Common Name	Scientific Name
Douglas fir	Pseudotsuga menziesii
Lodgepole Pine	Pinus contorta
Subalpine fir	Abies lasiocarpa
Hybrid White Spruce	Picea engelmannii X glauca

The most common shrubs include;

Common Name	Scientific Name
common juniper	Juniperus communis
birch-leaved spirea	Spiraea betulifolia
soopolallie	Shepherdia canadensis
false box	Paxistima myrsinites

The common herbs include;

Common Name	Scientific Name
bluebunch wheatgrass	Agropyron spicatum
pinegrass	Calamagrostis rubescens
kinnikinnick	Arctostaphylos uva-ursi

arctic lupine	Lupinus arcticus
heart leaved arnica	Arnica cordifolia

Prescribed fire areas 8, 10 and 11 are all in the ESSF dv biogeoclimatic zone. The main coniferous tree species include;

Common Name	Scientific Name
Whitebark Pine	Pinus albicaulis
Lodgepole Pine	Pinus contorta
Subalpine fir	Abies lasiocarpa
Engelmann Spruce	Picea engelmannii

The common shrubs include;

Common Name	Scientific Name
common juniper	Juniperus communis
false box	Paxistima myrsinites
black huckleberry	Vaccinium membranaceum
white flowered rhododendron	Rhododendron albiflorum

The more common herbs include;

Common Name	Scientific Name
pinegrass	Calamagrostis rubescens
kinnikinnick	Arctostaphylos uva-ursi
arctic lupine	Lupinus arcticus
junegrass	Koeleria macrantha
yarrow	Achillea millefolium

** All biogeoclimatic zone and plant association information was collected from an onsite visit to the lower elevation sites and from A Guide to Site Identification and Interpretation for the Kamloops Forest Region, Land Management Handbook Number 23.*

14 Fire Effects on Local Plant Species

The fire impacts on the local plant species was investigated using the Fire Effects Information System found at www.fs.fed.us/database/feis/ on the internet. Some specific plant species were not listed on the website, so other plants in the same genus were substituted. For example, Mahonia aquifolium was not available so Mahonia repens was used as a likely indicator of fire effects instead. The full information collected on each plant species is included in Appendix B.

Fire effects on plant communities varies greatly; with fire intensity, time of year, and maximum soil temperature being the leading factors. The hotter the fire intensity, and the greater the impacts on the soil, leads to higher plant mortality. Fires while the plants are actively growing also cause the most mortality. Also, plants react differently to wildfires. Many of the plants with rhizomes react very favourably to fires. Rhizomes that are segmented by the fire often sprout multiple new plants shortly after the fire. Others are easily killed and rely on a seed bed or seed migration to re-colonize a site after a fire.

14.1 Trees

Douglas fir and Ponderosa Pine trees are the most fire resistant trees in the area. Large diameter trees of both species are expected to survive surface fires. Crown scorch is the main reason for tree death in both species. Lodgepole Pine trees are more susceptible to surface fires, having thinner bark with less insulation capacity. Subalpine fir is one of the least fire-resistant western conifers. It has thin, flammable bark and a shallow root system. It also has low branches and highly flammable foliage that allows for easy candling of the entire tree. Even light intensity surface fires can often kill subalpine fire trees. Spruce trees are also easily killed by fires. Spruce also have thin bark and shallow root systems which are easily damaged by surface fires, especially when smoldering fires occur at the base of the tree. Whitebark Pine are moderately fire resistant. Hot surface fires can cause tree mortality due of the tree's thin bark.

14.2 Shrubs

Many of the local shrubs react favourably to light and medium intensity fires. Saskatoon, tall oregon grape, birch-leaved spirea, and soopolallie all show a positive response through increased plant growth and more cover. Falsebox has a generally neutral response to fires. Black Huckleberry and rhododendron can withstand light fires only and are often slow to respond afterwards. Common Juniper is severely damaged by fire and recovers very slowly.

14.3 Herbs

Bluebunch Wheatgrass, Pinegrass and Junegrass all show good survival and more vigour after fires. Kinnikinnick recovers well from light fires. Twinflower, Arctic Lupine, and heart-leaved Arnica are all easily killed by fire, but light lupine seeds allow for fast migration and re-colonization after fires.

15 Input From Stakeholders

The input from stakeholders on plans to conduct prescribed fires to improve ungulate winter range on the north side of Carpenter Lake was mostly positive, with only one person expressing concern about prescribed fires in this area. Support in principle was received from;

Jacquie Rasmussen	Ministry of Forests - Lillooet Forest District
Steve Newton	Ministry of Forests - Lillooet Fire Protection Zone
Darren Blom	Ainsworth Lumber Co - Lillooet
Rolly Thoms	Lillooet Livestock Association (verbal communication)
Tim Cody	Wild Sheep Society of B.C.
Doug Jury	Ministry of Env., Lands and Parks
Rick Tucker	Kamloops Forest Region
Clive Wilson	BC Hydro, Recreation Department

The Ministry of Forests brought up some issues about prescribed fire monitoring and planning that are very important. Colin Templeton, the Small Business Silviculture Practices Forester would like to see:

1. The plan backed up with sound scientific research.
2. Clear objectives and prescriptions.
3. Cost/Benefit analysis on the impact on the timber supply.
4. A Stand Management Prescription in addition to burn plans.
5. Establish responsibility for reforestation obligations in the event of fire escape.
6. More consideration for recreation and visual values.
7. A fuel inventory and pre-and post treatment vegetation surveys, stocking surveys, and perhaps pre- and post- browse intensity surveys.

A letter of concern was sent by Randy James of the Seton Indian Band. He feels that the winter range is good in the area and any prescribed burning would hurt the local habitat. Discussions with other Seton Lake Band Members suggest there is a generally more favourable attitude towards prescribed burning than expressed in Mr James' letter.

A full list of all individuals consulted for input into the planned prescribed fires, a copy of all written correspondence is included in Appendix D. This includes a copy of a reply to Randy James' letter.

16 Initiating the Prescribed Fire Process

To move the prescribed fire planning into the implementation stage, a number of steps must be taken.

16.1 Collection of Weather Data

Accurate fire weather for the north side of Carpenter Lake should be collected. This can be done in a variety of ways. The best option is to place a weather station in the area, adjacent to one of the planned prescribed fire areas. Weather stations can be rented from the Ministry of Forests on a monthly basis. A fully manual weather station would cost:

Set Up and Take Down	First Month Rental	Each Month After	Six Month Total Cost
$1000 each	$250	$150	$3000

In addition, a fee for data collection would be required for an individual to visit the site every two weeks, or more often as required, to collect the weather data. This may be arranged through the Lillooet Ministry of Forests Fire Zone Staff, or through a contracted individual. The data collection should be completed from April through September to get accurate weather data for both Spring and Fall prescribed fires. Fully automatic weather stations are also available. These stations report daily information into the Ministry of Forests weather data collection system. The cost of these stations will be similar to having an individual collect the data, but is far more convenient. Telemetry options would have to be worked out to fit one of these stations into the Ministry of Forests system.

A second option is to use existing weather stations in the area, and use an established calculation system to estimate the fire weather in the area. There is a weather station in Goldbridge, on a north aspect slope, that might be useful for this purpose.

The third option is to canvas other land management groups to determine if anyone has a weather station in the area that would be representative of North Carpenter Lake.

16.2 Address Land Management Concerns

Four different groups that submitted input into this planning process had concerns or suggested work that should be incorporated into the prescribed fire process. The complete letters, summarized here, are in Appendix E

a) Ainsworth Lumber Co Ltd - Lillooet Division

Ainsworth Lumber has a number of concerns, most relating to Cutting Permit 175 proposed openings, that are adjacent to planned prescribed fire areas. Ainsworth would like to:
- be informed before any burning is conducted,
- ensure that any trees remaining after selective harvesting are not destroyed,
- someone else is responsible for costs to replanting of any seedlings that are destroyed,
- not burn adjacent to any proposed blocks until after they are harvested, and
- provide an opportunity to salvage any timber that we find to be merchantable from areas that are to be burned. Ainsworth will be looking at the planned prescribed areas to identify any areas where salvage is a suitable option. Any planned salvage operations before prescribed fires take place is an issue between Ainsworth and the Lillooet Forest District but could affect the timing and availability of areas for prescribed fires.

Ainsworth is most concerned about the prescribed fire escaping into their harvested openings, destroying leave trees and planted seedlings. Some agency will have to take responsibility for covering any replanting costs caused by such an escape. Assurances that no leave trees will be destroyed is very difficult to provide. Prescribed fire spread is managed, but unexpected wind events can cause fire escapes. This point will have to be discussed further with Ainsworth and the Ministry of Forests in Lillooet.

b) Ministry of Forests - Lillooet

A letter from Jacquie Rasmussen of the Lillooet Forest District provides approval in principle for the wildlife enhancement project. Comments from Colin Templeton, Small Business Silviculture Practices Forester, include some additional planning and monitoring work to measure whether the planned objectives were met. He would like to see a Stand Management Prescription that addresses salvage and reforestation responsibilities, a fuel inventory and pre-and post-treatment vegetation survey, as well as browse intensity surveys.

c) Ministry of Forests - Kamloops Forest Region

Rick Tucker would like to see some monitoring of the prescribed fires, including photo points and post-burn pictures.

d) Seton Lake Indian Band

A letter from Seton Band representative, Randy James stated that 'if its not broken, don't fix it'. He believes the forest on the north side of Carpenter Lake is important ungulate habitat, and is best left the way it is. Discussions with other Band Members suggests that the Band is more open to prescribed fires in this area. More consultation with the Seton Band to get a consensus will be required.

16.3 Specific Work Required

In order to initiate at least one prescribed fire in the Fall of 2001, the following steps are required.

1. Determine the most accurate and cost effective fire weather data collection system and arrange for it to be in place by mid-April, 2001.
2. Have prescribed fire plans for the first intended burns approved by the Ministry of Forests - Lillooet Fire Zone by the end of November, 2000.
3. Provide copies of the approved prescribed fire plans to Ainsworth, the Ministry of Forests and the Seton Lake Band for comments in November, 2000.
4. Discuss the plans with the above three agencies to determine exactly what pre-burn and post burn stipulations they want to get their approval of the plan by the end of January, 2001.
5. Complete all pre-planning and plot work required by the agencies before August, 2001.
6. Arrange for AID Machine, ignition devices, helicopter, experienced fire crews and materials to conduct the planned prescribed fires under suitable weather conditions, at the first opportunity, likely Fall 2001.

17 Summary

Prescribed fires, properly planned an implemented, will improve the ungulate habitat on the north side of Carpenter Lake. A majority of the stakeholders in this area support this type of activity in principle. Concerns with planned harvesting, reforestation cost responsibilities in the event of an escape, and monitoring of the results to determine if the planned objectives were met, must still be worked out.

A total of nine areas, covering over 100 hectares, have been identified as suitable for prescribed fires. These areas have a combination of suitability for wildlife habitat, natural fuelbreaks, fuel types that will support fire, and topography that should allow quality prescribed fires with minimal chance of escape.

APPENDIX A

Prescribed Fire for Wildlife Habitat Improvement - 5 Year Program
Lillooet Forest District
Carpenter Lake Deer Improvement Project and Other Studies in the Bridge River Drainage System

PRESCRIBED FIRE FOR WILDLIFE HABITAT IMPROVEMENT - 5 YEAR PROGRAM LILLOOET FOREST DISTRICT

MINISTRY OF ENVIRONMENT
SOUTHERN INTERIOR REGION
THOMPSON-NICOLA SUBREGION

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INTRODUCTION:

Over the past fourteen years eight controlled burns have been carried out in the Lillooet Forest District to improve ungulate winter ranges. Mule deer have been the primary species to benefit from most of these burns, although California Bighorn sheep and blue grouse have shown good response from burns on their ranges.

Fire as a prescribed tool is the most effective natural method of manipulating ranges which are either topographically or vegetatively difficult to manipulate. Through the burning program it will possible to enhance the target species such as mule deer and California Bighorn sheep as well as produce some of the mosaics of habitats required to maintain the biotic diversity endemic to these areas.

Natural fires historically burnt at regular intervals in the Lillooet forest district. Over 40 fire scarred trees dating back to 1580 have been analyzed from Carpenter Lake area where the natural fire free period ranged from 2-46 years with a mean of 17.33 years. However, prior to 1920 the mean fire free period was less than 13 years vs over 23 years since then (Low, 1987). With the longer fire free periods those species of wildlife which forage on forest pests such as bark beetles and defoliators have benefited while species dependent on early successional stages of vegetation have suffered habitat deterioration.

Over the next five years treatment of approximately 2000 hectares will create some of these early successional habitats. Species such as mule deer, California bighorn sheep, mountain goat and blue and ruffed grouse as well as numerous non-game species requiring these stages of vegetation will benefit from burns.

OBJECTIVE:

The primary objective of the 5 year program is to use prescribed fire to set predesignated sites to early successional vegetation. This will produce abundant quality forage intermixed with old growth Douglas fir and ponderosa pine. This will favour mule deer, mountain goats, California Bighorn sheep and many non-game wildlife species requiring the forb-shrub vegetation component. Organic debris which can prevent herbaceous growth will be removed reducing fuel loading and the chance of uncontrolled catastrophic fire.

Sites priorized by year are identified in Table 1.

Burns+	Previous Plan	1989	1990	1991	1992	1993	1994
PLAN YEAR	Shulaps (Cedarvale) 250 ha	1. Moore Ridge (Ward Cr) 160 ha	Audrey Cr. (Seton Lk) 80 ha	Yalacom Mtn. 140 ha	Sebring Cr. 300 ha	2. Moore Ridge 250 ha	
	Moran 150 ha		Liza Cr. 150 ha		Hans Gulch (Big Bar Ferry) 150 ha		
Spring++		Moran 110 ha				Hans Gulch (Big Bar Ferry)	
ACTIVITY YEAR							
Fall++		Shulaps (Cedarvale) Cr.-reburn)	Moore (Ward Cr	Audrey (Seton Lk.) Liza Cr.	Yalakom	Sebring	Moore Ridge

\+ If natural burns occur in the same biogeoclimatic zone and possibilities exist for achieving similar results without major problems for control or cost, then they should be substituted for the planned activity when approved by M.O.E. Wildlife Section.

++ Burns (Spring and Fall) - need to occur when herbaceous plants are phenologically mature and/or dried off. For spring burns this follows snow melt but is prior to green-up or,in mid-summer, after herbaceous plants have dried off.

Table 2. Site Description

Site	Land Status	Potential Conflicts	Vegetation Zone	Wildl. Use*	Public Use
Moran	Crown	Mining claims	Grasslands	S,(D,Gr)	Sheep Hunting
Cedarvale Creek	Crown	Mining claims	Dry upper Douglas fir to subalpine	D(G,Gr)	Limited access
Moore Ridge	Crown	Grazing (spring & fall) Timber (poor-low forest)	Dry Douglas fir	D(Gr)	Hunting-Deer & grouse
Audrey Cr.	Crown	BC Railway-500 m below burn area	Dry Douglas fir	G(D)	Very limited access
Liza Creek	Crown	Unknown	dry open forest	SD	
Yalakom Mtn.	Crown	Unknown	Douglas fir to subalpine	S,D	Hunting-deer, sheep
Sebring Creek	Crown	Mining claims	Dry Douglas to subalpine	D(Gr)	Limited access deer hunting

*Wildlife Species or Groups - all life form requiring early succession stages will benefit.

D - deer Gr - Grouse
G - goats S - Sheep
( ) - Less than 30% of dominant species use

Within the Lillooet timber Supply Area (T.S.A.) the vast majority of public use is occurring during the open hunting season. This is spread throughout the area with the largest concentrations occurring on the north side of the Bridge river system. The objective is to provide increased public use, both summer hiking and fall hunting. This will occur through an increase in supply of ungulates and ease of access to the areas opened by burning as has happened at Viera Creek.

PRETREATMENT DESCRIPTION:

The areas chosen for burning have passed the most useable stages of succession. Forage production and productivity and habitat structure desirable for species adapted to early stages of succession have diminished as vegetation changes occurred. The absence of fire from these areas historically burnt at more frequent intervals has changed the biotic community from one that was much mre diverse, to a more homogeneous system within each of the biogeoclimatic zones. Over time this can develop into management problems for resource managers. This has been ecologically exemplified through the mountain pine beetle and spruce budworm problems.

The biogeoclimatic zones chosen are dry PPBG, IDFa and b as well as dry MS and ESSF types. Forest values are generally low and poor. Wildlife ungulate values are moderate to high and agricultural (grazing) values are generally low to moderate depending on physiographic features.

Public use is primarily associated with good populations of wild ungulates or open areas such as grasslands or, throughout this region, the alpine zones. It appears the vistas and more open vegetation draw the vast majority of recreation use. Through the burning program this becomes one of the desired objectives.

EVALUATION PROGRAM:

Assessment (preplots) have been made in a number of areas such as Carpenter Lake and Moore Ridge. These will be monitored to determine the impact of the burn on vegetation and wildlife use.

CARPENTER LAKE DEER IMPROVEMENT PROJECT AND OTHER STUDIES IN THE BRIDGE RIVER DRAINAGE SYSTEM

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ABSTRACT

This study was designed to improve winter range conditions and to investigate other factors affecting deer populations at Carpenter Lake. An inventory of fauna and flora in the Bridge River drainage system, population dynamics of Canada geese, and a survey of moose in the Carpenter Lake region was also performed.

The north slope of Carpenter Lake supports between 1,000 and 1,500 mule deer (Odocoileus hemieonus hemieonus) during winter and spring months and is the second largest winter range in Management Area No. 4. Spring carryover ratios of the deer herd have declined from a high of 41.8% in 1965 to a low of 10.0% in 1972. The decline cannot be attributed to either logging or domestic grazing on the winter range itself since neither is practiced here at present. H owever, seral succession, winter severity, over-browsing by deer, and predation may be implicated to varing degrees. Domestic grazing on the summer range in alpine and sub-alpine regions may also be affecting carryover, but this aspect was not investigated.

Seral succession on the winter range is a problem which can be corrected by cutting advanced deciduous growth back to a low profile, suckering stage. Treatment initially removed a considerable amount of palatable browse within reach of deer. However, by the following spring, some treated species, such as willows (Salix spp.), western choke cherry (Prunus virginiana demissa), and Douglas maple (Acer glabrum var.), had suckered well, thus producing more browse than was available prior to treatment. Other species, such as red-stem ceanothus (Ceanothus sanguineus), snowbrush ceanothus (Ceanothus velutinus), and saskatoon berry (Amelanchies spp.) suckered poorly, but may respond in future years.

Application of ammonium suphate (21-0-0) improved soil fertility and browse production. The grasses, particularly bluebunch wheatgrass (Agropyson spicatum) responded well to a treatment of 50 lb. of nitrogen (N) per acre while saskatoon berry, snowbrush ceanothus and Douglas maple required greater than 100 lbs. of nitrogen (N) per acre for any pronounced response.

The 1972-73 winter severity index was the lowest in seven years of recording. The mild winter permitted deer to remain at higher elevations above the treated range. Therefore, it was concluded that the increase in deer carry-over ratios observed this year was more a function of weather than improved range conditions.

Two key browse species on the winter range are snowbrush ceanothus and saskatoon berry. Both are heavily browsed during the late winter and early spring. A browse utilization survey conducted in June revealed an average leader use of 48.3% for snowbrush ceanothus and 23.1% for saskatoon berry. The overall average of 35.7% during the mild winter of 1972-73 indicates the range had been overbrowsed. Furthermore, the percentage of plants severely hedged and the percentage of decadent plants were 49.1% and 64.5% respectively for snowbrush ceanothus and 6.4% and 47.5% respectively for saskatoon. These values reflect past over-utilization, as well as the ability of snowbrush ceanothus to withstand heavy use.

Predation by coyotes (Canis latrans lestes) and cougars (Felis concolor) was found to be an extrinsic factor affecting deer carryover. Fifteen deer were found killed near the shore or on the ice of Carpenter Lake during the winter. For those for which the cause of death was determined, five were killed by coyotes, five by cougars, and two by wolves (Canis lupus columbianus). It was possible to age only 12 of the kills, half of which were healthy short-yearlings. Three of four coyote kills were healthy short-yearlings.

Coyotes are the most abundant predator on the winter range, although the actual number was not determined. They concentrate near the lake during December and January when pre-breeding activities reach a peak. All coyote kills were found on the ice of Carpenter Lake, but what percentage of the total coyote kills these represent was not determined.

Cougars are alos present, but tend to remain above the lake, higher up the winter range. Therefore, the number of cougar kills actually found may accoun for only a small fraction of total kills.

Wolves occassionally enter the deer winter range though they seldom remain for any length of time. The main concentration of wolves occurred in the Hurley River valley which also supports a number of moose during the winter. With completion of the Pemberton-Bralorne road, hunting pressure on the moose will no doubt increase, possibly jeopardizing the small pack of wolves which depend on them for food.

Insufficient information was gathered to determine whether or not the suppressed deer carryover ratios of recent years were primarily the result of predation. The number of kills observed this year may be lower than normal because of the mild winter. Nevertheless, in order to properly manage the Carpenter Lake deer herd additional information on both coyotes and cougars is required. The density of predators and their respective habits in selecting prey animals must be determined.

The drawdown flats of the Carpenter Lake reservoir support a substantial number of breeding Canada geese (<u>Branta canadensis</u>). In 1972, 86 non-breeders, 21 breeding pairs and 88 goslings, or a total of 216 geese, were recorded. Counts conducted in the spring of 1973 revealed 103 non-breeders, 20 breeding pairs, and 61 goslings, or a total of 184 geese. Additional geese may be expected as the rising waters of Downton Lake (the Hydro reservoir immediately upstream) force birds in that pondage to move down onto Carpenter Lake.

The time required to refill the reservoirs varies from year to year. When snowpack is large and the spring mild, most of the drawdown is flooded before the young geese hatch. Furthermore, B.C. Hydro's regulation of waterflow from Carpenter and Downton Lakes makes it difficult for nesting geese to adapt to changing water levels. Therefore, in an attempt to increase nesting success, 25 nesting tubs were constructed in the drawdown of Carpenter Lake. None of the tubs was used in the spring of 1973, although in future years when the geese become accustomed to them it is hoped they will be of value.

Perhaps 30 moose winter in the entire Carpenter Lake region, scattered among isolated patches of deciduous growth. The only concentration of moose was found in the Hurley River valley where there is ample deciduous browse and suitable riparian cover.

APPENDIX B

Fire Effects on Local Plant Species

FIRE EFFECTS

SPECIES: Abies lasiocarpa

IMMEDIATE FIRE EFFECT ON PLANT :
Subalpine fir is one of the least fire-resistant western conifers. It is very susceptible to fire because it has (1) thin bark that provides little insulation for the cambium, (2) bark which ignites readily, (3) shallow roots which are susceptible to soil heating, (4) low-growing branches, (5) a tendency to grow in dense stands, (6) highly flammable foliage, and (7) moderate to heavy lichen growth [37,111].

Subalpine fir forests are normally subject to highly destructive crown fires that occur at 100-year or longer intervals. Such fires typically kill all subalpine fir trees. Subalpine fir is also very susceptible to surface fires because fine fuels which are often concentrated under mature trees burn slowly and girdle the thin-barked bole [34].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Following fire, subalpine fir reestablishes via seeds dispersed by wind from trees surviving in protected pockets or from trees adjacent to burned areas. Subalpine fir readily establishes on burned mineral soil seedbeds [107]. Ash does not affect germination, but if it is deep, it can prevent a seedling's roots from reaching mineral soil [85]. Although seedling establishment is often favored by shade, it will establish in full sunlight following fire [87].

The rate of establishment is quite variable, and depends on the proximity of the seed source (because the heavy seeds are dispersed over short distances) and seed production during the year of the fire and immediate postfire years. In general, subalpine fir seedling establishment is very slow in areas suffering large, continuous crown fires but is relatively rapid on small burned-over areas where a seed source is nearby [90,124,128]. Three years after a late August wildfire in northern Colorado, in a dense, overmature stand composed of Engelmann spruce, subalpine fir, and lodgepole pine, subalpine fir had established 15,200 seedlings per acre (37,500/ha) on small burns that were less than one-tenth of an acre in size. But on areas within the middle of the main burn, subalpine fir had established only 12 seedling per acre (30/ha) 3 years after the fire [16]. In Colorado, Peet [90] found a 75-year-old burn that had few conifer seedlings even though an old-growth subalpine fir-Engelmann spruce stand was 218 yards (200 m) away.

Reinvasion into large burns is slow because much of the seed source is destroyed. However, sometimes sporadic survivors provide a limited seed source so that a small number of seedlings establish quickly following fire. When this occurs, large quantities of seeds are dispersed several decades later as the early invading seedlings mature and reach cone bearing age [128].

On areas where subalpine fir is abundant and lodgepole pine scarce before burning, subalpine fir establishes quickly following fire if sufficient numbers of seed trees survive or are near the burn. However, if lodgepole pine is present prior to burning, it usually seeds in aggressively and assumes a dominant role because it quickly overtops any fir seeding in at the same time [34]. Subalpine fir can be suppressed for several decades in seral lodgepole stands which develop following fire; one-hundred-year-old individuals may be only 3 feet (0.9 m) tall [90]. It may take 50 to 150 years after a fire for substantial subalpine fir establishment under dense lodgepole pine stands [18,109,128].

In the Olympic Mountains, tree seedling establishment following fires in closed mountain hemlock-subalpine fir forests was higher during wet growing seasons than during dry growing seasons. Establishment rates were higher near the edge of a fire or near survivors than in areas removed from a seed source [4]. On many burned areas, subalpine fir did not establish seedlings for several years because of poor seed crops. On some burns there was a lag time of 40 to 50 years after fire before there was substantial seedling establishment. This was a result of early invading trees maturing and dispersing seeds [4].

High elevation subalpine fir stands that have burned often remain open for several decades or more [18,31]. The harsh environment near treeline makes it difficult for tree seedlings to establish and survive [18]. Grasses and sedges may form a mat in subalpine meadows which prevents tree seeds from reaching mineral soil [109].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
NO-ENTRY

FIRE MANAGEMENT CONSIDERATIONS :
Subalpine fir is very fire sensitive and is often killed even by surface fires. Following timber harvest, on sites where subalpine fir is not a preferred species, light surface fires may be used to kill subalpine fir and promote the establishment of other conifers [93].

Fuels remain moist in many high elevation subalpine fir habitat types during most of the year, leaving only a short time period during certain years when prescribed burning can take place [63,91].

Subalpine fir seeds germinate poorly in soils under burned slash piles [130] but readily germinate on mineral soil seedbeds prepared by broadcast burning [16,107].

FIRE EFFECTS

SPECIES: Picea engelmannii

IMMEDIATE FIRE EFFECT ON PLANT :
Engelmann spruce is easily killed by fire. It is very susceptible to fire because it has (1) thin bark that provides little insulation for the cambium, (2) a moderate amount of resin in the bark which ignites readily, (3) shallow roots which are susceptible to soil heating, (4) low-growing branches, (5) a tendency to grow in dense stands, (6) moderately flammable foliage, and (7) heavy lichen growth [87].

Crown fires typically kill Engelmann spruce trees. Engelmann spruce is also very susceptible to surface fires because fine fuels which are often concentrated under mature trees burn slowly and girdle the thin-barked bole or char the shallow roots [20,31]. Some large Engelmann spruce may survive light, surface fires, but these often die later due to infection by wood-rotting fungi that enter through fire scars [31].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Following fire, Engelmann spruce reestablishes via seeds dispersed by wind from trees surviving in protected pockets or from trees adjacent to burned areas. The rate of reestablishment is variable and depends on the proximity of surviving cone-producing trees and seed production during the year of the fire and immediate postfire years. In general, Engelmann spruce seedling establishment is very slow in areas burned by large, continuous crown fires because much of the seed source is destroyed. However, on small burns or near pockets of surviving trees within a large burn, Engelmann spruce usually establishes numerous seedlings within 5 to 10 years [42,44].

In areas where Engelmann spruce is abundant and lodgepole pine scarce before burning, Engelmann spruce establishes rapidly after fire if sufficient numbers of seed trees survive or are near the burn. If lodgepole pine is present in the preburn community, it usually seeds in aggressively, assuming a dominant role as it overtops any spruce seedlings establishing on the site [24,28,42]. However, Engelmann spruce seedlings usually survive under the developing pine canopy because of its shade tolerance.

Above 9,850 feet (3,000 m), lodgepole pine does not regenerate, and burned areas remain open for several decades or longer. Postfire succession in this harsh, high-elevation zone (9,850 to 10,850 feet [3,000-3,300 m]) proceeds very slowly. Spruce slowly becomes established as scattered seedlings [12]. It may take 100 to 200 years before young spruce-fir forest covers the area. However, conditions in the upper parts of this zone sometimes make it difficult for tree seedlings to establish and survive at all. Here, grasses and sedges may form a mat which prevents tree seeds from reaching mineral soil [85]. Burned fir-spruce forest is replaced by alpine tundra which can persist for long periods of time [12].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :

Postfire Engelmann spruce seedling establishment is best on moist surfaces where fire has consumed most or all of the duff leaving bare mineral soil. Seedlings do require some shade to survive; thus regeneration after fire is best on sites where standing dead trees, logs, or developing vegetation is present [73]. Engelmann spruce postfire regeneration is poor on sites subjected to high light intensities. A 26,000 acre (64,200 ha) burn on a high-elevation site in southwestern Colorado showed poor conifer regeneration 100 years after the fire. This was attributed to intense solar radiation which inhibited photosynthesis, causing a high percentage of spruce seedlings to die [75]. Postfire spruce regeneration is also poor where shrub and herbaceous cover is dense, where exposed mineral soil is subject to excessive evaporation, and where fire has only charred the duff [10]. Ash does not affect germination, but if it is deep, it can prevent a seedling's roots from reaching mineral soil [62].

In northern Colorado, 3 years after a late August wildfire in a dense, overmature stand composed of Engelmann spruce, subalpine fir, and lodgepole pine, Engelmann spruce established 1,000 seedlings per acre (2,470/ha) in burned areas that were than less than 0.1 acre (0.05 ha). However, in the middle of the main burn, no Engelmann spruce seedlings had established by 3 years after the fire [10]. In Colorado, Peet [66] reported a 75-year-old burn that had good spruce regeneration near the burn boundary, but only 218 yards (200 m) inside the burn edge, few seedlings had established, and the area was still fairly open.

Day [24] sampled lodgepole pine-Engelmann spruce x white spruce hybrid stands in southern Alberta that had established after fires that had occurred 29 and 56 years prior to sampling. He found that both pine and spruce had initiated large numbers of seedlings imediately after the fire. Pine, however, had established more seedlings and rapidly outgrew the spruce, forming a canopy that was three to four times taller than the spruce canopy. Pine seedling establishment had ceased by 30 years after the fire, but spruce continued to establish seedlings. Engelmann spruce eventually dominates sites where spruce and pine come in together after fire.

FIRE MANAGEMENT CONSIDERATIONS :
After clearcutting Engelmann spruce stands, broadcast burning can be used to prepare seedbeds for natural regeneration. Broadcast burns which remove most of the duff or organic matter and burn hot enough to destroy some or all of the competing vegetation favor spruce seedling establishment [72]. However, seedling establishment is poor or nonexistent in areas where hot fires leave deep layers of ash or generate such intense heat that rocks are fractured, such as under slash pile fires [72,94]. For this reason, where large amounts of slash must be burned, windrows or piles should be kept small and cover a minimal portion of the area [3]. Engelmann spruce often occurs in cool and moist locations which restricts the time of year when effective broadcast burning can take place. Prior to burning, duff must be dry enough to ensure that it will be consumed. Seedling establishment will be inhibited on burns that only blacken the organic matter. Some cull logs and slash should be left in place to provide shade and protection for developing seedlings [72].

Engelmann spruce stocking was greater than 50 percent and averaged 573 seedlings per acre (1415/ha) 5 years after broadcast burning in clearcuts in northern Idaho where the uncut stand composition was 56 percent western larch, 22 percent Engelmann spruce, 15 percent mountain hemlock, and 7 percent subalpine fir. This broadcast burn exposed mineral soil on 53 percent of the area [14]. In northwestern Montana, Engelmann spruce seedling establishment was much greater on broadcast burned clearcuts where burning exposed mineral soil than on unburned clearcuts. Eleven years after burning, stocking of Engelmann spruce seedlings was 23 percent on burned cuts but only 1 percent on unburned cuts. Seventeen years after burning, stocking was 56 percent on burned cuts but only 2 percent on unburned cuts [84].

Broadcast burning is generally not recommended following partial cutting because residual Engelmann spruce trees are very fire sensitive.

FIRE EFFECTS

SPECIES: Pinus contorta var. latifolia

IMMEDIATE FIRE EFFECT ON PLANT :
Plant: Lodgepole pine is more damaged by ground fires than thicker barked species such as ponderosa pine or Douglas-fir are. Because its thin bark has poor insulating properties, many trees are killed from ground fires as a result of cambial heating [65]. However, some trees survive, and in general, low-intensity ground fires thin lodgepole pine stands [50]. In northwestern Wyoming, Loope and Gruell [47] observed numerous individuals in open lodgepole pine stands with two or three fire scars.

Seed: Seeds are well protected from heat inside sealed cones. However, the seeds can be destroyed by intense crown fires that ignite the cones [4,8].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Although lodgepole pine trees are killed by all but light ground fires, postfire recovery tends to be rapid as new stands quickly establish from seed released by serotinous cones. Seedling growth in fire-generated stands is influenced by stocking rates. In overstocked stands, trees may not grow more than 4 feet tall in several decades, but in understocked stands lodgepole pine grows fast. On burned and unburned clearcuts in western Montana, 9- to 11-year-old lodgepole pine seedlings averaged 6.6 feet (2 m) in height, and were considerably taller than the same-aged western larch (Larix occidentalis), Douglas-fir, Engelmann spruce, and subalpine fir [77]. Twelve years after the Sleeping Child Burn in western Montana, 30 percent of lodgepole seedlings were over 18 inches (45 cm) tall. Here, seedling density was 17,700 per acre (43,700/ha) [54].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
Lodgepole pine seedling establishment following fire is influenced by many factors, including prefire overstory density, competing vegetation, and probably most important, fire intensity, which in turn affects seedbed condition, opening of serotinous cones, and seed survival.

High-intensity fires: High-intensity fires generally expose much mineral soil and open serotinous cones [50]. Thus much seed is released onto favorable seedbeds resulting in abundant seedling establishment. An example is the Sleeping Child Burn in western Montana, in which 28,000 acres (11,000 ha) of predominantly lodgepole forest was destroyed by a high-intensity lightning-caused wildfire. Three years after the fire, lodgepole pine seedling density averaged 34,000 per acre (84,000/ha) [54]. With abundant seed and favorable moisture following high-intensity fires, stocking can be extremely high, with hundreds of thousands of seedlings per acre [8,39]. Some stands have had as many as 300,000 lodgepole pine seedlings per acre (741,000/ha) by the first postfire year [8]. Seedling growth in these overstocked stands stagnates, and trees may be only 4 feet tall at age 50 to 70 years [39].

Occasionally, crown fires may be intense enough to ignite cones in the crown. This destroys much of the seed supply resulting in low stocking. This occurred in central Idaho, where only 450 and 1,134 lodgepole pine seedlings per acre (1,100 and 2,800/ha) were present 1 and 5 years, respectively, following a high intensity wildfire in a lodgepole pine/beargrass community [6f8]. One year following the Yellowstone Fires of 1988, lodgepole pine seedling density was higher on moderate-severity burns where the trees were killed but the crowns were not consumed (1.6 to 21.9 seedlings/m2) than on sites where hot crown fires killed the trees and consumed the needles and fine branches (0.4 to 3.1 seedlings/m2) [4].

Low-intensity fires: Following low-intensity fires, lodgepole pine stocking depends on the amount of mineral soil exposed. Generally if the duff is dry, ground fires will expose mineral soils, but if the duff is moist, less mineral soil is exposed resulting in lowered stocking [50]. Surface fires will not open serotinous cones in the tree crowns, but most lodgepole stands in the Rockies have sufficient open-coned trees to provide seed for restocking [50].

FIRE MANAGEMENT CONSIDERATIONS :

Fire behavior of logging slash: Fresh, cured coniferous logging slash is generally very flammable because of its characteristic loose arrangement and high percentage of needles and twigs. Flammability decreases with time as needles drop to the forest floor and as a result of compaction by winter snow, but it may take more than 2 years for lodgepole pine to lose most of its needles. Fresh and 1-year-old lodgepole pine slash can burn very hot. Rate of fire spread during experimental burns with fresh and 1-year-old lodgepole pine logging slash was as follows [22]:

	20 tons of slash/acre		32.5 tons of slash/acre	
	relative humidity (%)	rate of spread (sec./foot)	relative humidity (%)	rate of spread (sec./foot)
fresh slash	84-88	48.5	52-64	17.5
1-year-old slash	73-92	88.8	54-93	33.5

Tree mortality: Published models can be used to predict fire-caused mortality of lodgepole pine [64,65,74]. Crown scorch and bole damage are the most important variables for determining mortality/survival.

Lodgepole pine girdled by ground fires, but with no crown scorching, may appear healthy for a couple of years after fire even though they are essentially dead. This is because it often takes more than 2 years for these trees to lose their needles [2].

Susceptibility of injured trees to insects and disease: Trees injured by fire are susceptible to attack by insects. Two years after wildfires in Yellowstone National Park, 44 percent of living but scorched lodgepole pines were infested by insects, primarily the pine engraver. Most commonly, trees infested were those with greater than 80 percent basal girdling. Mountain pine beetles, however, were not strongly attracted to fire-scarred trees [2].

Lodgepole pines that survive ground fires are susceptible to attack in later years by decay fungi that enter through basal wounds. In an 85-year-old stand in Alberta, 46 percent of trees with basal scars that resulted from a fire 33 years before sampling had decay fungi in the scars. Of these trees, about half were infected with red stain fungi [62].

Snagfall following fire-kill: Fire-killed lodgepole pine trees begin to fall 2 to 5 years after dying and most trees will be down in about 15 years [50]. Following the Sleeping Child Burn in western Montana, few 3- to 8-inch-diameter (7.5-20 cm) snags fell during the first 2 years after the fire. After 2 years they fell at an annual rate of 8.4 percent until postfire year 15 when about 30 percent remained [53].

FIRE EFFECTS

SPECIES: Pinus albicaulis

IMMEDIATE FIRE EFFECT ON PLANT :
The moderately fire-resistant whitebark pine is favored by both creeping surface or ground fires and severe fires. Both types of fire kill more shade-tolerant and fire-sensitive asssociate species of whitebark pine, such as subalpine fir. Hot surface fires that heat the cambium cause fire injury or death to these thin-barked trees. Fires of low to moderate severity can climb into trees if fuel ladders and downfall are present, thus increasing the potential of torching. Most fires occurring where whitebark pines grow are ignited by lightning and do not spread very rapidly or cause severe tree injury [1,2].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
The regeneration of whitebark pine in small openings is probably the result of surface fires. In contrast, the perpetuation of whitebark pine on moist sites where succession to shade-tolerant species is relatively rapid is probably due to severe fires. The occurrence of whitebark pine and Engelmann spruce in subalpine basins and on moist north slopes is probably the result of fire [2].

Postfire seedling survivor rate is reported as 25 percent. A maximum of 150 years is required for afforestation at current rates. Fires create sites conducive to the planting of seeds by Clark's nutcrackers and for seedling establishment [1,2,17,46,47].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
NO-ENTRY

FIRE MANAGEMENT CONSIDERATIONS :
NO-ENTRY

FIRE EFFECTS

SPECIES: Pinus ponderosa var. ponderosa

IMMEDIATE FIRE EFFECT ON PLANT :
Fire has a wide variety of potential effects on Pacific ponderosa pine. These effects vary according to size, configuration, and density of the stand, in addition to fire severity. Generally, well-spaced seedlings and saplings are able to withstand low-severity fires, as are pole-sized and mature trees. Moderate- to high-severity fires, however, will kill trees pole-sized and smaller. Mature Pacific ponderosa pines have a higher survival rate than younger trees due to their enhanced adaptations to fire [16,39,77].

The principal cause of mortality following fire is crown scorch rather than damage to the cambium or roots. The size of tree determines its ability to withstand scorch. A model has been developed to predict mortality using tree d.b.h. and scorch heights as independent variables. Fire effects are also dependent upon other factors such as season, site condition, tree age and vigor, available moisture, and occurrences of insect and disease attack [39,56].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
If fire consumes any part of tree canopy, the total leaf area is reduced, thus decreasing photosynthesis. If burning results in damage to the bole or roots, nutrient and water transport is impaired. Heat from fire may kill living tissue and result in a certain amount of stress [26,39,55].

Crown damage: Crown scorch appears to be the leading factor in the majority of damage to Pacific ponderosa pine. Estimation of percent crown volume scorch has been proven to be the best predictor of tree mortality following fire. Crown damage is most severe in spring and early summer due to low foliar moisture content and the succulent nature of the buds and twigs [39,55]. Survival of buds is also crucial to postburn survival of Pacific ponderosa pine. Buds can tolerate temperatures 68 degrees F (20 deg C) higher than the needles can due to their protective outer scales. Therefore, large trees can sometimes survive a 100 percent crown scorch provided not all the buds are heat killed [26,39,44,55].

Root damage: Following prescribed burning of old-growth Pacific ponderosa stands in Crater Lake National Park, Oregon, mortality was higher in burned areas (19.5 percent) than in unburned areas (6.6 percent). A major factor contributing to postfire mortality was the reduction of fine roots. Burning reduced fine-root dry weight 50 to 75 percent from 1 to 5 months after burning [64].

Bole damage: This pine is fire tolerant because it has a fire-resistant bark containing a 1/8- to 1/4-inch (0.3-0.6 cm) thick layer at 2 inches (5 cm) diameter [77]. It also has a very moist core of high density wood that dissipates the heat energy it receives, thus protecting the bole from lethal heat levels [55]. Ryan and Frandsen [53], however, found that mature Pacific ponderosa pine trees suffered more basal injuries from smoldering fires than did immature trees because of the greater quantities of accumulated duff surrounding their boles. Cambium damage most often occurs after the passing of high-severity fires. Young trees are most susceptible to cambium damage as a result of thinner bark and a higher occurrence of girdling [26,78]. Partially girdled trees may survive up to 25 percent basal loss if root and crown damage is minimal [71].

Season of burn: Pacific ponderosa pine can withstand low-severity fires which generally occur during the wet months of early spring or late fall. A dry spring fire may occur when trees are in stress during leaf and bud burst, resulting in higher mortality rates. Trees become dormant toward fall and thus are more fire resistant. In fall, Pacific ponderosa pine can withstand up to 50 percent crown scorch, while in spring only 30 percent [26,45].

PLANT RESPONSE TO FIRE :
Pacific ponderosa pine's response to fire will vary according to fire severity, tree age, and season. High-severity fires that occur during periods of high stress will generally result in death. Low- to medium-severity fires will generally restrict the growth and regeneration of the tree, but recovery is usually evident the following year [39]. Immediately following fire, Pacific ponderosa pine may experience a large needle drop as a reaction to hot convectional air movement through the canopy [55].

Postfire seedling establishment: Fire creates favorable seedbeds for seedling establishment. The soil is often rich in available inorganic nitrogen that benefits tree growth [52]. Postfire stocking rates depend upon site characterisitcs, fire severity, and weather. The potential for regeneration after fire is generally considered good [39]. On the Eldorado Natinal Forest, California,a low-severity burn resulted in 20,000 seedlings per acre (49,400/ha) on burned sites and no seedling establishment on unburned sites [39]. In a western Montana study, Pacific ponderosa pine produced 12 percent of the total number of sound seeds found on a burned clear-cut site over a 5-year period [64]. A postburn study in the Plumas National Forest, California, found that Pacific ponderosa pine had the highest postburn percent increase of all other associated species [39]. Postfire stocking rates depend upon site characterisitcs, fire severity, and weather. The potential for regeneration after fire is generally considered good [39]. In a western Montana study, Pacific ponderosa pine produced 12 percent of the total number of sound seeds found on a burned clear-cut site over a 5-year period [64]. A postburn study in the Plumas National Forest, California, found that Pacific ponderosa pine had the highest postburn percent increase of all other associated species [39].

Postfire growth and recovery: Information concerning Pacific ponderosa pine's response after fire is variable. This may be attributable to the beneficial effects of reduced competition and increased nutrient availability, along with the detrimental effects of damage to the crown, cambium, and roots. Some studies found reductions in diameter and height growth [46,76], while others reported increases in postfire growth [8,46,69,73].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
NO-ENTRY

FIRE MANAGEMENT CONSIDERATIONS :
The last 100 years has produced unplanned, radical changes in stand structure, fuel loadings, and role of fire in Pacific ponderosa pine ecosystems [2]. Postsettlement fire suppression has resulted in dense stockings of shade-tolerant species and the increase of insects and disease. These results have led to other concerns such as loss of timber productivity, loss of natural diversity and aesthetic values, and the increased risk of severe fire damage to homes and harvestable timber [26].

Prescribed fire: Reduction of fuel loads beneath existing stands of Pacific ponderosa pine by the use of prescribed fire has proven useful in reducing the potential threat of wildfires, while also favoring natural regeneration of seral species through site preparation. In western Montana, prescribed burning on an interval of 20 to 25 years is suggested to maintain seral species and open stocking. This would also prune lower branches thus increasing timber values, while also lowering the risk of wildfire [2,22,26,39].

Nutrient depletion: Prescribed fire often leads to the loss of volatile nutrients from the site, especially nitrogen (N). Following a prescribed fire on a Pacific ponderosa pine site in Oregon, all periodic annual growth increments were reduced in surviving trees four growing seasons later. Foliar N concentration was not affected by the fire; however, total foliar N content was reduced immediately after burning. Foliar N content was significantly correlated with the observed reductions in periodic annual increments [39,40].

FIRE EFFECTS

SPECIES: Pseudotsuga menziesii var. glauca

IMMEDIATE FIRE EFFECT ON PLANT :
The effects of fire on Rocky Mountain Douglas-fir vary with fire severity and tree size. Saplings are often killed by surface fires because their low branching habit allows fire to carry into the crown. Photosynthetically active bark, resin blisters, closely spaced flammable needles, and thin twigs and bud scales are additional characteristics that combine to make saplings vulnerable to surface fires [22]. Rocky Mountain Douglas-fir saplings are more susceptible to mortality from surface fires than ponderosa pine saplings are [6,92].

Chance of survival generally increases with tree size. Because they have thicker bark and larger crowns, large trees can withstand proportionally greater bole and crown damage than small trees. Following a low- to moderate-intensity ground fire in an open mixed conifer stand in Colorado, 64 of 103 Douglas-fir trees died within 2 years of burning. Live trees averaged 9.5 inches (24 cm) d.b.h. and 32 feet (9.8 m) in height, while dead trees averaged 5.6 inches (14.3 cm) d.b.h. and 22.6 feet (6.9 m) in height [95]. In western Montana, 75 of 176, 5- to 19-inch-diameter Douglas-fir trees were dead 1 year after low- to moderate-intensity prescribed understory burns. In general, surviving trees tended to be taller and have larger bole diameters than trees that died [9].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
Crown fire: Crown fires can kill trees over extensive areas. Even on thoroughly burned over areas, however, scattered survivors can be expected in unburned pockets or in areas where fires moderated [15,93].

Ground fire: Moderate-intensity surface fire kill varying proportions of pole-sized and larger Rocky Mountain Douglas-fir trees [93]. Crown scorch tends to be the principal cause of death, probably because ground fires intense enough to kill a tree by girdling it will also scorch the entire crown [95]. Crown scorching from summer fires is more damaging than late summer or fall fires because more buds are killed. During late summer the buds are set and subsequent-year needles are well protected [64]. Cambial damage from bole charring is the second most prevalent cause of death. Ryan and others [71] found that if more than 25 percent of the cambium on Rocky Mountain Douglas-fir trees at breast height was dead, there was a high probability that the tree would die. Trees damaged and weakened by fire are susceptible to insect attack. If attacked by bark beetles, fire-weakened trees often die [64]. Root damage can also affect survival. Rocky Mountain Douglas-fir frequently has shallow lateral roots that can be damaged if the organic layer burns [71].

Fuels and fire behavior: The amount of crown and bole damage a tree receives is related to fire behavior and the abundance of understory fuels. If there are heavy fuel accumulations around the base of the tree, severe cambial damage can occur from ground fires that burn primarily in the forest litter. Trees infested with dwarf mistletoe commonly have large accumulations of dead, fallen brooms around their base. When ignited, this fine debris burns hot, charring the bole. It can also provide a fuel ladder to torch the crown [94].

Fuel type and arrangement, and related fire behavior, vary greatly in dry Douglas-fir habitat types. Where surface fuels are discontinuous, many trees survive the resultant irregular burning [94]. Fire and grazing history greatly influence the fuel buildup. In northern Idaho, Douglas-fir was more susceptible to fire damage in stands subjected to years of livestock grazing than in ungrazed stands [92]. Ungrazed stands remained open and parklike, and had a nearly continuous distribution of small fuels which carried fire well. Prescribed fires had flame lengths up to 36 inches (91 cm) but spread rapidly and only scorched the lower crowns of large trees. On grazed sites open stands were converted to dense pole stands with sparse understories and numerous sapling thickets. These stands had a greater accumulation of duff and large woody fuels which contributed little to fire spread. This resulted in a less intense but slow-spreading fire which was more damaging to trees, probably because of the long residence time, which can kill trees through cambial heating [64]. On the grazed site, numerous trees up to 4 inches (10 cm) d.b.h., and a few more than 6 inches (15 cm) d.b.h. were killed.

PLANT RESPONSE TO FIRE :
Seedling establishment following fire is dependent on the spacing and number of surviving seed trees. Following large, stand-destroying fires, Rocky Mountain Douglas-fir seedling establishment is slow. Seedlings are restricted to the burn edge or near surviving trees within the main burn [15].

On logged-over sites, Rocky Mountain Douglas-fir readily establishes after slash burning, but establishment tends to be better where Douglas-fir is a seral species, such as in grand fir or subalpine fir habitat types, and on north- and east-facing slopes [17,79]. On dry, south- and west-facing slopes some shade is often needed for seedlings to survive [32]. Many tree associates are more dependent on mineral soil for seedling establishment than Douglas-fir is. Thus burning may increase the percentage of associates such as Engelmann spruce, grand fir, ponderosa pine, lodgepole pine, and western larch [17].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
NO-ENTRY

FIRE MANAGEMENT CONSIDERATIONS :
Prescribed burning: Published guides outline prescribed burning objectives and techniques for killing invading Douglas-fir in bunchgrass habitat types [29], and for understory burning for site preparation, fuel reduction, and habitat improvement in ponderosa pine-western larch-Douglas-fir forests [42]. When burning understory in pine-larch-fir forests, Douglas-fir leave trees should be larger than 16 inches (40 cm) in diameter when fuels exceed 30 tons/acre. Heavy fuels within 6 feet (1.8 m) of the base of leave trees should be removed.

Tree mortality: Published models can be used to predict fire-caused mortality of Douglas-fir [64,71]. Crown scorch, bole damage, and insect damage are the best variables for determining mortality/survival.

Duff reduction: In larch-Douglas-fir forests in western Montana, broadcast burning in clearcuts or in standing timber can be safe and practical when small diameter fuel (less than 4 inches [10 cm]) moisture content is between 10 and 17 percent [62]. Below 10 percent moisture content, fire behavior may become extreme and control problems arise; above 17 percent fuels are difficult to ignite. When burning between these moisture content values, duff consumption can be predicted by measuring the moisture content of the lower duff and the quantity of small fuels [62]. Shearer [80] found that when the lower duff is below 50 percent moisture content, almost all the duff is burned, but when above 100 percent moisture content, less than half the duff burns.

Fire behavior of logging slash: Fresh, cured coniferous logging slash is generally very flammable because of its characteristic loose arrangement and high percentage of needles and twigs. Flammability decreases with time as needles drop to the forest floor and as a result of compaction by winter snow. In experimental burns with 32.5 tons of slash per acre (80 tons/ha) and similar relative humidities (52-70 %), the rate of spread in fresh, cured Rocky Mountain Douglas-fir logging slash was 20.7 seconds/foot, while the rate of spread in 1-year-old slash was 70 seconds/foot [21].

FIRE EFFECTS

SPECIES: Achillea millefolium

- IMMEDIATE FIRE EFFECT ON PLANT
- DISCUSSION AND QUALIFICATION OF FIRE EFFECT
- PLANT RESPONSE TO FIRE
- DISCUSSION AND QUALIFICATION OF PLANT RESPONSE
- FIRE MANAGEMENT CONSIDERATIONS

IMMEDIATE FIRE EFFECT ON PLANT:

Western yarrow's rhizomes and mycorrhiza are usually only slightly damaged by fire [10,38,60], although western yarrow is susceptible to fire-kill and reduction by severe fire [51]. Western yarrow is not highly flammable. Out of 14 species commonly found in boreal forests, western yarrow has the lowest potential ignitability based on chemical characteristics measured on live stem, live leaf and dead leaf tissues. These rankings rely primarily on total ash, silica-free ash and energy content [40]. Ignitability is measured as time to ignition.

DISCUSSION AND QUALIFICATION OF FIRE EFFECT:

No entry

PLANT RESPONSE TO FIRE:

Fire results in fragmentation of western yarrow's rhizomes stimulating regeneration [15]. Cover and frequency of western yarrow generally increase 1 to 2 years after fire but not with any consistent pattern [4,13,14,32,40,56,71]. After initially increasing in cover, western yarrow may decrease to unburned levels as early as 3 years after fire [17,37,65,75]. Production doubled within 3 to 4 years postfire near Missoula, Montana [6] and other ponderosa pine/mountain grassland ecosystems [32,69]. In another study of fire effects in ponderosa pine, western yarrow increased by 0.37 stem/m in 6 years, a negligible amount [55]. Western yarrow is responsive to season of burning. Late spring burning usually reduces western yarrow [4,12,66].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE:

The initial surge of western yarrow is probably caused by extensive rhizome sprouting; mineral soil exposure and the resulting favorable seedbed; less competition from tree, grass and shrub cover; and nutrient release [28,53].

A burn was conducted each April for at least 24 years on a rough fescue(*Festuca scabrella*) grassland in a quaking aspen parkland in east-central Alberta. Average frequency and canopy cover values for western yarrow were as follows [3]:

% Frequency		% Cover	
burned	unburned	burned	unburned
36	23	3.0	1.1

Density and crown area of western yarrow (per 180,000 in^2) following an August wildfire of moderate severity in a northeastern California range dominated by bitterbrush (*Purshia tridentata*) and various perennial bunchgrasses were as follows [23]:

	Number of plants	Crown area (in^2)
Unburned plots	99	153
postfire yr 1	3	29
postfire yr 2	9	101
postfire yr 3	88	531
postfire yr 4	269	252
postfire yr 5	48	1391

Productivity values (kg/ha) of western yarrow before and after a late August fire in western Wyoming quaking aspen communities are listed below for plots of different burn intensities [9]:

Before burning: 14 kg/ha
After a "light" burn: 40 kg/ha
After a "moderate" burn: 16 kg/ha
After a "heavy" burn: 14 kg/ha

FIRE MANAGEMENT CONSIDERATIONS:

Western yarrow's good resprouting ability, high germination percentages, and competitive seedlings result in a remarkable persistence under fire disturbance. Western yarrow often appears in the first stages of succession [15,63]; however, no consistent trends relative to age of burns seem evident for the western yarrow [4,57].

Western yarrow has low ignitability, and can be used as a fire barrier, created by replacing highly flammable vegetation with species that are less likely to burn [41]. Planting less-flammable vegetation in fire-prone areas, or around property and fire-sensitive areas, may help prevent ignition or slow fire spread [40].

FIRE EFFECTS

SPECIES: Koeleria macrantha

IMMEDIATE FIRE EFFECT ON PLANT :
Prairie junegrass is variously reported as undamaged [71], slightly damaged [45], or moderately damaged [69] by fire. This nonrhizomatous bunchgrass is often killed when dry vegetation is consumed by fire. However, prairie junegrass exhibits several characteristics which minimize the potentially damaging effects of fire. Small clump size and coarsely textured foliage [71], make this species one of the most fire-resistant of bunchgrasses [9]. Coarse grasses such as prairie junegrass tend to burn quickly, and little heat is transferred below the soil surface. Residual survival is known to occur [61]. Generally, late spring burns are more damaging to prairie junegrass than early spring, summer, fall, or winter burns. Basal area reductions are common when plants are burned after senescence [8].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
Evidence suggests that the effect of fire on prairie junegrass is related to season of burn. Late spring burns appear to be more damaging than early spring, summer, or fall burns. Studies conducted in both the mixed-grass prairie of the Northern Plains and in sagebrush-grassland communities of eastern, Oregon indicate highest mortality and basal area reductions after late spring fires [8,68]. Limited evidence suggests that prairie junegrass is favored by winter fires [40]. Mortality and basal area reductions were documented as follows after fire in Oregon sagebrush-grassland communities [8]:

season of burn	mortality (%)	basal area reduction (%)
May	20	32
mid-June	10	16
October	0	--

Basal area of prairie junegrass burned after senescence was reduced by an average of 22 percent [8].

PLANT RESPONSE TO FIRE :
Prairie junegrass typically reoccupies a site through seed. Seed production is generally heavy [61], and prairie junegrass readily reseeds bare areas [11]. Although prairie junegrass does not resprout after fire [45], recovery time is described as moderate to very rapid [61]. Depending on site characteristics and climatic factors, recovery can occur within 1 to 8 years [69].

Prairie junegrass often exhibits increased vigor after fire, particularly during the first growing season [1,41]. Response to fire may include greater seed stalk production and an increase in mean height [30,41]. Inflorescences are often shorter but more numerous [75], and seed production potential is enhanced. Humes [30], in a western Montana study, noted greater spring leaf height growth and increased seed stalk production as follows:

	plants with seed stalks (percent)	# seed stalks/plant
site # 1-burned	82.5	5.6
unburned	60.0	2.5

site # 2-burned	67.5	5.0
unburned	52.5	3.0

Mean height increases were also observed after an August fire in the Selway-Bitterroot Wilderness of Idaho [40]:

burned - inches (cm) 1974 (1 yr. after fire)	1975	1976	unburned -inches (cm) 1974 - 1976
14 (36)	11 (29)	11 (29)	10 (26)

Frequency of prairie junegrass often increases following light to moderate fires but may decrease after hot fires [1,6,61]. Wright and Bailey [68], however, note that an increase in frequency does not necessarily imply an increase in herbage yield, which may be reduced for a number of years. Plant response varies according to season of burn, fire intensity and severity, weather conditions, and specific site characteristics.

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
Productivity: Postfire productivity of prairie junegrass varies according to fire intensity and severity. In southern Idaho, Blaisdell [6] found that junegrass produced 11 pounds (5 kg) per acre more on lightly burned ranges, and an additional 21 pounds (9.5 kg) per acre on moderately burned sites, than on unburned ranges. However, yields may be reduced by heavier burns [6]. Productivity at two Idaho sites was documented as follows [6]:

air-dry herbage production

unburned	light burn	moderate burn	heavy burn
9.4 lb(4.3kg)	14.2 lb(6.4kg)	13.3 lb(6.0kg)	10.7 lb(4.9kg)
32.8 lb(14.9kg)	43.6 lb(19.8kg)	53.4 lb(24.2kg)	36.8 lb(16.7kg)

air-dry productivity on burns-expressed as % of unburned:

	preburn	1937 (1 yr.after burn) (percent)	1939	1948
light burn	167	89	113	172
moderate burn	183	59	71	164
heavy burn	218	32	55	136

	preburn	1934 (1 yr.after burn) (percent)	1936	1948
light burn	143	320	33	137
moderate burn	110	380	52	162
heavy burn	60	340	28	108

In Idaho, yields of prairie junegrass were greatest on plots which had been burned 12 years earlier [69].

Frequency: Researchers have observed both increases and decreases in prairie junegrass frequency after fire. Increases are apparently more likely after light to moderate fires. However, it is difficult to discern general trends due to differences in fire intensity and severity, season of burn, weather conditions, grazing conditions, and site factors. Geographic variation is also possible. The frequency of prairie junegrass increased after fires in Alberta [2], Minnesota, Wisconsin [73], Montana [3], North Dakota [69], and South Dakota [20]. Frequency data, as presented below, indicate that increases may either be dramatic or scarcely perceptible:

east-central Alberta-

unburned	# plants/m sq.
burned	# plants/m sq.
36%	17
73%	14

Wisconsin-

	Unburned	Burned
site # 1	21%	51%
site # 2	10%	31%
site # 3	21%	27%

western Montana - (1977 burn)

	Unburned	Burned
fall 1977	1.6%	1.5%
spring 1978	1.4%	2.4%
summer 1978	1.5%	3.0%

The frequency of prairie junegrass increased following a fall burn on sandy soils in North Dakota [69], but was essentially unchanged after a hot fire in late May [68]. In Idaho, Merrill and others noted a slight decrease in prairie junegrass cover one year after an August fire [41]:

(1 year after fire)

1974				1976			
% Cover		% Frequency		%Cover		% Frequency	
Burned	Unburned	Burned	Unburned	Burned	Unburned	Burned	Unburned
1 +- 2	2+-5	2+-3	2+-3	2+-3	3+-4	4+-5	5+-6

FIRE MANAGEMENT CONSIDERATIONS :
Evidence suggests that changes in the frequency and productivity of prairie junegrass vary according to fire intensity, season of burn, and geographic location. The frequency of prairie junegrass is generally uncanged or increased by early spring burns but can be decreased by late spring burns in the mixed-grass prairie of the northern Great Plains [68]. In the shortgrass and mixed-grass prairie of the central Great Plains, prairie junegrass generally shows little change or increases slightly after fire [68].

FIRE EFFECTS

SPECIES: Arctostaphylos uva-ursi

IMMEDIATE FIRE EFFECT ON PLANT :
Fire effects vary with the season, severity and intensity of the fire, site and surface soil characteristics, and the age, location, and vigor of the plants. When bearberry is rooted in mineral soil, it can survive moderate fire [114]. However, when bearberry is rooted in organic soil horizons, a fire that removes those horizons will kill bearberry [6,14,39]. If the duff and soil are moist and not completely consumed by fire, some bearberry root crowns may survive [23]. Rooted stolons under rocks, moist logs, or in other protected microsites may also survive [22]. Bearberry plants are sufficiently resistant to ignition to inhibit fire spread in light, flashy fuels [46,68].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
In a controlled experiment, five bearberry plants were burned at different temperatures. Heat treatments lasted about 2 minutes apiece. Bearberry response was strongest at the middle temperature of 1112 degrees F (600 degrees C). The number of postfire sprouts after 3 months, and the amount of cover, height of the sprouts, and oven-dry biomass after 17 months were recorded [86]:

	Temperature in degrees F (degrees C)					
	752 (400)		1112 (600)		1472 (800)	
	mean	S.E.	mean	S.E.	mean	S.E.
Sprout numbers	44	20	48	13	26	7
Percent cover	42	15	78	19	45	19
Height (in)	2.4	3.5	2.4	0.4	1.6	0.4
(cm)	6	9	6	1	4	1
Biomass (oz)	1.1	0.4	1.9	0.5	0.9	0.4
(g)	30	11	54	15	26	10

PLANT RESPONSE TO FIRE :
Bearberry sprouts from the root crown and establishes from seedbank-stored seed after fire [85,114,115,129]. Bearberry seeds have been reported to survive fire in the upper soil and be stimulated to germinate by heat from the fire [114]. Rowe [114] suggests that bearberry may be a shade-intolerant species that stores seed in the soil.

After fire in heathland, bearberry sprouts vigorously and expands rapidly [85]. Bearberry reinvades burned sites from adjacent, unburned vegetation and/or from seed [6,23,39,81,148].

In boreal forest, bearberry has regenerated from surviving basal sprouts following fire [115,129]. Full recovery in many areas has been slow [17,32,120].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
Bearberry's response is variable and dependent upon survival of shallow regenerative organs and seed sources. Several studies seem to indicate a slow postfire response with a definite increase in early succession. Immediate postfire results of a study in Scotland heath were variable. In one set of plots, seedling establishment during the first 3 years

after a March fire was good [87]. A second set of plots monitored following the same fire had good vegetative recovery but no seedlings [88]. Results of a northwestern Montana study showed the following average percent cover of bearberry 3 years after fire on plots burned at different intensities [130]:

Unburned	Light burn	Medium burn	Hot burn
3.27	1.80	0.89	none

Following spring burning in a Montana shrubfield created 35 years previously by wildfire, bearberry volume decreased the first two seasons, but bearberry appeared to be recovering well [101]. Bearberry had an average of 0.6 percent frequency in samples from sites where slash pile fires occurred 2 to 15 years previously and was considered to be a retreater on hotly burned sites [144]. Following fire in Colorado lodgepole pine forest stands, bearberry was one of the major shrub dominants during the first century of succession [17]. However, data from this study do not show any bearberry in the first few years after fire [17]. Ten or 11 years after fire on the Tillamook Burn in Oregon, bearberry had 11 percent frequency on burned areas and was not present in or near plots in adjacent unburned forest [98]. Following fire in British Columbia, bearberry cover is weakly correlated with environmental factors. Evidently, bearberry is able to grow on a variety of sites under postfire conditions [41]. Twenty-nine years after an alpine wildfire in British Columbia, bearberry cover and frequency were slightly higher in burned areas of both krummholz and heath than in unburned areas [32].

During the first 3 years after prescribed fire on jack pine clearcuts in Michigan, bearberry cover and frequency were very low when compared to similar clearcuts that were not burned or undisturbed forest [1]. Another Michigan study found the highest postfire frequency of bearberry occured 31 years after fire [120]. Results of a paired plot study in the northern Wisconsin pine barrens indicated that bearberry frequency decreases after a single fire or repeated fires [143].

FIRE MANAGEMENT CONSIDERATIONS :
Equations have been developed for estimating the fuel loading of bearberry from cover and plant height values in the northern and central Rocky Mountains [4,16].

FIRE EFFECTS

SPECIES : Amelanchier alnifolia

IMMEDIATE FIRE EFFECT ON PLANT :
Saskatoon serviceberry is top-killed by moderate to severe fire. Larger branches may survive light-severity fire [19,80,95].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Saskatoon serviceberry sprouts after top-kill by fire [9,19,95]. Bradley [19] found that on burn sites in western Montana, Saskatoon serviceberry sprouted mostly from upper portions of the root crown. When the root crown was killed by fire, Sasktoon serviceberry sprouted from rhizomes further beneath the soil surface. Seed production may resume soon after fire: Saskatoon serviceberry sprouts produced fruits the second summer after a July 1977 wildfire in Pattee Canyon near Missoula, Montana [56].

Saskatoon serviceberry cover usually increases [9] or is unaffected [9,97] by fire. Even when there is little change between pre- and postfire cover, fire usually makes Saskatoon serviceberry more accessible as wildlife browse by lowering shrub height [97]. Arno and others [9] found that in western Montana, Sasktoon serviceberry cover generally increased after wildland or prescribed fires in Douglas-fir/ninebark habitat types. It sometimes took 10 or more years before the increase occurred, however. The authors suggested that slow recovery in some areas may be due to big game browsing pressure after fire.

Current-year annual twig production is usually greater after fire in the absence of heavy browsing pressure [9,24]. In a mountain brush community in Wyoming, Saskatoon serviceberry mortality was 12 percent, 15 percent, and 15 percent, 1, 2, and 3 years after fall wildfire, respectively. Mortality after spring prescribed burning a nearby site was one, two, and two percent at postfire years 1, 2, and 3. Postfire browsing pressure was not heavy, but wildfire- and prescription-burned areas were browsed more than unburned areas. Despite this, current-year twig production was significantly greater on burned sites than on unburned sites in postfire years 1 to 3. Current-year annual twig production was greater on the wildfire-burned site than on the spring prescribed-burned site (37 vs. 15 g/plant) [24].

Fire season: In a western Montana study contrasting the ability of spring vs. fall prescribed fire to improve wildlife habitat, severe fall fire killed 15 percent of Saskatoon serviceberry plants on the site, while a less severe spring treatment killed only 5 percent. Sprouting response in the first 2 postfire years was greater on the spring burn [79].

Fire in various habitat/plant community types: In a western redcedar (Thuja plicata)/ninebark habitat type of central Idaho, Saskatoon serviceberry sprouted from the root crown and grew rapidly after prescribed burning. Height growth of sprouts follows [11]. (Prefire height not available.)

Height (m)

Avery Site	Lochsa Site

postfire year 1	0.9	1.2
postfire year 2	1.5	1.3
postfire year 3	1.2	3.0
unburned control	2.3	3.2

In Douglas-fir/blue huckleberry (Vaccinium membranaceum) habitat types of western Montana, prescribed fire had little effect on Saskatoon serviceberry cover [11].

Near Ketchum, Idaho, a prescribed fire was conducted on August 1, 1963, to reduce dwarf-mistletoe (Arceuthobium douglasii) infestation in Douglas-fir and to promote sprouting of browse, which was above browseline. The fire was successful in both respects. Saskatoon serviceberry recovered from the fire as follows [68,69]:

	Plants*/1,000 sq ft	Percent Canopy Cover
prefire	0.2	0.25
postfire yr 1	0.1	0.03
postfire yr 2	0.1	0.05
posftire yr 3	0.2	0.06
postfire yr 4	0.1	0.06
postfire yr 5	0.1	0.09
postfire yr 6	0.3	0.12
postfire yr 7	0.2	0.12

*only plants over 18 inches in height were included in density measurements

After prescribed fire in Oregon white oak (Quercus garryana) woodlands in western Washington, Saskatoon serviceberry sprouts were most common on sites that were treated with low-severity fire and had no prefire mechanical disturbance. Saskatoon serviceberry sprouts usually co-occurred with Oregon white oak sprouts on such sites. Neither Saskatoon serviceberry sprouts, Saskatoon serviceberry seedlings, nor Oregon white oak sprouts occurred on microsites that were heavily disturbed before fire. After prescribed fire, those microsites were colonized by herbs, especially exotic herbs, and Oregon white oak seedlings [1].

Saskatoon serviceberry appears to be slow to recover from prescribed burning in the sub-boreal spruce-fir (Picea-Abies spp.) zone in British Columbia [45].

Response to very frequent fire: Saskatoon serviceberry response to repeated burning is unclear. In a quaking aspen-rough fescue (Festuca scabrella) ecotone in Alberta, Saskatoon serviceberry was one of the few woody shrubs that was not harmed by low-severity annual spring prescribed fire. Frequency was 8 percent on unburned sites and 16 percent on annually burned sites. Canopy cover was not significantly different between the two areas (4 and 1.4 percent, respectively) [5].

In the Willamette Valley of Oregon, Kalapuyan Indians apparently controlled Saskatoon serviceberry with frequent fire in order to promote acorn production by Oregon white oak. Open oak savannas were noted by early travellers, but in the absence of aboriginal burning, Saskatoon serviceberry has formed a closed subcanopy in Oregon white oak woodlands [18].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
NO-ENTRY

FIRE MANAGEMENT CONSIDERATIONS :
Saskatoon serviceberry is most vigorous in seral plant communities

[9,48,51], and prescribed fire can be used to maintain and/or promote seral communities. On big game rangelands, prescribed fire can improve condition of Saskatoon serviceberry and other shrubs by reducing shrub height, promoting growth of new twigs, and increasing nutritional content of browse [9,68,73]. Sites where prescribed burning may harm Saskatoon serviceberry in the long term include harsh (especially very dry) sites with low Saskatoon serviceberry density [48], and very cold sites where postfire growth would be limited by temperature [45].

Fire stimulates production of Saskatoon serviceberry by killing understory conifers, removing old Saskatoon serviceberry topgrowth, and promoting sprouting [9,73]. On Douglas-fir/ninebark winter elk range on the Lolo National Forest, Montana, Makela [71] found that after spring prescribed fire, biomass production of new Saskatoon serviceberry twigs was significantly greater ($p < 0.1$) on burned sites than on unburned sites the first two growing seasons after fire.

Ponderosa pine: Saskatoon serviceberry usually occurs in the moister, cooler ponderosa pine habitat types. Average loading of downed and dead woody fuels is slightly higher than in drier ponderosa pine types. Fire hazard is further increased by the tendency of this type to form subcanopies and dog-hair thickets of conifer saplings. Wildfire hazard is particularly high in this type during drought. Common management objectives are to eliminate large areas of overstocking and create a two-storied stand rather than a multilayered one. Periodic prescribed surface fire in early spring or late fall is recommended. Fuels management includes treatment of slash following logging and thinning, and controlling stocking levels. Scattered thickets of Saskatoon serviceberry and other shrubs can be left for wildlife [34].

Quaking aspen: Light fuels and grazing can inhibit fire spread in quaking aspen. Brown and Simmerman [22] assigned probabilites of successful prescribed burning in quaking aspen/Saskatoon serviceberry habitat types as follows:

		Fuel Type	
Grazing	Woody Fuel	Aspen/serviceberry	Mixed aspen-conifer/serviceberry
ungrazed	light	high	high
ungrazed	heavy	high	high
grazed	light	moderate	moderate
grazed	heavy	high	high

FIRE CASE STUDIES :
list of sub frames

FIRE EFFECTS

SPECIES: Spiraea betulifolia

IMMEDIATE FIRE EFFECT ON PLANT :
White spiraea is almost always top-killed following fires of moderate to high intensity. The rhizomes are seldom consumed in similar fire conditions [2,8,9,35].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
White spiraea demonstrates high survival capabilities following holocaustic wildfires [38]. It is a rhizomatous shrub that not only survives burning, but can often flower the year immediately following the burn [9,35]. Geier-Hayes [17] found white spiraea to increase in cover and frequency following disturbance by fire. In fact, white spiraea was found to increase in canopy cover 3 to 5 years after a burn [26]. On lightly burned sites, white spiraea showed no significant (5%) levels of nutrient accumulations [33].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
White spiraea relies on sprouting for postfire regeneration [25]. Resprouting from surviving rhizomes ensures abundant regrowth after fires, if conditions are suitable [25]. Bushey [4], however, found that white spiraea decreased noticeably in postburn transects. Soil morphology and depth to rhizomes are important components for estimating potential fire survival [2].

FIRE MANAGEMENT CONSIDERATIONS :
White spiraea has generally not been the primary target of fire management objectives. Because white spiraea has a substantial portion of its rhizomes in mineral soil, it has been ranked in the highest fire-survival category [2]. Therefore, white spiraea can be relied on as a dependable fire-survivor species.

FIRE EFFECTS

SPECIES: Agropyron cristatum

- IMMEDIATE FIRE EFFECT ON PLANT
- DISCUSSION AND QUALIFICATION OF FIRE EFFECT
- PLANT RESPONSE TO FIRE
- DISCUSSION AND QUALIFICATION OF PLANT RESPONSE
- FIRE MANAGEMENT CONSIDERATIONS

IMMEDIATE FIRE EFFECT ON PLANT:

Fire usually burns crested wheatgrass aboveground but underground parts survive [79].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT:

No entry

PLANT RESPONSE TO FIRE:

Researchers characterize crested wheatgrass as "slightly damaged" [97] or "undamaged" by prescribed fire [93,119], since coarse stems and sparse leafy parts inhibit heat transfer down into the culms or soil. Young [119] says postfire recovery is rapid.

Crested wheatgrass in eastern Idaho and western Wyoming occurs in low flammability growth habitats, and its deep underground tillers help it to survive fire. Crested wheatgrass growth may be favored by late summer fire, but spring fire can decrease yields for several years [21].

Crested wheatgrass can be used as a "greenstrip" or fuelbreak in semi-arid rangelands to help control wildfire [49]. It is moderately flammable, produces moderate litter, has an extensive range, competes well, and is a good sprouter. A mature stand of crested wheatgrass can help control annual grassland fires like those found in sites now invaded by cheatgrass throughout the arid West, particularly in sagebrush-steppe habitats [90,94].

A study at Experimental Farm, Swift Current, Saskatchewan, investigated the effects of spring and fall burns on crested wheatgrass pastures. The spring burn occurred while the grass was growing vigorously, and forage yield and domestic sheep consumption on the pasture were reduced for the following 2 years. The grass was dormant during the fall burn, which took place during November. Although forage yield was reduced in the following year, sheep consumption was not. Lodge [79] concluded the fall burning of crested wheatgrass reinvigorated the stand.

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE:

No entry

FIRE MANAGEMENT CONSIDERATIONS:

Haws and Bohart [53] studied infestation of monoculture crested wheatgrass stands with black grass bugs in Utah. They conclude that the bugs decrease regeneration by eating the grass seed, but that since the grass bug eggs are inserted in the stem of the grass, they can easily be destroyed by burning. Burning in the fall destroyed most eggs and depressed the bug population for several years.

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FIRE EFFECTS

SPECIES: Calamagrostis rubescens

IMMEDIATE FIRE EFFECT ON PLANT :
Fires that consume the duff layer can sometimes kill pinegrass rhizomes [10]. Grass is usually consumed by low-severity fires.

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Pinegrass sprouts from rhizomes following fire and may bloom profusely for the first 2 years [12,58,64]. It can also invade burned areas [68,59].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
Pinegrass typically has higher cover and frequency values on burned than on unburned sites [10,12,13,31]. Pinegrass produced new culms after fire in Wyoming quaking aspen stands but did not produce many in unburned areas. In these stands, pinegrass was prolific on severely burned sites and produced seed [15]. However, following a prescribed burn in an aspen community type in Idaho, pinegrass cover had decreased by the fourth postfire year [6]. Stickney [57] has summarized pinegrass cover and volume percentages for a 15-year period following a wildfire in a northern Idaho western redcedar (Thuja plicata)-western hemlock habitat type.

FIRE MANAGEMENT CONSIDERATIONS :
Stout and Brooke [55] developed an equation for determining the relationship between tiller height and leaf area, which may be useful for predicting fuel loading. Others have evaluated the National Fire Danger Rating System grass fuel models [53], compiled guides for appraising fuel loading in Rocky Mountain habitat types with pinegrass indicators [19], estimated fuel weights for pinegrass [7], and developed surface areas to volume ratio models as indicators of flammability [5,8]. Pinegrass varies in potential heat energy throughout its growing season, declining mid-season then increasing again before another decrease in fall [44].

Grazing can alter the fuels in pinegrass communities, promoting infrequent high-intensity fires and reducing more frequent low-intensity fires [66].

Periodic underburning in ponderosa types can maintain pinegrass at 500 to 600 pounds per acre (559-671 kg/ha) by preventing climax conifer establishment [23].

Light-intensity ground fires can be used to increase cover and frequency of pinegrass for black bears [48].

FIRE EFFECTS

SPECIES: Juniperus horizontalis

IMMEDIATE FIRE EFFECT ON PLANT :
Death occurs when the crown is totally consumed by fire [28]. Fires which consume most of the aboveground foliage usually produce serious damage to the root system as well [28]. Plants subjected to varying degrees of partial defoliation often survive, however. Where large extensive mats occur, fires may not carry across the entire plant, and survival is fairly common [28]. Smaller plants are believed to be more susceptible to fire.

Little is known about the specific effects of fire according to fire intensity or season of burn. Under some circumstances fires of even low intensity can produce serious damage. Miller [28] observed that temperatures less than 450 degrees Fahrenheit (267 deg C) are sometimes sufficient to kill creeping juniper. Creeping junipers survived temperatures of 109 degrees Fahrenheit (78 deg C) to 450 degrees Fahrenheit (267 deg C) during a fire in central Montana [28].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Creeping junipers which survived a fire in central Montana generally produced new leaves and exhibited good growth during the first postfire growing season [28]. Regrowth during the first growing season ranged from .005 to .14 ounce (0.14-3.95 g) per plant and averaged .05 ounce (1.4 g) per plant [28].

Reestablishment is through seed on sites where creeping juniper has been killed by fire. Germination of juniper seed is often poor [30], and regeneration is likely to be slow. The seed of most junipers can remain viable for a relatively long period of time. Some seed can presumably survive the damaging effects of fire if protected from heat by overlying layers of soil. Germination of these on-site seeds may occur when favorable conditions are encountered. Birds and mammals consume creeping juniper seed and can bring seed onto burned sites from unburned areas. The length of time required for postfire reestablishment of creeping juniper has not been documented.

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
NO-ENTRY

FIRE MANAGEMENT CONSIDERATIONS :
Fire management potential appears to be somewhat limited because many creeping juniper sites are much too rocky for fires to carry. Potential benefits may be slight.

FIRE EFFECTS

SPECIES: Shepherdia canadensis

IMMEDIATE FIRE EFFECT ON PLANT :
Severe fires will consume all aboveground leaves and stems of russet buffaloberry, while light to moderate fires will leave some stems standing [37].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Russet buffaloberry is normally fire resistant but can be eliminated by fire [34]. As a result it is classified as moderately resistant to burning [34,38]. Following a Montana wildfire, regrowth of buffaloberry was slow; 4 to 5 years were required for 25 percent of the eventual crown size to be obtained [30]. Recurrent, low-intensity ground fires are closely linked to maintaining russet buffaloberry density and vigor in stands with lodgepole pine and quaking aspen overstories, and dry upland meadows where it dominates the shrub layer [37].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
Following an intense wildfire in Colorado, essentially all aboveground vegetation in the perimeter died. The fire was the most intense where dominated by lodgepole pine, with lower intensities in areas dominated by subalpine fir and Engelmann spruce. Russet buffaloberry increased rapidly following this fire due to sprouting from surviving roots. A combination of delayed sprouting and seeds originating from outside the burn was hypothesized to be responsible for an increase in frequency over the study period. Three years after the fire, russet buffaloberry was mainly found on sites with a somewhat lower slope, a higher prefire tree basal area, and a higher number of prefire tree stems per acre. These factors appear to be conducive to russet buffaloberry establishment and growth [3].

FIRE MANAGEMENT CONSIDERATIONS :
Low- to moderate-intensity fires may increase vigor and density of russet buffaloberry in old-growth stands. Berry production may also be increased for several years after fire [3,37].

FIRE EFFECTS

SPECIES: Pachistima myrsinites

IMMEDIATE FIRE EFFECT ON PLANT :
Pachistima can survive low- to moderate-severity fires that do not consume the duff or raise the soil temperature too high [10]. It can, however, be killed by severe fires [9].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Pachistima usually sprouts from its root crown or from buds on its taproot following low- to moderate-severity fires [10,42].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
The development of pachistima cover following wildfire and clearcutting/ broadcast burning has been recorded for western larch (Larix occidentalis) and Douglas-fir forests in Montana [47]. Pachistima appears to have a varied response to both wildfire and broadcast burning, depending on site [8,16,47]. Stickney tracked first decade postfire succession following a severe fire in western hemlock/ pachistima habitat type. Pachistima exhibited a steady-state frequency pattern throughout the decade, with little expansion or reduction in distribution within the study site [48,49]. Some have classified pachistima as "neutral" in its resistance to fire, meaning that it has less than a 12.5 percent frequency increase or decrease when compared to average frequencies of those shrubs in unburned areas [53].

FIRE MANAGEMENT CONSIDERATIONS :
Nalley [41] developed models for predicting fuel loading in western redcedar/pachistima types in northern Idaho. Brown [6] lists bulk densities of some Montana and Idaho habitat types (in which pachistima is an indicator) for determining fuel depth. Fuel loadings and fire ratings for quaking aspen/pachistima community types have also been listed [7].

FIRE EFFECTS

SPECIES: Mahonia repens

IMMEDIATE FIRE EFFECT ON PLANT :
Oregon-grape usually survives all but severe fires that remove duff and cause extended heating of the upper soil [17,48]. One study reported that a severe fire favored Oregon-grape [11], but fire conditions were not specified.

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Oregon-grape was absent after severe fires in northern Idaho but unharmed by moderate fires [6]. Density and height increases have been noted in the second postfire growing season [48].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
Five years following a moderate- to high-intensity fire, Oregon-grape reached 60 percent of prefire biomass in a mixed aspen/conifer stand, 65 percent in an upper elevation aspen stand, and 85 percent in a lower elevation aspen stand [12].

Four different fires were studied to determine successional responses of Oregon-grape following fire. At postfire year 1 cover had decreased, remained the same at postfire year 2, decreased in postfire year 9, and was much higher at postfire year 18. Fire severity may be related to the survival of Oregon-grape. Generally, an increase in cover should occur by 9 postfire years [44].

Oregon-grape cover increased during postfire years 1 and 2 following an April fire in western Montana. It invaded an burn resulting from an October fire during the second postfire year [48].

FIRE MANAGEMENT CONSIDERATIONS :
Oregon-grape may be supressed in areas seeded to grass following wildfires. This should be considered before planting grasses in areas where Oregon-grape is an important food for wildlife [5]. Prescribed fire has a low probability of success in the aspen/low forb community type, of which Oregon-grape is a main component, because of the sparse vegetation [13].

FIRE EFFECTS

SPECIES: Vaccinium membranaceum

IMMEDIATE FIRE EFFECT ON PLANT :
Many deeper rhizomes of blue huckleberry survive light surface fires that kill aboveground stems [103]. However, rhizomes tend to occur in the organic forest floor [26] and are often killed by hot, duff-consuming fires [93]. Surviving blue huckleberry sprouts are often limited to protected microsites, suggesting that many rhizomes in less well-protected areas are killed [119].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
Rhizome mortality is generally greater following fall fires than following spring fires [92,93]. Evidence suggests that seasonal differences are related to the degree of heat penetration rather than the phenological state of the plant [93]. Fall fires tend to be much hotter, and soil moisture is often too low to offer much protection to rhizomes [93]. Rhizomes are rarely killed by fall fires when fuel loading is light, and duff and fine fuels are moist [93]. Spring fires which occur when soil and duff are still moist [94] generally do not produce temperatures lethal to blue huckleberry rhizomes [92]. Rhizome mortality can occur following spring fires if duff and soil moisture are unusually low [93].

PLANT RESPONSE TO FIRE :
Vegetative response: Blue huckleberry typically sprouts from underground rhizomes after light or moderate fires. Light fires can stimulate rhizome sprouting [61,103] and frequently produce increases in density. Hot fires may eliminate shallow rhizomes [78,129] and generally reduce density [8,89]. Blue huckleberry tends to sprout most prolifically if stems are killed to belowground level [26]. Where all aboveground vegetation is removed and heat penetrates into the soil, surviving rhizomes often sprout, rather than adventitious buds located above the soil surface [26]. More individual plants are produced if lethal temperatures reach portions of the underground rhizome network [92]. Where plants were senescent prior to fire, rhizomes are often severed and can produce large increases in the number of plants [92]. Phenological development does not appear to affect the number of shoots that develop after fire [94]. Generally, the more stems present prior to fire, the more sprouts that will result from pruning by fire [93]. Occasionally, fire transforms blue huckleberry from a "sprawling forest form" to "tightly separated clumps" [92].

Seed: Seedling establishment of blue huckleberry appears to be rare [7,127,137]. Current climatic conditions probably restrict seedling establishment to favorable sites in unusually moist years.

Rate of recovery: Rate of postfire reestablishment appears variable. Recovery of blue huckleberry may be moderate to rapid [135,146], but in some situations, postfire recovery proceeds very slowly. Haeussler and Coates [53] report that blue huckleberry recovers slowly after light fires that kill the crown but not underground rhizomes. Recovery is generally much slower after fires of high severity which destroy portions of the rhizomes [24]. Reestablishment may also be delayed on relatively xeric sites [87]. Recovery may take 10 to 20 years or more on some sites [8,61].

Plants generally sprout immediately after early spring or late summer fires [53], although plants burned in late summer or fall may not sprout until the following spring [85,93,107]. Cover often remains low during the first few years after fire but on some sites, plants can attain preburn cover within 3 to 5 years [53].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :

Season of burn: Seasonal differences in fire response of blue huckleberry are primarily related to the depth of heat penetration [93]. Miller [93] observed increases in stem numbers of 80 to 120 percent after spring burns. On one plot, blue huckleberry numbers increased by 900 percent within 1 year after a spring burn, although approximately 30 percent of the plants died by the following year. Fall fires conducted when are dry commonly result in relatively high huckleberry mortality and slow recovery, as those rhizomes which do survive tend to be at greater depths. One year after fall fires in western Montana, the total number of stems had decreased and blue huckleberry was present on fewer plots than in preburn samples [87]. By the second year after fire, "significant increases" in blue huckleberry were still occurring on 40 percent of the spring-burned plots but no new increases were noted on fall-burned plots [87]. Spring burns are more likely to increase huckleberry cover than fall burns [26,92]. Late summer or fall burns can greatly reduce huckleberry numbers [29].

Type of fire: Recovery of blue huckleberry is typically more rapid after relatively cool broadcast burns than after hotter wildfires which are more likely to damage rhizomes [87]. Blue huckleberry is generally decreased by hot slash burns where fuel accumulations are heavy [154].

FIRE MANAGEMENT CONSIDERATIONS :

Fuels and flammability: Foliage of blue huckleberry is relatively nonflammable [93]. Miller [93] reports that shrubs are consumed by fire only after the plants are dried and preheated by burning woody fuels. Dense stands of blue huckleberry may not burn because of limited fuels [93] and underburning may be difficult to accomplish without pretreatment [146].

Prescribed fire: Flower buds tend to be more numerous on new shoots and periodic removal of old shoots can increase flower production in many species of huckleberries (Vaccinium spp.) [87]. Prescribed fire has long been used to rejuvenate commercial low sweet blueberry (V. angustifolium) fields and to increase fruit production [87]. Shoot growth is often greater after fire pruning, than following mechanical removal [94]. Attempts have been made to increase blue huckleberry yields through the use of prescribed fire. Fire appears to be most beneficial where senescent aboveground vegetation is removed or pruned but where rhizomes suffer little damage [93]. Spring fires conducted when the lower duff and soil is still somewhat moist, appear to be most effective in increasing V. globulare in Douglas-fir-western larch forests of western Montana [93]. Similarly, fire may also prove useful for rejuvenating decadent V. membranaceum stands in the Pacific Northwest [26]. However, spring burning can be difficult to accomplish in many huckleberry fields in areas of heavy snow accumulation [107]. Rejuvenation with fire may not be economically feasible in many high elevation areas, such as in some stands dominated by lodgepole pine, because fires may carry only under extreme conditions [92].

Maintaining productive huckleberry fields is likely to be expensive [107]. For best short-term results (berry production maintained or enhanced without delays of 5 years or more), overstory trees should be removed, but the blue huckleberry understory left intact [107]. Bulldoze and burn treatments can be effective over the long run, but result in immediate declines in berry productivity and often diminish aesthetic qualities of the site [107]. Other treatments are similarly effective in the long term but cause short-term declines in berry production [107]. Recreational opportunities and wildlife concerns must be balanced to achieve satisfactory results. [see Case Studies].

Where management goals include brush reduction, fall fires carried out when soil and duff are dry can often decrease blue huckleberry density [93]. However, it should be noted that blue huckleberry rarely interferes with conifer regeneration and provides important food for wildlife.

Berry production: Fruit may be produced within 3 to 6 years after light broadcast burns although berries are often not abundant for 8 to 15 years. Berry production may be delayed 20 to 30 years or more on some sites [87]. Fruit production of blue huckleberry is often greatest on "old" burns [141,155]. In northwestern Montana, Martin [87] observed good berry production on mesic north or east slopes which had been burned by wildfire 15 to 25 years earlier. Wildfires which had occurred 25 to 60 years earlier also produced highly productive plots [87]. However, 60- to 100-year-old wildfire-created stands produced little fruit despite high vegetative cover [87]. Fruit production generally declines as stands age, although even some "old" shrubs produce limited quantities of fruit [87, 107].

Wildlife: Fire suppression may have an adverse impact on bear habitat [142,154]. Once-productive berry fields are now being invaded by conifers. Logging treatments which include severe soil scarification or hot slash burns may also result in decreased berry availability. Even where timber harvest favors berry production, lack of cover in early seral stages can limit bear use. However, wildfires often create diverse habitat mosaics [154] which include elements of hiding cover and favor grizzly use. Succession to conifers on high elevation berry fields may be slow, particularly on south slopes, and burns often generate shrubfields that remain productive for relatively long periods of time [154]. Prescribed burns, particularly during spring, may increase berry production for bears and other animals.

Potential for grizzly use of subalpine fir/beargrass-blue huckleberry habitat types after fire appears high and is also high after clearcuts in subalpine fir/queencup-menziesia habitat types [87]. Potential for use is described as moderate to high after broadcast burns in subalpine fir/queencup beadlily-menziesia habitat types [87]. Martin [87] provides detailed information on potential for bear use by timber treatment and habitat type in northwestern Montana.

FIRE EFFECTS

SPECIES: Rhododendron macrophyllum

IMMEDIATE FIRE EFFECT ON PLANT :
Pacific rhododendron appears to be top-killed by most fires. The shallow rootcrown could be heat-killed during severe fires, thus killing the entire plant. Low severity fires may allow the survival of basal stem buds, accounting for observations of its increased survival following such fires [11,20].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Following fire, Pacific rhododendron sprouts from stem bases or rootcrowns and new seedlings may establish [3,20,62]. There is a marked decrease in cover and frequency immediately after fire followed by a slow, gradual increase [10,11,48,58]. In the western Cascade Mountains of Oregon, Pacific rhododendron is a residual species following light fires but very scarce after more severe fires [11]. Nevertheless in this area, evidence of past fires is shown by brushfields that include Pacific rhododendron [53]. In Asia rhododendron seedlings rapidly colonize open areas after fire [35] and Pacific rhododendron's tiny, winged seeds might allow expansion from surviving plants.

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
Several studies that have used permanent plots to follow vegatation changes after logging and burning in Oregon and Washington demonstrate that Pacific rhododendron is fire-sensitive. Two studies following slash burning compared burned and unburned plots. In the first study, most plots were burned lightly or moderately by fall fires. Samples taken during the first 16 years after slash burning show Pacific rhododendron to be dominant on twice as many unburned plots as burned plots. Where it did attain significant cover on burned plots, Pacific rhododendron had resprouted by the second season after fire [39,40]. A second study found cover of Pacific rhododendron to be 30.5 percent on unburned plots and 4.9 percent on burned plots 11 to 16 years following fire [49].

Results of another postfire study demonstrated a slow increase in frequency of Pacific rhododendron from the first to the fifth and sixth growing seasons [58]. A comparison of old-growth western hemlock - Douglas-fir stands with 2- to 40-year-old stands found mean cover values of Pacific rhododendron decreased from 13 percent to 0.4 percent 2 years after broadcast burning and gradually increased to 6.8 percent at 40 years [48]. Early recovery of Pacific rhododendron on three clearcuts that were treated with medium-intensity fall fires was as follows [11]:

	Cover (%)	Frequency (%)
Before logging:	8.5	29.5
Year 1 after logging:	1.0	18.0
Year 1 after slash fire:	0.2	13.1
Year 2 after slash fire:	0.8	11.5
Year 5 after slash fire:	1.8	14.8

FIRE MANAGEMENT CONSIDERATIONS :

Since Pacific rhododendron is reduced by fire [20], burning after logging results in better conifer stocking [57]. However, communities with Pacific rhododendron as a dominant are frequently on infertile soils that are sensitive to the effects of fire [27,28]. Moderate to hot slash fires can cause damage to these soils and loss of nutrients, especially nitrogen [27,28].

FIRE EFFECTS

SPECIES: Agropyron cristatum

- IMMEDIATE FIRE EFFECT ON PLANT
- DISCUSSION AND QUALIFICATION OF FIRE EFFECT
- PLANT RESPONSE TO FIRE
- DISCUSSION AND QUALIFICATION OF PLANT RESPONSE
- FIRE MANAGEMENT CONSIDERATIONS

IMMEDIATE FIRE EFFECT ON PLANT:

Fire usually burns crested wheatgrass aboveground but underground parts survive [79].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT:

No entry

PLANT RESPONSE TO FIRE:

Researchers characterize crested wheatgrass as "slightly damaged" [97] or "undamaged" by prescribed fire [93,119], since coarse stems and sparse leafy parts inhibit heat transfer down into the culms or soil. Young [119] says postfire recovery is rapid.

Crested wheatgrass in eastern Idaho and western Wyoming occurs in low flammability growth habitats, and its deep underground tillers help it to survive fire. Crested wheatgrass growth may be favored by late summer fire, but spring fire can decrease yields for several years [21].

Crested wheatgrass can be used as a "greenstrip" or fuelbreak in semi-arid rangelands to help control wildfire [49]. It is moderately flammable, produces moderate litter, has an extensive range, competes well, and is a good sprouter. A mature stand of crested wheatgrass can help control annual grassland fires like those found in sites now invaded by cheatgrass throughout the arid West, particularly in sagebrush-steppe habitats [90,94].

A study at Experimental Farm, Swift Current, Saskatchewan, investigated the effects of spring and fall burns on crested wheatgrass pastures. The spring burn occurred while the grass was growing vigorously, and forage yield and domestic sheep consumption on the pasture were reduced for the following 2 years. The grass was dormant during the fall burn, which took place during November. Although forage yield was reduced in the following year, sheep consumption was not. Lodge [79] concluded the fall burning of crested wheatgrass reinvigorated the stand.

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE:

No entry

FIRE MANAGEMENT CONSIDERATIONS:

Haws and Bohart [53] studied infestation of monoculture crested wheatgrass stands with black grass bugs in Utah. They conclude that the bugs decrease regeneration by eating the grass seed, but that since the grass bug eggs are inserted in the stem of the grass, they can easily be destroyed by burning. Burning in the fall destroyed most eggs and depressed the bug population for several years.

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FIRE EFFECTS

SPECIES: Linnaea borealis

IMMEDIATE FIRE EFFECT ON PLANT :
Twinflower is killed even by low-intensity fire [9,17,23,50,65].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Twinflower sometimes colonizes new areas after fire. In northwestern Montana, broadcast burning was conducted to remove slash following logging of subalpine fir (Abies lasiocarpa). Twinflower had previously been absent from the site. Twinflower seedlings first appeared at postfire year 6, showing 1 percent ground cover. At postfire year 9, twinflower cover was still at 1 percent [65]. Broadcast burning was also conducted at a nearby site where prefire twinflower cover was 8 percent. The fire removed 11 percent of the duff, and all existing twinflower was killed. As with the previously mentioned fire, twinflower seedlings first established at postfire year 6, showing 1 percent cover. By postfire year 8, twinflower cover at this site had increased to 8 percent [65].

In Pacific silver fir (Abies amabilis)-subalpine fir forests of central British Columbia, twinflower frequency on 4- to 22-year-old burns was 60 percent. Frequency on 37- to 75-year-old burns was 70 percent [26].

Two consecutive annual, low-intensity prescribed fires were conducted on the Petawawa Experimental Station in Ontario. Prefire relative twinflower density was 9.65 percent. After the first fire, twinflower relative density lowered to 0.14 percent. It dropped to 0.11 percent after the second fire [52].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
NO-ENTRY

FIRE MANAGEMENT CONSIDERATIONS :
Brown and Marsden [11] have developed an equation for estimating fuel weight of twinflower and other small woody plants, grasses, and forbs in coniferous forests of western Montana and northern Idaho. Brown [10] developed a method of determing bulk densities of nonuniform surface fuels in subalpine fir/twinflower and other forest types of that region.

FIRE EFFECTS

SPECIES: Lupinus caudatus

IMMEDIATE FIRE EFFECT ON PLANT :
Aboveground parts of tailcup lupine are generally consumed by fire [55].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Some lupines are fire survivors and are present in the initial stages of postfire plant succession [18]. Tailcup lupine is favored or relatively unaffected by fire in sagebrush or pinyon-juniper habitats. It also germinates from buried seed after fire [33,52]. Pechanec [29] stated that top-killed plants may make a ready recovery and rapid increase in vigor, but an increase in plant numbers must await seed production, usually in the second growing season after burning.

In sagebrush-grassland habitats of the Upper Snake River Plains, Idaho, intense fire resulted in lower postfire forb production, most likely due to the destruction of buried seeds. Lupines (Lupinus caudatus and L. leucophyllus), however, were favored by burning. Biomass production of the two species at postfire year 12 years is as follows [4]:

	lbs/acre	kg/ha
Unburned	2.3	2.6
Light burn	3.6	4.1
Moderate burn	5.4	6.1
Heavy burn	54.4	61.2

In sagebrush habitats in the Great Basin Rate of Spread Study, done in Nevada, there was a flush of forb growth, including tailcup lupine, following fire. This growth was attributed to heat breaking seed dormancy, increased available nutrients, and possibly the removal of inhibitory compounds in shrub litter [33]. Following the Red Rock Fire in Nevada, tailcup lupine increased steadily in density in the first 4 postfire years [54].

Tailcup lupine was present 4 years after severe natural fires in pinyon-juniper stands in Colorado, with a postfire frequency of 8 percent. Its frequency on sites burned 29 years earlier was 2 percent, but it was not present in a 90-year-old burn in the same area [10]. Tailcup lupine was present in all stages of postfire succession in pinyon-juniper habitats in Nevada and California. Occurence and cover percentages follow [21]:

Successional stage	Years since fire	Occurence	Cover
Early	0-1	46.0	9.0
Early-Mid	4-8	20.0	7.0
Mid	15-17	32.0	0.0
Mid-Late	22-60	25.0	13.0
Late	60+	19.0	0.0

Some authors report that tailcup lupine is slightly to moderately damaged by fire [29,31,38].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
NO-ENTRY

FIRE MANAGEMENT CONSIDERATIONS :
NO-ENTRY

FIRE EFFECTS

SPECIES: Arnica cordifolia

IMMEDIATE FIRE EFFECT ON PLANT :
Heartleaf arnica is top-killed by fire. Rhizomes often survive. It is rated as susceptible [7,31] to intermediate [24] in resistance to fire damage. This probably varies according to how far below the soil surface rhizomes are buried.

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :
NO-ENTRY

PLANT RESPONSE TO FIRE :
Heartleaf arnica is apparently reduced by "high intensity" fires [24,30], but responds to "less intense" fires through rapid initial vegetative regrowth accompanied by heavy flowering and seedling establishment [24,42]. This is typically followed by a decline in cover and frequency within a few years [17]. Heartleaf arnica had the highest frequency and cover of all forbs 2 years following a severe fire (greater than 90 percent mortality of all trees) in a spruce-fir (Picea-Abies) ecosystem in Wyoming [3]. Frequency and cover values increased for 2 years following logging and broadcast burning in a Douglas-fir habitat type in Idaho. This trend was followed by a decline to 0 percent cover by postfire year 10 [17].

According to Barth, light, moisture, and soil depth are important factors determining the postfire density of heartleaf arnica [4].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE :
NO-ENTRY

FIRE MANAGEMENT CONSIDERATIONS :
NO-ENTRY

APPENDIX C

Fire Effects on Deer, Sheep and Goats

FIRE EFFECTS AND USE

WILDLIFE SPECIES: Oreamnos americanus

DIRECT FIRE EFFECTS ON ANIMALS :
Fire suppression on mountain goat range, especially in kidding areas, in the spring and summer may increase stress levels on mountain goats due to human disturbance. On the Lake Wenatchee Ranger District, in Washington, attempts were made to decrease disturbance to mountain goats. Pilots flew more than 500 feet (152 m) away from the kidding areas and did not use retardant drops on those sites until after July 31 [15].

Information was not available in the literature regarding the direct effects of fire on mountain goats.

HABITAT RELATED FIRE EFFECTS :
The effects of fire on mountain goat habitat has not been well studied. A study done on large mammal population changes following fires in dense forests showed that mountain goats ranged mostly at higher elevations than the fires and were affected little [20]. However, some grasslands used by mountain goats are the result of past fires, and effective fire suppression in recent years has resulted in the lack of new grassland development in some areas [17]. Periodic burning keeps seral grasslands from becoming dominated by climax coniferous tree cover [19].

Interior mountain goat winter ranges often support sparse stands of trees or shrubs that are used for forage. The steep slopes of these winter ranges are often used by mountain goats for their snow-shedding characteristics. Removing forage by fire in these areas may affect forage resources, shelter, or snow-shedding characteristics [3].

FIRE USE :
Prescribed burning has been used in some areas to improve habitat for mountain goats [6]. Fire has been used to establish and maintain subalpine ranges in British Columbia. According to Bentz and Woodard [1], burning provides an economical method of converting subalpine forests to earlier seral plant communities, which may provide forage for mountain goats. Although this burn was used to improve bighorn sheep range, mountain goat range may also be improved.

REFERENCES :
NO-ENTRY

FIRE EFFECTS AND USE

WILDLIFE SPECIES: Ovis canadensis

DIRECT FIRE EFFECTS ON ANIMALS :
Prescribed burning and its associated human activity in bighorn sheep range may increase stress levels in a population. Herd condition should be considered when planning time of fire [27]. No information is available regarding the direct effects of fire on bighorn sheep.

HABITAT RELATED FIRE EFFECTS :
Many bighorn sheep populations originally occurred in areas with frequent fire intervals [19,24]. Bighorn sheep inhabiting the Salmon River drainage of Idaho occupy a region where over 64 percent of their habitat has burned since 1900 [24].

Fire exclusion for over 50 years has allowed plant succession to alter many bighorn sheep habitats throughout North America [6,7]. Fire exclusion, which has allowed conifers to establish on grasslands, has decreased both the forage and security values on many bighorn sheep ranges [7].

Fire is an important factor in creating habitats that are heavily used by bighorn sheep [6,27]. Periodic burning keeps seral grasslands from becoming dominated by coniferous trees [27]. In April 1987, a prescribed fire was conducted on 235 acres (95 ha) of bighorn sheep winter range in Custer State Park, South Dakota. Burning expanded foraging habitat for bighorn sheep by curtailing encroachment of pondersosa pine (Pinus ponderosa) onto mixed-grass prairie.

Burning may regenerate rangelands and enhance the production, availability, and palatability of important bighorn sheep forage species [27]. Bighorn sheep heavily utilized burned winter range the following two winters after a September 1974 fire on the East Fork of the Salmon River, Idaho [19]. Over 66 percent of the plants on this burned range had been grazed by bighorn sheep. Utilization was consistently higher on burned sites than on adjacent unburned sites for at least 4 years after the fire [19].

Burning can increase visibility for bighorn sheep. Research has shown that on burned sites bighorn sheep use areas more distant to escape terrain than on adjacent unburned sites [27].

Fire can negatively affect bighorn sheep habitat when range condition is poor and forage species cannot recover, when nonsprouting species that provide important forage for bighorn sheep are eliminated, or when too much area is burned and forage is inadequate until the next growing season. Another potentially negative effect is when other species, especially elk, are attracted to prescribed burns intended to benefit bighorn sheep [19].

FIRE USE :
Prescribed fire can be useful tool in managing bighorn sheep habitat [19]. Prescribed burning has been widely used to increase the quantity and nutritional quality of bighorn sheep forage throughout North America [7].

Prescribed crown fires conducted in winter in mature conifer stands adjacent to escape terrain may provide an inexpensive solution to maintaining or establishing bighorn sheep winter range. In areas where the available bighorn sheep range is large and provides alternative and distant wintering sites, fires should be prescribed or located in areas that would minimize the stress on sheep. Early spring fires, particularly on south and southwest aspects, may provide more spring forage than would otherwise be available for bighorn sheep [27]. Burning immature forests and scrublands adjacent to bighorn sheep winter range could also provide migration corridors between winter and summer ranges [24].

Prescribed burning has been used to establish and maintain subalpine bighorn sheep range in British Columbia. According to Bentz and Woodard [2], burning provides an economical method of converting subalpine forests, which are of low value to bighorn sheep, to earlier seral plant communities. On the British Columbia range, bighorn sheep used burned sites more than adjacent unburned sites.

Since both positive and negative effects can occur from burning bighorn sheep range, a well-thought-out plan must be developed before fire is considered for use on their range. Plans must consider the following:

1) condition of plants
2) plant response to burning
3) adjacent conifers (The possibility of creating more open range exists if conifer stands or tall shrub fields occur next to currently used ranges.)
4) limiting factors (factors that may limit bighorn sheep populations should be identified, and an evaluation made as to how burning will effect these limiting factors)
5) lungworm (lungworm infections can possibly be altered by reducing bighorn sheep concentrations; however, if burns are small and concentrate bighorn sheep, results could be negative. If burns disperse populations, the effects could be positive)
6) competition from other ungulates attracted to burns [19]

REFERENCES :
NO-ENTRY

FIRE EFFECTS AND USE

WILDLIFE SPECIES: Odocoileus hemionus

DIRECT FIRE EFFECTS ON ANIMALS :
Although uncommon, mule deer can be trapped and killed by fast-moving fires [9,21].

HABITAT RELATED FIRE EFFECTS :
The effects of fire on mule deer habitat are widely varied and well documented in the literature. In general, fires that create mosaics of forage and cover are beneficial. Deer seem to prefer foraging in burned compared to unburned areas, although preference may vary seasonally [4,12,13,23,24,25,28,58]. This preference may indicate an increase in plant nutrients which usually occurs following fire [2,22,43]. Hobbs and Spowart [22] warned about making conclusions regarding the benefits of fire based on forage studies alone. Their study of fire on nutrition in Colorado revealed increases in the quality of deer diets due to changes in forage selection--not increases in nutrients of previously selected forage.

Burning in grassland communities reduces litter that otherwise inhibits new growth of grasses. Fire rejuvenates and improves these grasslands, which are important winter range in some areas [23,58]. Burning sagebrush communities can result in significant increases of herbaceous plants by reducing decadent sagebrush that outcompetes more nutritious and palatable species [44,47]. However, in areas where sagebrush is the only cover, its complete removal can be detrimental to mule deer populations [47].

Antelope bitterbrush is a highly preferred browse species on some mule deer winter ranges and is sensitive to burning [17,50]. Burned bitterbrush takes longer to recover than bitterbrush disturbed by other means [50]. Burned bitterbrush grows slower, is less dense, and plants are smaller than unburned specimens. Bitterbrush responds variably to fire intensity, temperature, and season [17]. Late summer fires in Idaho killed two-thirds of the bitterbrush, while a moderate-intensity spring fire in Montana killed one-third. A summer fire of moderate intensity in Oregon destroyed the entire stand of bitterbrush [17].

Shrubs and forbs in pinyon (Pinus spp.)-juniper (Juniperus spp.) communities tend to increase the first few years following fire, providing valuable browse [6,37]. Mule deer seem to use these areas more after 15 years [37,45]. Stager and Klebenow [45] reported that the beneficial effects of fire for mule deer in pinyon-juniper stands can last as long as 115 years. However, Bunting [7] concluded that burning of these stands becomes increasingly difficult as stands grow older because fine fuels in the understory are reduced. He stated that burning should take place at early successional stages and at intervals based on the fire tolerance of desirable forage species. Everett [14] warned that preburn conditions in pinyon-juniper stands will most likely determine the postfire plant composition. If perennial shrubs are present before a burn, they will come back following fire. If no shrubs are present, perennial grasses will develop [6].

FIRE USE :
Fire can be used to stimulate browse, create openings in dense, inaccessible plant communities, and reduce slash, as well as increase nutrient content and palatability of forage [11,17,38]. Gruell [17]

listed several factors that influence postfire plant composition, including the severity, size, and season of the burn, fuel type, postburn foraging intensity, and the preburn plant community composition. He stated that surface fires of moderate intensity following thinning or selection cuts can improve Douglas-fir or ponderosa pine (Pinus ponderosa) forests for mule deer by promoting regeneration of crown-sprouting shrubs and preparing the seedbed for herbs and shrubs. A mosaic of seral stages is best for mule deer [17].

In areas where chaparral adjoins oak woodlands, prescribed burns can create access through the chaparral to the understory forage of the oak woodlands [28]. Biswell [4] recommended burning chaparral every 30 years to create a mosaic of young stands. Late summer or early fall burning promotes the highest seed crop for most species in these plant communities. Wallmo and others [55] listed several recommendations for burning chaparral communities to improve mule deer habitat.

Fire can control pinyon-juniper woodlands by maintaining them in a subclimax state [6]. Small burns are more beneficial than large burns to mule deer because they tend to use burned areas close to cover. The optimum width for burns in these communities may be less than 0.25 mile (0.4 km) [6]. To maintain forage in bunchgrass communities, burning at 4- to 6-year intervals in winter or early spring is recommended [23].

Burning can control sagebrush in areas where it has dominated grasslands and reduced deer forage [47]. Where Gambel oak grows thick and impenetrable, fire can open stands and provide valuable winter range for mule deer [32]. Kufeld [31] recommended burning Gambel oak in autumn during or immediately following leaf fall and building fire breaks 26 feet wide (8 m) around the areas to be burned. Because Gambel oak recovers quickly following fire, particularly at low elevations where mule deer winter, its growth must be monitored and retarded to improve mule deer habitat [32].

REFERENCES :
NO-ENTRY

APPENDIX D

Prescribed Fire Burn Plans and Burn Area Pictures

PRESCRIBED BURN PLAN

CARPENTER LAKE UNGULATE WINTER RANGE ENHANCEMENT

funded by:

B.C. Hydro Bridge Coastal Fish and Wildlife Restoration Program

AREA #2

prepared by:

Bruce Morrow
Sage Forestry Ltd
6504 Barnhartvale Rd
Kamloops, B.C.
V2C 6V7

Site Information

Forest Region	Kamloops
Forest District	Lillooet
Geographic	Northeast side of Carpenter Lake, east of Viera Creek
Lat./Long.	N50 47' W122 16'
Mapsheet	92J.089
Forest Tenure	FLA 18700, CP 175 adjacent
Size	Approximately 300 hectares
Aspect	90 to 190 degrees
Slope	Highly Variable, 10% to 80%
Elevation	700 - 1800 meters

Burn Planning

Impact Rank

Intended	2-3
Maximum	4
Minimum	1

Fuel Moisture and Burning Indices

FFMC	85-89	Ignition Class	3 to 6
DMC	15-24	Spread Class	3 to 6
DC	101-250	Control Class	2 to 3

Conditions

This 300 hectare area is a relatively open stand of Douglas fir, with minor components of Ponderosa Pine and Lodgepole Pine. It is in the IDF dk2 biogeoclimatic zone, ranging in elevation from 700 to 1800 meters. Access to the area is from Highway 40 along Carpenter Lake on the south boundary and by an unmaintained road/trail through the area.

Slopes vary across the burn area. They are highest along the southern boundary, the northern boundary is relatively flat. The maximum slope measured in the area is 80%.

Burn Preparation

The burn area boundaries are a combination of the road/trail, Highway 40, major creeks, and some planned blacklines. Blacklines will be installed before the main burn ignition takes place. The northern boundary, and the southwest boundary will be enhanced and defined by establishments of blacklines. Approximately 2.5 to 3 kilometers of blackline will be installed before area ignition. These blacklines will be placed in open, light fuel areas. They will require the removal of fine surface fuels for at least ten meters in width. The blacklines must be continuous, and tied in on either end to other natural or man-made boundaries. All blacklines will be ignited by handlight crews and completely extinguished before the crew leaves the site each day. They must be completed at least one week in advance of the main burn.

This prescribed burn area has numerous secondary guards to control fire spread. The Viera Creek burn is immediately north and uphill from the planned burn area. This open area will prevent the spread of fire in that direction. Viera Creek to the west is a steep, rocky draw that will stop almost any fire spread in that direction. The weakest guard is the unnamed creek along the eastern boundary, but light, patchy fuels east of the creek draw will make fire spread slow and spotty.

Prescribed Fire Timing

Prescribed fires in this area are best conducted in early Spring or late Fall. The Fire Indices Codes stated above are easily attainable in the Spring. The low Drought Code value may be difficult to attain in the Fall. Due to mop up constraints, Fall is the best time for this prescribed fire to be ignited. Allowing the weather to extinguish the fire will be the most cost effective method for mop up. This will require good, accurate weather data and advanced planning as there is typically only one or two suitable Fall burning windows in this area (Dave Low, personal communication).

Ignition Plan

The burn area ignition will be a combination of handlighting of parts of the perimeter to establish blackline guards, and aerial ignition using a helicopter equipped with an Aerial Ignition Device (AID) Machine. No ground crews will be in the burn area during the helicopter ignition phase because of steep slopes and poor escape routes.

The helicopter ignition will be with a strip method as shown on the attached 1:15 000 scale map. The draw in the middle of the burn area will be ignited first. The fuels are heaviest in this area and should create a convection column to assist with control of the rest of the prescribed fire. The eastern and then western faces will be ignited next. The most southern and lowest part of the burn will be ignited last. The fuels are lightest and the slopes steepest in this area, it should burn quickly, but at a low intensity. There will probably be substantially more strips made for area ignition than shown on the ignition plan map attached. The intention is to keep the strips as tight as possible along the northern boundary to reduce fire intensity adjacent to the guards. The ignition pattern will probably widen as the helicopter moves away from the guards. Specific on-site conditions at the time of the burn will probably result in slight adjustments to the ignition plan shown.

The AID Machine will be set at maximum flow for the ignition devices. The number of ignition devices dropped and the distance between these devices will be controlled by the airspeed of the helicopter. This will ensure as continuous point ignition as possible.

Ignition - Resources On Site

Personnel

1 Burn Supervisor

1 Crew Supervisor and 4 person crew

1 AID Machine Supervisor plus assistant

Equipment

1 Bell 206B Jet Ranger Helicopter or equivalent

1 AID Machine

10,000 Ignition Devices

5 Drip Torches with extra burn mix

4 drums Additional Helicopter Fuel

Mop Up Plans

No mop up will be conducted within the burn area. The prescribed fire will be allowed to extinguish by itself. Mop up outside the prescribed area will vary with the time of year and the extent and location of the escape. Weather conditions will play an important role in deciding the extent of escape and perimeter mop up. Written instructions from a Forest Officer will be followed at that time.

Maximum Mop Up Resources

The maximum mop up resources committed to in this plan is fifteen trained individuals, plus two additional supervisors, complete with handtools, chainsaws and drip torches. Light helicopter support will also be required for crew and equipment moves as required.

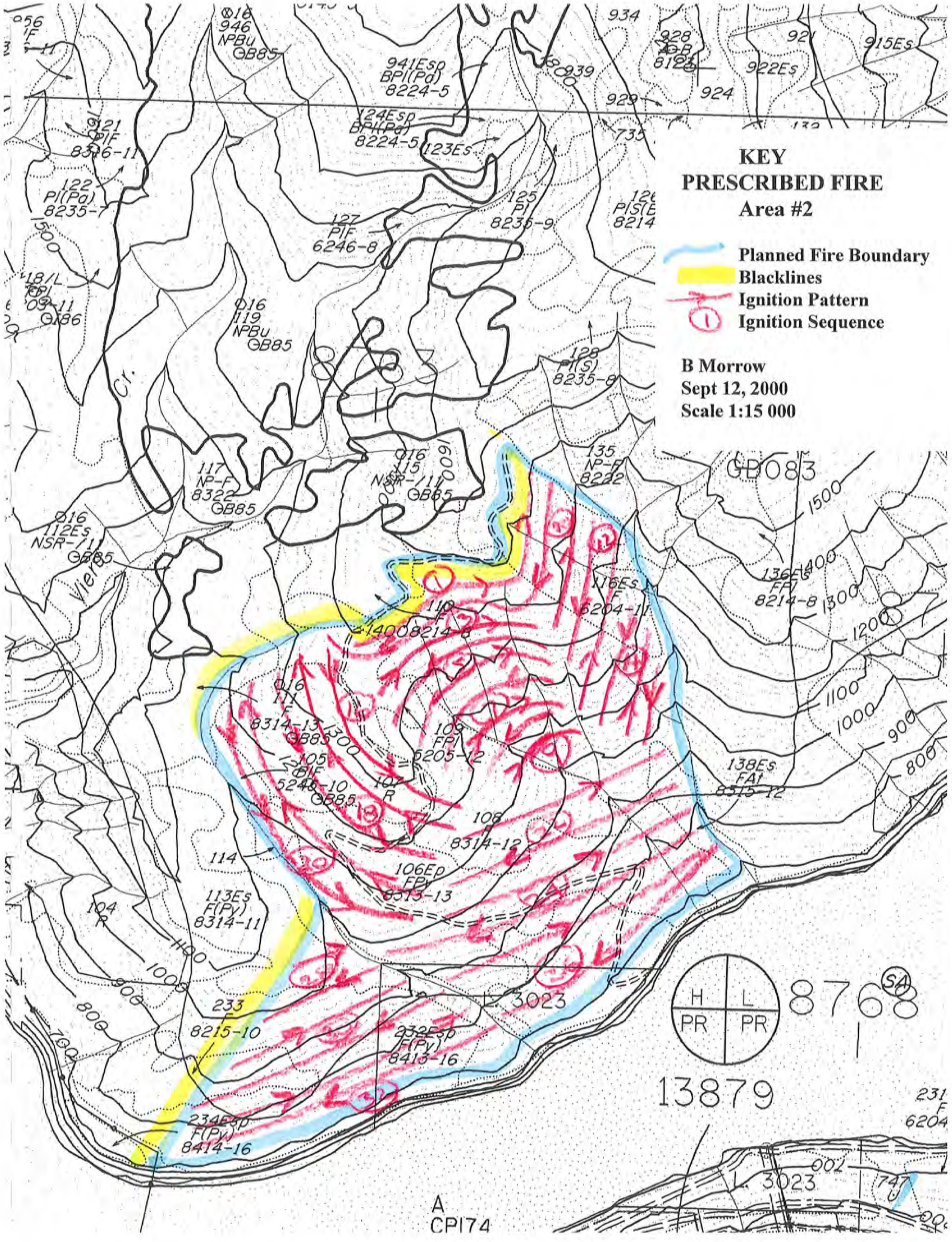
Special Values

An old cabin is present at the northeast end of the area access road. It is immediately adjacent to 1985 Viera Creek burn and only fifty meters from the boundary of this proposed prescribed burn. Keeping this cabin in its present condition will be a high priority. A fuel modification plan will have to be developed before burn ignition is conducted. Spacing and pruning the surrounding trees and conducting surface fuel reduction within twenty meters of the cabin will be a priority. Completely tarping or sealing off the building before burn ignition should be considered. This work must be completed at least three days before the planned prescribed fire ignition.

A high voltage powerline is located just outside the southwest corner of the prescribed burn area. The powerlines are supported by wooden poles. Although the powerline is outside the planned ignition area, all poles east of Viera Creek should have 5 meter wide no fuel zones constructed around them. This may require special training for the ground crew completing this task.

Smoke Management

This prescribed burn will meet the Kamloops Forest Region Smoke Management Guidelines for adequate venting.


KEY
PRESCRIBED FIRE
Area #2
Planned Fire Boundary
Blacklines
Ignition Pattern
Ignition Sequence
B Morrow
Sept 12, 2000
Scale 1:15 000
GD083
8768
13879
L 3023
A
CP174

PLANNED PRESCRIBED FIRE
AREA #2

PRESCRIBED BURN PLAN

CARPENTER LAKE UNGULATE WINTER RANGE ENHANCEMENT

funded by:

B.C. Hydro Bridge Coastal Fish and Wildlife Restoration Program

AREA #7

prepared by:

Bruce Morrow
Sage Forestry Ltd
6504 Barnhartvale Rd
Kamloops, B.C.
V2C 6V7

Site Information

Forest Region	Kamloops
Forest District	Lillooet
Geographic	North side of Carpenter Lake, lakeside between Jones and Bighorn Creeks
Lat./Long.	N50 49' W122 20'
Mapsheet	92J.088
Forest Tenure	FLA 18700, CP 175 adjacent
Size	Approximately 200 hectares
Aspect	90 to 270 degrees
Slope	Highly Variable, 15% to 80%
Elevation	700 - 1300 meters

Burn Planning

Impact Rank

Intended	2-3
Maximum	4
Minimum	1

Fuel Moisture and Burning Indices

FFMC	85-89	Ignition Class	3 to 6
DMC	15-24	Spread Class	3 to 6
DC	101-250	Control Class	2 to 3

Conditions

Area 7 is approximately 200 hectares is a relatively open stand of Douglas fir, with minor components of Ponderosa Pine and Lodgepole Pine. It is in the IDF dk2 biogeoclimatic zone, ranging in elevation from 700 to 1300 meters. Access to the area is from Highway 40 along Carpenter Lake on the south boundary and from the west side of Jones Creek, through private land.

Slopes vary across the burn area. They are highest along the southern boundary. The maximum slope measured in the area is 70%.

Burn Preparation

The burn area boundaries are a combination of the rock outcrops, Highway 40, Jones and Bighorn Creeks, and some planned blacklines. Blacklines will be installed before the main burn ignition takes place. The northwest and northeast boundaries will be enhanced and defined by establishments of blacklines. Approximately 2.5 kilometers of blackline will be installed before area ignition. These blacklines will be placed in along the top of ridges through open, light fuel areas. They will require the removal of fine surface fuels for at least ten meters in width. The blacklines must be continuous, and tied in on either end to other natural or man-made boundaries. All blacklines will be ignited by handlight crews and completely extinguished before the crew leaves the site each day. They must be completed at least one week in advance of the main burn.

The weakest guard is Bighorn Creek along the eastern boundary. This steep gully is lightly fuelled with open rock and should prove to be a suitable guard.

Prescribed Fire Timing

Prescribed fires in this area are best conducted in early Spring or late Fall. The Fire Indices Codes stated above are easily attainable in the Spring. The low Drought Code value may be difficult to attain in the Fall. Due to mop up constraints, Fall is the best time for this prescribed fire to be ignited. Allowing the weather to extinguish the fire will be the most cost effective method for mop up. This will require good, accurate weather data and advanced planning as there is typically only one or two suitable Fall burning windows in this area (Dave Low, personal communication).

The timing of the prescribed fire will largely be controlled by Ainsworth Lumber Co in Lillooet. This prescribed fire will have to be held until the harvesting adjacent planned cutblocks 1, 2, and 3 from Cutting Permit 175 has been completed. The three cutblocks, outlined in green on the attached map, are all immediately north of Area 7. Harvesting of these blocks before the prescribed fire is undertaken will ensure that no fire escapes impact on the quality or quantity of timber planned for harvesting.

Ignition Plan

The burn area ignition will be a combination of handlighting of parts of the perimeter to establish blackline guards, and aerial ignition using a helicopter equipped with an Aerial Ignition Device (AID) Machine. No ground crews will be in the burn area during the helicopter ignition phase because of steep slopes and poor escape routes.

The helicopter ignition will be with a strip method as shown on the attached 1:15 000 scale map. The deep draw in the middle of the burn area divides the area in two separate areas. The fuels are heaviest east of the draw, this area will be ignited first and will assist with control of the rest of the prescribed fire. The western face will be ignited second. The most southwest and southeast parts of the prescribed fire will be ignited last. The fuels are lightest and the slopes steepest in this area, it should burn quickly, but at a low intensity. There will probably be substantially more strips made for area ignition than shown on the ignition plan map attached. The intention is to keep the strips as tight as possible along the northern boundary to reduce fire intensity adjacent to the guards. The ignition pattern will probably widen as the helicopter moves away from the guards. Specific on-site conditions at the time of the burn will probably result in slight adjustments to the ignition plan shown.

The AID Machine will be set at maximum flow for the ignition devices. The number of ignition devices dropped and the distance between these devices will be controlled by the airspeed of the helicopter. This will ensure as continuous point ignition as possible.

Ignition - Resources On Site
Personnel
1 Burn Supervisor
1 Crew Supervisor and 4 person crew
1 AID Machine Supervisor plus assistant
Equipment
1 Bell 206B Jet Ranger Helicopter or equivalent
1 AID Machine
10,000 Ignition Devices
5 Drip Torches with extra burn mix
4 drums Additional Helicopter Fuel

Mop Up Plans

No mop up will be conducted within the burn area. The prescribed fire will be allowed to extinguish by itself. Mop up outside the prescribed area will vary with the time of year and the extent and location of the escape. Weather conditions will play an important role in deciding the extent of escape and perimeter mop up. Written instructions from a Forest Officer will be followed at that time.

Maximum Mop Up Resources

The maximum mop up resources committed to in this plan is fifteen trained individuals, plus two additional supervisors, complete with handtools, chainsaws and drip torches. Light helicopter support will also be required for crew and equipment moves as required.

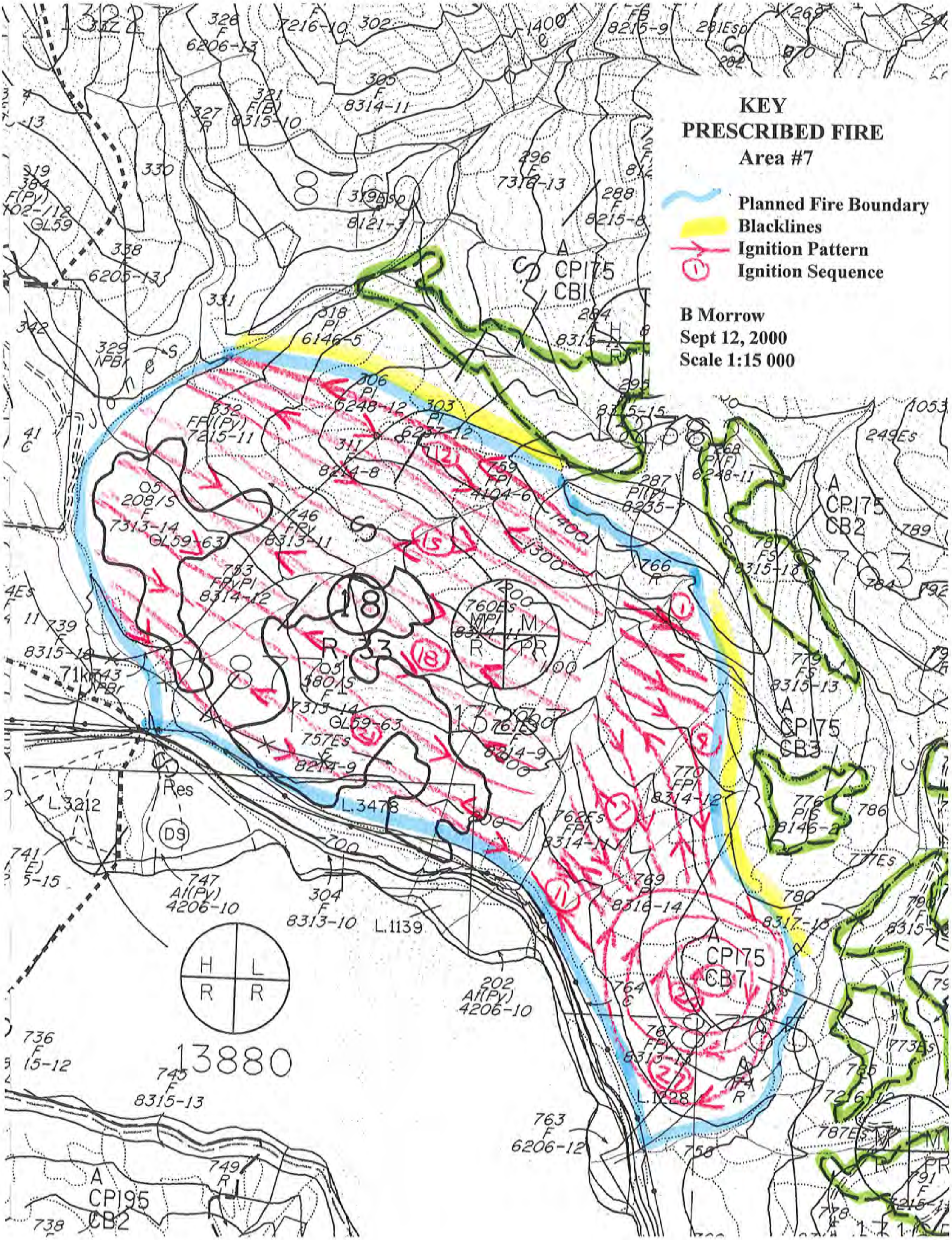
Special Values

The planned harvesting north of the prescribed fire area is of high value. This harvesting must be completed before this burn can be considered.

A high voltage powerline is located along Highway 40, the southern boundary of the prescribed fire area. The powerlines are supported by wooden poles. All poles between Jones and Bighorn Creeks will have 5 meter wide no fuel zones constructed around them. This may require special training for the ground crew completing this task. In addition, helicopter ignition will end at least fifty meters uphill from the powerlines. Handlighting of surface fuels between the powerlines and the last aerial ignition location will be an option after aerial ignition is complete. This may also occur one or more days after the main ignition of the prescribed fire.

Smoke Management

This prescribed burn will meet the Kamloops Forest Region Smoke Management Guidelines for adequate venting.


KEY
PRESCRIBED FIRE
Area #7
Planned Fire Boundary
Blacklines
Ignition Pattern
Ignition Sequence
B Morrow
Sept 12, 2000
Scale 1:15 000

PLANNED PRESCRIBED FIRE
AREA #7

PRESCRIBED BURN PLAN

CARPENTER LAKE UNGULATE WINTER RANGE ENHANCEMENT
funded by:
B.C. Hydro Bridge Coastal Fish and Wildlife Restoration Program
AREA #10

prepared by:

Bruce Morrow
Sage Forestry Ltd
6504 Barnhartvale Rd
Kamloops, B.C.
V2C 6V7

Site Information

Forest Region	Kamloops
Forest District	Lillooet
Geographic	North side of Carpenter Lake, treeline, east side of Bighorn Creek
Lat./Long.	N50 52' W122 18'
Mapsheet	92J.088
Forest Tenure	FLA 18700, CP 175 adjacent
Size	Approximately 90 hectares
Aspect	120 to 260 degrees
Slope	Highly Variable, 15% to 65%
Elevation	1400 - 2200 meters

Burn Planning

Impact Rank

Intended	2-3
Maximum	4
Minimum	1

Fuel Moisture and Burning Indices

FFMC	85-89	Ignition Class	3 to 6
DMC	15-24	Spread Class	3 to 6
DC	101-250	Control Class	2 to 3

Conditions

Area 10 is approximately 90 hectares covered with a mixture of Balsam Fir, Spruce, Whitebark Pine and a minor component of Douglas fir and Lodgepole Pine. It is in the EESF dv biogeoclimatic zone, ranging in elevation from 1400 to 2200 meters. There is no road access to the area. Helicopters or extensive hiking are the only options.

The slope is pretty consistent across the burn area. The maximum slope measured in the area is 70%.

Burn Preparation

The burn area boundaries are a combination of two creek draws and the alpine. No additional preparation work is required before this area is ignited. All natural guards appear wide and suitable for stopping the spread of an aggressive surface fire.

Prescribed Fire Timing

Prescribed fires in this area can only be conducted in the early Fall. This area is typically not snow free until mid-summer and temperatures at high elevations satart to drop quickly in late Summer.

There are no other limitations on the timing of the prescribed fire. Cutting Permit 175, Block 4 is approximately 400 meters downhill from prescribed fire area, but spread in that direction is not expected.

Ignition Plan

The burn area ignition will be completely by aerial ignition using a helicopter equipped with an Aerial Ignition Device (AID) Machine. No ground crews will be in the burn area during the helicopter ignition phase because of steep slopes and poor escape routes.

The helicopter ignition will be with a strip method as shown on the attached 1:15 000 scale map. The strip lines will start up against the alpine and work downwards, following the contours. The intention is to keep the strips spread evenly throughout the burn area. Effort will be made to make the last strip as close to the lower guards as possible to ensure only minimal fuel is left inside the guards to prevent smoldering and increased likelihood of escapes. Specific on-site conditions at the time of the burn will probably result in slight adjustments to the ignition plan shown.

The AID Machine will be set at maximum flow for the ignition devices. The number of ignition devices dropped and the distance between these devices will be controlled by the airspeed of the helicopter. This will ensure as continuous point ignition as possible.

Ignition - Resources On Site
Personnel
1 Burn Supervisor
1 AID Machine Supervisor plus assistant
Equipment
1 Bell 206B Jet Ranger Helicopter or equivalent
1 AID Machine
7,000 Ignition Devices
4 drums Additional Helicopter Fuel

Mop Up Plans

No mop up will be conducted within the burn area. The prescribed fire will be allowed to extinguish by itself. Mop up outside the prescribed area will vary with the time of year and the extent and location of the escape. The only area of concern is the southern boundary, spread in that direction will threaten an Ainsworth Lumber Co planned harvesting area. Weather conditions will play an important role in deciding the extent of escape and perimeter mop up. Written instructions from a Forest Officer will be followed at that time.

Maximum Mop Up Resources

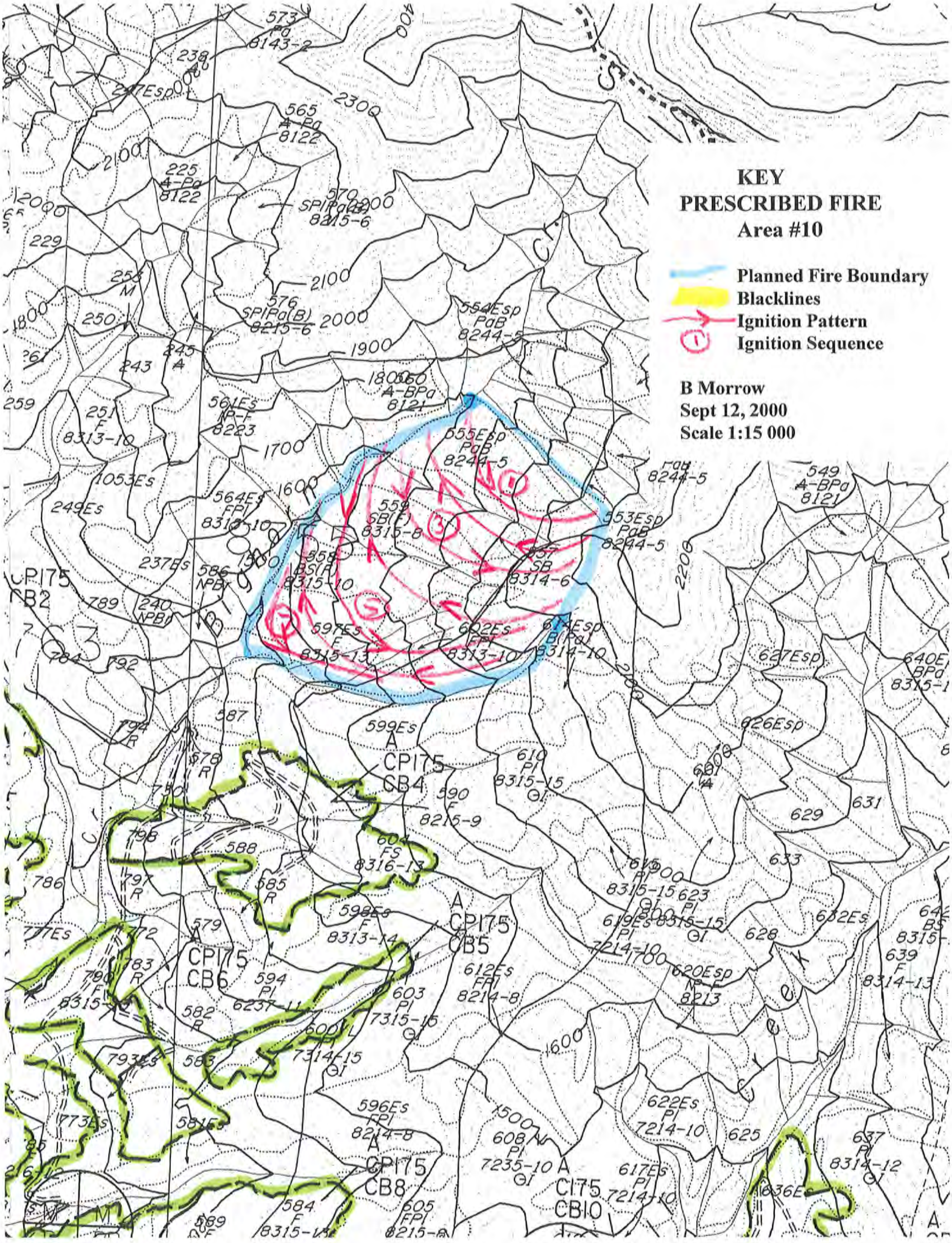
The maximum mop up resources committed to in this plan is ten trained individuals, plus two additional supervisors, complete with handtools, chainsaws and drip torches. Light helicopter support will also be required for crew and equipment moves as required.

Special Values

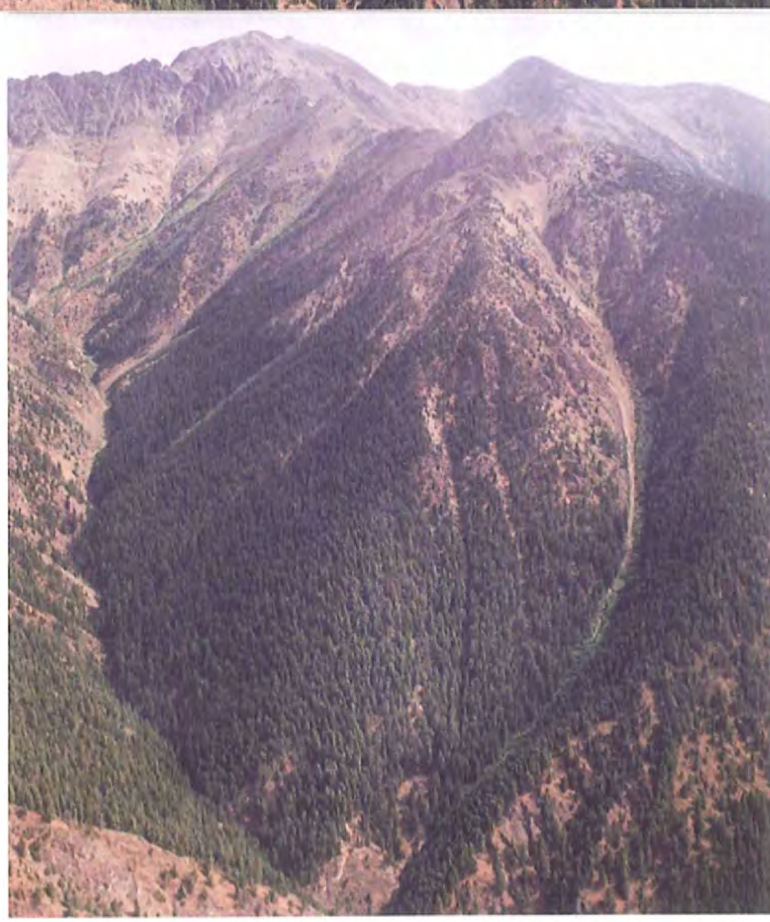
None

Smoke Management

This prescribed burn will meet the Kamloops Forest Region Smoke Management Guidelines for adequate venting.


KEY
PRESCRIBED FIRE
Area #10
Planned Fire Boundary
Blacklines
Ignition Pattern
Ignition Sequence
B Morrow
Sept 12, 2000
Scale 1:15 000

PLANNED PRESCRIBED FIRE
AREA #10



PRESCRIBED BURN PLAN

CARPENTER LAKE UNGULATE WINTER RANGE ENHANCEMENT

funded by:

B.C. Hydro Bridge Coastal Fish and Wildlife Restoration Program

AREA #11

prepared by:

Bruce Morrow
Sage Forestry Ltd
6504 Barnhartvale Rd
Kamloops, B.C.
V2C 6V7

Site Information

Forest Region	Kamloops
Forest District	Lillooet
Geographic	North side of Carpenter Lake, treeline, west side of East Jones Creek
Lat./Long.	N50 52' W122 22'
Mapsheet	92J.088
Forest Tenure	FLA 18700, CP 175 adjacent
Size	Approximately 115 hectares
Aspect	90 to 130 degrees
Slope	Highly Variable, 25% to 65%
Elevation	1200 - 2000 meters

Burn Planning

Impact Rank

Intended	2-3
Maximum	4
Minimum	1

Fuel Moisture and Burning Indices

FFMC	85-89	Ignition Class	3 to 6
DMC	15-24	Spread Class	3 to 6
DC	101-250	Control Class	2 to 3

Conditions

Area 11 is approximately 115 hectares covered with a mixture of Balsam Fir, Spruce, Douglas fir. It is in the EESF dv biogeoclimatic zone, ranging in elevation from 1200 to 2000 meters. There is no road access to the area. Helicopters or extensive hiking are the only options.

The slope is pretty consistent across the burn area. The maximum slope measured in the area is 65%.

Burn Preparation

The burn area boundaries are a combination of one creek draw, open rock, height of land and the alpine. No additional preparation work is required before this area is ignited. The weakest guard is the height of land along the western edge of the prescribed fire area. All other natural guards appear wide and suitable for stopping the spread of an aggressive surface fire.

Prescribed Fire Timing

Prescribed fires in this area can only be conducted in the early Fall. This area is typically not snow free until mid-summer and temperatures at high elevations start to drop quickly in late Summer.

There are no other limitations on the timing of the prescribed fire. Cutting Permit 175, Block 1 is approximately 500 meters downhill from prescribed fire area, but spread in that direction is not expected.

Ignition Plan

The burn area ignition will be completely by aerial ignition using a helicopter equipped with an Aerial Ignition Device (AID) Machine. No ground crews will be in the burn area during the helicopter ignition phase because of steep slopes and poor escape routes.

The helicopter ignition will be with a strip method as shown on the attached 1:15 000 scale map. The strip lines will start up against the western and northern boundaries and progress downwards, following the contours. The intention is to keep the strips spread evenly throughout the burn area. Effort will be made to make the last strip as close to the lower guards as possible to ensure only minimal fuel is left inside the guards to prevent smoldering and increased likelihood of escapes. Specific on-site conditions at the time of the burn will probably result in slight adjustments to the ignition plan shown.

The AID Machine will be set at maximum flow for the ignition devices. The number of ignition devices dropped and the distance between these devices will be controlled by the airspeed of the helicopter. This will ensure as continuous point ignition as possible.

Ignition - Resources On Site

Personnel

1	Burn Supervisor
1	AID Machine Supervisor plus assistant

Equipment

1	Bell 206B Jet Ranger Helicopter or equivalent
1	AID Machine
7,000	Ignition Devices
4 drums	Additional Helicopter Fuel

Mop Up Plans

No mop up will be conducted within the burn area. The prescribed fire will be allowed to extinguish by itself. Mop up outside the prescribed area will vary with the time of year and the extent and location of the escape. The only area of concern is the southern boundary, spread in that direction will threaten an Ainsworth Lumber Co planned harvesting area. Weather conditions will play an important role in deciding the extent of escape and perimeter mop up. Written instructions from a Forest Officer will be followed at that time.

Maximum Mop Up Resources

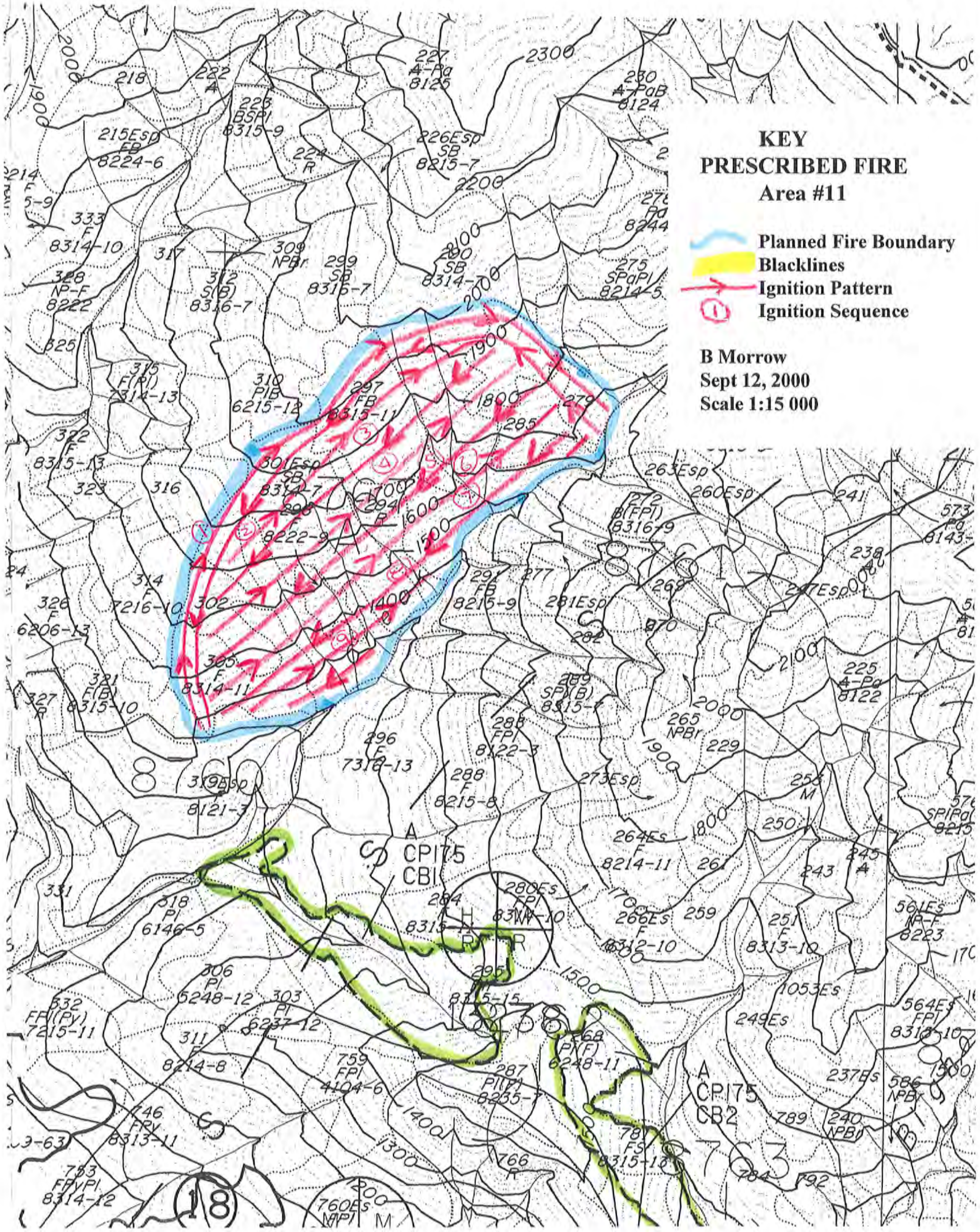
The maximum mop up resources committed to in this plan is ten trained individuals, plus two additional supervisors, complete with handtools, chainsaws and drip torches. Light helicopter support will also be required for crew and equipment moves as required.

Special Values

None

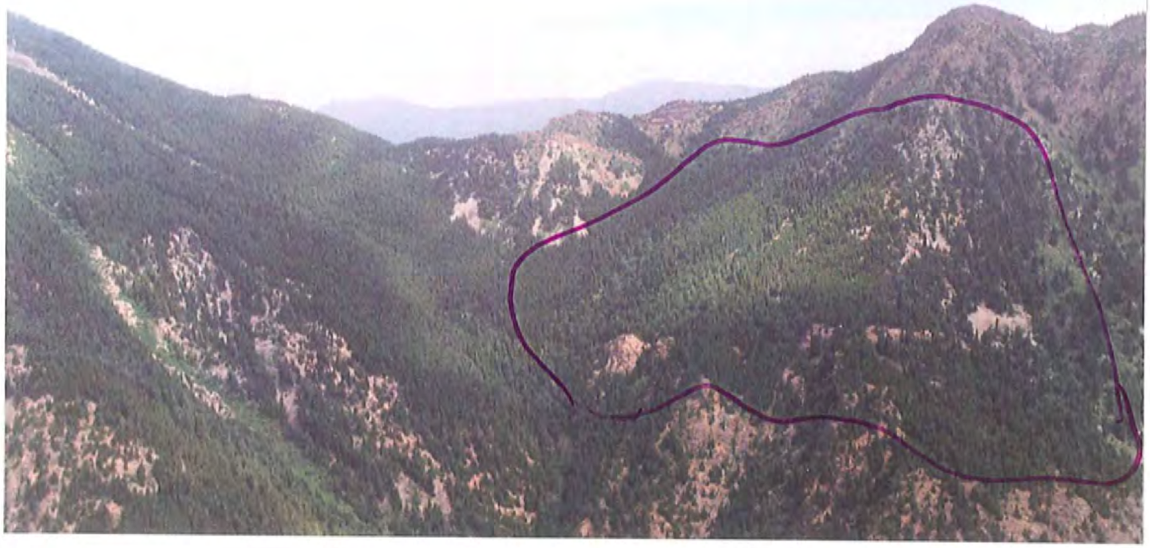
Smoke Management

This prescribed burn will meet the Kamloops Forest Region Smoke Management Guidelines for adequate venting.

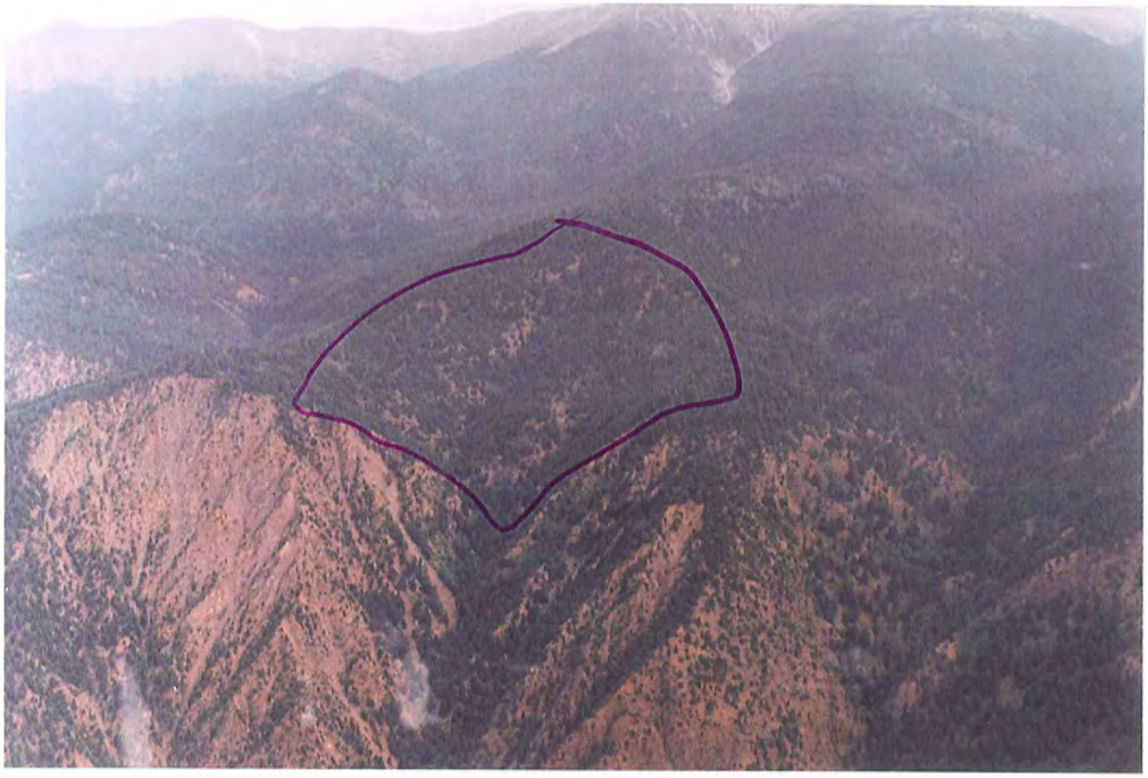

KEY
PRESCRIBED FIRE
Area #11
Planned Fire Boundary
Blacklines
Ignition Pattern
Ignition Sequence
B Morrow
Sept 12, 2000
Scale 1:15 000

PLANNED PRESCRIBED FIRE
AREA #11

PLANNED PRESCRIBED FIRE
AREA #1

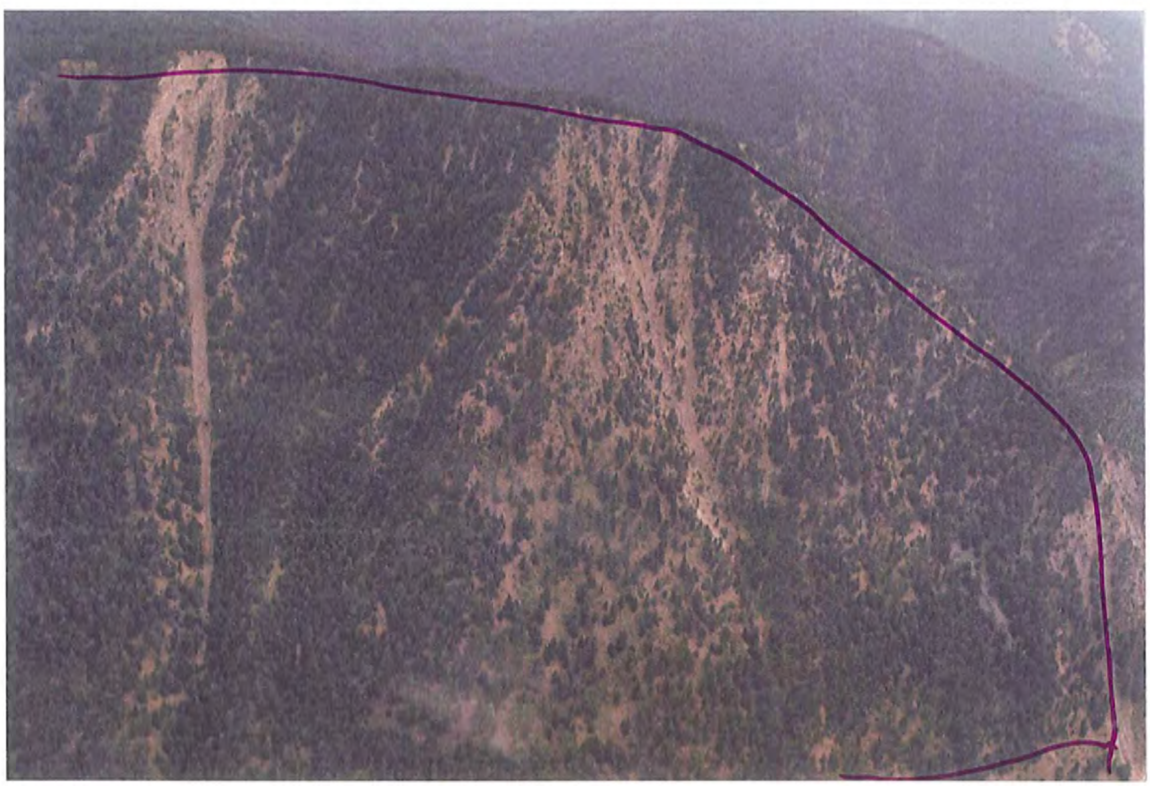


PLANNED PRESCRIBED FIRE
AREA #4



PLANNED PRESCRIBED FIRE
AREA #5

PLANNED PRESCRIBED FIRE
AREA #6



PLANNED PRESCRIBED FIRE
AREA #8

APPENDIX E

Input from Stakeholders

APPENDIX E

List of Individuals Consulted for Input into Carpenter Lake Prescribed Burn Plans
August 2000

Rod Louis	Seton Indian Band
Doug Jury	MELP
Phil Belliveau	MELP
Dave Low	MELP
Jacquie Rasmussen	MoF
Ron Letham	MoF
Keith Blom	MoF
Steve Newton	MoF - Protection
Tim Cody	Wild Sheep Society of B.C.
Chief Garry John	Seton Indian Band
Rudy Wortelboer	Ainsworth Lumber Co
Darwin John	Lillooet Tribal Council
Rolly Thoms	Lillooet Livestock Association
Jeff Saul	Fountain Indian Band
Bradley Jack	Bridge River Band

Ainsworth

Ainsworth Lumber Co. Ltd.
Lillooet Division
Box 880
Lillooet, British Columbia
Canada V0K 1V0

250 256 5200 Telephone
250 256 5250 Facsimile

info@ainsworth.ca
www.ainsworth.ca

September 18, 2000

Bruce Morrow, R.P.F.
Sage Forestry Ltd.
6504 Barnhartvale Road
Kamloops, B.C.
V2C 6V7

RE: Proposed Carpenter Lake Prescribed Fires

Bruce,

Thank you for coming and reviewing your proposed burn plan and for considering it's impacts on our proposed blocks along the north side of Carpenter Lake.

We have no objections to your proposed burn plans if you:

- Inform us of when you will be burning in advance
- Ensure that any trees remaining after selective harvesting are not destroyed
- Be responsible for costs due to replanting of any seedlings that are destroyed
- Do not burn adjacent to any of our proposed blocks until after they are harvested
- Give us the opportunity to salvage any timber that we find to be merchantable from areas that are to burnt

We will be going over aerial photos of the areas prescribed for burning this fall; ground checking any areas that we identify. We will inform you of our findings and will be pleased to arrange a meeting to discuss them.

If you have any suggestions in coordinating the block designs to accommodate burning or have any questions please call me at (250) 256-5205.

Ainsworth

Yours truly,

AINSWORTH LUMBER COMPANY LTD.
LILLOOET WOODLANDS DIVISION

Rudy Wortelboer
Area Engineering Superintendent

cc: Jacquie Rasmussen, Lillooet Forest District
Donna Romaine, Ministry of Environment, Lillooet
Gary John, Lillooet Tribal Council

BRITISH
COLUMBIA

File: 14060-20/DLI 2000

September 12, 2000

Bruce Morrow, RPF
Sage Forestry Ltd.
6504 Barnhartvale Road
Kamloops, British Columbia
V2C 6V7

Dear Bruce Morrow:

Please accept this letter as an approval in principle of the Wildlife Enhancement project for the North Carpenter Lake area. As we have stated in our letter dated August 30th, 2000, we do have some concerns but the overall goals of the project and proposed burn areas are appropriate.

Please ensure that future burn plans are referred to this office either through Keith Blom or myself.

FOREST SERVICE · BRITISH COLUMBIA

Yours truly,

Jacquie Rasmussen

Jacquie Rasmussen, P.Ag
Acting Agrology Officer

Ministry of Forests

Lillooet Forest District

Location:
650 Industrial Place
Lillooet, BC

Mailing Address:
Bag Service 700
Lillooet, BC V0K 1V0

Tel: (250) 256-1200
Fax: (250) 256-1290

BRITISH COLUMBIA

File: 14060-20/DLI 2000

August 30, 2000

Bruce Morrow, RPF
Sage Forestry Ltd.
6504 Barnhartvale Road
Kamloops, British Columbia
V2C 6V7

Dear Bruce Morrow:

Thank you for the opportunity to comment on the Wildlife Habitat Enhancement project proposed for Carpenter Lake. As a district, we are supportive of these types of initiatives, which involve the re-introduction of fire into the Lillooet Forest District for restoration purposes. We have a Coordinated Fire Management Committee that is committed to the responsible use of fire as a management tool. I have sent a copy of your letter to most members (excluding members you have covered) of this committee so that they have a chance to make comments as well.

Due to the potential risk to other values, the district is approaching the re-introduction of fire carefully. Planning is the key to achieving set objectives and reducing risk. We understand that this project is in its very early stages, but the information presented, flags some concerns regarding the level of planning for the project. For example, areas shown on the map do not seem to follow natural boundaries and the goals and objectives are not clear.

Our Small Business Silviculture Practices Forester, Colin Templeton has aptly summarised our concerns:

> "I recognise that the planning for this project is in its infancy. My comments are not directed toward criticising the idea presented, rather they are directed at highlighting a few issues that need to be addressed in the plan as it is developed.
> 1) The plan should be backed up with sound scientific research. Too often plans are based on assumptions or opinions that have little basis in reality. I would like to see a plan with a significant literature cited section, and the objectives of the plan based on scientific principles.
> 2) For the plan to succeed, there must be clear objectives, and the prescription must demonstrate how the objectives will be reached. For example, an objective may be to stimulate the growth of soopalalie. There needs to be a clearly linked relationship between the conditions under which the area will be burned and the achievement of the objectives. For example, if burning occurs (at a certain time,

Ministry of Forests
Lillooet Forest District
Location: 650 Industrial Place Lillooet, BC
Mailing Address: Bag Service 700 Lillooet, BC V0K 1V0
Tel: (250) 256-1200
Fax: (250) 256-1290

> or under certain weather conditions etc.) then soopalalie growth will be enhanced.
> 3) Operability of the stands in question must be considered. If operations are to occur on the operable land base, then the impact of the plan on timber supply must be considered. Ideally this should take the form of a cost-benefit type of analysis. In particular, the issue of reduced stocking must be addressed. The stated project is a stand management technique. The plan should therefor include a Stand Management Prescription at a minimum. Salvage may need to be considered, as well as the implications for long-term timber production. IN case of an over-achievement, who will bear responsibility for reforestation obligations? This must be considered.
> 4) The table on conflicts is a good start, and needs further expansion. The memo talks a bit about other resource values such as recreation, visuals, etc. More consideration for these values needs to appear in the final document.
> 5) A whole lot more information about the plan is also needed. A fuel inventory and pre-treatment vegetation survey are minimum needs. Also, there needs to be a clear follow-up plan. This should include post-treatment vegetation and stocking surveys, perhaps pre- and post-browse intensity surveys, etc. Otherwise, it will be impossible to determine if the treatment has achieved its objectives."

As burn plans are completed, we would like to have the chance to review these. Keith Blom and myself are the primary contacts at the Ministry of Forest and we can be reached at 250-256-1200. One of us will also be available on Tuesday, September 5, 2000 should an overview flight take place for this area.

Yours truly,

Jacquie Rasmussen

Jacquie Rasmussen, P.Ag
Acting Agrology Officer

SEP 13 2000 15:57 FR MOF LILLOOET 2502561290 TO 8-12505732936 P.01/01

Province of British Columbia

FAX HEADER

Ministry of Forests

TO		FROM	
NAME: Bruce Morrow Sage Forestry		NAME: Jacquie Rasmussen Acting Agrology officer	
MINISTRY:		MINISTRY: LILLOOET FOREST DISTRICT	
OFFICE OR:		OFFICE OR:	
FACILITY:		FACILITY:	
PHONE NO: —	FAX NO: 250-573-2936	PHONE NO: 256-1200	FAX NO: 256-1290
SENT BY: JR	DATE: Sept. 13/00	NO. PAGES TO FOLLOW: -0-	

Bruce,

I left a very long-winded message on your machine - sorry. Here are the main points again:

Rick Tucker from the Kamloops Regional NDT4 group gave me a summary of their comments on the burn plan:

① Make the objectives clear → something as simple as "Increase ceonothus (sp?)"

② Include some monitoring but not too cumbersome - some photo points on similar aspects/elevation

③ Take a photo of the burn (post-burn).

Just a note: I talked to Darwyn John of LTC and he did get the letter at the beginning of Aug.

Jacquie.

Subject: FW: Carpentor Burn Plan
Date: Wed, 13 Sep 2000 09:53:30 -0700
From: "Lamont, Carol" <Carol.Lamont@BCHydro.bc.ca>
To: "'Bruce Morrow'" <sageforestry@direct.ca>

Bruce, here is an additional comment from our recreation staff. thx. carol.

> ----------
> From: Wilson, Clive
> Sent: 2000 September 12 4:33 PM
> To: Bruce, David; Gurnsey, Colin; Lamont, Carol
> Subject: RE: Carpentor Burn Plan
>
> Carol, I spoke briefly to Dave Bruce regarding this but I am not sure if
> he got back to you.
>
> The only concern from a recreation perspective is water quality in Big
> Horn Creek. We do not have a well at the Big Horn Creek Campsite. As the
> creek runs year round people take their water directly from the creek,
> boiling for drinking at their own discretion. (This is the practice at a
> number of rustic campsites throughout the province.)
>
> The burning proposal proponents should be made aware of this informal use
> of the water in Big Horn Creek.
>
> ----------
> From: Gurnsey, Colin
> Sent: 2000 September 06 11:15 AM
> To: Wilson, Clive; Bruce, David
> Subject: FW: Carpentor Burn Plan
>
> Attached is an outline of a burning project funded by the Bridge / Coastal
> Restoration program at Carpenter Lake. Please review and comment to carol
> Lamont asap.
>
> ----------
> From: Lamont, Carol
> Sent: 2000 September 06 10:20 AM
> To: Gurnsey, Colin; Carter, Glen; Sakamoto, Wayne
> Cc: Riley, Deirdre; Sakamoto, Wayne
> Subject: Carpentor Burn Plan
>
> I have attached two documents that outline a project funded by the
> Bridge Coastal Restoration Program. The project was undertaken to develop
> a prescribed fire plan for the Carpentor Lake watershed, a technique used
> to improve wildlife habitat.
>
> The plan evaluates the entire watershed and selects the best areas
> for prescribed burning.
>
> Please review these two short documents and let me know if you have
> any comments.
>
> thx. carol.
>
> <<File: Carpenter cover letter aug00.doc>><<File: carpenter burn
> limitations july00.doc>>

FAX # (250) 573-2936

Sage Forestry Ltd.,
6504 Barnhartvale Rd.,
Kamloops, B.C.
V2C 6V7.

Attn: Bruce Morrow;

Re: Burn Plans for wildlife habitat enhancement in the Carpenter Lake area.

My apologies, for being late with our comments to the planning process, but the executive of the W.S.S. of B.C. did not receive the request until Sept 1/00. However, here are our comments

1) From Jones Cr. easterly thru Bighorn, Falls and Cedarvale Cr. is a historic wintering area for California bighorn sheep and mule deer.
This habitat definitely needs a prescribed burn to help bring ungulate forage back to its former state.

2) If there are any plans for timber harvest in the above mentioned area, this too could be beneficial for ungulate habitat. Blocks logged in this area tend to come back in grasses before conifer encroachment takes place.
The only disadvantage of logging would be road construction into blocks where overwinter ungulates are present. This is fairly steep terrain with a road located along the lakeshore at the base of hill. Heli-logging or skyline methods could be employed here, leaving

BRITISH
COLUMBIA

July 14, 2000

Bruce Morrow
Sage Forestry Ltd.
6504 Barnhartvale Road
Kamloops, B.C.
V2C-6V7

Dear Bruce;

This letter is to inform you that our office is prepared to support your prescribed fire planning and operations activities within the Lillooet Zone of the Kamloops Fire Centre. We will issue burn reference numbers for Category 8 burns provided they meet all conditions as defined in the Forest Fire Prevention and Suppression Regulation, including a thorough burn plan with adequate mapping.

As you are aware, using prescribed fire as a land management tool has its inherent risks. These risks can be substantially mitigated through proper planning and the use of relevant available tools such as local weather stations or a generally accepted fire behavior prediction system. The time of year also plays a key role in the use of prescribed fire.

Some land management objectives can only be met with spring burning, which can often create more potential risk of fire escape. This requires that all spring burns be completely extinguished, usually within two weeks of ignition. Fall burns, can often be left to self-extinguish over the winter. However, they must be checked in the spring for any hot spots and these hot spots must be extinguished. Summer burns are generally not allowed after an open burning ban has been placed in effect but there is an exemption process that may apply in certain situations.

In the Lillooet Zone, we are managing prescribed fire using a consultative approach involving area stakeholders. This approach facilitates the achievement of multiple land management goals in a single project. We would like you to incorporate this approach into your activities. Some local area stakeholders that you might like to consider would be Lillooet Forest District, Ainsworth Lumber, local first nations groups, BC Hydro. Ministry of Environment, and local area residents. We've found that notification prior to burns through the local media is a valuable tool as well.

Our office is available to assist you with any way we can. Please don't hesitate to call.

Sincerely,

Steve Newton
Manager, Lillooet Fire Zone

Ministry of Forests

Kamloops Fire Centre

Mailing Address:
4000 Airport Drive
Kamloops BC V2B 7X2

Bruce Morrow R.P.F
Sage Forestry LTD
6504 Barnhartvale rd.
Kamloops, BC
V2C 6V7

Bruce,

RE: Wildlife Habitat Enhancement on Carpenter Lake

The people of Seton Lake have always known that the area on the north side of Carpenter Lake is an ideal wintering area for ungulates. The St'at'imc have managed the area since time out of mind. This area is the wintering range for the deer that migrate down from the, Spruce Lake to Graveyard Valley area. The north side of Carpenter Lake has been used since before the white man set foot on our land, and is still used by the Seton Lake Band to harvest Mule Deer.

The plans to burn the area to open up the canopy causes concern since the forest is an old growth forest. It is typical in an old growth forest for the canopy to be closed, and for the forest floor to consist of shade loving grass and small brush. The Mule deer are present in the area because it is ideal wintering conditions for Mule Deer as the forest is now. The food the deer require to survive the cold winters in the area are not present in a new growth forest. The Mule deer require the canopy to be closed to protect them from the cold winds that frequent the area during the winter months. There is a good saying that applies to this situation: "If it isn't broken don't fix it".

I can safely say that you will not be allowed to destroy the Mule Deer habitat on the North Shore of Carpenter Lake. Anyone wishing to destroy the Mule deer must answer to the People of Seton Lake. The actions you are asking for input to, are in direct conflict with the Aboriginal Rights of the original Peoples of this land.

Randy James
Seton Lake Band
Seton Portage BC
V0N 3B0

Sage
FORESTRY LTD.

6504 Barnhartvale Road
Kamloops, B.C.
V2C 6V7
Bus: 573-2393
Fax: 573-2936
sage@wkpowerlink.com

September 12, 2000

Randy James
Seton Lake Band
Seton Portage, B.C.
V0N 3B0

Randy,

<u>Re: Reply to Wildlife Habitat Enhancement on Carpenter Lake Letter</u>

Thank you for your input into the planning process for prescribed fires on the north side of Carpenter Lake. Your letter will be included in the final report of this initial phase of the project.

The intention of this project is not to 'destroy Mule Deer habitat' as is suggested in your letter, but the exact opposite. Studies have shown that Mule Deer prefer a mosaic of open areas and mixed dense cover. This type of forest is most conducive to meet deer requirements for forage, protection and shelter. As you accurately stated, the forest canopy in this area is mostly closed. The intention of this project is to open small areas of the forest to promote shrub, and grass production, while maintaining a large majority of the forest cover. The plans only affect approximately 1100 hectares, and the intention is to open up the forest on ten to twenty percent of that area. A light surface fire should cover the rest of the area, keeping the forest cover intact, while re-invigorating most of the surface shrubs, herbs and grasses.

I have attached some information on fire effects on ungulates. This and more is available on www.fs.fed.us/database/feis/. I will be contacting you in the near future to discuss this further. If you have any questions in the short term, please do not hesitate to contact me by any of the methods listed above.

Thanks again for your prompt response.

Yours truly,

Bruce Morrow

the wintering area for ungulates undisturbed by vehicular access, which in our opinion is a 'big plus'!

(3) As for high elevation burns, we see no loss all ungulates, sheep, goat, and mule deer would benefit.

(4) From Cedarvale cr. to Terazagi Dam there are some deciduous patches that may need slashing before a burn takes place; but a lot of this area is extremely steep and rocky and hand work might be very costly.

(5) The Wild Sheep Society of B.C. has already taken part, financially, in spring burns early this year at Spences Bridge along the Thompson River, and a fall burn is planned for the north side of Seton Lake, with follow-up burns for 2001 in the immediate vicinity.

We hope these comments will be acknowledged in your plans for the Carpenter Lake area.

Yours truly,

Led Ross

Director and Burn Comm. Representative,

Wild Sheep Society of B.C.
Box 252
Pemberton, B.C.
V0N 2L0.

CC. STEVE NEWTON FAX # (250) 256-4367
ZONE MANAGER
LILLOOET FIRE ZONE

APPENDIX F

1:15 000 Scale map of North Carpenter Lake - Identified Prescribed Fire Areas