Analysis of the Occurrence and Cause of Fires in Slash Fuels in Alberta for the Period 1961-2000

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Introduction

Both the Alberta Sustainable Resource Development (ASRD) and the forest industry within Alberta have voiced concerns over debris burning in Alberta. The ASRD views the debris as a fire hazard, both as ignition points and as a result of wildfires moving into the unburned debris. Industry is concerned over the potential liability from escaped pile fires.

Approximately 42 000 hectares of land are harvested annually in Alberta (Natural Resources Canada 2000) producing a large amount of debris, usually in piles. The current management technique is to burn the debris, resulting in a risk of fire escape. Unburnt slash piles may also create control problems and spotting[1] when wildfires burn into a cutblock. These risks affect fire control efforts and create potential financial and fibre losses, as the expense of a large fire can have a substantial impact on a forest company. However, the overall risk posed by unburnt top-piles, either as ignition points or for the hazard they represent as concentrations of fuel, has not been previously quantified.

Forest companies are now investigating alternatives to the practice of burning the debris, including changes in pile configurations (size and shape), spreading the debris, or piling and not burning.

Presently, about 80% of the debris piles in Alberta are created by roadside processing. The Provincial Policy (Forest and Prairie Protection Regulations Part II), in place for 14 years, requires the forest industry to pile and burn. This policy coincided with the introduction and application of mechanical processing equipment that enabled stems to be more efficiently topped and delimbed at roadside or landings. Before this, stems were topped and delimbed at the stump and the debris was left in cutblocks with fireguards built around the blocks. Another common practice was to pile the tops and limbs, and then build fireguards around the pile.

Because wood decomposition in Alberta is slow, top-piles are a long-term fire risk, remaining a fire hazard for 30 or more years. Decomposition of debris on the ground surface, although slow, is more rapid than when wood is piled. When piled wood dries in the air, it is resistant to decay and decomposition time increases.

[1] Definition – a fire ignited by firebrands that are carried outside the main fire perimeter by air currents, gravity, and/or firewhirls. Source – The 2000 Glossary of Forest Fire Management Terms. The Canadian Interagency Forest Fire Centre (CIFFC).

Top-piles are defined as piles or windrows of debris produced by the topping and delimbing of trees during harvest operations. The term 'slash' is used interchangeably with top-piles because the description 'top-piles' is not included in the fire history database as a fuel type. Slash includes debris from top-piles, debris left on a cutblock, and material produced from land clearing activities (e.g., the oil and gas industry). In this report, slash is any accumulation of woody debris. The term slash may be more indicative of top-piles after 1985 when piling became the more common method of debris management.

Has this technology-driven policy resulted in greater numbers of fires involving top-piles? Is it still a viable policy and practice? ASRD approached FERIC to undertake an analysis using the provincial fire history database to determine if unburnt top piles constitute a problem as potential ignition points or as areas that pose other fire control problems. The results may provide the foundation for industry and policy makers to either continue with 'business-as-usual' (pile and burn) or examine alternatives to this practice.

Objectives

The objective of this fire history study was to investigate whether the current practices are the appropriate strategy in terms of the fire risk created by the top-piles and to provide this information to policy makers to assist in future decisions. Which practice will result in the least loss from fire involving harvest debris? Do debris piles constitute a problem as 'potential ignition points' for lightning or man-caused fires or as areas that pose or create other fire control problems during the control or extinguishment of wildfires involving debris piles?

To accomplish this, we quantified the risk slash piles create by comparing the number of slash fires to the overall number of wildfires that occur in Alberta. These fires were sorted and presented by:

- Location
- Cause
- Season
- Cost
- Size

If new guidelines are required, outcomes from the fire history study may be used in developing guidelines for debris disposal by the forest industry in Alberta.

Methods

Fire history data from archives kept by the Forest Protection Division of ASRD were used for this report[2]. Because the data are available in electronic format from 1961 to the present, this time period was chosen for this study. Any fire involving 'slash' as either the primary or secondary fuel, or with the word 'slash' included as a comment, was included in the analysis. The data were organized by size, location, cause, cost and other attributes. These final datasets were then used to quantify the fire history of slash fuels. Over the last 40 years, slash has been

[2] These data are found at http://envweb.env.gov.ab.ca/env/forests/fpd/index.html.

recorded in different ways (Table 1). The way fire cause has been archived has also evolved over time (Table 2).

Table 1. Descriptors of slash in the database from 1961 to present.

Year	Attribute	Description
1961–82	PRIFUEL SECFUEL	slash
1961–82	COVER	clearcuts
1983–93	FUELSPEC	slash
1994–2000	FUELSPEC	S-1;Jack or Lodgepole Pine slash S-2; White Spruce-Balsam slash
1983-2000	FUELTYPE	written description e.g., brush pile

Table 2. Changes in descriptors of fire cause from 1961 to present.

Year	Attribute	Description
1961–82	SPECAUSE	includes causes from Lightning to playing with matches
1983–90	ACTIVITY	causes 1 to 23
1991–94	ACTIVITY	causes 1 to 29
1995–2000	ACTIVITY	causes 1 to 29

Fire location (Forest) was consistent until 1995 when Alberta was reorganized from 10 Forests to 4 Regions. For consistency, the data from 1995 are categorized by Fire Number (where the 'old' Forests still appear as Districts) and placed into the appropriate Forest.

Slash fire data were sorted by cause, location and time of year. Fire Weather Indices (FWI) and weather conditions associated with the slash fires were also examined.

Results and Discussion

Slash fires as a percentage of all fires in Alberta

The number of fires involving slash fuels was compared to the total number of forest fires occurring in the Provincial fire protection area (green zone) (Figures 1 to 3). Results are presented by time period to illustrate trends and for consistency. A further classification of the data to illustrate the changes around 1982 was done. Figure 1 shows the total number of forest fires per year occurring in Alberta by decade. The annual number of fires involving slash, by time period, is shown in Figure 2.

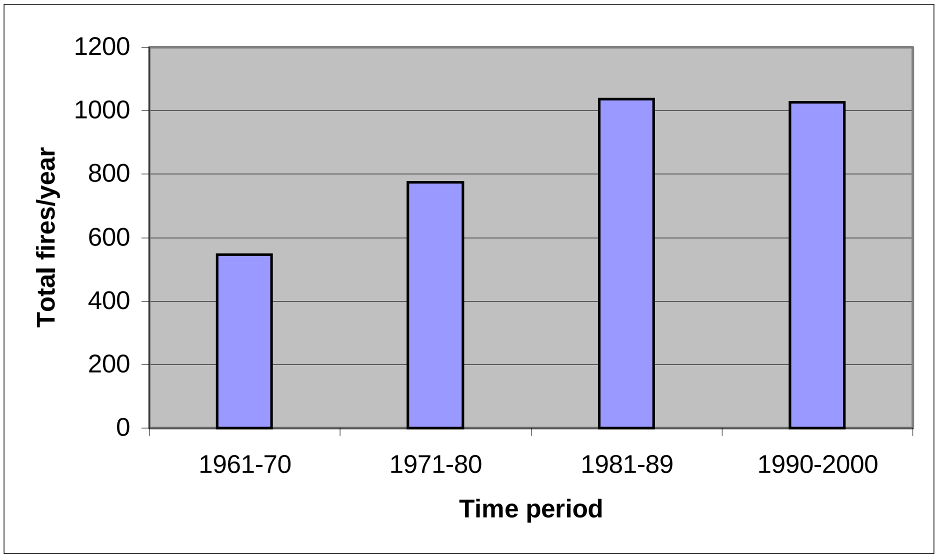

Figure 1. The total number of reported forest fires/year in Alberta over the last four decades.

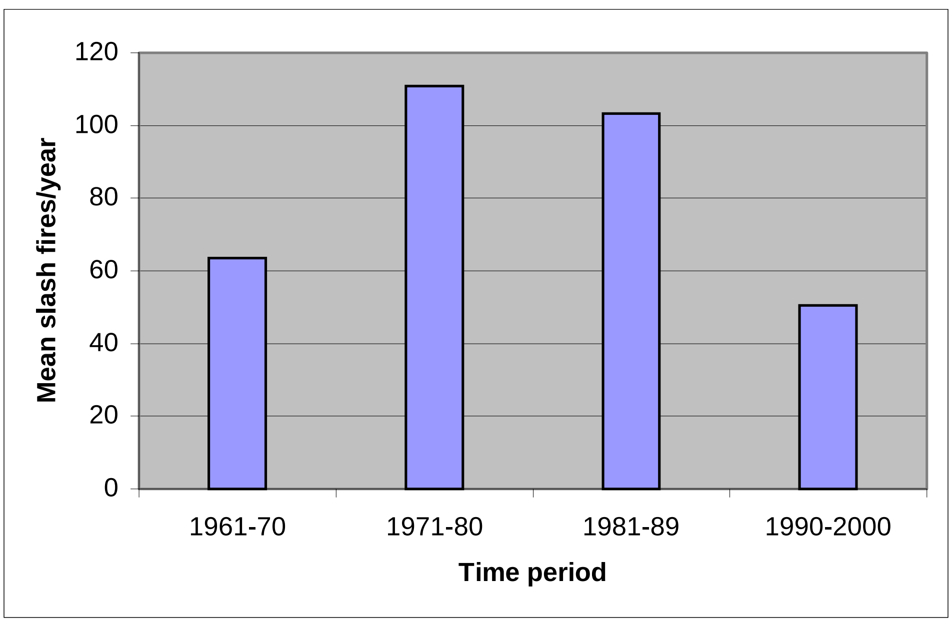

Figure 2. The mean number of slash fires/year by time period from 1961 to 2000.

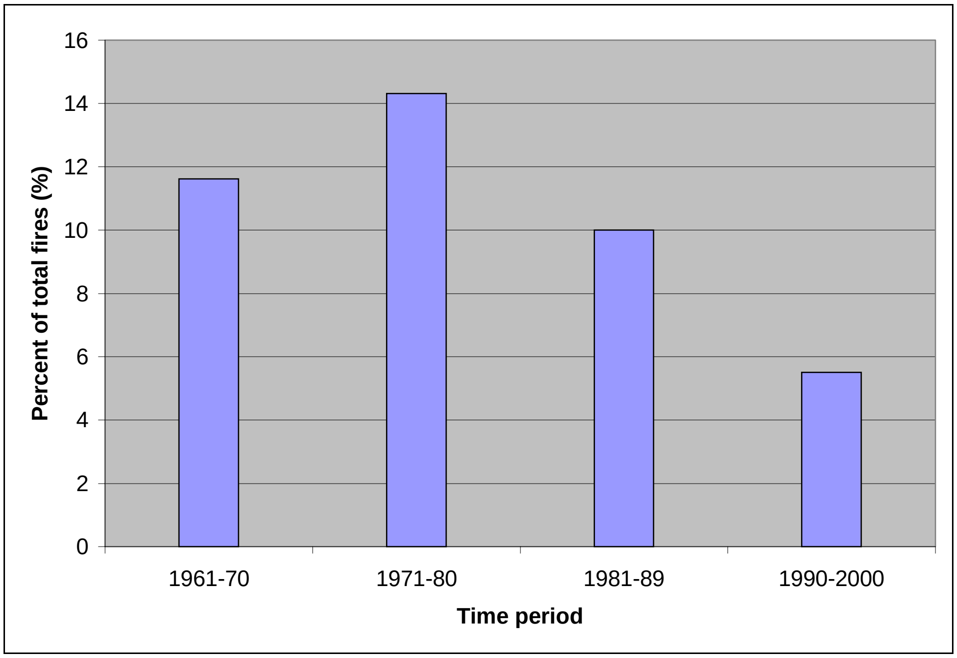

Figure 3. Slash fires as a percentage of the total number of forest fires in Alberta by decade from 1961 to present.

Figure 3 shows that the percentage of fires involving slash has decreased over the last four decades even though the number of provincial fires has increased (Figure 1). Better detection (including more efficient initial attack) and warmer summers are believed to have contributed to the increase in the overall number of forest fires reported.

A comparison of the number of hectares burned per decade does not show the same trend as the number of fires (Table 3). This is a common feature of fire statistics because average size of fires can vary greatly between years.

Table 3. Annual area burned and number of slash fires, by time period.

Time period	Area burned by slash fires (ha)	Slash fires (total)
1961–70	69 271	635
1971–80	43 750	1 108
1981–89	566 855	749
1990–2000	11 473 [a]	556

[a] Slash was not an official fuel type for any of the large Slave Lake fires in 1998 and therefore is not reflected in the hectares burned.

Slash fires, by month of occurrence

When slash fires are presented by month (Figure 4), the data show a very high number of fires occurring in May. High numbers of slash fires during 1971, 1972 and 1973, result in the peak for that month.

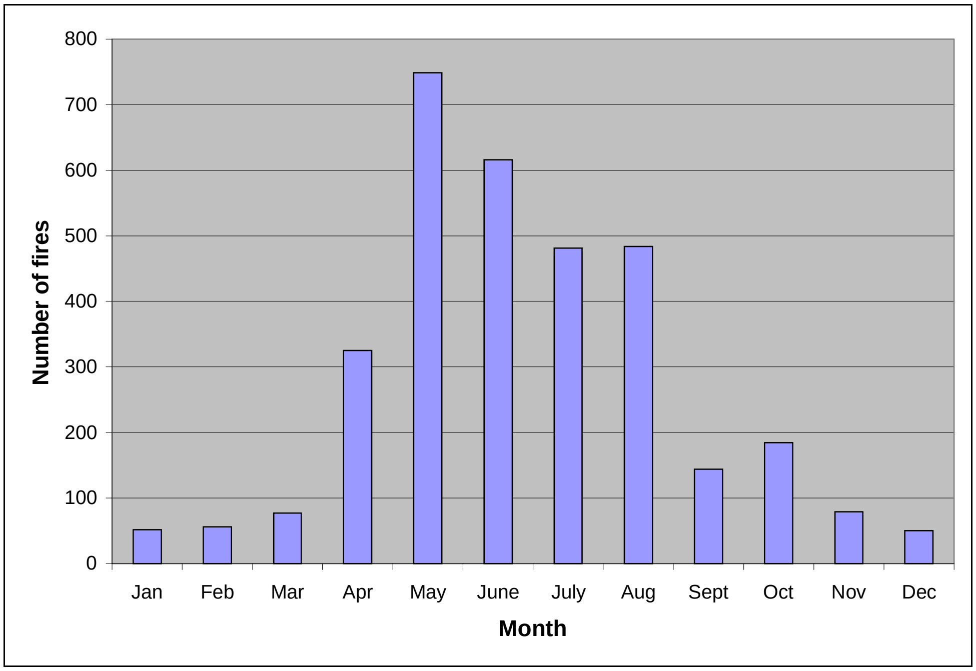

Figure 4. The numbers of fires involving slash fuels by month since 1961.

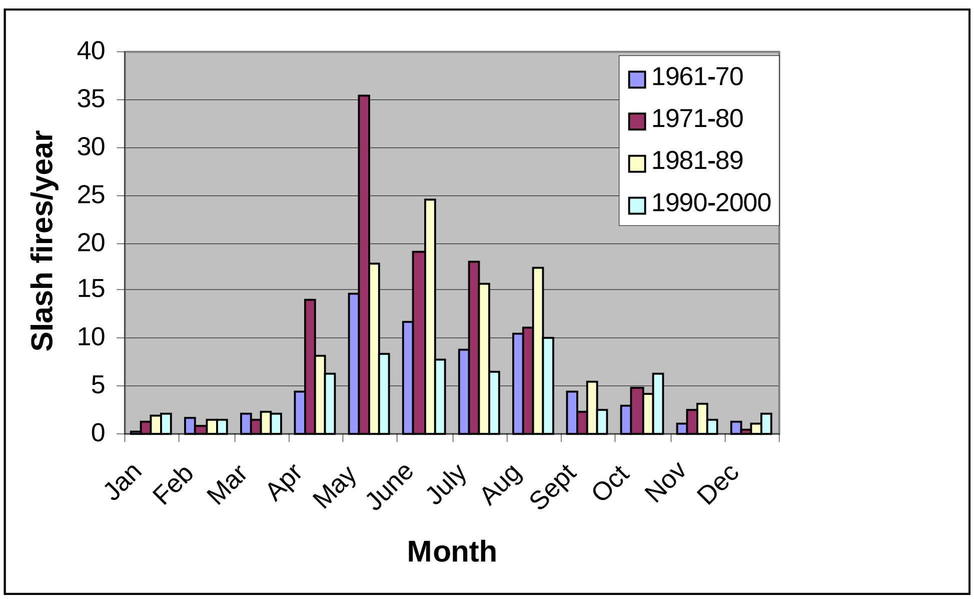

Figure 5. Number of slash fires/year from 1961-2000 by month. The active slash fire season coincides with the normal high activity season, especially May and June.

Fire numbers have increased slightly during the winter months in the 1990s, particularly in October, December and January (Figure 5). Figure 5 also identifies May to August as the months with the highest occurrence of fires involving slash fuels. These are also the most active months for fire activity in the Province and it is not surprising that more slash fires do occur during this period. The results for May are consistent with Johnson *et al*. (1971) who found the greatest number of slash fires in Alberta occur in spring. If a fire occurring over the winter did not result in expenditures to ASRD, it would not receive a fire number, and therefore would not be present in the database. However, there is little indication that many fires were missed for this reason.

The number of winter slash fires has been increasing since the 1960s (Table 4). Reasons may include more industry-related activity during these months and milder winters.

Table 4. Winter slash fires/year for the entire province.

Month	**1961–70**	**1971–80**	**1981–89**	**1990–2000**
January	0.3	1.2	1.8	1.9
February	1.6	.9	1.5	1.5
March	2.0	1.4	2.3	2
November	1.0	2.6	3.1	1.4
December	1.3	.4	1.1	2.1
Total	6.2	6.5	9.8	8.9

Causes of slash fires

Four main causal factors of wildfires were identified in the study, in order of significance:

1. *Lightning*. Alberta receives high numbers of lightning strikes each year. Any fire report involving slash with lightning listed as the specific cause was identified, meaning that lightning ignited a fire that eventually involved slash fuels. Determining the occurrence of lightning actually striking and igniting top piles is from anecdotal evidence. A quick survey of personnel reporting piles ignited by lightning revealed no pattern in terms of pile location, either in the cutblock or on the landscape as a whole. It was initially assumed that piles struck by lightning would be located beside a stand or on a hilltop, but evidence showed the location of these pile fires was random.

2. Land clearing activities are a second causal group, and includes activities such as land clearing for range improvement, garbage burning, slash/brush disposal burns and hazard reduction fires from forestry, oil and gas, railroads and public projects.

3. Man – Accident includes accidental fires caused by activities such as smoking, campfires (including cooking), and children playing with matches.

4. *Man – Intent* involves any fires where vandalism, arson, grudge or employment is suspected. Again, these fires are summarized by decade (Figure 6).

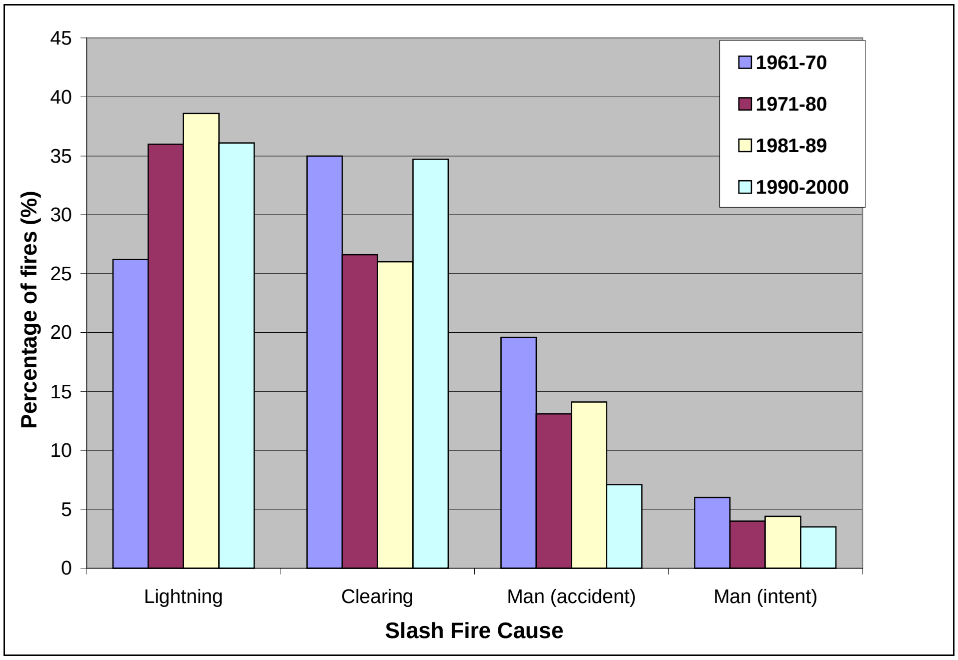

Figure 6. Slash fires by cause and decade.

While the percentages of Man (accident) and Man (intent) fires have decreased over the last two decades, the percentage of fires caused by land clearing activities has increased. Lightning is the major cause of fires involving slash fuels, igniting an average of 35% of the fires involving slash since 1971. The data suggest that arsonists do not specifically target slash.

In Figure 7, fire cause has been expanded to include fires resulting from equipment, including vehicles, heavy equipment, powerlines and flaring gas; piles, which includes re-piles and windrows; and Man (accident) which includes smoking, cooking and garbage fires. These data are from the 1983-89 time period and uses the attributes FIRE_START_DATE and ACTIVITY from the fire history data for all slash fires. One sample period was chosen as an example because the attributes change over time. Note the influence of lightning season (June-August) and the influence of grass in the spring. Spring pile burning also shows a pronounced peak that then drops during the summer period.

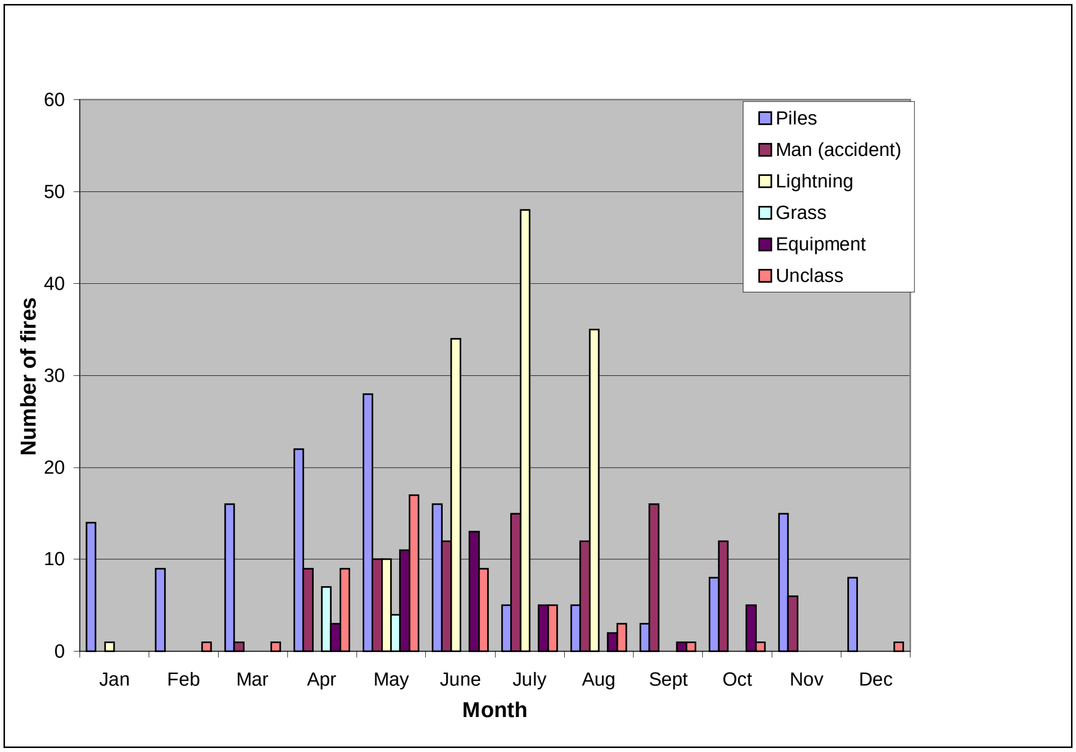

Figure 7. Slash fire causes by month.

Table 5 compares hectares burned by cause and time period. As expected, lightning fires generally burn greater numbers of hectares due to more remote ignition locations.

Table 5. Total and average number of hectares burned by time period and cause (lightning and industry).

Period	Lightning (ha)	Avg. fire size (ha)	Industry (ha)	Avg. fire size (ha)
1961–70	12 496	75	4 373	25
1971–80	25 348	648	5 840	29
1981–89	560 059	1 586	1 610	10
1990–2000	2807	11	1 619	11

Location of slash fires

Location refers to the Forest or Region where the slash fire occurred. Fire Protection boundaries within the Province have varied over time and in 1995 four Regions were implemented as the new Protection boundaries and replaced the 10 Forests. These boundaries (now Protection Districts) reverted to the original 10 Forests for the 2001 fire season and therefore the data are presented using the original boundaries. For the period 1995 to 2000 the districts within the

Regions were extracted from the data (these boundaries are very similar to the original Forest boundaries and in fact, the 10 Forests appear as Districts within the Regions). Other changes in jurisdiction include the merging of Forests. For example, Clearwater Forest combined with Rocky in 1982 and the data prior to this date are included in the totals for the Rocky Forest. Figure 8 shows the average number of fires involving slash fuels by Forest for time periods from 1961 to 2000.

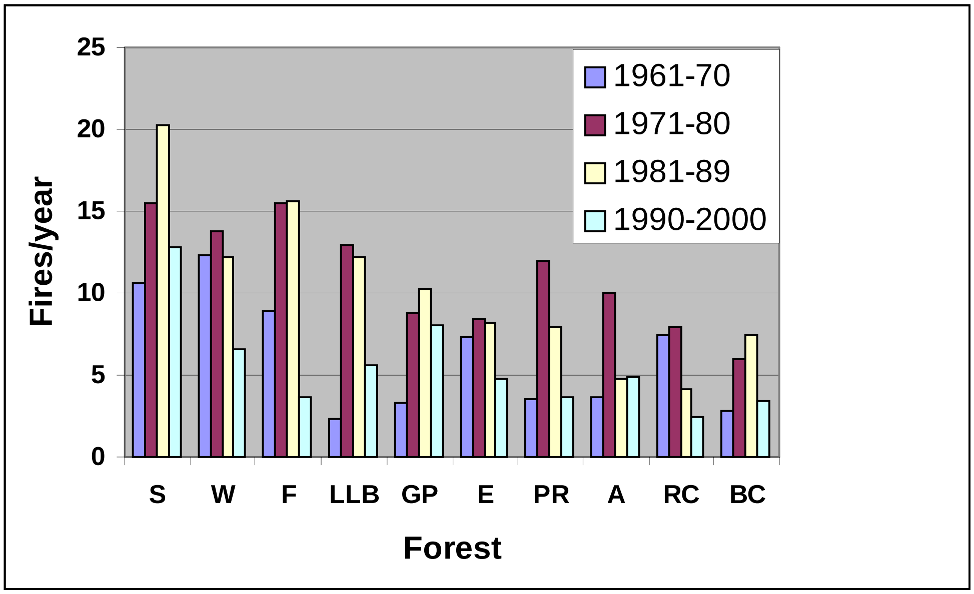

Figure 8. The number of fires/year involving slash by Forest and time period up to and including 2000. Forests are ranked from highest to lowest slash fire occurrence. X-axis abbreviations are:
A: Athabasca; BC: Bow-Crow; E: Edson; F: Footner; GP: Grand Prairie; LLB: Lac La Biche; PR: Peace River; RC: Rocky-Clearwater; S: Slave; W: Whitecourt. (Bow-Crow is now Calgary).

When examining the number of fires, Slave Lake, Whitecourt and Footner have the highest number, reflecting, in part, the large areas each Forest encompasses. Whitecourt Forest has the second highest number, despite its relatively small size.

Figure 9 shows the location of all slash fires from 1961 to 1999; Figure 10 shows those fires caused by both lightning and industry; and Figure 11 shows the location of fires caused only by industry.

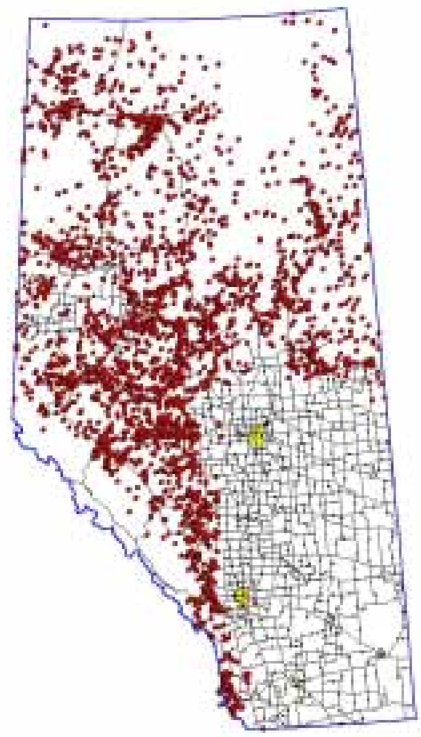

Figure 9. The locations of the 3224 fires involving slash fuels in Alberta from 1961-99. The data represent fires in Alberta Environment's fire history database.

Figure 10. The location of the 1809 slash fires caused by either industry or lightning.

The fires shown in Figure 10 burned a total of 614 143 hectares, for an average size of 339 ha/fire over the study period. The area with the highest occurrence of lightning-caused fires is also one of the most active harvest areas. All slash fires resulting from industry (forest, oil and gas, railroads, and public projects) and lightning are included. These account for 56% of all the fires involving slash. Fewer slash fires are present in the Bow Crow, Fort Vermillion and Peace River regions, compared to the fire locations in Figure 9, because fires caused by agriculture and those accidentally started (e.g., camping or picnicking) are not included in Figure 10.

Figure 11. The locations of the 675 fires caused of industry and involving slash, from 1961-99. These fires have burned 13 433 hectares (an average fire size of 20 ha).

Figures 12 and 13 show the distribution of slash fires by size class. Due to the continual changing of attributes, this dataset is based on the size of the fire at the time efforts were initiated to suppress it. If control efforts are initiated on a spot fire and that fire eventually becomes a Class D or E fire, it would not have been included as a large fire.

Class A: 0.01 to 0.1 hectare
Class B: 0.11 to 4.0
Class C: 4.1 to 40.0
Class D: 40.1 to 200
Class E: 200.1+

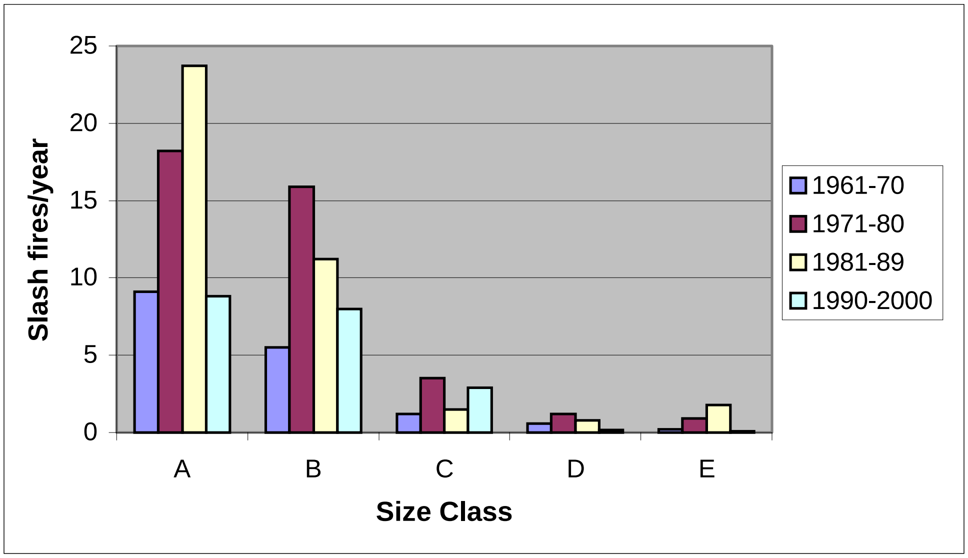

Figure 12. Size class distribution of lightning caused slash fires/year from 1961-2000. The size distribution is similar to the size distribution of all forest fires occurring in Alberta. Roughly 5% of fires make it to Class D and E size.

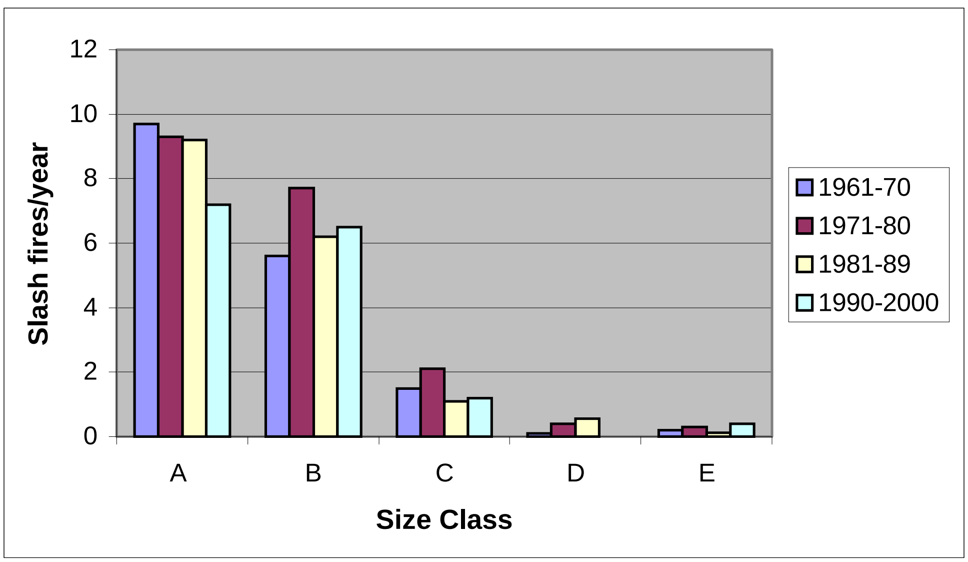

Figure 13. Size class distribution of industry caused slash fires/year from 1961-2000. Very few fires of class D and E (only 3%) occur. *Note: scale is different than Figure 12.

Fire costs

The costs of controlling and extinguishing fires burning in slash fuels by cause are presented in unadjusted dollars by time period (Table 6).

Table 6. The cost/fire ($) for slash fires for four time periods.

	Time period			
Cause of slash fire	**1961–70**	**1971–80**	**1981–89**	**1990–95**
industry ($/fire)	2 112	6 450	6 598	22 341
lightning ($/fire)	2 506	8 020	57 200	11 609
all slash ($/fire)	2 631	5 133	29 600	52 189

For perspective, the average cost per fire of *all* provincial fires was approximately $16,492 for the 1990-95 period. Thus, fires involving slash are more expensive to control and extinguish than other fires. Slash fires account for only 10% of all provincial fires, but may require a higher proportion of the fire fighting resources.

Lightning fires by forest

The data were sorted by cause (lightning) and location (Forest) to identify the high-risk lightning locations in the province (Figure 14). These data indicate locations that might require special attention due to their high lightning risk (e.g., location and orientation of piles within the cutblock, general fire proofing, or strategies to 'cool the forest'). Athabasca Forest is a good example of the potential use of the results. While it does not have the highest overall fire numbers, the percentage of slash fires caused by lightning is relatively high at 70%. This area also has an increasingly active harvest schedule and thus lightning should be considered in forest planning.

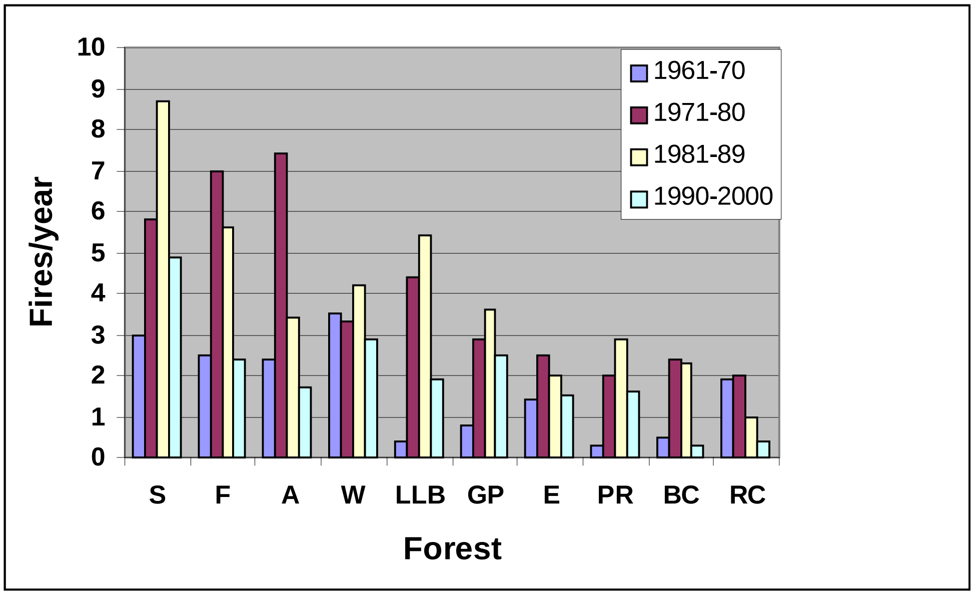

Figure 14. The number of fires in slash fuels, caused by lightning, per year, by forest and decade 1961-2000.

Figure 14 and the Lightning Occurrence map for1992-96[3] show lightning is a key factor in the number of slash fires in both the Slave Lake and Whitecourt Forests. The Southern Slave Forest lies in a high lightning occurrence region, as does the entire Whitecourt Forest.

Table 7 shows the percentage of lightning caused fires as a proportion of the total number of slash fires by Forest for the period 1961- 1995.

Table 7. Lightning fires as a percentage of all slash fires by Forest Region.

Forest	**Lightning fires as a % of total slash fires**
Athabasca	69
Footner	39
Lac LaBiche	36
Slave Lake	36
Grand Prairie	34
Whitecourt	29
Bow-Crow (Calgary)	26
Rocky Clearwater	25
Edson	25
Peace River	23
Provincial Average	34

It is interesting to note that even though Whitecourt is located in the heart of lightning country and has a very active timber industry, it has less than the mean number of lighting caused slash fires.

FWI thresholds and windspeed for slash fires in the fire history database

Both the Drought Code (DC) and Buildup Index (BUI) of the Canadian Forest Fire Weather Index (FWI) system were analysed to determine under what drying conditions slash fuels become involved in fires. The objective was to find threshold values of when fires in slash fuels began to occur. The FWI is not calculated during the winter and thus no values were available for that period (or appeared as 0).

The Drought Code (DC) is a numerical index rating the average moisture content of the deep, compact organic layers (10-20 cm) or woody fuels greater than 7 cm in diameter (thus it is an

[3] A provincial lightning occurrence map is available via the internet at:

http://envweb.env.gov.ab.ca/env/forests/fpd/clom.html appropriate index for slash fuels). The DC is also a good indicator of seasonal drought and may relate to the ease of involvement of the slash fuels. Figure 15 shows the DC and the number of fires occurring at various threshold levels for the period from 1983 to 1989. A large increase in the number of slash fires occurs once the DC reaches 101. All fires occurring over the same time period were compared to slash fire values to determine if slash fuels have different threshold values than other fuel types (Table 8). The 0-50 range, for the most part, represents winter fires occurring when the FWI indices are not calculated. DCs of 51-100 generally typify April and early-May conditions in the province, when fire activity is low, but increasing.

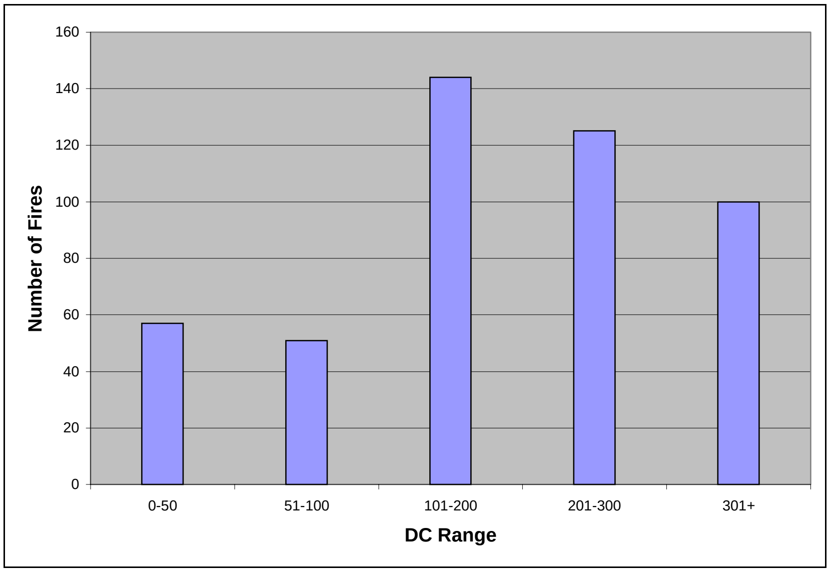

Figure 15. The number of fires involving slash fuels based on the DC index of the FWI system for the 1983-89 period.

Table 8. A comparison of the percentage of slash and total fires by DC.

Slash fires			**All fires**	
No. of Fires	**%**	**DC Range**	**No. of Fires**	**%**
57	12	0–50	707	10.7
51	10.6	51–100	525	8.0
144	30.1	101–200	1986	30.3
125	26.2	201–300	1872	28.6
100	20.9	301+	1453	22.2

The number of slash fires increase at DC values of 101-200, which is generally considered low to moderate danger. Because slash tends to be piled, greater airflow produces more efficient drying, and slash piles may be more susceptible to fires during low to moderate fire danger levels, compared to slash in direct contact with the ground. In Alberta, a DC value of 300 + is considered high. At high risk, forest activity should be curtailed. Only lightning ignited wildfires should therefore occur, but this is not the case (see below).

When DC values are above 300 the distribution of fire causes are as follows:

Lightning	30%
Recreation	20%
Resident	13%
Misc. Unknown	13%
Other	24%

Thus, seventy percent of slash fires occurring when the DC is > 300 are man-caused. Education of the public and landowners continues to be required to reduce or prevent these man-caused fires at high fire danger levels.

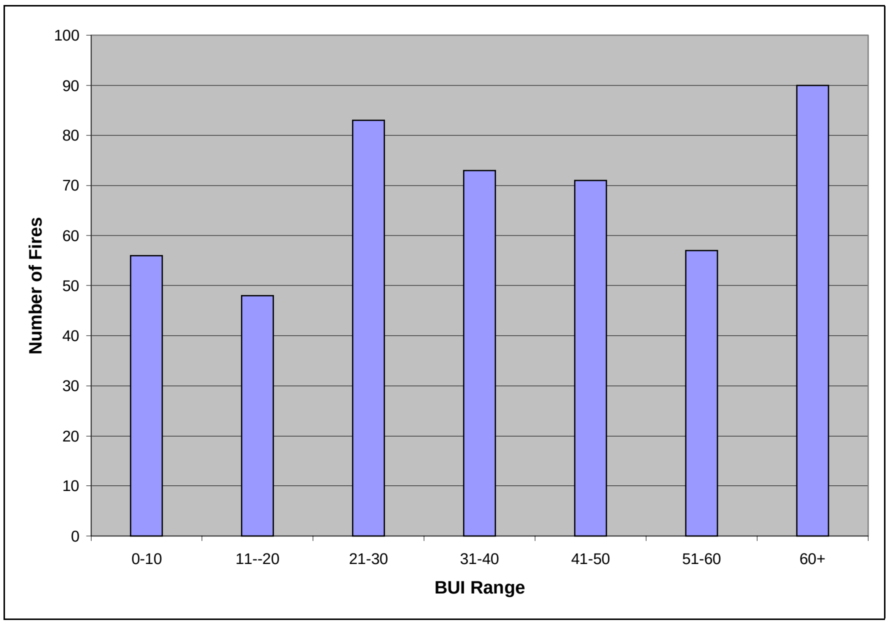

Figure 16. The number of fires involving slash based on the Buildup Index (BUI) of the FWI system.

The Buildup Index (BUI) is a numerical rating of the total amount of fuel available for combustion. It combines the Duff Moisture Content (DMC) and the DC, and it is not surprising that the same pattern exists in Figures 15 and 16. Fire activity in slash fuels increases substantially at BUI values greater than 21.

Windspeed

Many anecdotal comments have been collected telling of the influence wind has on slash fire ignition, excursion, and difficulty of control. Because not all time periods include windspeed data, only three periods were used to compare windspeed at the time of initial attack for industry caused fires and all fires involving slash. (Table 8).

Table 8. Mean windspeed at the time of initial attack for industry caused slash fires and all slash fires for three time periods.

Time Period	Industry-caused fires (km/h)	All slash fires (km/h)
1971–80	14.1	9.0
1981–82	14.2	10.0
1995–2000	24.6*	17.4

* 12 of 80 fires occurred on December 14, 1997 with 80 km/h used for the windspeed.

Wind is the most important factor in industry-caused slash fires. When piles are being burned for disposal purposes, or when they are not completely extinguished, they are susceptible to strong (usually chinook) winds. For example, in 1995-2000, 74% of all the fires with windspeeds above the mean (17.4 km/h), and either a SW, W or NW wind direction, burned south of latitude 56º (just south of Peace River). This region is considered the chinook belt. Of these fires, almost half (43%) occurred between October and March, when chinook winds are more common and more fires for slash disposal are ignited (this also includes only fires west of 114º W longitude). Clearly, care must be taken when burning along the eastern slopes during chinook season. These winds can be predicted up to five days in advance, and this information must be used to plan and extinguish these fires.

Discussion

An objective of this fire history study was to determine if the current practice of debris disposal by burning remains the best practice—specifically as it pertains to fire ignition and fire suppression activities. The number of fires involving slash fuels (as defined previously) decreased considerably around the time period when roadside processing became standard practice in the Province (1986) (Figure 17).

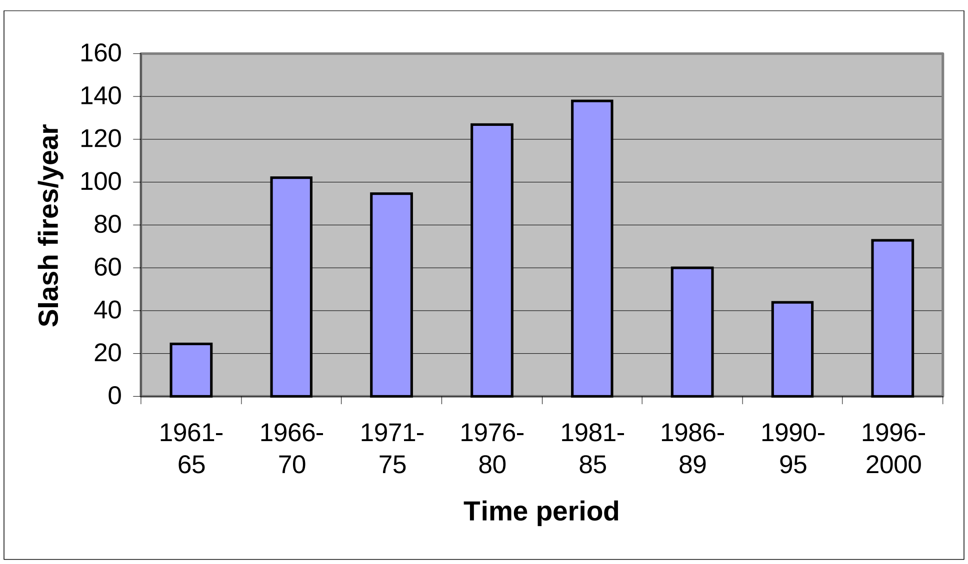

Figure 17. The number of fires/year involving slash fuels by time period.

The number of fires involving slash decreased after 1985. Possible explanations for the sudden decrease in slash fire numbers are:

- The practice of skidding to roadside allows industry to control the location of the fuels and access to them. The roadside piles have good access and therefore any fire can be quickly acted upon by the company (or the provincial fire protection division). If the fire is dealt with promptly, it may not become a provincial fire statistic.
- Less slash is left within the cutblock, therefore the total area containing slash fuels is less (smaller area with a hazard). The overall fire ignition risk may be lower.
- There is less broadcast burning and consequently a reduction in the number of fire escapes.

A less influential reason is that by burning the larger piles in more controlled circumstances, better overall containment is achieved. Escapes, although expensive, have been reduced.

Conclusions

The objective of this fire history study was to identify whether current practices of debris management are the appropriate strategies in terms of the fire risk posed by top-piles. This was done using the fire history of Alberta from 1961 – 2000.

Slash fire trends

The number of slash fires has decreased, but are beginning to increase once more even though the number of provincial forest fires have increased over the time period of the study. Even with the number of cutblocks increasing in number, the centralizing of the debris in the piles rather than spreading the debris has reduced the overall number of hectares containing slash thus reducing the risk of ignition based solely on the reduction in area covered with debris.

Regional disposal practices

Regional distribution of the data shows different trends in slash fire occurrence between the various regions of the province. These trends require separate investigations and different approaches may be necessary to address the problem or to answer the objectives of debris disposal. Topography, climate, weather, and the species harvested all play a role in slash fire occurrence. Because of this, four regions have been identified requiring individual study. These are:

1. The southeastern slopes region of the Rocky Mountains — report in draft.
2. The east-central region (aspen) — research planned for 2003.
3. The west-central region — research planned for 2003.
4. The northern region of the province — research underway.

Overall conclusions

The following are the conclusions of this slash fire history study:

- The overall number of all provincial forest fires is increasing.
- The number of fires involving slash is decreasing (although there has been minor increases since 1985).
- Slash fires make up approximately 10% of all fires in the provincial database, with a decrease to 6% in the 1990s.
- There was a large decrease in the number of hectares burned in the 1990s in slash fuels.
- The May through August period experiences the highest proportions of slash fires.
- The number of fires occurring in slash fuels during the winter is increasing.
- Lightning is the main cause of slash fires, followed closely by land clearing activities.
- Piles (re-ignitions, escapes, or holdovers) are the main cause of slash fires from November through May.
- Slave Lake, Whitecourt and Footner Forests experience the greatest number of slash fires.
- The size class distribution of slash fires at the time of action is similar to that of fires in general, i.e., most are less than 0.1 ha in size and a very small percentage become greater than 200 ha.
- Slave Lake, Footner and Athabasca Forests have the highest number of lightning caused slash fires.
- The numbers of slash fires increases when the Drought Code is above 100.
- Windspeed is a very important factor in slash fires escapes.
- Slash fires are approximately twice as expensive to fight as fires not involving slash fuels.

The results of this study indicate that in general the current practices are effective in reducing the overall loss from fires involving slash fuels. Confounding this trend are conditions and activities in Slave Lake and Lac LaBiche during the 2001 and 2002 fire seasons. As the northeastern protection regions have had heightened slash fire activity over the past four years, they should be given priority as the location for co-generation projects that utilize forest residues as biofuels.

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