



# Analysis of the Configuration of British Columbia Wildfire Service Crews

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## EXECUTIVE SUMMARY

The wildfire environment in British Columbia is changing. Climate change, growing accumulations of volatile forest fuels, the expansion of the wildland-urban interface, and proliferation of other values across the forest landscape have created the potential for extreme fire behaviour and high-consequence fires. The increased complexity of response to wildland fire has added to the responsibilities placed on initial attack (IA) crew leaders.

At the same time that these changes in the fire environment are occurring, technologies and resource capabilities in the fire suppression industry are evolving. Specifically, the advent of intermediate helicopters has provided an opportunity to advance the utilization of helicopters for fire suppression and explore ways to optimize resource deployments on initial attack fires.

FPIInnovations reviewed current BC Wildfire Service (BCWS) initial attack operations and crew size. The analysis assessed 3-person, 4-person, and 5-person IA crews to determine the optimal IA crew configuration. Unit crew operations were also reviewed to explore options for enhanced interoperability between these two programs<sup>s.13</sup>

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British Columbia currently has 138 3-person IA crews comprising 429 personnel. In practice the current configuration is being adapted through various means to satisfy operational requirements,<sup>s.13</sup>

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The research has shown that more complex fires require a larger crew with a higher level of experience.

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Two approaches were developed for implementing 4-person crews: (1) redistribute the current 429 personnel into 101 4-person crews, and (2) add one person to each of the 138 crews, resulting in 567 personnel.

A five-person IA crew is larger than is needed for the more common low-complexity initial attack fires. Although the added productivity of a fifth person would benefit operations during more difficult burning conditions and on more active fires, the additional cost outweighs the benefits. Five-person IA crews would also be more difficult to implement.

Future fire operations in British Columbia would benefit from a greater degree of interoperability between IA crew and unit crew resources. Currently, unit crews can be used for initial attack response in extraordinary situations when initial attack capacity is strained due to a high incidence of new fire starts.<sup>s.13</sup>

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Operational practices such as these should be exploited to expand the utilization of both programs and develop efficiencies in the overall execution of the fire suppression program. Interoperability initiatives may also influence the total number of initial attack (IA) crews needed in the province.

## GLOSSARY OF ABBREVIATIONS AND TERMS

BCWS BC Wildfire Service

IA initial attack

UC unit crew

WUI wildland-urban interface

Bravo The second most experienced person in the crew

Charlie The third most experienced person in the crew

Delta The fourth most experienced person in the crew

Echo The fifth most experienced person in the crew

IA crew An initial attack (IA) crew consists of two crew members and a crew leader.

UC squad unit crew squad

unit crew A unit crew is made up of four squads, including three squad leaders and one unit crew supervisor.

## INTRODUCTION

Over the last four decades, the BC Wildfire Service (BCWS) has configured its initial attack (IA) crews as 3-person crews and has, in fact, used 2-person crews in some regions. Innovations in suppression technologies have evolved wildfire operations with continued efforts to modernize initial attack operations. Specifically, a new generation of helicopters that are more powerful and larger than those used in the early 1970s when IA crews were implemented in British Columbia are now common. With an increased useful load of 50%, current helicopters provide far more operational flexibility.

During the 2014 fire season, the Southeast Fire Centre undertook a pilot project in two fire zones to test the concept of increasing initial attack (IA) crew size to four personnel. The 4-person crew configuration was expanded to the entire fire centre in 2015. There is uncertainty as to whether the 4-person crew concept should be further pursued provincially or whether the BCWS should consider other configuration alternatives. The potential impact of changing the fire crew configuration is both financial and operational, and therefore BCWS needs to carefully weigh the alternatives.

BCWS has contracted FPInnovations to review three different fire crew configurations and report findings to inform a management decision by the Wildfire Leadership Team on future optimal provincial fire crew configuration.

## OBJECTIVES

Identify the optimal crew configuration for BCWS initial attack crews and unit crews.

## METHODS

### Overview of methods

Development and execution of this project was through a multi-pronged approach involving a broad spectrum of BCWS personnel and utilizing several different methods to collect and process data. These various service initiatives were designed to address key issues and objectives presented in the project charter. The initiatives employed in the crew configuration analysis included the following:

- Preliminary information gathering sessions with BCWS personnel
- Crew leader survey
- Forest Protection Officer survey
- Wildfire simulations
- Comparative analysis of 3-person and 4-person crew on 2014 3-person and 4-person fires
- Fire history analysis
- Benefits and disadvantages of five approaches to crew configuration

### Preliminary information-gathering interviews

Prior to any field work or formal data collection, information-gathering sessions were conducted through the BCWS fire centres.

Fire centre managers, Forest Protection Officers, crew leaders, administrative staff, and several other personnel were interviewed to gain a better understanding of the current key issues surrounding initial attack and unit crew programs and to solicit feedback on potential changes to these programs.

Notes from conversations with over 135 BCWS staff were collected during the review. Our focus was to explore with BCWS staff their thoughts about how a change in crew configuration might impact operations, logistics, safety, and other aspects of being a firefighter in B.C. The conversations were open-ended to allow for voicing of ideas, concerns, and local issues.

## **Crew leader survey**

During initial interviews, several major themes were identified as topics that should be explored to further evaluate the advantages and disadvantages of IA crews of different sizes. These themes had earlier been highlighted in the project charter designed to “conduct a cost-benefit analysis” by considering the following:

- Crew productivity when engaged in firefighting, helipad construction, chainsaw operations, and other related functions
- Safety considerations, including crew capacity to address first aid situations on incidents
- Crew transportation implications
- Crew firefighting equipment configuration

With these directives from the project charter and other major concerns identified during interviews, we structured the crew leader survey with the following major topic areas:

- Crew leader personal experience
  - fire experience
  - years of experience as a crew leader
- Crew certifications and experience
- Initial attack response
  - implications of various initial attack responses for efficiency and safety
- Water delivery
  - use of water delivery systems for initial attack operations
- Safety
  - perceptions of high-risk activities
  - concerns with crew's ability to respond to emergencies
  - influence of crew size on margin of safety and crew fatigue
- Work/life balance
  - how each initial attack base reconfigures crews when crew members are absent or unavailable for work
- Crew cohesion
- Mentorship
- Crew leader retention



Each of these major topics for evaluation has several contributing influences. In many cases, the factors impacting one of the major topics also have an impact on one or more other topics and, hence, responses from one topic area could not be analyzed independently of others. A holistic approach to analyzing responses was necessary to ensure data was synthesized appropriately from all topic areas.

Both IA crew leaders and unit crew leaders/supervisors were the intended respondents for the crew leader survey. Unit crew leaders/supervisors were included because 5-person unit crews can be used for initial attack and we needed to determine the extent of this utilization and the potential for expanded utilization.

We received 184 responses to this survey. Of these, 112 were from initial attack leaders and 72 were from unit crew leaders and supervisors.

## Forest Protection Officer survey

This survey was designed to solicit feedback from fire zone protection officers and staff on how their fire zone might be impacted by different approaches to configuring IA crews. Most importantly, the survey attempted to collect data on how a change in crew configuration might impact a specific zone's ability to control new fire starts.

The first section outlined the five proposed approaches to crew configuration (Table 1) and asked for thoughts on the benefits and disadvantages for each of the configurations.

**Table 1. Proposed approaches to configuring initial attack crews**

Approach A	Status quo
Approach B	The creation of 4-person crews by adding an additional crew member to each crew
Approach C	The creation of 4-person crews by maintaining the same number of initial attack personnel but reducing the number of crews
Approach D	The creation of five-person crews by adding two additional crew members to each crew at the fire zone
Approach E	The creation of 5-person crews by maintaining the same number of initial attack personnel but reducing the number of IA crews

### *Identifying benefits and disadvantages of five different crew configurations*

Traditional cost-benefit analysis would identify various scenarios and then associate costs and benefits with each scenario (or approach), with the objective of selecting the scenario with the most benefit and lowest cost. We summarized the survey responses identifying the benefits and disadvantages of the five crew configurations.

The second section of the survey requested feedback on key areas of concern that were identified during initial interviews, including the following:

- Initial attack resource capacity
- Certifications and capacity building
- Faller certification and implications for initial attack

- Changes in crew configuration and impacts on mentorship and training
- Unit crew squads on initial attack fires
- Contract crews

We received 30 responses to this survey.

## Analysis of historical wildfire frequency

To help better understand the impact of reducing the number of crews while maintaining the number of personnel, we looked at the potential workload of initial attack crews using a simple approach of defining workload based on daily new fire starts. In theory all fires will be responded to and controlled by 10 a.m. the day following discovery. We acknowledge that daily new fire starts do not fully reflect workload for IA crews, but this approach provides a snapshot of potential workload, which is the purpose. Certainly new fires are a primary source of workload for IA crews.

### *Fire starts and initial attack load*

We used 36 years of data (1980 to 2015) to identify fire seasons when multiple fire starts occurred within a relatively short period of time. These are not necessarily the busiest years; rather, these are years in which there were high number of fire starts within a 3-day period and provide perspective on potential initial attack workload. From the historical fire data, we sorted and analyzed the frequency of fire starts to determine:

- The busiest day and busiest week by region.
- The maximum number of fire starts in a 7-day period by zone. The combined maximum number of fire starts per fire zone yielded the total fire starts (initial attack workload) by fire centre for that 7-day period.

We also reviewed fire starts in 2009 because several unit crew leaders told us this was a year when unit crew were widely used for initial attack.

## Wildfire simulations

In initial discussions with BCWS personnel and within the project charter, the duties and responsibilities of crew leaders during fire suppression operations were identified as key considerations for developing study methods. During initial attack and sustained fire suppression, a crew leader is responsible for numerous operational and administrative tasks, including:

- Developing strategies and tactics on initial attack incidents and sustained action
- Providing supervision and direction to crew members and other resources (personnel) under their control
- Ensuring that danger tree and other hazard assessments are conducted
- Documenting decisions, actions, and observations in writing and taking pertinent photographs
- Communicating regular and accurate assessments and updates to a regional wildfire coordination centre and/or a zone wildfire coordination officer

Fundamentally, we have assumed that the amount of time a crew leader needs to focus on administrative responsibilities often impedes the leader in directly engaging in crew supervision or suppression activities.

In order to better understand and evaluate the time committed to each of these tasks, we staged wildfire simulations and engaged personnel from IA crews and unit crews to configure as 3-person, 4-person, and 5-person crews to perform an initial attack simulation at the site. During each wildfire simulation, we observed and documented suppression activities, administrative duties, and communications between crew members and with the fire centre. Our objective was to capture time and motion data for crews of different sizes to demonstrate the amount of time that a crew leader dedicates to each activity in order to evaluate how this time allocation might change with a different crew size.

Another objective of the time and motion study was to determine any time savings and to identify efficiencies inherent in one crew size over another. As part of the time and motion study we established simulation rules that identified the simulation end time, which was representative of the time to containment.

Wildfire simulations were conducted in three distinct fuel environments in three geographical areas (Table 2). At each simulation site, we observed and documented the activities of crew members from six crews (two 3-person, two 4-person, and two 5-person).

**Table 2. Wildfire simulation sites**

Region and fire zone	Geographical area	Fuel environment
Southeast (Arrow Fire Zone)	Koch Creek FSR	Interior cedar hemlock
Cariboo (Cariboo/Chilcotin Fire Zone)	Till Lake	Mixed conifer with blowdown from beetle kill
Kamloops (Kamloops Fire Zone)	O'Connor Lake FSR	Open mature Ponderosa pine

Note: FSR = Forest Service Road.

Prior to the simulation, we briefed each crew on the objective of this research component in relation to the overall project goals. We provided the crew with an initial public report, an overview of the fire hazard conditions for the simulated burning day, and simulation rules. With the information provided through the briefing, coupled with a substantial amount of experienced-based imagination, the crew leaders were able to develop a fire scenario that would allow them to realistically perform essential fireline activities and communications. Scouting of the fire scene, fire size-up, hazard tree assessment, fire investigation, and installation of a water delivery system were required elements. Because of a lack of suitable hazardous trees in the simulation site and to eliminate exposure to risk during falling activities, a surrogate activity was incorporated that would require the sawyer to “chap up,” prepare the saw, and make several cuts in a downed log. This activity was standardized to simulate the amount of time required to mitigate a hazardous tree and demonstrate the time that crew leader or member is unable to participate in other fireline activities or communications.

To complement the time and motion data capture, we used a video capture method developed for fireline activities by Parker, Moore, Baille, Pearce & Anderson (2008) in which the crew leader had a GoPro camera attached to his helmet to verify actions and communications that might not be directly observed. We provided GoPro cameras to IA crews from three fire bases with the objective of capturing video and audio during initial attack operations on wildfires. This video was to be used to create a broad base of data to support findings from wildfire simulations. Unfortunately, due to a late project initiation and a slow fire season, crews did not have opportunity to collect video on wildfires.

## RESULTS

### Provincial overview of initial attack crews and unit crews

Initial attack (IA) crews and unit crews are strategically stationed throughout the province to respond to new fire incidents by truck or helicopter and to provide sustained action on more difficult wildfire incidents. British Columbia Wildfire Service operates 138 three-person initial attack crews (Appendix A) and 30 twenty-person unit crews (Appendix B) comprised of approximately 429 and 600 personnel, respectively (British Columbia, 2016).

#### *The changing and unique roles of the crew leader*

Crew leaders with BC Wildfire Service (BCWS) are placed in high-risk, high-consequence emergency situations that demand quick thinking based on training and experience to develop cost-effective response strategies and implement safe suppression tactics. The many fireline roles that the leader often must fill coupled with the increasing administrative and liaison roles place a growing load of responsibility on the leader.

As first responders, initial attack crew leaders are responsible for quickly assessing and communicating fire behaviour potential and the risk to values while also developing a suppression strategy that may include additional aviation and ground-based resources. The decisions that an initial attack crew leader makes have a large impact on initial attack success and financial expenditure. The gravity of this decision-making process is heightened with an expanding wildland-urban interface (WUI) and an increasing number of values on the landscape. Administrative duties; communications with crew members, fire centre and other responding resources; fire size-up; and hazard assessment and mitigation are all critical components of a crew leader's responsibilities.

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IA crews can be amalgamated to form 20-person crews for export to other fire centres or agencies during the shoulder seasons or if fire hazard in their home centre permits their release. Of initial attack leaders that responded to our survey, 74% indicated that they had been deployed as part of a 20-person crew. Resource-sharing agreements provide for the call-back of resources if the fire hazard in the sending agency's region grows to a hazardous level.

Although unit crew leaders have been effectively utilized as first responders to initial attack in several busy fire seasons, their primary firefighting assignments are to sustained action fires. Unit crews have the capability of working as a 20-person crew and also have the leadership capacity to be broken into separate squads for independent assignments on project fires or on initial attack.

The majority of unit crew leaders surveyed indicated that their squad had been utilized for initial attack. However, the expertise that these leaders have developed over time is in developing longer-term strategies on sustained action fires that can effectively utilize the additional human power that the larger crew size provides.

Each of these programs offers unique challenges and opportunities that appeal to people with different temperaments, abilities, and lifestyle choices. A sentiment that was repeated during preliminary interviews is that BCWS firefighting crews have developed expertise in their assigned mode of operation and that this system has been exploited to provide cost-effective initial attack and sustained action crews. Having said that, the capability of both programs to step into job roles of another and perform these satisfactorily is a tremendous asset to BCWS that should be explored and developed to a greater extent.

### *Experience and certifications*

During our initial interviews with BCWS staff, several staff commented on the broad range of experience and certifications across the province within the ranks of IA crew leaders and members. Data provided in the crew leader survey supports this general trend of regional concentrations of experience and certification.

Provincially, the median value for number of years as an IA crew leader (including 2016) was 2 years and the median value for overall total years of fire experience was 7 (Appendix C). In the Southeast region and Kamloops region, the median value for crew leader experience was close to 5 years, with the total years of fire experience per crew leader as high as 8. In contrast, in the Northwest region, these values were 1 year as a crew leader with 5 years of fire experience per crew leader.

The experience base of IA crew members is similar across all regions, with the exception of Prince George, where the experience level for the Bravo (second most experienced) and Charlie (third most experienced) members was somewhat higher at 4 and 2 years, respectively.

The experience base of UC leaders and supervisors appears to be more uniform across the province, with median values for years as crew leader and total years of fire experience per crew leader of 3 and 7 years, respectively. One strong anomaly in this analysis was the median value for total number of years of experience per crew leader in Kamloops, at 14.

A similar trend in certification levels was identified. Provincially, 65% of IA crew leaders have faller certification, with the highest and lowest regional values at 88% and 17% (Appendix E). Two regions (Southeast and Prince George) had a higher percentage of certified fallers than the provincial median.

In spite of an apparent shortage of certified fallers in the initial attack program, 46% of surveyed IA crew leaders indicated that they had not requested additional sawyer support during the 2015 fire season. However, 54% of IA crews requested an additional faller on one or more occasions and a small percentage (7%) of IA crews required sawyer support six or more times.

Provincially, the unit crew program has a similar overall percentage of crew leaders certified as fallers (63%). However, the survey analysis also indicates that, compared to the initial attack program, there is a larger percentage of personnel within the ranks of unit crew member who are certified (Appendix E).

### *Current initial attack crew configurations*

Most BCWS IA crews are currently pre-configured as 3-person crews with a set roster of crew members and crew leader assigned to a crew. However, repeated feedback from crew leaders and Forest Protection Officers during interviews indicated that crew size and roster can often be adapted to respond to several scenarios.

An injury to a crew member can reduce a 3-person crew to a configuration that is not acceptable by BCWS Occupational Safe Work Standard #6. In this case, crews have been reconfigured, with the two remaining personnel assigned to other crews in the zone. As a result, two other crews would become 4-person crews. Similarly, crew members often need to attend to personal commitments, and fire zones can make similar adjustments to crews.

When responding to fires of higher complexity (e.g., WUI, values at risk, multi-jurisdictional), a response officer or successional crew leader may join a 3-person crew to take on the role of Incident Commander 3 (IC3). Including this single resource has the added benefit of allowing the IA crew leader to focus on leading the crew in safe suppression operations.

Several 3-person crews do not have certified fallers. When initial fire observations indicate that saw work is required to remove dangerous trees, a certified faller can be dispatched with the crew. Commonly, 4-person crews are created with the addition of a fourth crew member through the junior forest worker program.

Results from the crew leader survey indicate that a single resource will often join the crew on the incident as a response officer, investigator, or dangerous tree faller, or in another specialized fireline position.

Additionally, 5-person crews have been used when a unit crew squad is dispatched for initial attack on a fire. However, there is some hesitation to deploy a 5-person squad to smaller zone fires (especially when there is potential to be deployed to a larger incident). When one squad is deployed on a small zone fire, the duty days incurred by the squad can put the crew into a situation that might jeopardize the entire crew's opportunity for deployment to a larger incident.

In some regions with volatile fuel types and longer flight time to fires, two 3-person crews can be dispatched during periods of high fire hazard. Dispatching two 3-person crews is more common in areas where a medium-sized helicopter is available.

### *Junior forest worker program*

During initial interviews, BCWS personnel provided several insights into the value of the junior forest worker program to the recruitment of crew members and the retention and progression of these individuals in the firefighting programs. Hiring and retaining local youth in the firefighting programs is often a good solution to recruiting in remote areas that might otherwise have difficulty in filling seasonal positions. Solid and productive relationships have been built with local school systems, which produce good crew members to the initial attack and unit crew programs.

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The value of having a fourth crew member (junior forest worker) is evident during fire operations even if that additional junior member is limited to support work on higher intensity fires when they are not permitted to suppress fire directly. With regard to travel in the initial attack truck and having a junior forest worker join a 4-person crew, IA crew leaders commented that this is “a bit tight but possible.” Dispatches to initial attack targets by helicopter could be problematic with a fifth crew member. However, those IA crews that have a crew member follow up to the fire in the initial attack truck would benefit from having two members follow up in the initial attack truck.

### *Parattack*

The current crew configuration for the Parattack (usually parachuted from a fixed-wing aircraft) crew is three. Discussions with the crew supervisor and jumpers indicated the current deployment method from the aircraft enables the team to configure the crew size to match the complexity of the incident. The aircraft carries a load of equipment and personnel that can be configured “on the fly” based on the fire situation. The flexibility to add to the standard 3-person crew as needed is viewed as an operational benefit enhancing effectiveness. Because of the unique nature of the Parattack operation and the practice of recruiting only experienced firefighters to the program, some of the issues related to lack of experience and certifications are less apparent in the Parattack operations.

### *Rapattack*

In 2016, 50% of the crew leaders in the Rapattack (usually rappelled from a helicopter) program were in their first year in a leadership role. Crew leader survey response suggests the rappel program has one of the lowest levels of leader experience when compared to fire centre locations. Faller certification is a challenge for the rappel program and resulted in two fewer crews being fielded in 2016. Historic use of rappel crews has included constructing helipads for access. Rapattack crew leader survey responses indicated there are a limited number of certified fallers in the program and helipad construction is uncommon.

### *Retention of personnel*

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**Table 3. Attendance at boot camp for recruits to the initial attack crew and unit crew programs**

Fire season	Number of recruits	New recruits as a percentage of seasonal workforce
2006	163	17%
*2007	254	24%
2008	154	15%
2009	133	13%
2010	120	11%
2011	114	11%
2012	194	18%
2013	201	19%
2014	215	21%
2015	223	22%
2016	183	18%

\*Note: In 2007, BCWS added three unit crews provincially and this is reflected in the greater number of recruits. The overall number of seasonal firefighters is 1029 (969 in 2006).

Of initial attack leaders who responded to our survey, 31% (35) indicated that they are currently (2016) in their first year as a crew leader. Of unit crew leaders, 23% (17) indicated that they are in their first year as a unit crew leader.

During initial interviews, BCWS personnel indicated that there was notable transfer of personnel between the initial attack and unit crew programs. The crew leader survey indicates a general trend of greater migration from the initial attack program to the unit crew program. Of the 72 responding unit crew leaders/supervisors, 23 (32%) had previously worked in the initial attack program. Fourteen unit crew leaders had previously worked as an IA crew leader. Of the 112 responding IA crew leaders, 25 (22%) had previously worked in the unit crew program. Nine IA crew leaders had previously worked as a unit crew leader.

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The crew leader and an experienced Bravo are very instrumental in building crew capacity through active training and mentoring of crew members, maintaining good crew morale, and, essentially, developing the firefighting programs at each individual fire zone.

## **Initial attack operations**

### *Helicopter usage in initial attack operations*

Helicopters are an integral component of initial attack operations for the purposes of transporting personnel and fire suppression equipment. Even though helicopter utilization varies by region, water delivery is a universal suppression activity that accounts for a large percentage of helicopter time. Water delivery is achieved either through direct attack on the fire or through indirect means including delivery of Stilwell portable water containers or filling porta tanks.

Through the crew leader survey, 46% of initial attack (IA) crew leaders indicated that they respond to fire starts by helicopter 50% of the time or more. Preliminary analysis of helicopter usage by fire zone suggests that geography is a significant factor in helicopter usage. In mountainous areas with limited road access or larger zones with greater dispatch distance, helicopter usage is greater. In regions with good road access (Kamloops and Cariboo), dispatch by helicopter occurs less than 50% of the time. Naturally, initial attack response by the Rapattack program is by helicopter almost 100% of the time while helicopter response by the Parattack program is minimal (less than 25%). The survey results also indicate that the intermediate helicopter is the most widely used helicopter resource for transport and aerial support.

Depending on fuel type, using a bucket can be more effective than adding additional firefighters. We used a survey to gather information on the use of pump and hose vs. bucketing to test the hypothesis that having a larger crew resulted in more pump and hose use and lower helicopter costs. We could not confirm this either way with our data from survey.

Interviews indicated 800 lb (362 kg) is a typical three-person manifest weight. This weight would include a 3-person crew and firefighting gear. Adding an additional crew member has the potential to increase crew total weight by up to 200 lbs (90 kg) for each person added. Additional weight reduces the helicopter options when crew and equipment are dispatched as one unit, and density altitude becomes a further consideration.

IA crews are trained in hover exit. The maximum dressed crew weight for hover exit is 200 lb (90 kg), and this is the maximum allowable weight for IA crew members. Unit crew members are not trained for hover exit and do not have a weight restriction.

When asked in the crew leader survey about the number of hover exits in 2015, 34% responded zero, 44% fewer than five, and 22% six or more.

### *Use of the initial attack truck*

During initial interviews, crew leaders highlighted the utility of the initial attack truck as more than just a means of transport but as an integral part of suppression strategy and tactics. In dispatches to road-accessed targets, a truck with a water tank provides a tool for getting water to the fire quickly.

IA crews operating in regions with good road networks typically respond to more of their dispatches by initial attack truck. During initial interviews some IA crew leaders in the Kamloops Fire Centre commented that their crew responded to 90% of their fires by initial attack truck. The crew leader survey supports this assertion, with the majority of IA crews in the Cariboo and Kamloops fire centres responding to dispatches by initial attack truck more than 75% of the time. Additionally, some fire zones in the Coastal and Southeast fire centres have a high percentage of initial attack response by initial attack truck.

As part of initial attack responses by helicopter, the initial attack truck is commonly utilized as a supplemental resource in which a crew member will follow up in the initial attack truck while the other crew members travel by helicopter. In the Southeast region, this practice is applied on more than 75% of dispatches by helicopter. This strategy is applied to lesser extents in other regions with limited road access, while the Parattack and Rapattack crew very rarely follow up a dispatch with an initial attack truck for support.

Having the initial attack truck available at a staging area near the fire site provides access to extra equipment and can reduce the amount of helicopter time required to move equipment and personnel. During periods of high fire hazard at high temperatures and especially at altitude, helicopter capacity is reduced. Essential equipment including extra hose and Stilwells can be transported via the initial attack truck and be more quickly available to the crew. In this scenario, a crew member is available at the staging area to prepare sling loads and fill Stilwells. With the initial attack truck available, an IA crew can remain at the fire to extend their suppression activities when the pilots' duty day has ended.

### *Higher-complexity incidents*

Double dispatches for initial attack by helicopter (two crews by helicopter) appear to be infrequent. Almost half of the crew leader survey respondents indicated that their initial attack responses by helicopter are never double dispatches and a solid majority (94%) indicated that less than a quarter of their initial attack dispatches by helicopter would be double dispatches.

Similarly, it is more common for initial attack dispatches by initial attack truck to be a single resource response. Eighty-one percent of respondents indicated that during initial attack dispatches by truck, there could be multiple resources on less than half of these dispatches.

The turnover of initial attack fires from an IA crew to sustained action crews is infrequent. Twenty-two percent of IA crews indicated that they did not turn over any of their fires to sustained action crews, and 89% said that they turn over less than a quarter of their initial attack fires to sustained action crews. Nineteen percent of IA crews call all of their initial attack fires “out,” while 75% of IA crews call most (75% or more) of their fires “out.”

In 2015, 91% of IA crews responded to five or fewer wildland-urban interface fires. On these WUI fires, the IA crew leader acted as incident commander on less than half of these incidents.

## Unit crew operations

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Many zones have bolstered their initial attack capacity by pre-configuring their unit crew squads (UC squads) for initial attack. Unit crew squads are deployed either by truck or, with some consideration to crew weight and hover exit certification, by helicopter.

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The use of UC squads for initial attack is an area we explored in conversation and in our survey. Unit crew firefighters were widely used in the 2009 fire season to support initial attack. In some cases the unit crew members were dispatched in groups as small as three. A barrier for the use of unit crew members is the weight restriction for initial attack and hover exit training. We understand those crew members weighing over 200 lb are not used for helicopter initial attack targets and are segregated for truck dispatch.

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## Scenarios in which all firefighters are treated as the same

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## Safety

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The responses from IA crew leaders and unit crew leaders imply that they are very safety conscious. All leaders expressed concerns regarding safety and crew capacity when sizing up a fire and developing a plan that could be conducted safely. While this does not apply to the same extent to unit crews, Occupational Safe Work Standard #6 was stated as a limiting factor in the type of suppression strategy and activities that are initiated. This is especially applicable to IA crews responding by helicopter and a crew member following up in the initial attack truck. With only two people arriving at the fire, they are often limited to activities such as fire size-up, danger tree assessment (DTA), and scouting for water sources.

During initial interviews and the crew leader survey, leaders commented that the buddy system can enhance safety and increase overall situational awareness. Chainsaw work with a swamper/spotter could improve productivity and enhance safety.

### *Distribution of workload*

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### **Power saw operation/certification**

Qualifications for power saw operators working in BCWS firefighting operations are governed by WorkSafeBC general requirement 26.21. Training standards for falling operations are outlined in WorkSafeBC 26.22.

BCWS is one of three WorkSafeBC designated administrators of the BC Faller Certification Program. The British Columbia Forest Safety Council and Enform are the other two administrators. Through the administrative privileges granted, BCWS delivers chainsaw operator training and certifies operators at three levels (Chainsaw Awareness, Basic Chainsaw Operator, and Faller). Currently, there are 11 Qualified Supervisor Trainers and 24 Qualified Faller Trainers (14 certified) within BCWS ranks. The BC Wildlife Service has targets of expanding the chainsaw training program to maintain a baseline membership of 30 to 40 Qualified Faller Trainers.

Our crew leader survey indicates that there is a greater depth of chainsaw trainers within the unit crew program. Of the 72 responses from unit crew supervisors and leaders, 20 (12.5%) of the personnel from these crews were chainsaw trainers. Of the 112 responses from initial attack leaders, 12 (9.5%) of the personnel from these crews were chainsaw trainers.

With a higher concentration of chainsaw trainers within the unit crew program and a larger crew size, it follows that more unit crew members may have more exposure to a chainsaw trainer with increased training opportunities. Even though the overall provincial inequity in faller trainers between the two programs is modest, this difference can be exacerbated in fire centres with low experience levels at the crew leader level.

Good depth in chainsaw certification within a firefighting crew is also important to satisfy the requirement for a Qualified Assistant. The basic requirements for a Qualified Assistant are to be within 10 minutes response time, have first aid certification, and have first aid supplies. A more subjective requirement for the Qualified Assistant is to be trained and competent.

This level of competence is on something of a sliding scale and dictated by the complexity of a response situation. Hence, there is not a strict certification level that can be applied for all situations.

## Historical fire starts and initial attack workload

### *Periods of peak fire activity*

We sorted and summarized 36 years of fire history to determine, for each fire centre, the periods of peak fire activity with the highest occurrence of new fire starts (Table 4).

**Table 4. Historical analysis of fire starts (1980 to 2015)**

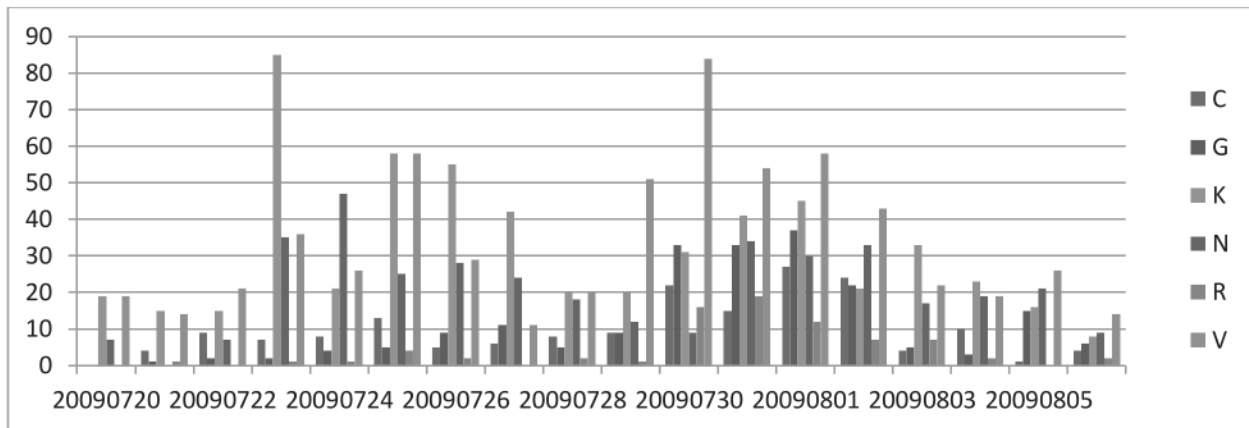
Busiest week and busiest 3-day period, by fire centre				
Fire centre	Time frame	Maximum number of fire starts per fire centre in one day	Maximum number of fires in one zone, over 3 days in this timeframe	Total number of fire centre fires in this week
Coastal	Aug. 8 to 14, 1990	108	107	240
Cariboo	July 30 to Aug. 5, 1992	135	141	290
Prince George	July 22 to 28, 1981	126	154	351
Kamloops	July 31 to Aug. 6, 1994	193	98	466
Southeast	July 31 to Aug. 6, 1994	135	71	377
Northwest	Aug. 10 to 16, 1990	54	43	149

The weeks of August 8 to 14, 1990<sup>1</sup>, and July 31 to August 6, 1994, were the busiest fire start periods between 1980 and 2015. The week of August 8 to 14, 1990, resulted in the most fires in a 7-day period in the Northwest and Coastal fire centres. During the same week, Kamloops managed 199 fires and Prince George 192. The daily provincial fire start totals for August 12, 13, and 14 were 289, 246, and 222, respectively, with a seven day total of 976 fires during the week.

During the week of July 31 to August 6, 1994, 1194 fires occurred provincially, with 466 in Kamloops and 377 in the Southeast (Appendix F). There were 460 new fire starts on August 3 alone. Additional new starts were as follows: August 2, 54; August 3, 460; August 4, 291; August 5, 217; and August 6, 113. In 1994 Kamloops had three zones with more than 80 fires during the week, and the Southeast had one zone with 93 fires.

Between July 22 and July 28, 2009, 865 fires occurred in B.C., and between July 29 and August 6, 2009, 1138 fires occurred (Figure 1). The spikes in fire activity on July 23 and 30 were followed by 2 days of high fire activity.

<sup>1</sup> In the table, the Northwest Fire Centre dates do not match the Coastal Fire Centre dates. Fifteen fires occurred on August 15 and 16, 1990 in the Northwest.



**Figure 1. Fire history analysis for 2009 showing periods of peak fire activity.**

During lightning busts like those experienced in 1990, 1994, and 2009, BCWS initial attack capacity will be challenged. Importing crews through the Canadian Interagency Forest Fire Centre will provide limited relief because imported crews will not meet the faller certification requirements. The use of unit crews and contractors is an option to address the shortfall in initial attack capacity.

In all three periods noted above, there is a 1-day spike with an extreme number of fire starts, followed by 2 days of high numbers of fire starts, followed by a steep reduction. Using those UC squads available for initial attack during a 3-day surge in fire starts could provide the extra response capacity to meet the higher demand. Unit crew leaders indicated that this strategy of dispatching unit crews to initial attack targets was used in 2009 to lessen the impact of high number of fire starts.

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## Analysis of comparative crew productivity

Using the time and motion data for each crew, we documented the overall simulation time and calculated any change in time to containment as a function of crew size (Table 7). We compared only the times for the six crews that participated at a single simulation site. We observed that wildfire simulations of greater size and complexity required a longer completion time for crews of all sizes. The primary factors that impacted the overall time to containment were fire size and the amount of chainsaw work required to mitigate danger trees and to clear downed stems and understory for the fuel-free or hose line surrounding the fire. In one simulation site, there was large quantity of downed stems, and we were able to exploit this feature as a standardized hose line construction for all crews using that site. Access to a water source and the amount of hose to lay (fire size) also had a large impact on the overall time.

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## APPENDIX A: INITIAL ATTACK CREW LOCATIONS

Cariboo Fire Centre (12 crews, 36 personnel)					
Williams Lake	12 crews	36 persons	Forward based as required		
Coastal Fire Centre (19 crews, 60 personnel)					
Cobble Hill	3 crews	10 persons	Powell River	1 crew	3 persons
Errington	3 crews	9 persons	Sechelt	2 crew	6 persons
Haig	4 crews	13 persons	Pemberton	2 crews	6 persons
Quinsam	3 crews	10 persons	Squamish	1 crew	3 persons
Kamloops Fire Centre (37 crews, 123 personnel)					
Kamloops	6 crews	18 persons	Salmon Arm (Rapattack)	10 crews	35 persons
Lillooet	3 crews	10 persons	Vernon	3 crews	10 persons
Merritt	4 crews	13 persons	Clearwater	2 crews	9 persons
Penticton	7 crews	22 persons	Lytton	2 crews	6 persons
Northwest Fire Centre (8 crews, 24 personnel)					
Burns Lake	2 crews	6 persons	Terrace	2 crews	6 persons
Telkwa	2 crews	6 persons	Houston	2 crews	6 persons
Prince George Fire Centre (32 crews, 96 personnel)					
Chetwynd	3 crews	9 persons	Pr. George	5 crews	15 persons
Fort Nelson	4 crews	12 persons	Vanderhoof	4 crews	12 persons
Valemount	3 crews	9 persons	Fort St. John (Parattack)	10 crews	30 persons
Mackenzie (Parattack)		3 crews	9 persons		
Southeast Fire Centre (30 crews <sup>2</sup> , 90 personnel)					
Shoreacres	6 crews	18 persons	Grand Forks	3 crews	9 persons
Cranbrook	5 crews	15 persons	Nelson	4 crews	12 persons
Invermere	4 crews	12 persons	Revelstoke	5 crews	15 persons
Nakusp		3 crews	9 persons		

Note: <sup>1</sup>Southeast Fire Centre had 29 crews but maintained 90 initial attack personnel.

Source: British Columbia, 2016

## APPENDIX B: UNIT CREW LOCATIONS

<b>Cariboo Fire Centre</b> (4 crews)	
Vesta (Williams Lake)	Stormriders (100 Mile House)
Blackwater (Quesnel)	Ravens (Alexis Creek)
<b>Coastal Fire Centre</b> (5 crews)	
Trail Blazers (Haig)	Thunderbirds (Port Alberni)
Heatseekers (D'Arcy)	Fraser (Cultus Lake)
Salish (Mount Currie)	
<b>Kamloops Fire Centre</b> (7 crews)	
Big Horns (Kamloops)	Thunderstrike (Seton Lake)
Fire Devils (Merritt)	Fire Stalkers (Vernon)
Sierras (Princeton)	Nicola Knights (Merritt)
Rattlers (Lytton)	
<b>Northwest Fire Centre</b> (4 crews)	
Firebirds (Terrace)	Rangers (Telkwa)
Rainmakers (Hazelton)	Burns Lake
<b>Prince George Fire Centre</b> (4 crews)	
Rhinos (Fort St. John)	Firehawks (Prince George)
Titans (Vanderhoof)	Mackenzie
<b>Southeast Fire Centre</b> (6 crews)	
Sentinel (Shoreacres)	Valhalla (Shoreacres)
Rocky Mountain (Cranbrook)	Flathead (Cranbrook)
Columbia (Revelstoke)	Monashee (Revelstoke)

Source: British Columbia, 2016

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## APPENDIX D: UNIT CREW EXPERIENCE

Fire centre	Number of crew leaders and supervisors	Crew leader experience		Number of years of fire experience			
		Years as crew leader	Total years of fire experience	Bravo	Charlie	Delta	Echo
Cariboo	10	2	5	4	3	1	1
Southeast	15	2	8	4	3	2	2
Northwest	10	2	6	5	3	3	2
Prince George	12	2	7	4.5	3	1.5	1
Kamloops	11	3	14	6	5	3	2
Coastal	14	3	9	6	6	4	3
<b>Provincial total or median</b>	<b>72</b>	<b>3</b>	<b>7</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>1</b>

Note: Bravo = second most experienced crew member; Charlie = third most experienced; Delta = fourth most experienced; Echo = fifth most experienced.

## APPENDIX E: FALLER CERTIFICATION

Initial attack crews - faller certifications						
	Number of certified fallers/total responses and percentage of total					
Fire centre	initial attack crew leaders		Bravo		Charlie	
	Certifications /total	%	Certifications /total	%	Certifications /total	%
Cariboo	2/10	20	0/10	0	No responses	0
Southeast	22/25	88	6/25	25	1/25	4
Northwest	1/6	17	0/6	0	No responses	0
Prince George	15/20	75	8/20	40	1/20	5
Kamloops	24/30	80	0/30	0	2/30	7
Coastal	9/21	43	1/21	5	0/21	0
Certifications	<b>73/112</b>	<b>65</b>	<b>15/112</b>	<b>13</b>	<b>4/112</b>	<b>4</b>

Notes:

Bravo = second most experienced crew member; Charlie = third most experienced.

Unit crews - faller certifications										
	Number of certified fallers/total responses and percentage of total									
Fire Centre	Unit crew leaders		Bravo		Charlie		Delta		Echo	
	Certifications /total	%	Certifications /total	%	Certifications /total	%	Certifications /total	%	Certifications /total	%
Cariboo	6/10	60	5/10	50	3/10	30	3/10	30	0/10	0
Southeast	12/15	80	2/15	13	1/15	7	0/15	0	0/15	0
Northwest	6/10	60	4/10	40	2/10	20	0/20	0	0/20	0
Prince George	9/12	75	2/12	17	1/12	8	0/12	0	1/12	8
Kamloops	7/11	64	4/11	37	1/11	9	0/11	0	1/11	9
Coastal	5/14	36	7/14	50	6/14	43	1/14	7	3/14	2
<b>Provincial total or average</b>	<b>45/72</b>	<b>63</b>	<b>20/72</b>	<b>28</b>	<b>14/72</b>	<b>19</b>	<b>4/72</b>	<b>6</b>	<b>5/72</b>	<b>7</b>

Notes:

Bravo = second most experienced crew member; Charlie = third most experienced; Delta = fourth most experienced; Echo = fifth most experienced.



## APPENDIX F: FIRE STARTS BY FIRE CENTRE AND FIRE ZONE

July 31 to August 6, 1994 fire starts by fire center and zone			
<b>Cariboo</b>	<b>Total 103</b>	<b>Southeast</b>	<b>Total 377</b>
Zone 1	3	Zone 1	29
Zone 2	8	Zone 2	39
Zone 3	51	Zone 3	43
Zone 4	37	Zone 4	79
Zone 5	4	Zone 5	93
		Zone 6	54
		Zone 7	40
<b>Prince George</b>	<b>Total 113</b>	<b>Northwest</b>	<b>Total 35</b>
Zone 1	66	Zone 1	3
Zone 3	26	Zone 2	4
Zone 4	3	Zone 3	6
Zone 5	9	Zone 4	1
Zone 6	8	Zone 5	20
Zone 9	1	Zone 8	1
<b>Kamloops</b>	<b>Total 466</b>	<b>Coastal</b>	<b>Total 100</b>
Zone 1	115	Zone 1	24
Zone 2	86	Zone 3	22
Zone 3	93	Zone 5	22
Zone 4	63	Zone 6	15
Zone 5	53	Zone 7	5
Zone 6	40	Zone 8	8
Zone 7	16	Zone 9	2
		Zone 10	1

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