Advantage

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Contents

Management of harvesting debris in west-central Alberta

Abstract

The Forest Engineering Research Institute of Canada (FERIC) reviewed forty years of historical fire data for the west-central region of Alberta. This report presents the expected costs, based on the data, of the two conventional approaches to managing harvesting debris, which are to burn the debris piles or to leave them unburned within the cutblock. FERIC also provides recommendations on the management of this debris for operators within this region. This report is the third of four planned reports that will address the harvesting debris issues for different regions of the province.

Keywords

Fire history, Harvesting debris, Top piles, Debris management, Alberta.

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Introduction

The fire history of harvesting debris in Alberta was explored by Baxter (2002a) and showed different trends for different regions of the province. Four regions were identified for more in-depth fire history studies and debris management recommendations: the eastern slopes of the Rocky Mountains, and east-central, west-central, and northern Alberta. Each region has specific characteristics and different fire histories associated with harvesting debris. This report is the third of four planned reports, and addresses the harvesting debris issues for the west-central region.[1] The first two reports (Baxter 2002b and 2004) examined the eastern slopes of Alberta's Rocky Mountains and the east-central region, respectively, and made suggestions for the management of harvesting debris in those areas.

The west-central region of Alberta extends from gently rolling boreal mixedwood regions in the east to rugged alpine areas in the west. The alpine/montane, upper/lower foothills, and boreal areas create five distinct fire regimes. The alpine areas are strongly influenced by the Rocky Mountains whereas the boreal area experiences a more continental weather regime. The western region lies in the Chinook[2] belt and has influence as far east as the town of Swan Hills and its surrounding area. Many of the concerns documented for the eastern slopes (Baxter 2002b) exist in this region. There are, however, three differences between the eastern slopes and the west-central region that influence debris management:

- lightning frequency
- amount of harvesting activity in the region
- strength and frequency of Chinook winds

Lightning frequency and harvesting activity are related to an increase in the number of fires. This region experiences the most strikes per square kilometre of any other region in the province. Although the Chinook

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[1] The area from 53° N to 56.5° N latitude and from 115° W longitude to the western border of the province.

[2] A warm dry wind on the lee side of a mountain range, whose temperature is increased as the wind descends down the slope. It is created when air flows downhill from a high elevation, raising the temperature by adiabatic compression.

is less of an influence than it is farther south, it still affects winter burning. These three factors contribute to the difference in the number of fires between the two regions (410 along the eastern slopes compared to 1492 in the west-central region from 1961 to 2000), and are the reasons why the west-central area is studied independently of the eastern slopes region. From 1961 to 1995, debris fires in the region have cost the province over $12 million.

The primary species harvested are white spruce, lodgepole or jack pine, and aspen. Debris management considerations dealing with aspen were documented in the report on the east-central region (Baxter 2004). The majority of debris in the west-central area is already burned by forest companies as part of their debris management programs and provincial obligations. With the combination of Chinook winds and an inconsistent snow cover, little burning takes place during some winters (e.g., the winter of 2002/03). Even with cautious burning, fires still occur from wildfires involving slash and from pile-burning excursions. Harvesting debris can be managed using one of two options—piling and burning in a safe manner or piling and leaving on the landscape to decompose. Unburned piles, either left from previous years or new piles drying during the summer, are susceptible to ignition from lightning and can contribute to the number of fires the region experiences.

Definitions used in this report

Industry-caused fire: any fire involving slash fuels where the fuel accumulation was created by industrial activity, and where the ignition agent or cause was linked to industrial activities. This includes forestry, oil and gas, highways, railroads, and hydro-electric development.

Probability of fire: the calculated chance of a fire occurring, based on 40 years of fire history data, e.g., P(fire) = 0.37.

Expected monetary value (EMV): the product obtained by multiplying the probability of an outcome occurring and the conditional value (or worth) that is received if the outcome does occur. EMV is also the weighted arithmetic average of the profit that can be expected if the decision was repeated over a series of trials (Newendorp 1975). In this report, all values are negative, i.e., they are costs.

Objective

The objective of this study was to develop debris management recommendations specific to the west-central region of Alberta. To accomplish this, the fire history of slash fuels in this area is quantified. These results were synthesized with a compilation of observations of current debris management techniques, and discussions with regional forest industry and agency personnel, to develop recommendations specific to the conditions of the area.

Methods

All fires in the west-central region involving slash[3] as a fuel type were compiled from the provincial fire history dataset. The data were sorted according to the number of fires, the month the fires occurred, the size and cost of the fires, and the wind speed from the initial fire report. The fire history data were combined with observations made during field trips and discussions with forestry personnel working in the west-central region. Note that most fires outside of the fire season, those occuring from November 1 to March 31, were not recorded. Exceptions would be when the fire became large in size. For example, the winter of

[3] Any fire identified in the fire history reports as having slash (i.e., piles, slash, FBP System Fuel Type S-1 [jack or lodgepole pine slash], FBP System Fuel Type S-2 [white spruce/balsam slash], windrows, debris, brush pile, cutblocks, etc.) as either the primary or secondary fuel type, or included as a comment.

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1999 had very little snow and strong warm westerly winds. Twenty-four excursions occurred but only four were numbered as fires whereas the companies extinguished twenty. All the fires occurred in cutblocks where winter burning had occurred.

Expected value theory was used to illustrate the economic outcomes associated with the two management options for handling harvesting debris. Expected value is developed using the probability of debris fires by size and cost. This includes the probability of fires escaping from debris piles and of wildfires involving debris piles. Probabilities were derived from the provincial fire history dataset and anecdotal evidence from industry personnel. The outcomes from the expected value calculations were used to develop the recommendations for debris management.

Results and discussion

Fire history

From 1961 to 2000, there were 1492 wildfires in this region, or approximately 37 fires per year, with slash listed as a fuel type (Figure 1). This is approximately 13% of the total of 11 680 wildfires that occurred in this region, compared to the provincial average of 9.7% over the same time period. There are two primary reasons for the high number of fires involving slash in the west-central region: an active forest industry and a high frequency of lightning. Since 1967, the number of fires involving slash has remained relatively steady with a peak during the early 1980s, before returning to lower numbers. Since 1961, 112 800 ha of fire involving debris have burned in the west-central region, whereas 98 000 ha have burned in the east-central region.

Slash fires by season

The provincial fire history dataset shows that spring (May to early June) is generally the busiest period of fire activity in Alberta. This pattern is consistent for slash fires in the west-central region (Figure 2). Most fires occurring during May are caused by humans, and the primary causes during the spring months are listed as “resident”[4] and “incendiary”.[5]

Winter fires result primarily from industrial activities (forestry, highways, etc.). Ten percent of the debris fires in the west-central region occurred from November to March (a total of 158 fires). Table 1 shows the number of winter fires has doubled from 2.4 per year in the 1960s to 4.9 per year in

4 Resident: a wildfire resulting from activity performed by people or machines for the purpose of agriculture or an accidental fire caused by activity associated with normal living in a forested area.

5 Incendiary: a wildfire wilfully started for the purpose of mischief, grudge, or gain.

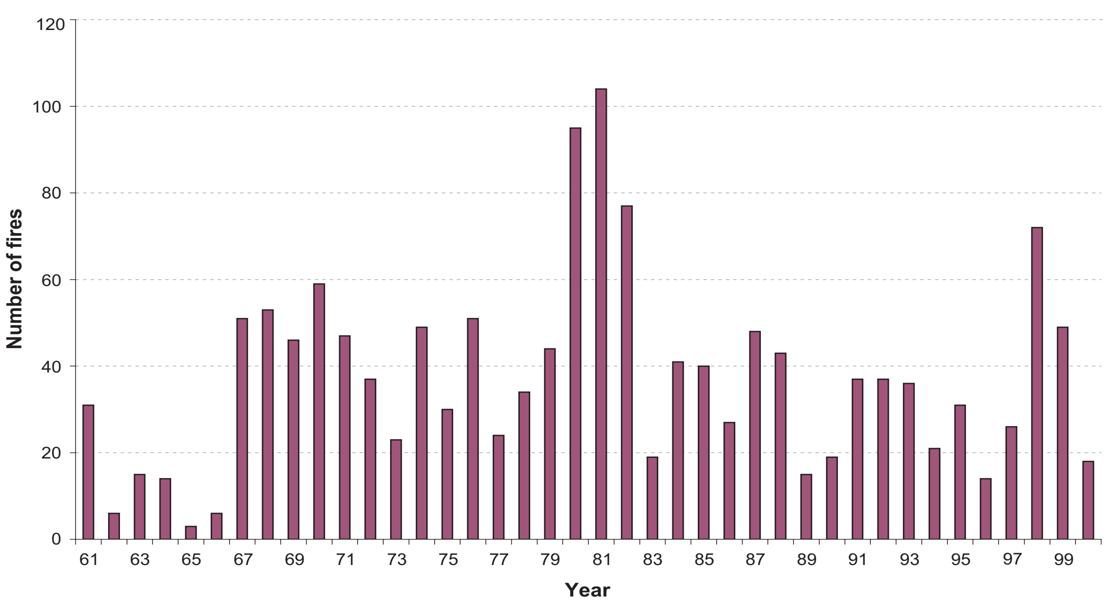

Figure 1. The numbers of fires per year involving slash fuels in the west-central region of the province.

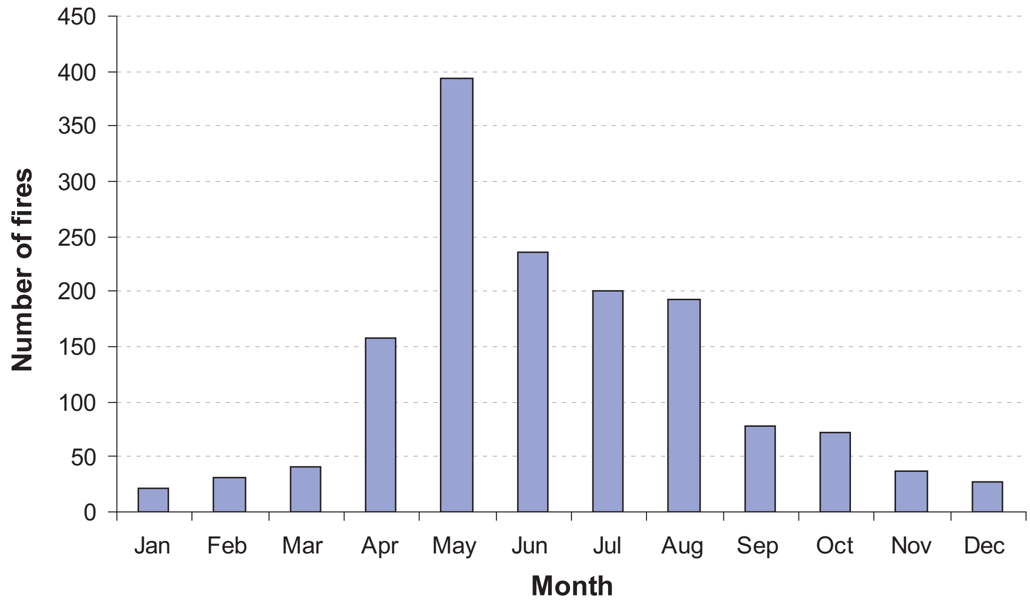

Figure 2. The average number of fires per month involving slash fuels in the west-central region of the province for 1961-2000.

Table 1. Winter fires in the west-central region of Alberta for the period 1961–2000

Time period	Number of fires	Fires/year
1961–70	24	2.4
1971–80	30	3.0
1981–89	50	5.5
1990–2000	54	4.9

the 1990s. The 1980s had the most winter fires, averaging 5.5 per year. Large or unpredicted Chinook events can result in multiple fire excursions during the winter. For example, a Chinook on December 14, 1997 was responsible for the escape of 12 individual debris fires in this region alone.

El Niño and Fire Weather Index thresholds

Fire history data were compared to El Niño events during the 1990s to identify if a relationship existed between El Niño and the number of fires. El Niño events of different strengths have occurred in 1991–92, 1993, 1994, and 1997–98. In the year following an El Niño event, the number of slash fires increased slightly. The resulting warmer winters may have assisted in drying the fuels which made them more receptive to fire in the next year. This analysis, however, was based on a very small sample size.

End-of-season Fire Weather Index (FWI) values were compared to winter fire activity for the 1990–2000 period. This analysis found no relationship linking the end-of-year Drought Code (DC) and Build Up Index (BUI) values to fire activity.[6] A more important influence appears to be the weather following freeze-up, i.e., the amount of snow cover and the day-to-day weather (e.g., warm, windy). Snow-on-ground data were obtained and compared with winter fire activity. A weak relationship was found between snow-on-ground anomalies and the frequency of winter fires. The winters of 1998 and 2000 experienced the most fires since 1990, and these winters had below-normal snow-on-ground amounts for four weather stations within the region. Although this comparison covers only 11 years, it shows the importance of snowfall on fire activity and the industry's confidence in burning debris.

Over-wintering fires

Over-wintering fires are ignited in the winter and are identified with a firefighting-detection date after the start of the fire season (April 1).

[6] Only the DC and BUI were used in this comparison because the other indices monitor moisture change over only hours or days, and thus cannot predict drought conditions.

Twenty-six percent of all debris fires occurred in May. At this time of year, weather and slash conditions tend to be dry, grass vegetation is cured, and spring winds can be brisk to strong. Many fires in April and May were listed with "abandoned fires" as the true cause. This suggests that these may be piles burned during the winter but not extinguished before the spring fire season. These over-wintering fires can then re-surface during favourable burning conditions. Even if piles are scanned, the heat from the fire may remain undetected and re-ignite debris or grass.

Table 2 shows over twice the frequency of over-wintering fires between the periods ending and beginning in the early 1980s, even though the total number of slash fires decreased by 34%. This suggests more aggressive action is required to ensure piles are extinguished before the start of the fire season, and may reflect inadequate infrared scanning skills or scanning frequency. Existing new technology would allow burned areas to be monitored after piles are believed to be extinguished. This technology requires field testing to determine its effectiveness in this environment and cost.[7]

Fire cause

The fire history dataset was queried and sorted based on fire cause (Figure 3). Lightning was the primary ignition agent for fires involving slash fuels. The west-central region lies in a lightning belt, receiving more strikes per hectare than other areas of Alberta.[8]

"Resident" fires were the second most common cause of fires in the region. Lightning- and resident-caused fires tended to be the larger fires (Table 3).

Since 1983, 193 fires have been linked to windrows, piles, brush, and slash (Figure 4). For the 1990–95 period, 41 fires were listed with this linkage. Of these 41 fires, 34% occurred during the winter and 36% occurred in April and May. These are fires that either escaped or re-surfaced after they were believed to be extinguished.

Table 2. Over-wintering fires

Time period	Total slash fires (no.)	Over-wintering fires (no.)	Over-wintering fires (%)
1961–1982	901	28	3.1
1983–2000	594	50	8.4

[7] For an example of this technology see the Ambient Control Systems website at http://www.ambientalert.com.

[8] The provincial cumulative lightning map can be found at the following website: http://envweb.env.gov.ab.ca/env/forests/fpd/clom.html.

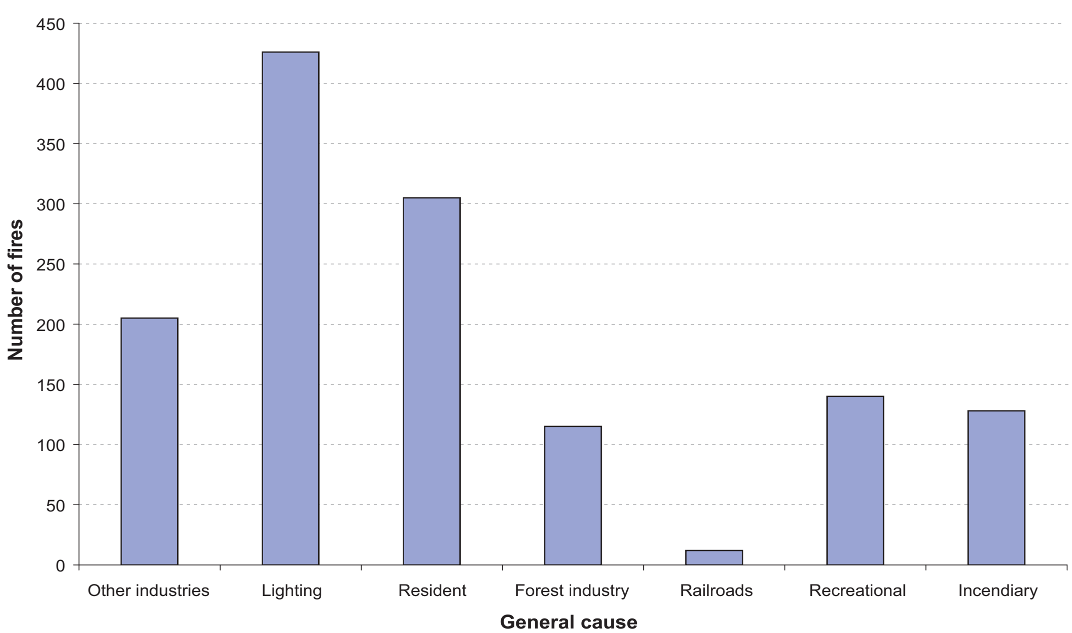

Figure 3. General cause of fires involving debris in the west-central region of Alberta for 1961–2000. The forest industry accounts for 8% of debris fires.

Table 3. Mean fire size by cause and time period [a]

	Other industries	Lightning	Resident	Forest industry	Railroads	Recreational	Incendiary
1961–70	5.0	161	286	11	-[b]	156	49
1971–80	4.5	21	31	39	24	19	30
1981–82	1.8	676	55	-[b]	-[b]	2	28

[a] Data only to 1982 because listing of causes in the fire history dataset changed after 1982.
[b] Insignificant hectares burned.

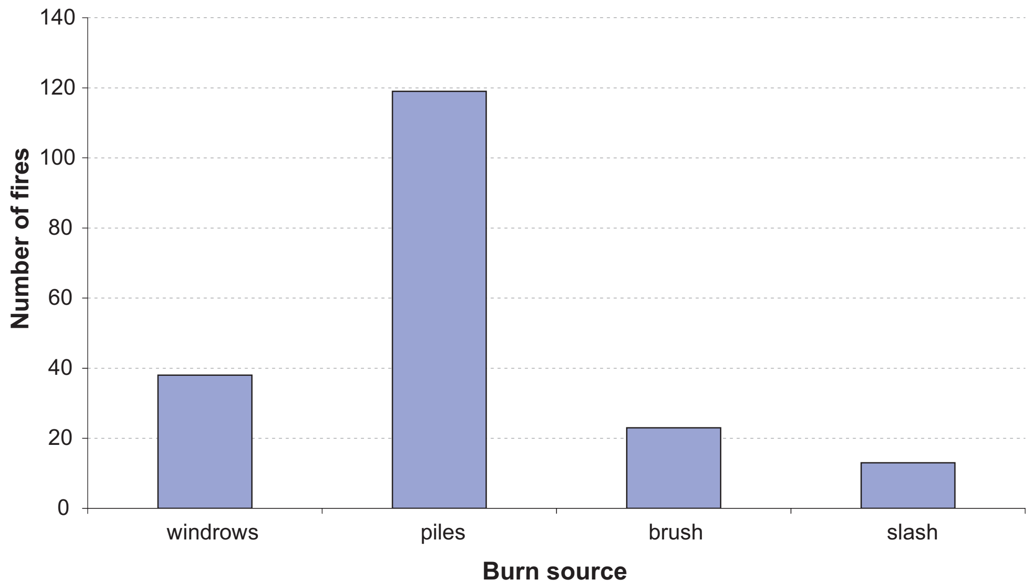

Figure 4. The number of fires since 1983 directly caused by the burning of windrows, piles, brush and slash. The fire history database did not have these specific categories before 1983.

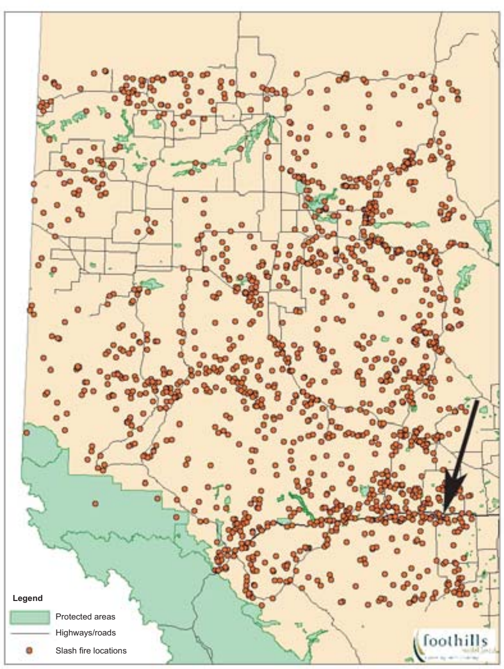

Figure 5. The ignition points of all slash fires in the region for 1961–2000. The arrow points to Highway 16.

Hectares burned

Typically, a small percentage of wildfires account for the majority of hectares burned, and these data support this pattern. For example, from 1983 to 1989, the mean size of all fires in Alberta was 23 ha +/- 398 SD. For slash fires during the same time period, the mean size was 8.6 ha +/- 64 SD, showing few fires account for the majority of hectares burned. The same relationship exists for the number of hectares burned in the west-central region of the province by fires involving slash fuels.

Location of fires

The ignition location points of all slash fires in the region (Figure 5) show that many fires occur along the transportation routes with a large concentration of fire occurrences along Highway 16. Fox Creek and the area south of Grande Prairie appear to have the most lightning-caused slash fires (Figure 6).

The spatial distribution of winter fires (Figure 7) shows a grouping of fires close to the mountains in a relatively small area. Chinook winds are a contributing factor to the majority of these fires.

Wind speed

Wind speed, as indicated at the time of the initial fire report, may be the reason fires escape or are problematic. December has the highest mean wind speed for debris fires, and spring wind speeds are also relatively high (Figure 8). These observations reflect the two general wind regimes in this region. The area adjacent to the mountains is influenced by the prevailing westerly wind, particularly the Chinook, and wind speeds tend to increase during the early part of the winter (i.e., November/December/ early January). When burning in Chinook conditions, supervision of the piles should be undertaken. In the eastern part of this region, the prevailing westerly wind has a lower physical strength and frequency.

Firefighting costs

Controlling and extinguishing debris fires is an expensive undertaking. Time of year, access, and equipment required to fight these fires can all contribute to high costs. More information on firefighting costs is provided later in this report in the *Expected economic outcomes of current practices* section.

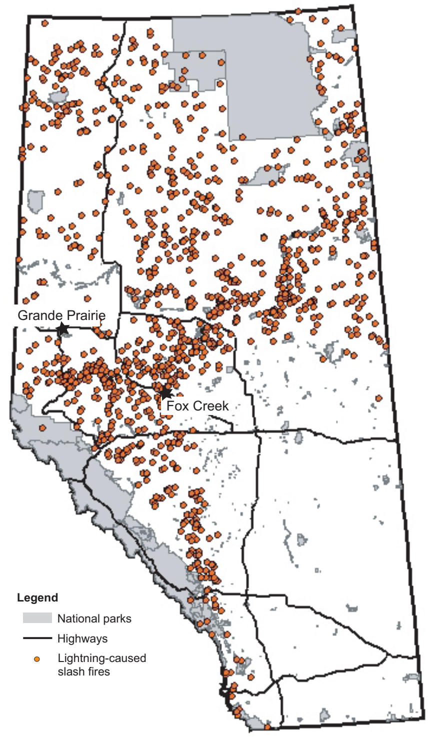

Figure 6. Location of lightning caused slash fires.

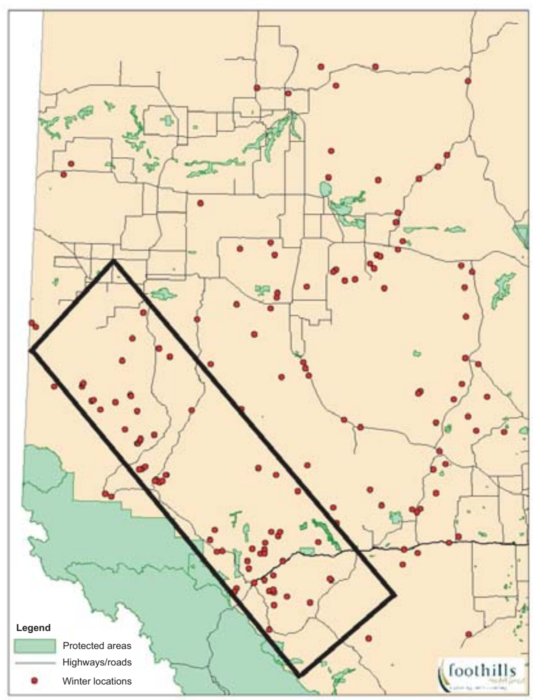

Figure 7. The location of winter fires (November–March) in the region for the period 1961–2000. The map shows a distinct grouping of fires along the eastern slopes area of the region. The box is a rough representation of the area more frequently influenced by Chinook winds.

Current debris management practices

In the west-central region, pile and burn is the standard practice for disposing of harvesting debris. Because less aspen is harvested, little debris is intentionally left to decompose on the landscape. Piles that exist longer than 24 months tend to be those whose conditions were not adequate for burning.

Fire behaviour characteristics

Fire behaviour characteristics in coniferous debris have been understood since timber harvesting and land clearing began in the province. These residues have a high risk of ignition during the first few years after harvest due to the high amounts of fine fuels such as needles and twigs. After these fine fuels have fallen to the ground, the heavy loading of debris can exhibit extreme fire behaviour (spotting, high flame lengths, etc.).

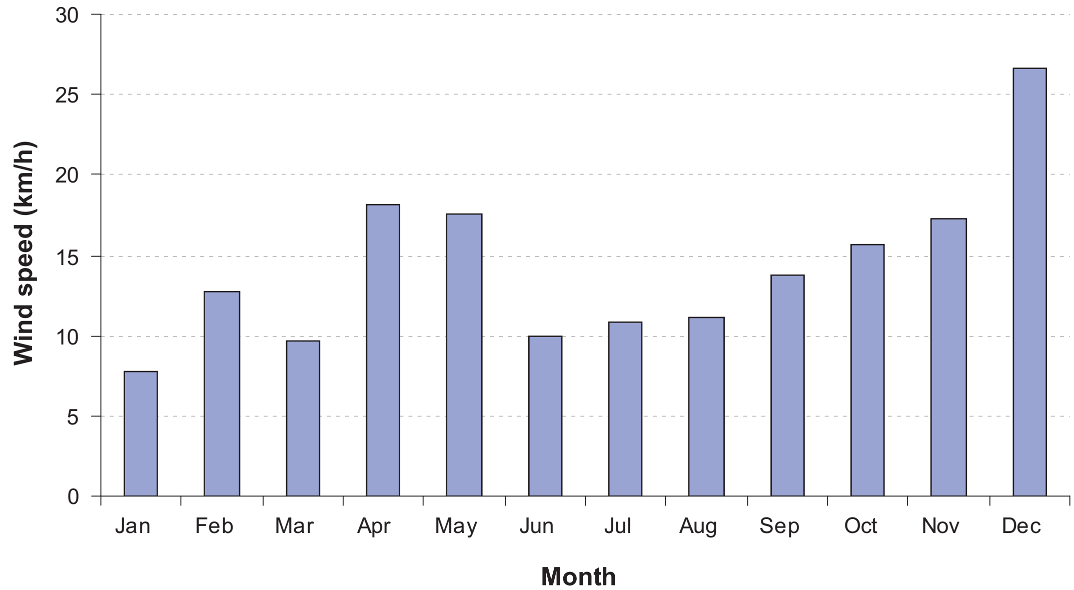

Figure 8. Mean wind speed (in km/h) by month for slash fires in the west-central region for the periods 1961–82 and 1996–99 (based on data from 1079 fires). Wind speeds were not recorded from 1983 through 1995.

This debris can remain on the landscape for 20 years or longer, and can contribute to problematic fire behaviour during wildfires. The fuel is elevated which increases potential spotting distances. The elevated position improves the drying of the fuels compared to residues in direct contact with the ground surface. For a description of potential fire behaviour in aspen debris, see Baxter (2003, 2004).

Concerns about fires in slash in west-central Alberta

Forest industry views

FERIC consulted and visited several companies in the region to discuss debris disposal and to listen to their concerns regarding debris burning. The main issues from these conversations follow. These companies are referred to as Company A, B and C in this report.

Company A harvests an area that stretches from just west of Fox Creek to Willmore Wilderness Park, occupying a large area of the Berland Plateau. The company's primary concern regarding debris burning is the Chinook wind. The harvest is done primarily in C-2 and C-3 fuel types[9] and therefore creates abundant debris. The recommendations stated in Baxter (2002b) are applicable to this area, including aggressive supervision of debris piles when Chinook conditions occur, knowing the Chinook forecast, and having local knowledge of the area—in this case, an understanding of how Chinooks generally affect the Berland Plateau.

Company A follows provincial ground rules for structure retention that retains snags and residual trees in the harvested area for biota that depend on these structures following disturbances. While stands are retained within the cutblock, they may create pile-burning difficulties due to their proximity to piles. The company does not want to risk fire in these residual stands. To avoid this, debris piles should be at least 20 m away from these retention stands. This is a potential for conflict with the ground rules.

Company A's own ground rules state that one pile must be left for every four hectares for wildlife use. Baxter (2002b) recommends that in the eastern slopes region, one in four piles may be left (based on an average of 2.8 piles/ha) in the cutblocks in approved locations—perhaps near the retention stands. The value reported for the eastern slopes region is based on a fire history that differs from the west-central region. Because there are considerably more fires in the west-central region, the one-in-four-hectare

[9] C-2: boreal spruce. C-3: mature jack or lodgepole pine.

value appears justified. This guideline would create 36% fewer wildlife piles (one compared to 2.8) in the cutblocks than was suggested along the eastern slopes.

Company A does not hesitate to delay or cancel debris burning if conditions are unfavourable or if the manager's experience suggests conditions are not right to burn. Currently, long-range forecasts are not accurate enough for companies to have complete confidence; predicting weather along the eastern slopes is one of the most challenging forecasting tasks in Canada. During the winter of 2002/03, very little burning was done due to the late arrival of an adequate snowpack. Existing models can predict the frequency and relative strength of winds based on historical data and topographical features. This information can be used to develop maps to help locate cutblocks based on expected wind direction and strength—in effect, a Chinook map (Baxter 2002b).

Company B harvests an area on the eastern side of the region, consisting primarily of coniferous timber, and burns its debris. While its concern with Chinook winds is not as great as on the western side, burning is influenced by the amount of snow on the ground. Snow levels have been inconsistent over the last several years, varying from well below to well above normal on a year-to-year basis. However, this trend may now be considered normal for the region. The company has had only a few small excursions in its debris piles and is not too concerned with its operation in this region.

Company C operates directly in the shadow of the Rocky Mountains and therefore operations are influenced by the Chinook. Its winter burning schedule is handled accordingly.

Influence of lightning

One company has taken the initiative and researched the lightning distribution pattern within its Forest Management Area, as it relates to the company's debris management program. The company has concluded that it is not concerned about the potential effects of lightning because of the randomness of the lightning distribution and the fact that only one strike is necessary to do damage.

However, probabilities can be used to estimate the chance of pile involvement. Lightning location maps and probability of ignition models exist. Figure 6 shows that the west-central region lies in the primary lightning belt in the province and therefore should be managed to include the risk of pile ignition due to lightning. Lightning causes 29% of fires involving harvesting debris in this region. Location information could be used by industry to develop landscape scale debris management practices. Techniques to minimize the effects of pile fires ignited by lightning can be investigated.

Debris piles in high-risk areas require attention. At this time, solutions are merely speculative and require a greater understanding of lightning physics and lightning protection techniques. Piles could be crushed to lower their heights in relation to the surrounding terrain, with all extending stems cut to reduce the likelihood of the piles being hit. Eliminating the risk of piles being struck would mean eliminating piles, and this is unrealistic. Alternative actions are spreading and/or broadcast burning, crushing piles, and mechanically treating them. An in-depth, site-specific look at the lightning history of the area and cutblock locations should be made before operational treatments are attempted.

Expected economic outcomes of current practices

An expected value analysis is presented to illustrate potential economic consequences of current debris management practices. For a description of expected outcomes theory, refer to Baxter (2002b).

The data for the west-central region differ considerably from the other three regions in both the number of fires involving harvesting debris and the amount of area harvested. Table 4 was derived from the fire history dataset for the west-central region of

Table 4. Fires involving debris in the west-central region of Alberta, 1961–1995

Size class (ha)	Fires (no.)	Probability of fire size	Cost $/fire	Cost $/ha
A (≤0.1)	690	0.465	843	843
B (0.11–4.0)	525	0.354	2 189	1 390
C (4.1– 40.0)	189	0.127	5 192	300
D (40.1–200)	56	0.037	8 906	95
E (>200)	23	0.015	226 535	113

Alberta and includes fire sizes and costs for debris fires from 1961 to 1995.

The decision tree (Appendix I) shows that the calculated expected monetary values (EMVs) are high in this region due to the high number of fires and larger fire sizes compared to those along the eastern slopes.

The west-central region of the province experiences the most debris fires of all regions. This high frequency of fire makes piling and leaving debris on the landscape more costly than piling and burning. An EMV of $1 069 353 is calculated for burning, compared to $1 238 666 for piling and not burning. Expected costs of fires by size are less than those fires in the east-central region, but the greater number of fires increases expected values. Fires involving debris have occurred in every year, making the probability of a debris fire occurring equal to 1. The exposure to the industry and government is high. The minimum, mean, and maximum exposure to the industry and government on an annual basis are $480 942, $1 202 355, and $2 645 181, respectively. These costs can be added to piling and not burning to understand the potential costs of not burning debris piles.

The EMV exercise indicates that piling and burning is the best economic option for industry in this region. With the high number of debris fires, leaving debris on the landscape to become involved in a wildfire is not the best economic decision.

Implementation and recommendations

The west-central region has an active forest industry in a fire-prone fuel type (C-2), lies in one of the most active lightning areas in the province, and experiences Chinook winds in the western part of the region. These factors contribute to the relatively high number of fires involving slash fuels in this region. The following recommendations pertain to forest industry practices, and other industries or landowners that pile or spread debris to reduce fire risk. They are grouped to address various weather, debris management, and environmental concerns.

Chinook concerns

The recommendations regarding burning in Chinook-influenced regions are listed below. These include aggressive supervision of piles during Chinook conditions. The development of a Chinook map for the eastern slopes should include this region (Baxter 2002b). Recommendations include:

- Implement and use simple Burn Plans.
- Locate piles within the cutblock at a minimum of 20 m apart and at least 20 m from a cutblock edge.
- Supervise and monitor piles closely while burning under Chinook conditions.
- Extinguish or increase monitoring of piles during high risk conditions (Baxter 2002b).

Wildlife piles

- Leave one pile for every four hectares as wildlife piles. These should be strategically located within the cutblock and may be piles that cause problems when burned. These piles should not be larger than the standard pile and not closer than 20 m from the cutblock edge. Optimum locations can be determined by consultations with fish and wildlife biologists.

Lightning concerns

- Investigate techniques to reduce the probability of piles struck by lightning. Spreading debris in high-risk locations, crushing piles, or mechanically treating debris in these areas may be appropriate.
- Investigate the development of a regional lightning occurrence map to allow industry to identify high-risk locations.
- Investigate techniques to minimize the extent of damage from piles hit by lightning.

Overwintering fires

- Reinforce the importance of scanning piles thoroughly before the fire season begins. SRD has regulations regarding this, but the data show that fires caused by piles re-igniting have doubled over the last 20 years and now constitute 8.4% of the slash fires in the region.
- Identify the most effective scanners for this type of work. Scanner operators should be certified to industry standards, or standards should be developed.
- Investigate the use of technology to monitor debris piles believed to be extinguished. These systems would alert operators if fires re-surface.
- Monitor snow conditions and schedule scans and patrols of piles until green-up occurs in the grass fuels. There is a three- or four-week window when all surface fuels are available to carry fire.

Climate influences

- Investigate the influence of various climatic conditions on winter burning. This includes analyzing end-of-year FWI values, snow cover, and the influence of El Niño. This type of analysis may result in winter burning thresholds that may be used by industry.
- Identify indicators that can be used to predict potential burning problems.

Structure retention

- Where structure is retained, no piles should be within 20 m of the island or extension. It is important to protect these areas from fire, and these areas should be treated as cutblock edges.

Expected outcomes

- On an annual basis, the best economic solution is to pile and burn the debris.

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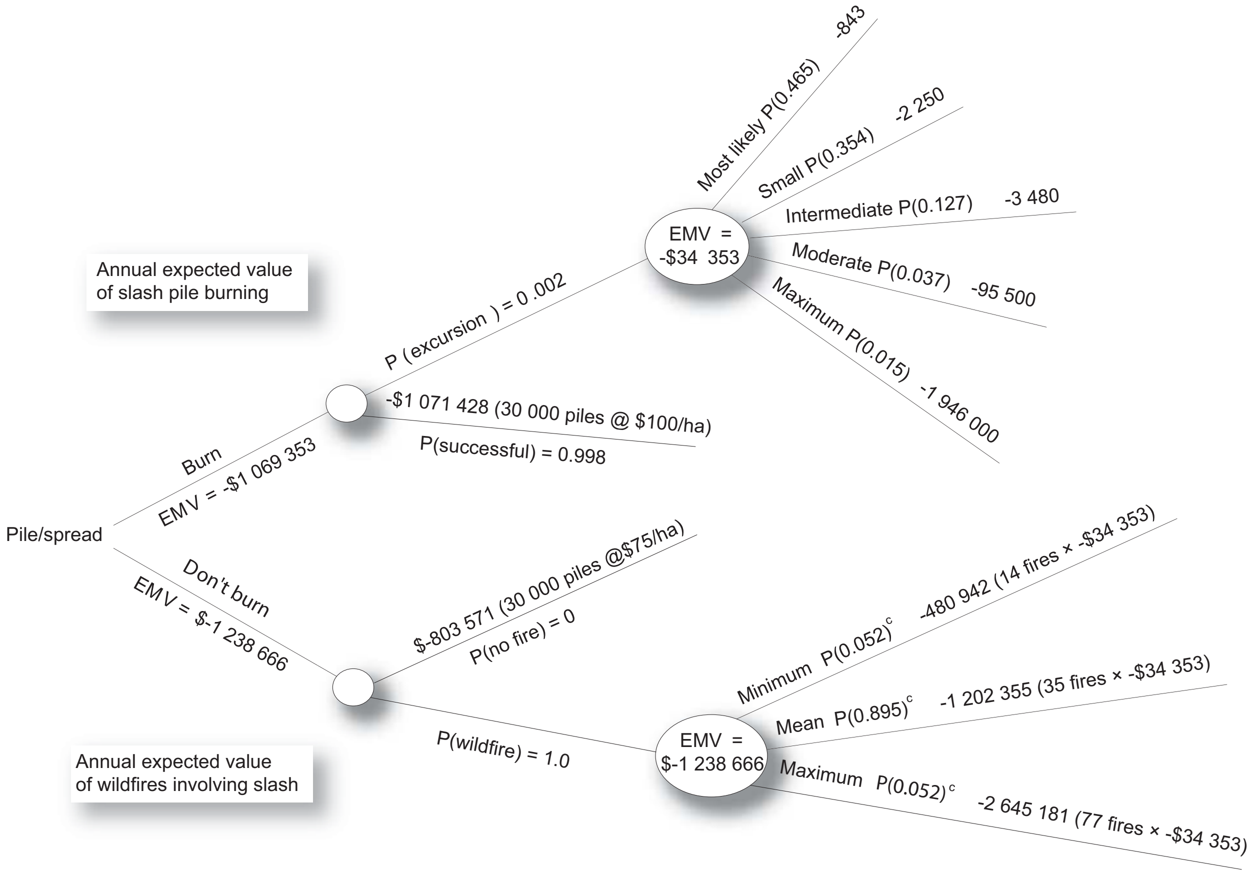
Appendix I

Decision tree analysis [a, b]



Most likely	0.01 ha	$843/fire
Small	1 ha	$1390/ha
Intermediate	3 ha	$300ha
Moderate	100 ha	$95/ha
Maximum	2000 ha	$113/ha

[a] Probabilites do not equal 1 in this Appendix due to rounding.

[b] Timber lost due to fire is valued using current Alberta Lands and Forest Service values which are $860/ha. Regeneration loss is assumed to be $860/ha.

[c] Probabilities calculated using annual fire frequency data for 1982–2000 for the west-central region, where 670 fires occurred over 19 years and where all 19 of those years experienced fire.