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Contents

Management of harvesting debris along the eastern slopes of Alberta's Rocky Mountains

Abstract

Forty years of historical fire data are presented and used to calculate the expected costs of the two current approaches to managing harvesting debris along the eastern slopes of Alberta's Rocky Mountains. These two approaches are to burn the debris piles or to leave them unburned within the cutblock. Recommendations on the management of this debris are made to forest operators within this region.

Keywords

Fire history, Harvesting debris, Top piles, Debris management, Rocky Mountains, Chinook winds, Alberta.

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Introduction

The area south of 53° N latitude in western Alberta—the eastern slopes of the Rocky Mountains—is distinct from the rest of the province and characterized by its steep slopes, high volumes of decadent timber, unreliable snow packs, and unpredictable strong Chinook (foehn) winds. Forest companies in this region consider the burning of harvesting debris piles[1] risky, in terms of both loss of timber volume and the costs associated with an excursion.

The fire history of slash fuels in Alberta (Baxter 2002) shows the number of fires involving slash fuels has decreased considerably since 1985 when roadside harvesting became the common logging practice. Although fewer wildfires are taking place, large difficult to control fires still occur along the eastern slopes, and these influence policies and actions within the forest industry and government.

Data from the provincial fire history showed different trends for slash fires in different regions of the province, influenced by the physical environment and the harvested species. Therefore, FERIC divided the province into four regions for more in-depth fire history studies and debris management recommendations. The four regions are: the eastern slopes of the Rocky Mountains (south of 53° N latitude); the east-central region (Slave Lake East—deciduous operations); the west-central region; and northern Alberta. This report focusses on the eastern slopes of the Rocky Mountains, and develops and presents recommendations for the management of harvesting debris.

Objective

The objective of this study was to develop debris management recommendations specific to the eastern slopes 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 management techniques, and

[1] Consisting of tops and limbs removed from stems during mechanical processing.

discussions with regional forest industry personnel, to develop recommendations specific to the conditions of the area.

Methods

All fires occurring in this eastern slopes region and involving slash[2] as a fuel type—including Canadian Forest Fire Behavior Prediction (FBP) System fuel types (Forestry Canada Fire Danger Group 1992)—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 and direction at the time the fire was reported. Linear trendlines were developed using Microsoft Excel© for the number of fires and hectares burned per year. The fire history data were combined with observations made during field trips and discussions with forestry personnel working along the eastern slopes region. Because wind speed is reported at time of initial attack, there may be variations in the strength over the course of the fire.

Expected value theory (Newendorp 1975) was used to illustrate the economic outcomes associated with the two management options for handling harvested debris—piling and burning the debris, or piling it to decompose on the landscape. Expected values were developed using the probability of debris fires classified by size and cost, including fires escaping from debris piles and wildfires involving debris piles. Costs are estimated using actual piling and ignition costs from operations on the eastern slopes. For ease of calculation, 250 m^3 of timber per hectare are assumed with the value of $860/ha, as used by the Alberta Sustainable Resource Development for its fire report calculations (ASRD 2001). This value includes the standing timber, the annual allowable cut, and reforestation costs. Probabilities were derived from the provincial fire history data and anecdotal evidence from industry personnel. The expected monetary values (EMV) of various scenarios were then calculated to illustrate expected costs from fires in slash fuels along the eastern slopes.

The outcomes from the expected value calculations were used to develop the recommendations for debris management.

Definitions used in this paper

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, meaning a 37% probability of occurring.

Expected monetary value (EMV): the product obtained by multiplying the probability of the outcome occurring by 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.

[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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Results and discussion

To understand current debris management in this region, FERIC discussed the issues with both industry and government personnel operating on the eastern slopes. These discussions are summarized and presented as three main issues: fire behaviour, regeneration, and wildlife.

Fire behaviour

- Top piles left on the cutblocks are a fire hazard for 30 or more years (visual observation).
- When heavy fuel loads result from the harvest of decadent forests, treatment is required to reduce fire hazard.
- Steep slopes increase fire intensity and rates of spread.
- On steep slopes, determining the least hazardous location for debris piles is problematic.
- Piles were observed less than the 8 m distance from the block edge or standing timber that is required by current legislation.
- In the Blairmore area, recent pile-burning experience is low.
- Anecdotal evidence suggests that top-piles are a hazard to other resources such as standing timber. The forces of a fire in these piles can project embers many metres (even after the fire has been controlled).
- The Cherry Hill Fire of 2000 started in three consecutive roadside piles. These piles continued to burn after the fire front had moved on, spotting new ignition points in windy conditions.
- Predicting when and where strong Chinook winds will occur is the major issue influencing the scheduling of prescribed pile burning along the eastern slopes. This forecasting is not normally supplied outside of fire season operations. However, the Provincial Forest Fire Centre may provide a Chinook forecast if requested.[3]

Wildlife

- Wildlife utilize the piles left in the cutblocks. Therefore, it is important to retain some piles for habitat.

Regeneration

- The protection from sun and wind offered by piles and debris is important for regeneration (when the regeneration is located on the leeward side of the debris).
- The required regeneration standards can be achieved even when debris piles are left on-site.
- After 10 years, the risk of fire spread in regenerated stands is greater than the hazard posed by the piles.
- Currently, in the Blairmore area, 5000 unburned piles occupy an area of approximately 100 hectares of potential plantable space. Some of these piles are 15 or more years old, and very large (15 × 8 × 5 m).

These observations and concerns are addressed in this report.

Fire history

The number of wildfires and fires involving slash fuels in the eastern slopes region are proportional to the region's size, when compared to the provincial protection area (Table 1).

The number of slash fires per year along the eastern slopes (Figure 1) is generally decreasing although the 1996–2000 mean shows an increase. This general decrease is in part due to a better awareness of the potential risks of slash burning and an increase in the precautions taken.

Wildfires involving slash, by season

At a provincial level, wildfires involving slash on the eastern slopes make up 13% of

[3] L. Avis, meteorologist, Alberta Sustainable Resource Development, Edmonton, Alberta, personnel communication November 2001.

Table 1. A comparison of the size and the number of fires for the eastern slopes region and the Province

	Provincial green zone	Eastern slopes region	Eastern slopes as proportion of total (%)
Area (km^2)	351 381	39 009	11
All wildfires 1961–2000 (no.)	33 738	4 231	12.5
Wildfires involving slash 1961–2000 (no.)	3 224	410	12.7

Figure 1. The number of wildfires involving slash, by 5-year time period, in the eastern slopes region.

all these fires in the province. From the 1960s through the 1980s, the eastern slopes region contributed 33% of all winter wildfires in slash, but this dropped to 11% over the last decade. The decrease suggests a larger percentage of winter fires now occur farther north—perhaps reflecting changes in climatic patterns or increased harvest levels in the north (Table 2).

Table 2. Total number of winter wildfires involving slash along the eastern slopes, by time period [a]

Month	1961–70 (no.)	1971–80 (no.)	1981–89 (no.)	1990–2000 (no.)
January	1	3	8	2
February	4	2	5	1
March	12	2	7	5
November	4	12	7	1
December	1	3	4	2
Total winter fires	22	22	31	11

[a] Time periods are of different length because the attributes in the provincial fire history database change.

The probability of a wildfire occurring in slash in a given year anywhere along the eastern slopes, P(slash fire), is relatively high at 0.975. Wildfires in slash occurred in 39 of the 40 years included in the analysis. The P(of an excursion) is less likely—1 per 1000 debris piles burned, a P of (0.001). Even with this low probability, several notable fires in the 1990s have kept industry well-aware of the risk associated with pile burning. The 1997 Gregg River Fire (not included in this dataset) and the Cherry Hill Fire near Blairmore in August of 2000 both had ignition points in piles, and were spread by strong west winds.

Occurence of fires and area burned

The mean annual number of fires involving slash has decreased since 1985 (Figure 2). Skidding full tree with roadside delimbing became the common harvest technique during the mid 1980s. This

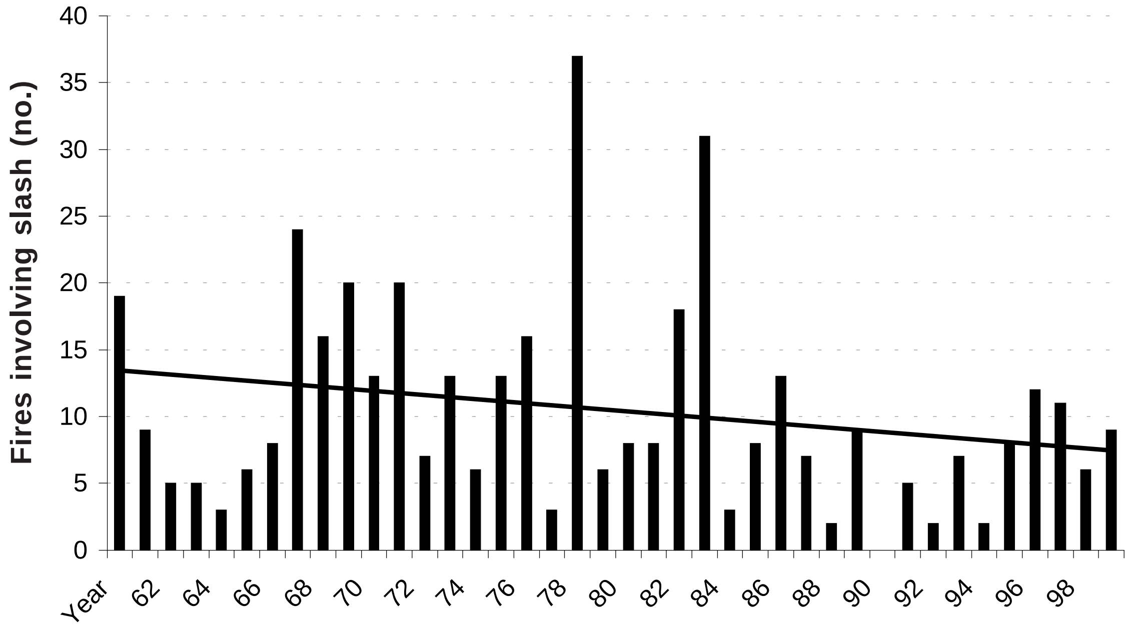

Figure 2. The number of wildfires involving slash, per year, along the eastern slopes from 1961 to 2000. The mean value is 10.25 fires/year. The trend line shows a gradual decrease in fire numbers.

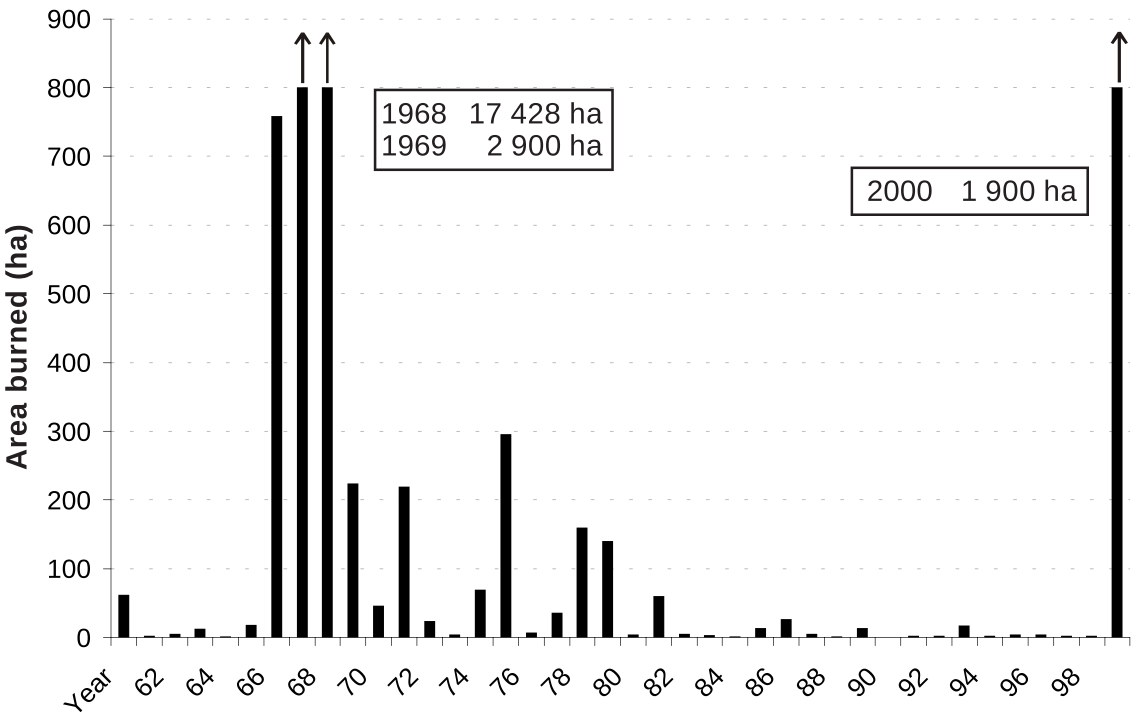

Figure 3. The number of hectares burned by wildfires involving slash, per year, along the eastern slopes from 1961 to 2000. The values in the boxes represent the actual hectares burned for the three years where area burned is beyond the scale.

change in practices concentrated debris over less area, which may explain the decrease in fires.

The decrease in the number of hectares burned (Figure 3) coincides with changes in the province's Pre-suppression Preparedness System (PPS) and other developments beginning in 1982 (e.g., the formation of the Rapattack program). This suggests that the initial attack system has been effective in reducing fire size and losses, at least during the summer months in this region.

Fire size and firefighting costs

Table 3 shows the proportion of fires and cost of suppression by fire size class, for wildfires in slash along the eastern slopes for the period 1961–2000. Later in the report,

Table 3. Fire size and cost of suppression for wildfires involving slash					
	Class A fire size 0.01–0.1 ha	Class B fire size 0.11–4.0 ha	Class C fire size 4.1–40.0 ha	Class D fire size 40.1–200.0 ha	Class E fire size >200.0 ha
Proportion of fires (%)	70	20	4	4	1
Cost of suppression ($/fire)	608	2 500	3 663	7 200	52 177

Table 4. Mean cost/fire for selected time periods				
	1961–70	1971–80	1981–89	1990–95
Mean cost for all wildfires ($/fire)	2 794	6 791	13 893	16 492
Mean cost for all wildfires involving slash ($/fire)	2 631	5 133	29 600	52 189

[a] values in dollars current for each time period.

this information is used to calculate expected values for fires involving debris. Although the total cost spent on a fire increases with size, the cost/hectare decreases.

Wildfires involving slash have higher mean cost than all wildfires combined (regardless of cause) (Table 4). The high concentrations of fuel in slash fires mean the amount of equipment, the number of firefighters, and length of time required to extinguish the fire are greater than for fires without slash involvement. As well, the cost/fire has risen dramatically since 1981 for all fire types, primarily due to the greater use of aircraft.

Wind speed and wildfires involving slash

The mean wind speeds for slash fires caused by industry are higher than those for all slash fires (Figure 4). For the period 1995–2000, the mean wind speed recorded during the fires south of 55° latitude, was 44.0 km/h, and north of this point was 30 km/h.

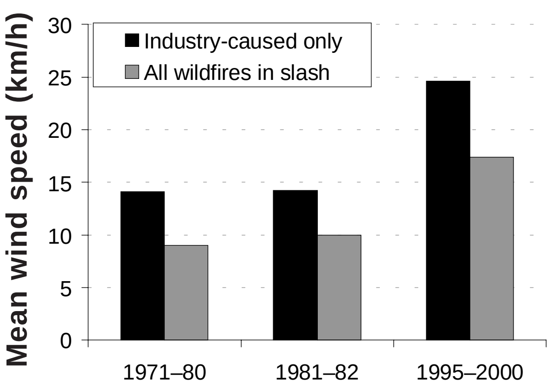

Figure 4. Mean wind speeds for industry-caused wildfires in slash compared to all fires involving slash, for selected time periods for all regions.

Chinook winds characteristically have a higher wind speed than other types of wind, and they are from the west or southwest in direction. The analysis showed these two features were common during wildfires in Alberta's eastern slopes. Chinook winds clearly play an important role in wildfire during the winter months in this region. Therefore, the probability of experiencing a Chinook must be considered before undertaking pile burning along the eastern slopes.

Expected economic outcomes of current practices

An expected outcomes exercise is presented to illustrate the potential costs of two debris management practices—piling and burning the debris, or piling it to decompose on the landscape.

Generally, expected value exercises use three scenarios when solving a statistically-based problem. These scenarios represent the minimum, most-likely (single value most frequently occurring), and maximum outcomes that can be expected based on user decisions. Fire does not follow a normal distribution for fire sizes, and the mean can be very misleading. Instead, most-likely, small, intermediate, moderate and maximum size descriptors were used for fire size, and to calculate probability and costs. Because 60% of all slash fires are spot fires (less than 0.1 ha), this value represents both the minimum expected value as well as the most likely (Table 5).

Wildfire frequency was calculated using the number of slash fires occurring each year in the study area for the period 1982–2000. During this 19-year period, 161 wildfires involving slash fuels occurred, with annual fire frequencies along the eastern slopes shown in Table 6.

Table 5. Size, probability, and cost for the five fire size classes used in the expected value calculations

Scenario	Size (ha)	Probability	Cost
Most likely	up to 0. 10	0.6	$608/fire [a]
Small	0.11–2.0	0.265	$1000/ha
Intermediate	2.1–4.0	0.045	$1000/ha
Moderate	4.1–200	0.08	$100/ha
Maximum	1 900	0.01	$104/ha

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

Table 6. Frequency of wildfires involving slash, 1982–2000

Year	Wildfires involving slash (no./year)
1982	7
1983	18
1984	31
1985	3
1986	8
1987	13
1988	7
1989	2
1990	9
1991	0
1992	5
1993	2
1994	7
1995	2
1996	8
1997	12
1998	11
1999	7
2000	9

Probability of occurrence was calculated as:

- Fires occurred in 18 of 19 years, thus the P(fire) = 0.947
- Maximum number of fires (31) occurred once for P = 0.052
- Minimum number of fires (2) occurred three times in 19 years = 0.157
- Mean = 8.5 fires/year and we will use 14 of 19 years, for 0.736
- Other costs used in the expected outcome calculations:
  - Piling: $75/ha
  - Normal supervision until fire extinguished: $50/ha (includes scanning, etc.)
  - Extra protection efforts: add up to $125/ha.

Additional protection includes additional equipment, sprinkler systems, patrols, etc. This cost is added to illustrate potential costs if industry is interested in adding additional protection efforts.

Decision tree analysis

The decision tree developed from the expected value information (Appendix I) is read from left to right, and the probabilities for each chance node sums to 1.0. The outcomes of this analysis are to be read for the region as a whole, even though calculations are presented by the hectare.

Because the legislated and most common practice is to pile tops and branches, we begin with the action of *PILING*, with a probability of 1.0 (that is, the act of piling debris is assumed to be a certainty). Two decision nodes branch from this—burn the piles or don't burn them. There are no probabilities associated with these nodes as they are decisions made by the forest manager.

Burn the piles

Two scenarios are possible at this decision node—pile burning is successful or it is not. Data show a 0.999 probability that the burn is successful. The probability of an excursion is calculated to be 1 in 1 000 piles burned or 0.001. If the burn is successful (P(0.999)), 10 000 piles are burned with 2.8 piles/ha, and the burning cost is $100/ha, then the EMV is $-357 142.

If an excursion occurs, five possibilities may result. The most-likely outcome, a fire 0.1 ha in size, has a probability of 0.6. This value is combined with a mean fire cost of $610/fire. Timber resource loss is negligible in this case. The probability of the fire being 1 ha in size is 0.27 and the costs of this fire would be $1 000/ha for firefighting and $860/ha in lost forest resources, for a total EMV of $-1 860. The EMV for fires of other sizes are calculated the same way and are as follows:

- 3 ha fire: EMV is $-5 580.
- 100 ha fire: EMV is $-96 000.
- maximum size fire: EMV is $-1 831 600.

The calculated EMV is then multiplied by the respective probabilities to determine an expected cost for this node.

The EMV for this node is $-17 957. This is multiplied by the P(excursion) (0.001) for an EMV of $-17.95. The EMV of a successful burn is calculated using the 10 000 piles at 2.8 piles/ha, and $100/ha for a value of $-356 784. The *Total Annual Expected Value* of slash-pile burning is the sum of these nodes, $-$356 802.

- Given an excursion, the expected cost is $-17 957.
- A company's minimum exposure is $-610 for a fire and,
- A company's maximum exposure is $-1 831 600.

Don't burn the piles

If slash piles aren't burned, two scenarios are possible—a wildfire ignites in the piles or involves the piles in some way, or no wildfire occurs in the unburned piles. The P(wildfire involving slash fuels) is 0.947. This is based on fires in slash fuels occurring in 18 of the 19 years of data (from 1982 to the present). P(no fire) then is 0.053.

If a wildfire does occur in a given year, the three potential outcomes are:

- The cost of a minimum number of slash fires (3 × $-17 957) is $-53 871 (from expected cost of an excursion). The probability of the minimum number of fires is P(0.157).
- The mean number of fires, 8.5, would cost $-152 634 with P (0.736).
- The maximum number of fires, 31, would cost $-556 667.

The total expected cost of a wildfire is $-149 743 with a P(0.947). The only costs associated with having no fire are the piling costs. This is calculated to be $-267 857 based on an average of 10 000 piles burned annually at $75/ha (2.8 piles/ha). Summing the two chance branches we get a final Annual EMV for slash-pile wildfires of $-156 002.

The exposure for the annual costs associated with wildfires involving unburned slash piles is:

- $-149 743 expected exposure
- $-556 667 maximum exposure
- $-53 871 minimum exposure

The annual expected value of slash pile burning is $-356 802.

The annual expected value of wildfires in slash fuels is $-156 002.

In this study, the decision tree is not all-inclusive. Other potential scenarios are:

- The probability of a wildfire following a successful pile and burn program. At the Virginia Hills Fire of 1998, piles were burned on the cutblocks but the area still experienced a wildfire.
- The decision tree does not differentiate between summer and winter fires.
- Extra protection using firebreaks and less hazardous pile locations within a block is not incorporated as a cost in the pile and don't burn scenario.
- P does not change even if a successful pile and burn results from additional supervision and related costs.

An example of expected costs

The scenarios in Table 7 assume that a 1900-ha wildfire starts in or involves slash fuels once in 20 years, and 500 ha/year contain piles (with 2.8 piles/ha).

Piling and burning, even with additional supervision, is less costly than piling and not burning, and experiencing a large wildfire

Table 7. Three scenarios for treatment of harvesting debris			
	Scenario 1 Pile / not burn / wildfire	Scenario 2 Pile / burn	Scenario 3 Pile / burn / increase supervision
Piling costs ($)	750 000	750 000	750 000
Ignition costs ($)	0	250 000	250 000
Fire suppression costs ($)	197 600	0	0
Value lost ($)	1 634 000	0	0
Supervision ($)	0	500 000	1 250 000
Total ($)	2 581 600	1 500 000	2 250 000

withing the cutblock. It is less expensive over a 20-year period to double prevention efforts than it is to be liable for a large wildfire.

Conclusions

The fire history study for the eastern slopes of Alberta's Rocky Mountains showed a number of trends over the past forty years. Slash fire numbers have increased consistently since 1986–89, although they have not yet reached pre-1985 levels. However, the number of winter slash fires along the eastern slopes is decreasing. The annual area burned since 1982 has decreased, coinciding with changes in the province's wildfire management program (e.g., the development and use of a formal, systematic PPS). Over the forty-year period, large fires (i.e., over 1900 ha) occur roughly once every 8 years, but only one large fire has occurred since 1980 (1 year in 20). Industry-caused slash fires are more expensive to extinguish than all other wildfires. Examination of the weather conditions at the time of initial attack showed Chinook winds have a pronounced influence on industry-caused fires involving slash.

The analysis of expected economic outcomes compared the probabilities and costs of various scenarios to determine expected values. Although on an annual basis, piling and not burning is a cheaper alternative, the probability shows that a large fire will occur, exposing a company to large financial losses; therefore, extra protection while burning is more cost effective over the long term. Expected industry/provincial losses to slash-pile wildfires will remain significant at $149 743 annually.

One cost-effective way to reduce these potential costs is to burn harvesting debris. Burning need not be as risky as commonly believed. Response times and firefighting efficiency appear to be at optimum levels; only one excursion in 1000 piles burned and one significant wildfire occurred in the last 20 years.

Implementation and recommendations

The following recommendations are put forward for pile burning along the eastern slopes.

Burn plans

The current regulations (Alberta Lands and Forest Service 1994) state: "Removal of these piles …… by burning, does not require an approved prescribed burn plan provided the following criteria are met:

a) The Forest Protection Supplement of the Annual Operating Plan (TM 118A) is completed for all timber dispositions, or:

b) The Forest Duty Officer is notified, prior to ignition, on the day of the burn that the project is to proceed."

However, a simple and easy to complete burn plan is recommended to accompany the Operating Plan. This plan would include the analysis of the specific risks associated with burning piles in a specific area, at the planned time. The burn plan would include information on the following factors:

- percentage of ground covered by snow at the time of ignition. A rainfall equivalent should be calculated to track the Buildup Index (BUI) of the Fire Weather Index (FWI) system (Van Wagner 1974).

- extended weather forecast (5 day): this spot forecast should be requested from the Provincial Forest Fire Centre fire weather meteorologists including a P(Chinook) (probability of a Chinook occurring).
- age of piles (which influences rate-of-burn) and number of piles/day to be burned.
- a description of piles which are anticipated to present problems, and any special considerations for burning them.
- end of fire season FWI values (provide an indication of the state of the fuels). In grass areas, calculate a daily Fine Fuel Moisture Content (FFMC).
- map of ignition pattern, including how the problem piles will be handled.
- resources on-site and excursion plan, including values at risk.
- identify fire boss and certification.
- expected results: post-fire fuel loading.
- soil type and its influence on fire behaviour, e.g., potential for ground or subsurface fires in organic soils.
- Communications Plan.

Location of piles within a block

A minimum of 75 m should be between a pile and the adjacent timber, and at least 50 m between piles, to reduce the risk of spotting and scorching.

Wildlife piles

Currently, 10 wildfires involving slash occur each year along the eastern slopes and 90% of these are less than 4 hectares in size. If the number of piles on the landscape is reduced by safe-burning practices, the number of wildfires will decrease. Debris piles are important wildlife habitat, and therefore some must be maintained. If one in four debris piles is retained, the overall probability of a wildfire involving slash will still decrease substantially. These piles would be pre-selected[4] and marked, with the approval from Alberta Sustainable Resource Development.

Size of piles

Establish a maximum pile size based on potential fire intensity and the resulting flamelength to reduce spotting and scorching.

Supervision

Maintain close supervision of burning piles, especially during moisture-deficit periods.

Develop a Chinook map. This map would depict the influence of the Chinook along the entire eastern slopes, and would assist the forest industry when designing cutblocks and identifying where more caution should be used when burning. Relative wind strengths would also be mapped.[5]

Extinguishing burning piles

Extinguish burning piles if P(Chinook) is greater than or equal to 0.41 over the five-day forecast period. If P(Chinook) is less than 0.15 for the five day extended spot weather forecast, burning may proceed. If P(0.15–0.40), additional resources should be on site. If P(>0.41), burning should not occur until the risk decreases.

Burning to reduce risk

Burn existing piles at the earliest opportunity to reduce the overall risk.

Alternative fuel reduction options

Investigate other fuel reduction options such as mechanical removal or use debris as hogfuel for co-generation, especially in high-risk Chinook areas.

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4 Crowsnest Area Policy: Policy No: FM 1.0 Subject: Debris Piles in Cutblocks.

5 An eastern slope scale map can be developed using wind flow models for approximately $35 000 Cdn.

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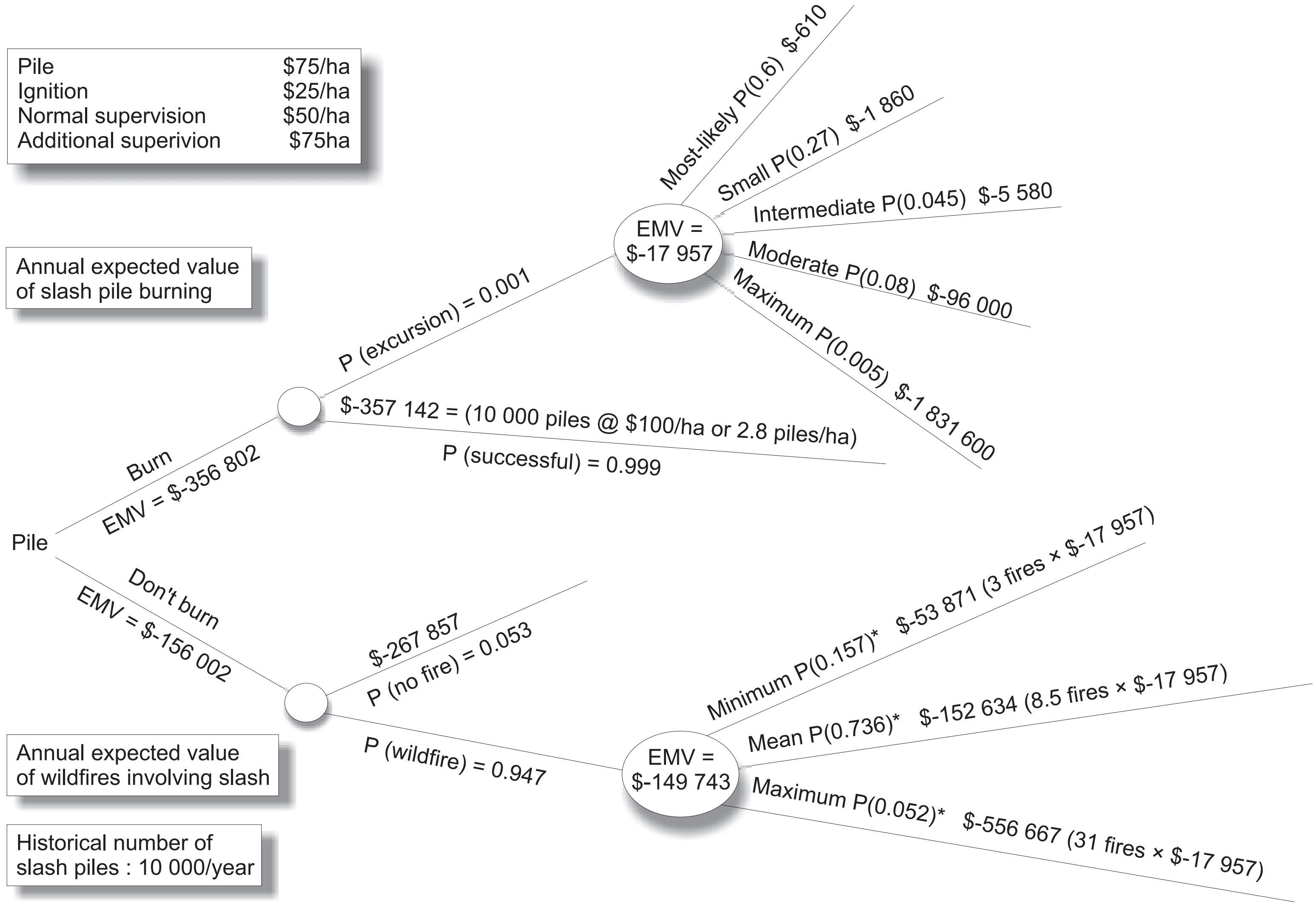
Appendix I
Decision tree analysis



Most likely	.01 ha	$610/fire
Small	1 ha	$1000/ha
Intermediate	3 ha	$1000/ha
Moderate	100 ha	$100/ha
Maximum	500 ha	$104/ha

Timber lost due to fire is valued using current Alberta Lands and Forest Service values which are $860/ha.

* Probabilities calculated using annual fire frequency data for 1982–2000 for 161 fires over 19 years. Fires occurred 18 of those years.