Advantage

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Contents

Management of harvesting debris in east-central Alberta

Abstract

The Forest Engineering Research Institute of Canada (FERIC) reviewed forty years of historical fire data for the east-central region of Alberta. These data are presented and used to calculate the expected costs of the two conventional approaches to managing harvesting debris, which are to burn the debris piles or to leave them unburned within the cutblock. As well, recommendations on the management of this debris are made to forest operators within this region. This report is the second 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 second of four planned reports, and addresses the harvesting debris issues for the east-central region.[1] The first report (Baxter 2002b) examined the eastern slopes of Alberta's Rocky Mountains, and made suggestions for the management of harvesting debris in that area.

The east-central region of Alberta is characterized by flat to gently undulating terrain, less severe winter winds, and a more stable winter than the eastern slopes region of the province. It is also different in that aspen is the dominant forest type harvested. Industrial forest activity is relatively recent in this region, and the harvesting of trembling aspen, lodgepole pine, and white spruce has been increasing in the last twenty years. Conventional harvesting practices include piling and burning debris (e.g., tops, limbs, and unmerchantable stems and logs) and piling and leaving it to decompose on the landscape. Because the morphology and physiology of aspen and conifers are different, they display different fire behaviour characteristics. Therefore, the appropriate debris management techniques may differ for the two debris types.

The forest industry is already using some debris management alternatives: spreading aspen debris, decreasing pile sizes, changing pile shape, and increasing the distances between both piles and windrows. Additionally, it is increasing utilization levels of harvested trees and reducing the amount of debris left on-site. Cut-to-length harvesting and leaving debris at the stump are also taking place.

[1] The area east of 115° W longitude over to the Alberta/Saskatchewan border and between 54.5° N and 56.5° N latitude.

This report presents recommendations for the management of harvesting debris for east-central Alberta. As well, an expected monetary value (EMV) analysis is performed to estimate the costs of various debris management options.

Objective

The objective of this study is to develop debris management recommendations specific to the east-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.

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.

Methods

All fires in the east-central region involving slash[2] 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, and the size and cost of the fires. The fire history data were combined with observations made during field trips and discussions with forestry personnel working in the east-central region.

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 data 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

The fire history of slash fuels in Alberta was analyzed (Baxter 2002a) and several trends emerged.

Traditionally, there were few fires involving slash in this region (Figure 1) but starting in 1967, the number of fires fuelled by post-harvest debris has increased, and recently from 1983 to 2000, the number per year quadrupled from 5.5 to 22. This trend is opposite to that seen on Alberta's eastern slopes where, during the same time period, the number of slash-fuelled fires decreased.

Recently, the number of hectares burned has decreased relative to the period prior to

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[2] 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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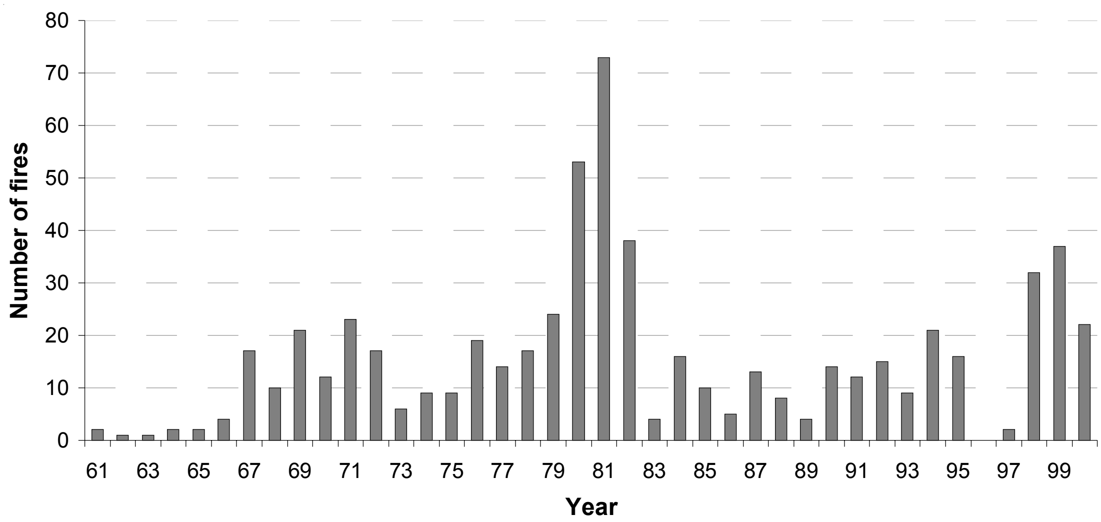


Figure 1. Number of fires involving slash by year, from 1961 to 2000, for the east-central region of Alberta.

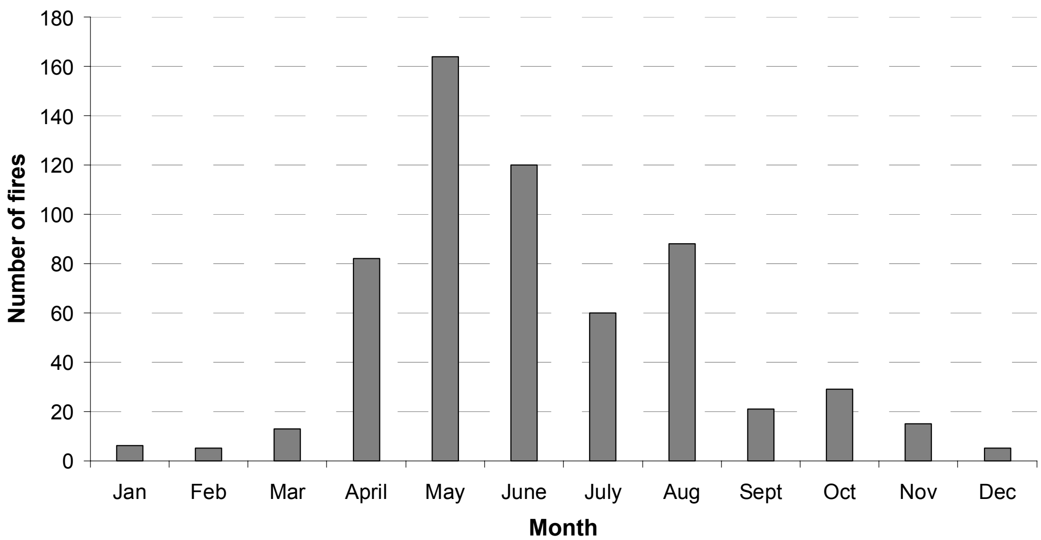


Figure 2. Month when fires occurred in slash in the east-central region of Alberta from 1961 to 2000.

1983 (Appendix I). In fact, relatively few hectares burned during these 17 years. In 1983, the forest industry started creating debris piles—rather than leaving debris at the stump—thereby reducing the area containing debris.

Over the four decades studied, most fires involving slash occurred in spring and early summer (Figure 2). This seasonal pattern holds true for most parts of the province and for wildfires as well. The fewest fires in slash occurred in December, January, and February. Although winter fires rarely occur, they have increased in number—the 1990s experienced about three times the number of fires in slash in winter (November through March) than during the 1960s, 70s and 80s (Table 1). Most winter fires occurred in November and March, perhaps indicating that burning should be restricted to December, January, and February or when sustained snow cover is forecast.

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). During the 1960s, 70s, and 80s, the number of over-wintering fires in east-central Alberta remained steady at two in the 1960s and three in each of the following two decades. In the 1990s, the number quadrupled—likely a result of milder winters and increased harvesting activity. Even with

Table 1. Total fires involving slash during the winter in east-central Alberta, by decade [a]				
Month	1961–1970 (no.)	1971–1980 (no.)	1981–1989 (no.)	1990–2000 (no.)
January	0	1	0	5
February	1	0	1	3
March	1	3	1	8
November	3	3	5	4
December	2	0	1	2
Total	7	7	8	22

[a] Time periods are not equal due to a change in data collection that occurred.

the increase, the number of over-wintering fires is low, as the average is two winter fires per year (Table 1) during the 1990s (22 fires over 11 years).

Causes of fires

Among the many causes of fires in east-central Alberta from 1961 to 2000, lightning and residents were the most common (Figure 3). N/A refers to a category (Public Project) that was discontinued in 1983.

Firefighting costs

The fire sizes and costs of suppression for fires involving slash are shown in Table 2.

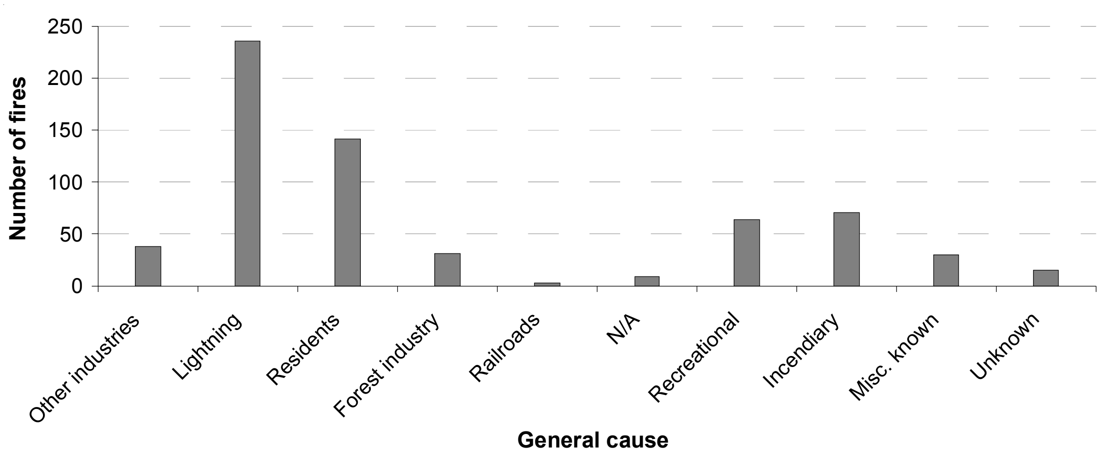
Current debris management practices

In east-central Alberta where both aspen and conifers are harvested, the forest industry is experimenting with debris management techniques other than pile-and-leave and pile-and-burn. For example, on a small scale, the industry is chipping and grinding the slash material. It is also modifying the size and location of debris piles, spreading debris within cutblocks, and increasing the utilization of harvested trees to reduce slash volumes.

Table 2. Fire size and cost of suppression for wildfires involving slash, for 1961–1995

Fire size class	Cost/fire ($)
A (≤0.1 ha)	1 107
B (0.11 to 4.0 ha)	3 226
C (4.1 to 40.0 ha)	7 185
D (40.1 to 200.0 ha)	13 324
E (>200.0 ha)	251 881

Figure 3. Causes of fire involving slash in the east-central region of Alberta from 1961 to 2000.



Size and location of debris piles

Smaller debris piles or windrows are being created within cutblocks as a method of reducing the fire hazard. Although more debris piles are present, they are smaller and have lower fire-intensity potential compared to conventional large piles. These smaller piles likely have a faster decomposition rate and, consequently, remain a hazard for less time. Smaller and rounder piles are also being tried.[3] Currently, piles are located within four metres of each other, and radiant heat transfer may allow the relatively easy movement of fire from one pile to another. Consideration should be given to increasing the distance to lower the risk of pile-to-pile ignition. FERIC observed flame lengths of five metres at a prescribed burn at Heart Lake during the spring of 2003. Flames physically "touched" adjacent piles and ignited them when the flames were blown over. Five-metre flame lengths approximate an intensity of 7500 kW/m, which is extreme fire intensity (Figure 4).

Embers are often released from burning piles as the air currents created by the fire lift and spread burning material. These embers can cause spot fires. Generally, smaller piles have less potential to cause spot fires because the fires have less intensity and the sparks generate from a lower initial height.

Fires in debris piles intermixed with grass are very difficult to control. Therefore, this debris arrangement should be avoided around communities and values at risk. The pile-free distance from values at risk should be based on the overall wildfire threat as determined by Alberta's newly developed Wildfire Threat Analysis Model.[4]

Debris spreading

In debris spreading, a skidder rearranges the material in a thin layer no deeper than 30 cm (or one log diameter), and leaves open ground for aspen regeneration. Spruce debris, if present, is rearranged first, and aspen debris is then laid over it. This procedure compresses coniferous branches and allows fine fuels to break down more rapidly. It reportedly has negligible impact on regeneration success.[5] Vanderwell Contractors (1971) Ltd., on the other hand, prefers to plant right up against debris piles as they believe spreading reduces regeneration success.

Figure 4. The ignition of one pile through direct flame contact with another. These piles were 3 m apart.

Improved utilization of harvested stems

Another debris management technique involves improving the utilization of harvested stems and leaving less debris on-site. Cut-to-length harvesting, for example, can result in debris distributed throughout the block rather than in piles. Moreover, logs can be sorted on-site and less unmerchantable material may be forwarded to roadside.

Debris as hog fuel

Daishowa-Marubeni International Ltd. and Vanderwell are trying to utilize the debris as hog fuel. This practice reduces the amount of debris in the cutblocks and reduces the potential fire hazard.

Fire behaviour characteristics

In east-central Alberta, fire behaviour includes over-wintering potential, lower potential for flammability in standing aspen, easy fire spread via grasses, potential for spot ignition of new fires from debris

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3 A. Winter, Alberta-Pacific Forest Industries Inc., personal communication, 2001.

4 Spatial Fire Management System – Wildfire Threat Assessment Model, Alberta Forest Protection Division (FPD) Version 4.4.

5 Ian Whitby, Weyerhaeuser Company Limited, personal communication.

piles, and a long period of fire hazard in hard-dried aspen.

Fires can over-winter

The east-central region of Alberta lies in the boreal mixedwood ecosystem, and is characterized by deep layers of organic material. This material may be ignited when burning debris piles, which produce fires that are time-consuming to fight and difficult to extinguish. Once thought to be extinguished, these duff-burning fires can smoulder during the winter and resurface in cured grasses during spring, typically in extreme fire weather. Although these piles are scanned, heat sources may not be detected and, therefore, the piles may continue burning into the spring. This is a site-specific phenomenon as lowlands contain more duff and thus are more susceptible to these kinds of fires. Currently, there are no industry standards for either scanning equipment or techniques. This may be an area for further research.

Different slash types may have different ignition risks

Because of aspen's morphology, aspen slash has significantly fewer fine fuels than coniferous slash and, therefore, it is believed to be less flammable. The numerous needles and fine branches of conifers can ignite easily during the first two years following harvest. Aspen piles have a significantly lower ignition risk during this time. FERIC observed no difference in flammability between 8–9 year old aspen debris and coniferous debris at a prescribed burn near Heart Lake, Alberta in the spring of 2003, suggesting this difference exists only during the first few years following harvest. Ignition testing of aspen and coniferous debris piles is required to quantify differences.

Fire spreads easily in cured grasses

Grasses grow immediately after aspen harvest as the canopy is removed and more light is available on the ground surface. When dried and cured, grasses can catch fire easily, and allow fire to spread quickly between debris piles and between cutblocks. Grasses can create fire-control problems for as many as five months of the year, including the most active months of the fire season—April, May, and early June. Within individual cutblocks, grass may create problems for up to 10 years, until the regenerating aspen canopy closes and the grass cover decreases.[6] Natural aspen stands are relatively inflammable and create firebreaks, but with their abundance of grasses, aspen cutblocks can create serious fire control problems. Grass also occurs in coniferous cutblocks. However, the length of time that it remains a hazard in deciduous cutblocks is shorter due to the time required for crown closure to occur.

New fires spot from burning debris piles

Debris piles are a mixture of fuel and air, and thus are capable of feeding a steady flame (Chase 1984). Firebrands—burning fuel separated from the main fire—can be lofted high into the air by thermal updrafts, where they can be carried by winds to other piles or to the surrounding forest. This behaviour is called spotting. During extreme fire behaviour, spotting can occur up to one kilometre downwind from the fire front. To lower the risk of spotting around communities, the use of piles as a debris management technique near communities should be minimized.

Little quantitative evidence exists to document spotting from fires burning in aspen debris piles. In one study, Alexander (1982) provided quantitative data on aspen debris that was spread within the cutblock. He suggested that under similar environmental conditions, fire behaviour might be less extreme in spread aspen debris than in other fuel types.

Ignition potential remains for many years in hard-dried aspen piles

Little is known about decomposition time for aspen debris in piles, and therefore

[6] The estimate of up to 10 years is based on a number of opinions from both industry and provincial personnel.

little is known about the duration of a fire hazard in this material. From visual observations, however, it appears that elevated stems dry to a greater degree than surrounding fuels, and that these stems take longer to decompose than stems laying on the ground. Debris spread on the ground is in direct contact with a moister environment, which should increase its rate of decomposition. However, this idea of faster decomposition has not been documented, but is based on the author's opinion and on anecdotal evidence.

Observations of wildfires

Spotting was reported to play a critical role in the 1998 Slave Lake and 2001 Chisholm fires. The latter fire was observed to jump 25 metres from one coniferous pile to another. In the 2002 House River fire, grasses played a role.[7] This fire was difficult to control, particularly at night due to several reasons: the cutblocks that burned were numerous and close to each other, and they contained cured grasses amid debris piles, windrows, and spread debris. Fire spread from one debris pile to another as well as in grasses between piles, and even small aspen piles spotted. Black spruce also played a role in spreading fire when adjacent to cutblocks.

Concerns about fires in slash in east-central Alberta

During March 2002, personnel from Alberta Sustainable Resource Development and the forest industry participated in a tour of the east-central region of Alberta. Provincial personnel included fire managers and foresters, while industry personnel included employees from three companies working in the area. The following opinions about debris management were expressed.

Forest industry views

- If we do not ignite fires, we do not get over-wintering fires and, thus, we limit our liability.
- If piles are left, we can reclaim and close off access to the cutblock quickly, which limits the negative impacts on regeneration and other issues such as wildlife concerns.
- We can plant seedlings densely next to the debris piles and thereby maintain the productivity on valuable land base.
- Some people believe that debris piles can serve as anchor points during wildfires, i.e., areas from which to deploy equipment.
- Every cutblock is unique, so a blanket prescription should not be applied.

Alberta Sustainable Resource Development concerns

- Coniferous and deciduous slash exhibit different fire behaviour and ignition potential.
- Every cutblock is unique, so a blanket prescription should not be applied.
- We should reduce slash that is located near a community or near other human values, and therefore reduce the impacts of a fire.
- We should not pile and burn debris just to reduce operating costs. However, we should pile and burn debris if it reduces suppression costs.
- We need to investigate if we lose land base when we use debris-handling techniques other than burning. We also need to investigate whether burning sterilizes the soil, thus making the burn area unproductive.
- Given the two choices of spreading debris or piling debris, spreading debris more closely mimics nature.
- For fire containment and spotting reasons, the Forest Protection Division does not condone the piling of debris

Other concerns

- Grass encroachment following harvesting and its relationship to fire risk through the seasons and over time is a concern in east-central Alberta.

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7 For further information on the House River fire, see Baxter (2003).

- Proximity of cutblocks to each other and number of cutblocks may exacerbate fire risk. Qualitative data suggest that where cutblocks are numerous and close together, fire may spread quickly over large areas.
- The passive land base, i.e., unmerchantable timber, near communities poses a hazard. These areas require treatment to reduce the fire hazard.

Expected economic outcomes of current practices

An expected value analysis is presented to illustrate the potential economic consequences of current debris management practices.

The data for the east-central region differ significantly in both the number of fires involving harvest debris and the amount of area harvested compared to the eastern slopes area. Fires tend to be larger in the boreal regions than along the slopes of the Rocky Mountains due to topography and fuel continuity. Table 3 was derived from the fire history dataset of the east-central region of Alberta. The dataset includes fire size and costs for debris fires occurring in the region from 1961 to 1995.

The decision tree (Appendix II) shows calculated expected monetary values higher in the east-central region compared to the eastern slopes of the Rocky Mountains, because more fires occurred and because these fires have a greater potential to be larger than the fires along the eastern slopes.

Two findings are derived from the decision tree. First, in any given year burning debris has almost the same expected value as piling and not burning, or spreading debris in the cutblocks without burning. Burning debris would cost $1 297 550 annually for the region. Piling without burning produces expected costs of $1 087 390. If the last 19 years of data are used to calculate the probability of fire occurring, the data show that the exposure to a company can be very high by not burning debris (Appendix II). Minimum exposure is $0 (based on one year that had no debris fires). The mean exposure on an annual basis would be $1 055 530, based on an average of 14 fires per year involving debris. Maximum exposure (which may be typified by a year like 2002) is $2 865 010. However, this value is influenced by one year within the study period that had 38 fires. The values in the decision tree are calculated using mean fire sizes and the costs per hectare of these fires. The "exposure" calculations do not include the loss of regeneration which is a time investment, or the impact on fibre flow resulting from a large fire. Although burning debris may be slightly more expensive than spreading or piling/leaving, given all the costs associated with debris fires and the potential size of these

Table 3. Fires involving debris in the east-central region of Alberta, 1961–1995

Size class	Fires involving slash (no.)	Probability of fire size	Cost ($/fire)	Cost ($/ha)
A (≤0.1 ha)	267	0.436	1 107	1 107 [a]
B (0.11 to 4.0 ha)	201	0.328	3 226	1 954
C (4.1 to 40.0 ha)	93	0.152	7 185	396
D (40.1 to 200.0 ha)	27	0.044	13 324	151
E (>200.0 ha)	23	0.037	251 881	72

[a] Because Class A fires have a maximum size of 0.1 ha, the expected value is calculated on a cost/fire basis rather than a cost/ha basis as in all other size classes.

fires, burning may be the best economic choice over the long term.

If the difference in costs between burning and not burning is carried over 19 years, the difference is \$3 993 040[8] in favour of not burning. Maximum cost exposure to industry and government can be as high as \$2 865 010 in one fire season due to wildfire.

The House River fire in 2002 involved debris piles, which created difficulties in fire control efforts. This fire cost the province \$47 million, but it was not included in the dataset as it occurred after the data collection period.

Conclusions

The expected annual values for burning or not burning debris indicate that it is more expensive to pile and burn. It was shown that the difference in costs between burning and not burning carried over 19 years is \$3 993 040 in favour of not burning, and the maximum cost exposure to industry and government can be as high as \$2 865 010 in one fire season due to wildfire. These values do not include the loss of regenerating stock or the influence on the wood flow to the mill.

The following future research is needed:

- Investigate the differences in decomposition rate between piled and spread aspen debris.
- Document and compare fire behaviour in spread debris, small debris piles, and windrows. Research should include fuel-load data of spread debris.
- Investigate the costs and the effects on regeneration of spreading, mulching, and chipping debris.
- Examine how fire risk for aspen debris changes with time. Specifically, how does it change from time of harvest to time of decomposition?
- Investigate reducing the use of checkerboard patterns of small cutblocks on the landscape. This may lead to prescribing larger cutblocks separated by similarly larger areas of standing aspen which can serve as firebreaks. Allow the regenerating aspen to achieve free growing status in the large cutblocks and then harvest the reserves.
- Work with industry to develop operational standards for scanning practices.

Implementation and recommendations

The following recommendations pertain to forest industry practices, and other industries or landowners that pile or spread aspen debris to reduce the fire risk. These recommendations apply where aspen is the primary harvested species. These recommendations are also based in part on the House River fire observations (Baxter 2003).

- Separate the aspen piles by 6 to 8 m. Alberta Sustainable Resource Development recommends a minimum distance of 15 m, with an understanding that continued research and monitoring will be ongoing. Greater separation distances will decrease the potential for fire spread between piles for fires of less than 20 000 kW/m intensity. Recommended debris pile dimensions are 3 m wide and 2 m high. Windrows should not exceed 10 m in length. Debris piles should be at least 20 m from the cutblock edge to prevent fire spreading from radiant heat and spotting. Where these dimensions cannot be met, the extra debris should be spread or disposed of by other approved means.
- Spread the debris no more than 30 cm (or one log diameter) deep. This recommendation pertains to fuel loading and regeneration success. Avoid spreading debris within 15 m of the cutblock edge to reduce the probability of fire spreading into the standing timber or of fire moving from the standing timber

Note:
These guidelines comply with the Forest and Prairie Protection Act and its associated regulations.

[8] This value comes from the annual cost of piling and burning (-\$1 297 550) minus the cost of just piling (-\$1 087 390) multiplied by 19.

into the cutblock. Debris spreading might be an acceptable technique near settlements.
- Use a 10-km "pile-free" distance from communities, using the provincial Wildfire Threat Analysis Model. Spreading debris in this area may be deemed acceptable.
- Scan debris piles thoroughly before the fire season begins using infrared scanning equipment to identify potential over-wintering fires. Deal with these fires promptly. Work with industry to develop operational standards for scanning practices.

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Appendix I

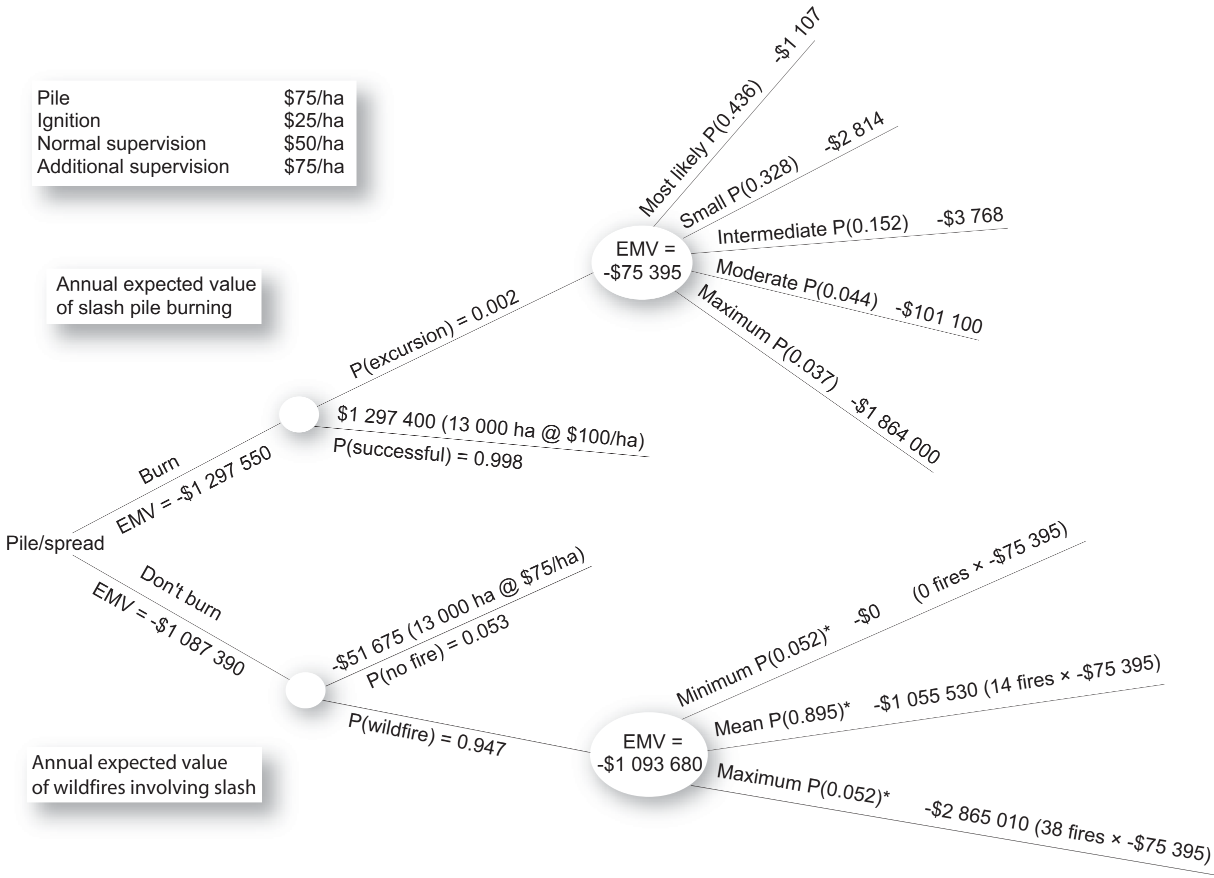
Area burned by fires fuelled by slash, in the east-central region of Alberta

The following table presents a conservative estimate of fires involving slash in the past four decades. Numbers denote only fires having fire reports that list slash as the primary or secondary fuel type. They do not include fires where slash was involved and important, but was not a primary or secondary fuel.

Year	Fires in slash fuels (ha)
1961	70
1962	0
1963	30
1964	0
1965	1
1966	8
1967	125
1968	36
1969	369
1970	20 476
1971	7 339
1972	1 175
1973	116
1974	178
1975	124
1976	311
1977	167
1978	366
1979	733
1980	3 888
1981	1 024
1982	60 872
1983	1
1984	8
1985	8
1986	4
1987	8
1988	7
1989	1
1990	3
1991	288
1992	11
1993	1
1994	33
1995	119
1996	0
1997	0
1998	80
1999	203
2000	81

Appendix II

Decision tree analysis



Most likely	0.01	ha	$1107/fire
Small	1	ha	$1954/ha
Intermediate	3	ha	$396/ha
Moderate	100	ha	$151/ha
Maximum	2000	ha	$72/ha

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.

* Probabilities calculated using annual fire frequency data for 1982–2000 for the east-central region where 278 fires occurred over 19 years and where 18 of those years had fire.