The effectiveness of Alberta’s presuppression preparedness planning system

Abstract
The Forest Engineering Research Institute of Canada (FERIC) studied Alberta’s presuppression preparedness planning system (PPS). Operations were observed in three fire management duty rooms during active fire days. Statistical analysis was carried out to determine whether percent coverage levels, which are set in policy, are adequate to meet initial attack objectives. This report provides a detailed description of the PPS, describes potential weaknesses of the system, and summarizes the results of the statistical analysis.

Keywords
Presuppression preparedness planning, Resources, Fire management, Fire suppression, Alberta.

Introduction
The responsibility for wildfires in Alberta rests with the provincial government, specifically, the Environment and Sustainable Resource Development (SRD) ministries. The presuppression preparedness planning system (PPS)—the planning done before a fire occurs—reflects the administrative conditions and suppression objectives within SRD (Frederick 2000). For administrative purposes, Alberta is divided into 10 Wildfire Management Areas (Figure 1), and area duty officers must make daily decisions on the amount and type of fire control resources that will be required in the area, where they should be deployed, and what level of readiness they should adhere to. These decisions are then approved by a provincial duty officer, who is responsible for coordinating suppression activities among the province’s ten Wildfire Management Areas. Decisions regarding initial attack resources—those resources intended for the first suppression action on a fire—are crucial to reduce suppression costs and losses.

The goal of Alberta’s initial attack program is to take action on all fires before they reach two hectares in size. Initial attack crews in Alberta are called helitack crews, and comprise three to eight members with or without rappel capabilities. Approximately 32 helitack crews operate in Alberta, and many of these crews move throughout the province as required by fire hazard and risk. These crews are hired on a seasonal basis and are specifically trained to fight forest fires. With additional guidance from the provincial duty officer, area duty officers decide on the best allocation of resources within their protection areas, based on anticipated conditions of the fire environment.

Severe fire seasons and organizational changes in recent times have lead fire managers and forest industry representatives to question the adequacy of Alberta’s PPS (Nash et al. 1999), prompting SRD to request FERIC to conduct an evaluation of the system. This report presents the results of FERIC’s study.

Objectives
The primary objectives were to:
- Develop a methodology to determine whether current PPS processes result in allocating enough suppression resources
to address initial attack requirements effectively.
• Based on this research, make recommendations to improve current PPS processes and initial attack success.

**Methodology**

A problem analysis was necessary to determine whether initial attack requirements were met. This was accomplished by:

- Reviewing the PPS process and decisions made by provincial and area duty officers over several active days during the fire season.
- Conducting a statistical analysis of historical fire data to determine whether any of the criteria used in the PPS process had an impact on initial attack success.
Planning process review

During August 2001, FERIC evaluated Alberta’s PPS by reviewing the planning process as carried out at both provincial and Wildfire Management Area levels, including fire weather forecasting. The planning process was reviewed in the Edmonton, Whitecourt, and Slave Lake duty rooms. Interviews were conducted with several duty officers who offered insights into the strengths and weaknesses of the PPS.

Analysis of historical fire data

The existing PPS has only been in operation since 1999, and current administrative boundaries were implemented in 2000 when the province re-organized 20 regions into 10 Wildfire Management Areas. Therefore, only two years of historical fire data, for 2001 and 2002, were analyzed to determine if the documented PPS could explain why initial attack efforts succeeded (less than or equal to two hectares) or failed (greater than two hectares).

Results and discussion

Alberta’s current PPS

Area duty officers deploy and pre-position resources at pre-determined initial attack bases and field locations in anticipation of fire starts. The number of initial attack resources required for any one day is determined by using the forecasted noon weather data (temperature, relative humidity, wind speed, and precipitation) for that day and indices of the Canadian Forest Fire Danger Rating System (Stocks et al. 1989; Forestry Canada Fire Danger Group 1992) as implemented in Alberta’s adaptation of the Spatial Fire Management System (SFMS), which is a modelling software used to indicate the location of the greatest fire hazard (Lee 1995; Lee et al. 2000). The initial attack resources are based on forecasted P.M. weather, and may be revised by the duty officer if precipitation is received through the evening until the following morning.

Given the location of initial attack aircraft and their travel speeds, SFMS can be used to calculate the minimum time required for a suppression resource to reach each cell. Minimum travel times can then be compared with the attack time objectives to determine whether suppression resources can reach a fire before it attains two hectares in size. The product of this analysis is a coverage assessment map, which classifies each cell on the basis of coverage (Frederick 2000):

- not covered
- partially covered: this means that if a cell requires coverage by two resources, it is only covered by one resource
- covered: this means that if a cell requires coverage by one resource, then it is covered by at least one resource; if it requires coverage by two resources, then it is covered by at least two resources
- no resources required

The percent coverage defines the proportion of a fire area that one or more suppression resources can reach before a fire in that area would exceed two hectares, and includes those areas that do not require any coverage (due to their headfire intensity rank being 1 or 2, as explained later).

The number of initial attack crews and rotary wing aircraft required for deployment in each Wildfire Management Area is determined by analyzing deployments with the coverage assessment map. In implementation of SFMS, each Wildfire Management Area is divided into grid cells that are 1000 × 1000 m, while the provincial system in Edmonton is run using a grid resolution of 5000 × 5000 m. Using interpolation techniques, the Canadian Forest Fire Weather Index System (Van Wagner 1987) inputs and outputs are estimated between weather stations using SFMS. These weather index system outputs are then used in conjunction with the Canadian Fire Behaviour Prediction System (Forestry Canada Fire Danger Group 1992) fuel types, and fire behaviour potential is evaluated spatially for a protection area (Lee and Anderson 1989, 1993). Fire behaviour potential maps such as forward rate of spread, headfire intensity, and time to reach a specific fire size can be calculated.

The duty officer enters the number of crews and types of rotary wing aircraft that are to be positioned at each attack base, and SFMS is then used to determine whether each cell can be reached before a fire within it would exceed two hectares in size. Resource
deployments are altered and SFMS is re-run until percent coverage requirements are met. Current PPS policy states that certain coverage requirements must be met depending on the mean headfire intensity rank for the area. SFMS is used to calculate headfire intensity (Byram 1959; Alexander 1982) for each cell, which is then classified and given a headfire intensity class rank. Fire intensity class ranks 1 through 6 are assigned based on calculated intensity values (Taylor et al. 1997): <10, 10–500, 500–2000, 2000–4000, 4000–10,000, and >10,000 kW/m.

Current PPS policy states that percent coverage requirements must be based on the mean headfire intensity rank for the area as follows:

- Rank 1: no coverage is required
- Ranks 2, 3, and 4: 80% coverage is required
- Ranks 5 and 6: more than 80% coverage is required

Additional PPS requirements are based on the headfire intensity rank within an individual cell. Individual cells with high values at risk that have forecasted fire behaviour in excess of Rank 4 require coverage by at least two initial attack resources. Policy also states that individual cells with projected fire behaviour less than Rank 3 do not require coverage by any initial attack resources.

At the time of this study, there was neither a values at risk map available within SFMS to allow users to evaluate additional coverage requirements for individual cells, nor a consistent process used to define high values at risk. Therefore, this part of the PPS process was largely subjective and not implemented consistently throughout the province. It may actually be impossible for Alberta to meet PPS requirements for two helitack crews per cell with high values at risk under forecasted Rank 5 or 6 conditions. For example, about 40 helitack crews would be required just to protect 20 high values threatened provincially under Rank 5 or 6 conditions.

Percent coverage for the day is calculated as follows:

\[
\% \text{ coverage} = (100\%) - (\% \text{ not covered})
\]

Given this calculation, however, unless areas “not covered” require no more than a single resource, the calculation may overstate how well policy requirements have been met. This is illustrated in the hypothetical situation that is presented in Table 1.

A value of 0 for “Available minus Required” indicates that coverage requirements have been met, while negative and positive numbers indicate that an area is under- or over-resourced, respectively. Existing procedures suggest that percent coverage would be 60%, since two cells are “not covered” in this scenario. Nonetheless, the percent area under-resourced is 40 and the percent area over-resourced is 20, while the percent area adequately or better resourced is 60. Using the existing process, the coverage requirement met is not calculated as a percentage of the total coverage required, which may result in under-resourcing. The current process is focused on achieving coverage requirements with little emphasis on over-resourcing, which may lead to cost inefficiencies.

PPS planning takes place daily in the late afternoon, when resource requirements based on forecasted weather are generated for the next day. Current procedures allow subjective amendments to allocated resources the following morning if, for example, actual overnight weather conditions deviate significantly from those forecasted (e.g., unforecasted rain has occurred or forecasted overnight rain has not occurred), but SFMS is not re-run. The duty officer reviews the A.M. forecasted indices that use actual overnight precipitation to modify the previous day’s P.M. forecast, and this allows a

<table>
<thead>
<tr>
<th>Resources to meet initial attack objectives (“Available”)</th>
<th>1</th>
<th>1</th>
<th>0</th>
<th>0</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources required per cell (“Required”)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>“Available minus Required”</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>-2</td>
<td>+1</td>
</tr>
</tbody>
</table>
re-calculation of headfire intensity ranks and initial attack coverage.

Current policy states that set PPS requirements must be met from April 1 to October 31. Fire weather forecasting and PPS planning were not initiated early in 2001 despite an early fire season being declared due to severe overwinter drought. Although snow-free conditions are generally required to initiate the Fire Weather Index codes in the spring, the fire behaviour potential for flashy forest fuel types and cured grasses could be tracked and used for preparedness planning throughout the year.

Unfortunately, the typical planning process is based primarily on potential fire behaviour characteristics without considering the presence or absence of causal agents. Risk of ignition or fire occurrence prediction is not explicitly considered in the planning process, although the duty officer is expected to intuitively consider risk from humans or lightning. This means that while a crew can get to a given area before a fire reaches two hectares, the number of fires that may require initial attack is not considered. This is important in the case of multiple fire starts following significant lightning events. Lightning is often associated with light showers. It is possible for showers to reduce the Fire Weather Index's fine fuel moisture code, and thus temporarily reduce headfire intensity values. Lightning fire occurrence prediction models, e.g., developed by Kourtz and Todd (1991) and Anderson (2002), consider that lightning fires may smoulder undetected for several days. Given a one-day planning window, it may become difficult to mobilize enough resources to meet initial attack objectives when multiple fires start several days later. This circumstance may tax helitack crews under the modest coverage requirements recommended by the current PPS.¹

Other maps such as WIPP (Wildfire Ignition Probability Prediction [Lawson et al. 1996]) and ORAP (Optimal Resource Allocation and Positioning) can be generated by SFMS (Anderson and Lee 1991; Anderson and Hirsch 1998; Englefield et al. 2000), but these were not used operationally in any of the duty rooms visited.

The planning process is somewhat cumbersome because the other various systems used, including that used to track suppression resources and another used to disseminate forecasted weather data, are not integrated with SFMS, which makes evaluating the impacts of resource sharing between Wildfire Management Areas difficult. The success of the initial attack may also be related to on-site factors not considered explicitly in the planning process, including:

- time of ignition
- length of the burning period
- fire size, spread rate, and intensity on crew arrival
- water availability and accessibility

The current PPS does not take into account the seasonality of fire causal agents (Martel et al. 1989) or how the duration of the burning period may change with day length (Beck et al. 2002). The policy also does not consider the potential for persistent deep burning fires that may present suppression and mop-up difficulties. Such conditions are not directly reflected in headfire intensity values but may be indicated by drought code values within the Fire Weather Index system. Also, this type of information is incorporated into the planning process intuitively by the duty officer, but this application of knowledge is difficult to evaluate, is not recorded, and cannot be assessed quantitatively.

PPS policy goals are identical for all Wildfire Management Areas even though the values at risk, fire causal agents, frequency of multiple fire starts, and other environmental conditions that govern suppression difficulty may vary significantly between the areas.

**Analytical results**

The following summary statistics are provided in Table 2 for initial attack successes and failures: the initial attack time (i.e., the elapsed time between fire discovery and the initial attack crew's arrival at the fire), the

¹ The wildfire threat rating function in the 2003 version of SFMS is expected to improve this capability somewhat by providing maps that indicate the frequency of historical fire occurrence.
time lapse between initial attack and report time, the percent coverage for the area, the forecasted mean headfire intensity rank for the area, the number of fires for the day for the area, and the number of fires for the day for the province. Mann-Whitney tests were used to determine whether values differed significantly as a function of initial attack success. Report time lapses were significantly greater for initial attack successes than failures, suggesting that area losses are not generally occurring as a result of delays in initial attack. Wildfire Management Area coverage levels, however, were significantly less for initial attack failures than successes.

A Kruskal-Wallis one-way analysis of variance indicated that there was a significant difference among initial attack success based on mean headfire intensity rank. There were, however, significant differences (p < 0.0005) in typical values of percent coverage among mean headfire intensity ranks, although differences between percent coverage levels for initial attack successes versus failures were only significant (p 0.071) for fires that occurred when the mean headfire intensity rank for the area was Rank 2 (Table 3). In general, percent coverage decreased with increasing mean headfire intensity rank.

Although initial attack failures might be expected to be associated with low coverage levels or very high fire intensity values, the data analyzed to date do not clearly support this.

When these data were examined based on Wildfire Management Area, mean percent coverage levels were significantly different (p < 0.10) between initial attack failures and successes for only two areas—Grande Prairie/Smoky (90.6 versus 82.7) and Rocky/Clearwater (91.1 versus 88.8). Mean coverage values, however, were lower for initial attack failures than successes except for the Whitecourt/Woodlands area. When assessed by Wildfire Management Area, the percentage of the total number of fires that were initial attack successes generally increased with mean coverage on fire days (Figure 2), although the results for the Peace River/Peace area do not fit this trend particularly well.

The percentage of the total number of fires for the Wildfire Management Area that were initial attack successes did not appear to vary directly with forecasted mean headfire intensity rank.

### Table 2. Comparison of initial attack successes and failures

<table>
<thead>
<tr>
<th></th>
<th>Initial attack time</th>
<th>Report lapse</th>
<th>Percent coverage for area</th>
<th>Headfire intensity rank</th>
<th>Fires/day for area</th>
<th>Fires/day for province</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Successes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>11.60</td>
<td><strong>174.11</strong></td>
<td><strong>84.20</strong></td>
<td><strong>3.96</strong></td>
<td>6.62</td>
<td>22.29</td>
</tr>
<tr>
<td>(P 0.007)</td>
<td>(P &lt; 0.000)</td>
<td>(P &lt; 0.006)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of fires</td>
<td>1531</td>
<td>1747</td>
<td>1618</td>
<td>1623</td>
<td>1747</td>
<td>1747</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>16.13</td>
<td>1598.70</td>
<td>15.52</td>
<td>1.36</td>
<td>10.61</td>
<td>29.64</td>
</tr>
<tr>
<td><strong>Failures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>11.08</td>
<td><strong>114.72</strong></td>
<td><strong>80.137</strong></td>
<td><strong>4.21</strong></td>
<td>6.60</td>
<td>19.29</td>
</tr>
<tr>
<td>(P &lt;0.000)</td>
<td>(P &lt;0.000)</td>
<td>(P &lt;0.000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of fires</td>
<td>234</td>
<td>268</td>
<td>241</td>
<td>242</td>
<td>271</td>
<td>271</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>14.40</td>
<td>418.88</td>
<td>17.43</td>
<td>1.33</td>
<td>10.54</td>
<td>24.16</td>
</tr>
</tbody>
</table>

a **Bold** indicates significant differences with probability values given in parentheses

### Table 3. Comparison of average coverage level by headfire intensity rank for initial attack successes and failures

<table>
<thead>
<tr>
<th>Headfire intensity rank</th>
<th>Mean percent coverage for area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Successes</td>
</tr>
<tr>
<td>1</td>
<td>99.7</td>
</tr>
<tr>
<td>2</td>
<td>96.5</td>
</tr>
<tr>
<td>3</td>
<td>87.0</td>
</tr>
<tr>
<td>4</td>
<td>83.1</td>
</tr>
<tr>
<td>5</td>
<td>80.6</td>
</tr>
<tr>
<td>6</td>
<td>70.0</td>
</tr>
</tbody>
</table>
Conclusions

FERIC’s review of duty room processes provided evidence to suggest that PPS policy and requirements as established may be inadequate under several circumstances. Deficiencies can be summarized as follows:

- The daily planning time frame may be too short to ensure that adequate resources are mobilized, especially when severe lightning results in multiple fire starts several days after the storm has passed.
- Initial attack success may be governed by other factors that are not considered in the existing PPS, e.g., time of ignition, length of the burning period, suppression difficulty inherent in the fuels or terrain at hand, or rate of fire spread.
- “High values at risk” need to be defined explicitly to ensure consistency between Wildfire Management Areas on the implementation of PPS policy.
- The potential number of fire starts is not considered in the PPS decision-making process.
- Procedures or models could be established to forecast the number and location of fires for a given Wildfire Management Area. Prediction models for human- and lightning-caused fire occurrence need to be developed and implemented for Alberta.
- PPS procedures could be initiated when an early fire season has been declared, or the fire season has been extended.
- If the SFMS, weather, and fire systems used in PPS planning were integrated, the planning process may be less cumbersome and may promote resource sharing between Wildfire Management Areas.

Statistical analysis of historical fires suggests that initial attack success is related to PPS percent coverage levels. When assessed by Wildfire Management Area, the percentage of fires that were successfully treated by initial attack generally increased with mean PPS percent coverage on fire days. Percent coverage values were significantly lower for initial attack failures versus successes (96.5% versus 92.8%, respectively) given a forecasted mean headfire of Rank 2 for the area. Further analysis would be required to determine if low coverage levels were due to a lack of available resources or were imposed consciously to ensure crew safety. Given paramount concerns for crew safety under extreme fire behaviour conditions, increasing coverage levels under forecasted mean Rank 6 conditions for the Wildfire Management Area should proceed with caution.

The results suggested that a coverage objective of 80% yields an initial attack success rate of 85%, and only two of ten Wildfire Management Areas did not meet this objective. The statistical analysis that was carried out in this study should be considered as yielding only very preliminary results because only two years of data were available for analysis.
References


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