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# Why Do We Still Not Know How to Prevent Firefighter Entrapments?—Thoughts and Observations from a Few Perplexed Fire Practitioners

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**Abstract:** Wildland firefighters continue to die in the line of duty. Flammable landscapes intersect with bold but good-intentioned doers and trigger entrapment—a situation where personnel is unexpectedly caught in fire behaviour-related, life-threatening positions where planned escape routes or safety zones are absent, inadequate, or compromised. We often document, share and discuss these stories, but many are missed, especially when the situation is a near miss. Entrapment continues to be a significant cause of wildland firefighter deaths. Why do we still not know how to prevent them? We review a selection of entrapment reports courtesy of the Wildland Fire Lessons Learned Centre (WFLLC) and focus on human factors involved in entrapment rather than the specifics of fire behaviour and the environment. We found that in order for operational supervisors to make more informed strategic and tactical decisions, a more holistic and complete trend analysis is necessary of the existing database of entrapment incidents. Analysis of the entrapment data would allow training to include a more fulsome understanding of when suppression resources are applying strategies and tactics that might expose them to a higher likelihood of entrapment. Operational supervisors would make more informed decisions as to where and when to deploy resources in critical situations in order to reduce the exposure to unnecessary risk of entrapment.

**Keywords:** wildland firefighter; entrapment; fatality; lessons learned



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## 1. Introduction

Wildland firefighters' lives are threatened when bold and good-intentioned doers intersect with flammable landscapes during conditions capable of triggering an entrapment—a situation where personnel are unexpectedly caught in fire behaviour-related, life-threatening positions where planned escape routes or safety zones are absent, inadequate or compromised [1–4]. Many entrapment stories are documented, shared and discussed, but many are not [5], especially when they are considered a near-miss or close call. Despite our best efforts in training, reporting and learning practices, entrapments continue to occur regularly and are a significant source of wildland firefighter deaths and injuries [3]; we still do not know how to prevent them.

This article discusses the findings of a few perplexed fire practitioners who took a layperson tour of documented entrapment incidents courtesy of the Wildland Fire Lessons Learned Center (WFLLC), Tucson, AZ, USA, (https://www.wildfirelessons.net/home accessed 13 January 2022) in search of answers to a few questions about strategies and tactics related to the likelihood of entrapment. Although quantitatively-based investigations of entrapment incidents have recently been published [6,7], they have tended to focus on

possible causes related to components such as weather and fire behaviour rather than on human or behavioural factors [8]. A human factor is typically defined as those factors that affect a person's ability to make decisions during stressful conditions and include previous training, fatigue, and organizational controls, which are difficult to assess objectively [8].

The questions we asked include:

- Which firefighting strategy leads to more entrapments—direct or indirect attack?
- What kind of resources are most likely to be involved in an entrapment situation?
- Maybe most importantly, if we do not have any information on these first two questions, how can we make better operational decisions to avoid potential entrapments?

We used simple assumptions to tour more than 60 WFLLC reports to find answers to the above questions to inform future decisions about risks related to entrapments. As some of the findings surprised us, we shared the results and challenged the assumptions of other practitioners, including attendees at a wildland fire safety conference. We recommend a more detailed investigation of entrapment reporting standards, along with a thorough analysis that focuses on when suppression resources are applying strategies and tactics that might expose them to a higher likelihood of entrapment.

## 2. Materials and Methods

A review of the literature and help from subject matter experts [9] revealed several formal and informal reports focused on summarizing the causes of previous entrapments [10–13]. They document a mix of recommendations for changes to human behaviour and training as well as similarities, i.e., common denominators, in the fire environment during entrapments. Without specific commentary related to suppression methods and tactics, one of us (K.F.), an experienced Canadian firefighter, reviewed ten years of incident report documents from the WFLLC website in early 2018 using the keyword 'entrapment'. Using US and Canadian national definitions for 'entrapment', 'direct attack' and 'indirect attack' (Table 1) each entrapment incident was categorized [14,15]. Additionally noted were what type(s) of resources were involved in each entrapment incident. Using his personal experience, K.F. compiled results in a spreadsheet format listing: report name, year completed, firefighting activity (direct attack, indirect attack, scouting/lookout), and resource type (engine, heavy equipment, single resource, multiple units, helitack, interagency hotshot crew, inmate hand crew). Totals and percentages were tallied and displayed in simple charts as a summary.

**Table 1.** National definitions used to summarize data from the Wildland Fire Lessons Learned Center reports [14,15].

| Term | National Wildfire Coordinating Group (NWCG) USA | Canadian Interagency Forest Fire Centre (CIFFC) Canada |
|---|---|---|
| Entrapment | A situation where personnel is unexpectedly caught in a fire behaviour-related, life-threatening position where planned escape routes or safety zones are absent, inadequate or compromised. An entrapment may or may not include deployment of a fire shelter for its intended purpose. These situations may or may not result in injury. They include 'near misses' | A situation where firefighters are in danger of being burned over, with no access to an escape route or safety zone |
| Direct attack | Any treatment applied directly to burning fuel such as wetting, smothering or chemically quenching the fire or by physically separating the burning from unburned fuel | A method whereby the fire is attacked on to the burning fuel [sic] |
| Indirect attack | A method of suppression in which the control line is located some considerable distance away from the fire's active edge. Generally carried out in the case of a fast-spreading or high-intensity fire and to utilize natural or constructed firebreaks or fuel breaks and favorable breaks in the topography. The intervening fuel is usually backfired, but occasionally the main fire is allowed to burn to the line, depending on conditions | A method whereby the control line is strategically located to take advantage of favorable terrain and natural breaks in advance of the fire perimeter and the intervening strip is usually burned out or backfired |

This summary of results of the analyses was presented to multiple subject matter experts including Canadian fire behaviour analysts, the International Association of Wildland Fire (IAWF) Students of Fire online community, and attendees of the 15th International Wildland Fire Safety Summit held in Asheville, NC in December 2018. We surveyed assumptions about entrapments and documented discussion around key topics for inclusion in this article.

## 3. Results

We asked a number of wildfire practitioners the question "which firefighting strategy leads to more entrapments—direct or indirect attack?" (Figure 1). In all cases, the majority of respondents believed that entrapments were more likely during indirect firefighting operations.


**Figure 1.** Results from informal polls with subject matter experts about their expectations for entrapments related to firefighting activity. (**i**) Online poll posted on the International Association of Wildland Fire Students of Fire Facebook page showing a 36% vote for direct attack and a 64% vote for indirect attack ($n$ = 66); (**ii**) A live poll conducted in a presentation at the Canadian national Wildland Fire Behaviour Specialist Course held in Hinton, AB in February 2018 showing a 30% vote for direct attack and a 70% vote for indirect attack ($n$ = 24); and (**iii**) A live poll conducted during a conference presentation at the 15th International Wildland Fire Safety Summit held in Asheville, NC in December 2018 showing a 14% vote for direct attack and an 86% vote for indirect attack ($n$ = 15).

A total of 60 reports from 2008 to 2017 in the WFLLC dataset had the tag 'entrapment' (Appendix A). Of those reports, 48 involved direct firefighting tactics while 13 involved indirect tactics (Table 2). Seven of those reports did not fit into the classic definition of direct or indirect as the resources were either working away from their main group while scouting new line or acting as a lookout.

**Table 2.** Analysis of WFLLC reports of type of firefighting activity when entrapped.

| Firefighting Activity | Number of Entrapment Incidents |
|---|---|
| Direct attack | 48 |
| Indirect attack | 13 |
| Scouting/lookout | 7 |
| TOTAL | 68 |

If only the events that fit the definitions for direct and indirect attack are considered ($n$ = 61), then 79% of the entrapments in the WFLLC reports occurred during direct attack firefighting tactics while 21% of entrapments occurred during indirect firefighting tactics. Note that this is contrary to the opinion of the practitioners questioned in Figure 1.

Similar polls were conducted using the question "What kind of firefighting resources are most likely to be involved in entrapments?". The most common response from practitioners included hotshot crews and heavy equipment. The review of the WFLLC reports again provided a contradictory result to the common practitioner, showing more than half (53%) of the entrapments involved a wildland engine rather than hotshot crews (Figure 2). Heavy equipment had the next highest frequency of entrapment (19%) followed by single resources (such as lookouts or trail scouts).

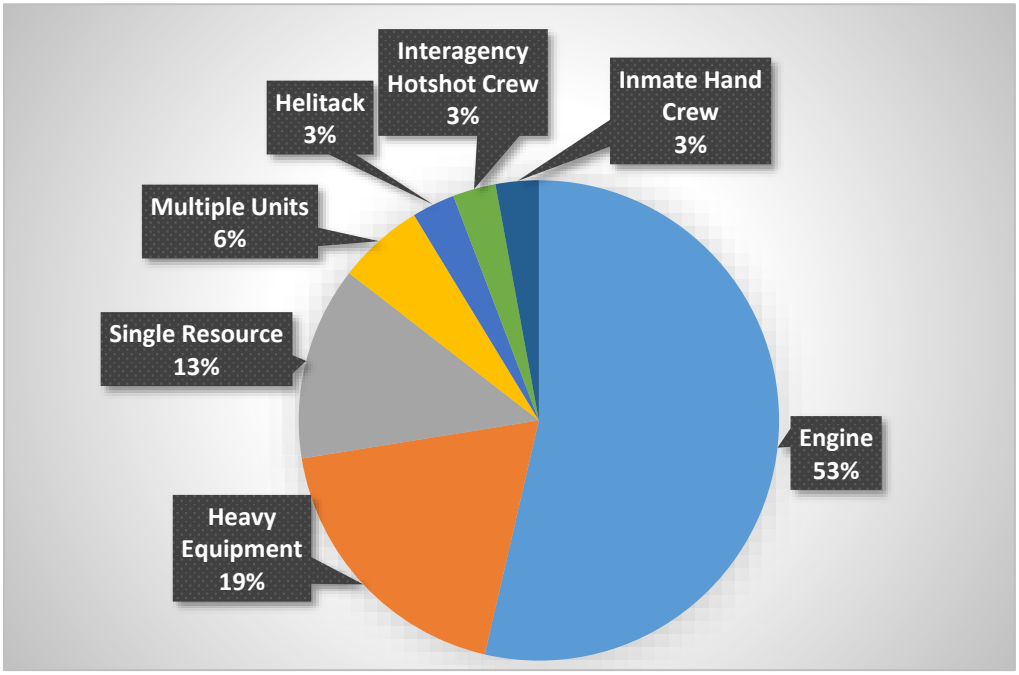


**Figure 2.** Type of firefighting resource entrapped according to the relevant reports contained on the WFLLC website.

## 4. Discussion

This article is not intended to document a scientific process but rather to initiate discussion and highlight what appear to be gaps in our knowledge. There are a number of obvious limitations to our approach including using finite definitions of direct and indirect attack; not knowing the relative amount of time we spend on each firefighting tactic throughout the season or which resources we use the most for a given activity; not differentiating between entrapments with and without fatalities; and the fact that entrapments are suspected to be under- and incorrectly reported [5].

Regardless of what the absolute numbers in our work show, what it does speak to is that, as decision-makers, we do not fully understand the strategic and operational risks related to entrapments. We do not know what firefighting activities are more likely to be

associated with being entrapped, nor do we understand what resources are more at risk of finding themselves in a burnover situation. Direct and indirect attack were used a proxy to challenge the way we think about exposing firefighting resources to risk and they do not fully represent the suite of decisions that are made on the fireline when an entrapment occurs. For example, in at least eighteen of the WFLLC reports we reviewed, the resources had stopped firefighting, disengaged from the line or were headed to their safety zone, which makes it difficult to class them into direct or indirect tactics. Despite the fact there were some difficulties related to classifying the specific tactics of each unique entrapment incident, we know there are a limited number of ways in which an entrapment with a burnover can occur. Page [9] and Page et al. [16] suggests three primary scenarios:

(1) The firefighters were in an area with a substantial amount of unburned fuel between them and the fire and could not escape, which suggests either indirect or parallel attack;
(2) The firefighters were adjacent to burned fuels (direct attack) but the fuel was only partially burned or very recently burned so it was inadequate to escape into;
(3) The firefighters were adjacent to burned fuel (direct attack) but decided to leave and attempt an escape through the green and were caught.

Additional scenarios are plausible, including being outflanked by fire during direct attack. Regardless, in order to properly assess the risk of entrapment related to firefighting tactics, future studies should focus on the specific strategies and tactics employed in relation to escape routes and safety zones in finer detail. What components of LACES (lookouts, anchor points, communication, escape routes, safety zones) [17] or LCES [18] were compromised before firefighters found themselves entrapped?

Fortunately, there is a large enough database of material that has been honorably and wisely compiled by the WFLLC that could provide insight into these gaps—why have we not looked? This resource provides a starting point to complete a more fulsome trend analysis of common operational situations and what kind and type of resources are more likely to be at higher risk of entrapment. However, our experience suggests that maybe the reason we have not looked relates to the way the WFLLC reports are presented. Our simple review of the last 10 years of data took a large amount of time and forced subjectivity into our final report both through ambiguities in terminology and in difficulty locating and interpreting facts. The national agencies have provided a canned description of what an entrapment is, but out on the fireline there tends to be murkiness about the difference between terms such as “tactical withdrawal”, “retreat”, “burnover” and “entrapment”. Travis Dotson of the WFLLC states, “in 2017, of the 20 reports that met the NWCG definition for entrapment only 4 chose to describe the event as entrapment” [5]. Clarifying definitions may improve the state of entrapment reporting [4]. Our dataset was also limited by only returning reports with the term “entrapment” in the title; without the ability to search for keywords in a more detailed way, we overlooked near-miss reports, narratives on potential for burnover and other compromises to firefighter safety including incidents during sustained action and during firing operations. When it comes to defining resources that become entrapped, inconsistent crew typing between Canada and the USA, and a lack of clarity on their primary roles, is yet another confounding factor, making it challenging to conduct a proper analysis of the data.

## 5. Conclusions

In summary, for operational supervisors to make more informed strategic and tactical decisions, a more holistic and complete trend analysis should be completed of the existing database of entrapment incidents. This may involve an overhaul of the existing WFLLC reports to better categorize and classify data as well as a shift towards a more standardized layout. Analysis of the entrapment data would allow training to include a more fulsome understanding of when suppression resources are applying strategies and tactics that might expose them to a higher likelihood of entrapment. Operational supervisors would make more informed decisions as to where and when to deploy resources in critical

situations in order to reduce the exposure to unnecessary risk of entrapment. Without simple information such as this, how can we expect operational supervisors to make fully informed risk management decisions?

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## Appendix A

**Table A1.** List of entrapment reports documented on the Wildland Fire Lessons Learned Centre website used in the analysis.

| | | |
|---|---|---|
| Thomas Fire Entrapment (2017), CA | Frog Fire Entrapment Fatality (2015), CA | Twisp River Fire Entrapment & Fatalities (2015), WA |
| Thomas Fire Entrapment Fatality (2017), CA | Lowell Fire Burn Injuries (2015), CA | Acadian Fire Burn Injury (2011), MS |
| Chetco Bar Fire Entrapment (2017), OR | Cattail Fire UTV Destroyed (2015), FL | Bull Fire Entrapment FLA (2011), AZ |
| Liberty Fire Entrapment (2017), MT | King Fire Entrapment USFS (2014), CA | 323 Fire Fatality (2011), TX |
| Pleasant Fire Dozer Burn Over (2017), CA | Upper Lyons RX Shelter Deployment (2014), CA | County Road U Fire Fatality (2011), TX |
| Chetco Bar Fire Engine Entrapment (2017), OR | King Fire Entrapment CALFIRE (2014), CA | Shrimp Fire Burn Injury (2011), GA |
| Preacher Fire Entrapment (2017), NV | Black Fire Entrapment (2014), CA | McCormick Highway Fire (2011), GA |
| Parkfield Fire Entrapment (2017), CA | Beaver Fire Entrapment (2014), CA | Smokey Hill Wind Farm Fire Entrapment (2011), KS |
| Nara Visa FD Fatality (2017), NM | Little Fire (2013), CA | Davin Road Fire (2010), WA |
| West Mims Fire Tractor Plow Burnover 2017), GA | Chariot Dozer Entrapment (2013), CA | Shultz Fire (2010), AZ |
| Crane Island Fire Tractor Plow Entrapment (2017), FL | Likely Fire Entrapment (2012), CA | Woody Ridge Prescribed Fire (2009), AZ |
| Doubleside Fire Tractor Burn Damage (2017), FL | North Pass Fire Entrapment (2012), CA | Muddy Creek (2009), OR |
| Ringling Fire Entrapment & Burn Injury (2017), OK | Holloway Fire Entrapment (2012), OR | Jesusita Fire (2009), CA |
| Canyon Fire Shelter Deployment & Entrapment (2016), CA | Ridgetop Fire Entrapment (2012), ID | Committee Drive Fire Burnover (2008), NC |
| Blue Cut Fire IA Structure Protection (2016), CA | Flat Fire Entrapment (2012), CA | Panther Fire Entrapment Fatality (2008), CA |
| Sand Ledges Fire Dozer Burn Over (2016), UT | Unit 233 RX Entrapment (2012), FL | Nicolaus Fire (2008), CA |
| Withers Fire Engine Burn Over (2016), OR | Clay Springs Entrapment (2012), UT | Jackson Burnover (2008), CA |
| Pacheco Fire Engine Burn Over (2016), CA | Rock Creek RX Entrapment (2011), AR | Indians Fire (2008), CA |
| Cedar Fire Shelter Deployments (2016), AZ | Salt Fire Entrapment (2011), ID | Buckingham County Fire (2008), VA |
| Engine Air Brake Failure (2016), KS | Bowles Creek Bottom Fire (384)(2011), TX | Charles Taylor Road Fire (2008), NC |
| Lumpkin Fire-Burn Over of Two Bulldozers (2015), CA | Coal Canyon Fire Fatality (2011), SD | Summit Fire Burn Injury (2013), CA |
| Valley Fire Shelter Deployment (2015), CA | Blue Ribbon Fire Fatalities (2011), FL | Horseshoe 2 Fire Entrapment (2011), AZ |

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