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Quantifying the effect of wildfire suppression actions

Knowledge of the suitability and effectiveness of different suppression actions is essential for sound planning and response decisions that reduce the impact of wildfires. The effect of suppression actions at a tactical level during a wildfire are difficult to measure and assess. The development of novel methods for collecting operational data from a range of new and traditional sources will extend our understanding of suppression effectiveness and improve firefighter safety and wildfire outcomes.

Suppression knowledge gaps

Gaps in our knowledge of suppression resource suitability and effectiveness add to the many sources of uncertainty that impede reliable wildfire management decisions. They also limit the ability to measure firefighting success and present a barrier to the improvement of suppression cost effectiveness. A non-exhaustive list of suppression effectiveness knowledge gaps includes the influence of individual variables on suppression difficulty, resource use during defensive tactics, the growth rate of new fires and the influence of resource quantity on initial attack success. Of critical concern is the ability to quantify the effectiveness and efficiency of suppression tactics (Fig. 1).

Effectiveness thresholds

Fire behaviour thresholds used to estimate conditions when suppression is likely to be effective have been incorporated in many wildfire management decision-making systems and firefighter training material. They have also been applied in predictive studies examining the impacts of fuel modification and climate change on likely suppression outcomes. Fire behaviour thresholds have mostly been expressed in terms of Byram's fireline intensity (Byram 1959), although other aspects of fire behaviour, such as the prevalence of spotting, have been more closely attributed to the viability of particular suppression actions. Data on fire behaviour thresholds is difficult to acquire as it necessarily requires observations from suppression efforts that were both successful and unsuccessful and measures of the associated fire behaviour conditions. Existing thresholds have been established from a limited number of poorly documented observations and are often extrapolated well beyond their applicable range (Hirsch and Martell 1996).

Figure 1. Gel being dropped on the head of a 6.9 MW/m experimental fire, which halted spread along 15 m of the perimeter for 6.5 minutes.

Resource productivity and use

Understanding fireline production rates is essential for determining the minimum number of resources to be deployed effectively to incidents and the planning of the number of resources required in any particular location. Resource productivity rates may be used for simulating containment, estimating the benefit of deploying firefighters to potentially dangerous situations, and evaluating the efficiency of fire suppression operations. A more refined understanding of productivity will allow the impact

of weather, fuel, terrain and fire behaviour variables to be quantitively appreciated and could also provide insights into the influence of fuel management and other factors affecting suppression difficulty.

Existing productivity models focus on only a few resource types (e.g. hand crews, earthmoving machinery and aircraft), and only account for a few environmental variables. Many existing models have been developed using data collected in non-wildfire situations and have subsequently been found to over-predict productivity at wildfires. As a result, these tools may exhibit large errors in their predictions which limits their applicability. There is a need for a better understanding of the productivity of a broader range of resources in a variety of wildfire conditions and applications, including combinations of resources working together and use in indirect attack, such as backburns.

Filling suppression knowledge gaps

Understanding the effective opportunity window and productivity of different suppression actions requires an extensive database compiled from detailed case studies of wildfire suppression operations. Such a dataset will require a combination of critical information on environmental conditions, fire behaviour, resource accessibility, movements and suppression objectives and resultant firefighting and fire behaviour outcomes.

Previous research on the effectiveness of suppression resources at a tactical level relied on *ad hoc* observations of operations. The recent advent of cheap automated location tracking devices that can be installed in appliances presents an opportunity to passively acquire this data in a way that does not affect the performance of the resource being studied thereby providing more accurate and complete data with less effort. Resource location tracking data will need to be supplemented with information describing the activities being undertaken, objectives and details of the methodology including crew strength, equipment used and specific techniques.

Cross-referencing resource tracking and objective data with fire location, fire behaviour and environmental data will provide a complete record for a suppression action (Fig. 2). A database compiled from many suppression action records will enable robust quantitative analysis of suppression thresholds and productivity. From this analysis operational tools can be developed that are both realistic and representative of wildfire operations and which can be tailored for specific conditions. Such models will be able to consider variables that cannot be accounted for in current systems.

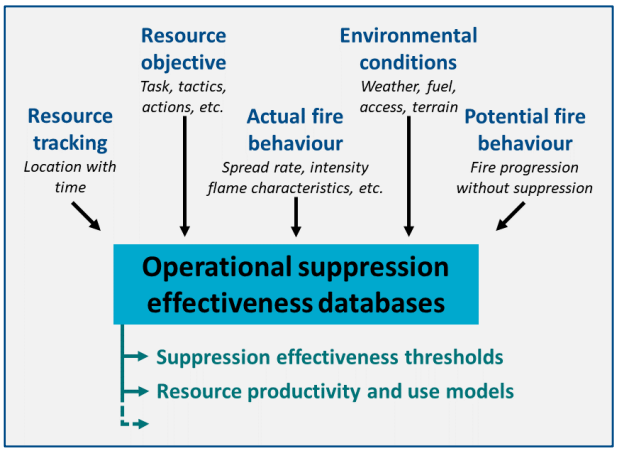

Figure 2. Primary inputs and outputs for a suppression effectiveness database designed for the development of effectiveness thresholds and resource productivity models.

Further reading

Plucinski, MP (2019) Fighting flames and forging firelines: wildfire suppression effectiveness at the fire edge. *Current Forestry Reports* 5, 1-19. doi: 10.1007/s40725-019-00084-5.

Plucinski, MP (2019) Contain and control: wildfire suppression effectiveness at incidents and across landscapes. *Current Forestry Reports* 5, 20-40. doi: 10.1007/s40725-019-00085-4.

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