

# IABLE OF CONTENTS

	NAY
Executive Summary	1
1. Introduction	2
2. Methods	3
3. Results	4
3.1 A Note on Perspective	4
3.2 Reflections on Unexpected Fire Behavior over Time	5
3.3 Reflections on more Recent Observations of Unexpected	
Fire Behavior	6
3.4 Implications for Future Wildfire Management	8
4. Discussion	10
4.1 Identifying Observations of Unexpected Fire Behavior	11/
4.2 Identifying Factors Influencing Recruitment and Retention	1 /12
4.3 Identifying Opportunities for the Preservation and	
Inter-generational Transfer of Knowledge	13
5. Conclusion	14
References	15



REPORTS OF INCREASED WILDFIRE ACTIVITY throughout much of the US during the last several decades have prompted recent research into observations of unexpected fire behavior in an effort to help inform firefighter education and training, fire management, and public awareness. Building on that work, the following report presents findings from a series of semi-structured interviews with 31 senior career and retired wildland firefighters that explore their reflections on observations of unexpected fire behavior over a longer timeframe, the 34 to 50+ years of their respective careers. The motivation for this project has been to work toward understanding whether observations of unexpected fire behavior should be anticipated to occur more frequently given the reported increase in wildfire activity, and if there are associated implications for fire management. A grounded theory approach was used to analyze the interview data. Findings from that analysis include:

- 1) observations of unexpected fire behavior are not necessarily uncommon, especially in earlier career firefighting, yet should largely be preempted through education and training;
- 2) the cumulative effects of climatic and environmental change, fire suppression and lack of fuels management, and growth of the wildland-urban interface (WUI) can shape wildfire in ways that may be influencing the perceptions of earlier career firefighters with respect to the unexpected; and
- 3) the decline in recruitment and retention of earlier career firefighters coincident to the retirement of senior career firefighters poses challenges to future fire management and the preservation and inter-generational transfer of experiential knowledge, including that which may help explain unexpected fire behavior.

Given the anticipated continuation of these trends — both in cumulative effects and in decline in recruitment and retention — we suggest the development of new research as well as the expansion of recent research to help identify: 1) observations of unexpected fire behavior that result in surprise for earlier career firefighters to help inform education and training; 2) factors influencing earlier career firefighter recruitment and retention to generate recommendations for sustaining and/or growing the workforce; and 3) opportunities for the preservation and inter-generational transfer of experiential knowledge under changing conditions and as senior career firefighters retire.

## 1. INTRODUCTION

#### THERE IS A LONG-ACKNOWLEDGED

understanding that experience is among the primary factors that shape firefighter expectations of fire behavior, and that response to the unexpected, though often reactionary, becomes integrated into the evolution of strategies and operational tactics then applied over time (see Burrows 1984; Moriarty et al. 2019). Given the reported increase in wildfire activity throughout much of the US during the last decades - including in area burned, number of large fires, and fire season length (Abatzoglou and Williams 2016; An et al. 2015; Barbero et al. 2015) — recently researchers have turned attention to exploring wildland firefighter observations of unexpected fire behavior, and relatedly, changes in strategic or operational response (Moriarty et al. 2019; Wall et al. 2018). Despite the salience of experience in shaping expectations of fire behavior (see Burrows 1984), such work nonetheless has the potential to help inform firefighter education and training (e.g., by identifying gaps in knowledge and/or training), fire management (e.g., by identifying changes in, or the need for changes in, strategies and operational tactics), and public awareness (e.g., by informing officials and the public of what to expect) (see Moriarty et al. 2019; Wall et al. 2018). The present study is a continuation

of a specific contribution within that work, wherein Wall et al. (2018) examined 227 narratives from wildland firefighters about their observations of unexpected fire behavior, finding that about half (52%) were perceived to have resulted from weatherrelated drivers, almost two-thirds (65%) of which were wind. Noting the frequency with which firefighters reported observations of unexpected fire behavior during that project (see Wall et al. 2018), the motivation for this study has been to explore the notion of "surprise," or the unexpected, over a longer timeframe. Of particular interest has been to understand whether observations of unexpected fire behavior should be anticipated to occur more frequently given the reported increase in wildfire activity, and if there are associated implications for fire management. As such, here we rely on a series of semi-structured interviews with 31 senior career and retired wildland firefighters that explore their reflections on observations of unexpected fire behavior over the past 34 to 50+ years, representing either the current or full duration of their respective careers. Following, we introduce the methods used to elicit interviewee reflections on observations of unexpected fire behavior before presenting the findings and elaborating future directions of research.



## 2. METHODS

To explore reflections on observations of unexpected fire behavior over a longer timeframe, we conducted semi-structured interviews with 31 senior career and retired wildland firefighters with between 34 and 50+ years of experience. All interviewees had worked on fires throughout much of the contiguous US 48 states, and in several instances, in Alaska and internationally. At the time of the project, however, the interviewees were either stationed or had retired in the following geographic areas: Northern Rocky Mountains (14), southeastern (8), upper midwestern (4), and western (3) states, and Alaska (2). The interviews were conducted either in-person or by phone,

audio-recorded, and transcribed. We then uploaded the interview transcripts into the qualitative analysis software application Dedoose and, following a grounded-theory approach, used in-vivo coding techniques to identify emergent themes (e.g., climatic and environmental change can shape wildfire in ways that may influence the perceptions of earlier career firefighters) and patterns therein (e.g., longer fire seasons, shorter fire return intervals, higher nighttime temperatures, ...) (Bernard 2006; Ryan and Bernard 2003).

In what follows, we describe the themes and patterns identified.







#### 3. RESULTS

#### 3.1 A Note on Perspective

"Just a few days ago, I was reading an article over my days off about the start of the 1910 fires. There's been no event in my 43 years [of firefighting] that compared to what occurred that year. So it'd be hard to say that in my short time snapshot, in the time of my career, that there's a significant difference in the context of what happened in 1910."

-SENIOR CAREER WILDLAND FIREFIGHTER

The senior career and retired wildland firefighters interviewed for this project have tremendous depth and breadth of knowledge and experience. Most interviewees began their careers in their late teens or early twenties, have occupied numerous positions within fire management and, as mentioned, have worked throughout much of the contiguous US 48 states if not also in Alaska and internationally. That depth and breadth notwithstanding, the interviewees were cautious to note that the reflections shared capture only a small window of US and North American fire history (see also Doerr and Santín 2016). The importance of this caution regarding observations of unexpected fire behavior merits antecedent attention due to the degree to which it was emphasized by interviewees and for highlighting the temporal limitations of what follows.

"At the dawn of time [recalling first fire season], it feels like that anyway, 1957, and was on a Del Rosa Hotshot Crew out of San Bernardino, California, and got to watch and participate in a lot of interesting fire control activities. Then I worked summers, I was an engine boss in California. Sometime along that time I figure out that I was having a lot of fun, but in 20 or 30 years maybe my body wouldn't be able to run up and down mountainsides like I could then. I figured I'd better maybe go back to school and get re-treaded a bit. So, I went to grad school, Montana, and got a degree in fire science. [...] Then when I graduated, wasn't sure where I wanted to go, but one of my mentors at the Missoula Fire Lab told me, 'You know, you take a job in the South, you can burn all year long, whereas if you take a job in California, or anyplace north of the Mason Dixon line, for example, you can't burn in the winter or during the drought season.' So I opted for burning all year long and took a job down in the South, spent the next 45 or 50 years [there], retiring in 2003."

# 3.2 Reflections on Unexpected Fire Behavior over Time

"I know at Yellowstone [1988] it was like, wow, we had never seen fire behave like this before. You go back through, it just seems like whenever there's a really big fire event — wow, we've never seen this before."

-SENIOR CAREER WILDLAND FIREFIGHTER

Most interviewees recalled serving on fires in decades past where they observed unexpected fire behavior, explaining that it was not uncommon for firefighters to make such observations over the course of their careers as they gained experience in different geographic regions and on different types of fire. As an example, several interviewees recalled making statements similar to the above not only about the 1988 Yellowstone but also about more recent fires, among them, Monument (2011), Chimney Tops 2 (2016), Tubbs (2017), and Roosevelt (2018); in one example:

"All the locals told us that we didn't have to worry about it, that fire would not come down out of the sky islands and threaten the towns there along the foothills. About every other day it did, it came out of a different canyon [...]. Then we'd get it corralled and make a little progress for a day or two and then it'd blow out another canyon. We finally got it corralled and for that I'm thankful, but I saw fire behavior there that I'd never seen before, and the fire behavior fooled everyone, including the locals that had been there for decades [2011 Monument Fire]."

Yet the interviewees suggested that, in theory, given adequate training and preparedness, fire behavior should not be unexpected. They therefore emphasized that when observations of unexpected fire behavior do occur, explanations can and should be sought, for example by way of the experiential knowledge of more senior firefighters:

"Even one back, way back, 1960. I was just a second-year fireman, but we had a fire outside of Idaho City, and half of these fires, I can't remember their names anymore [...] but anyway, that one, I saw a whole canyon, that was the first time that I had ever seen an entire canyon explode. And I mean literally explode. It was a pool of gases in there, and when it went the whole thing just went 'whoosh.' I've never seen anything before or since quite like it. I've heard about that, but I'd never seen it and I saw it that day and it is scary. Our foreman, who was a pretty moxie fire guy, had pulled us out of there probably 15 minutes before that happened, and there was no reason nobody told him to pull out, it was just he said, 'I'm getting a bad feeling about this.' He said, 'It might be we ought to get up to the ridge and get out of here.' So we did, and we just barely got to the ridge when that whole thing just literally exploded. Within three seconds that whole canyon was on fire."

"That one has always hit me like nails on a chalkboard. It's like no, it's not unexpected. That's exactly how that fuel profile on that piece of ground with that atmosphere over it is going to behave. It's not unexpected at all. Now, if the individual says, 'This isn't in my slide tray,' then that's an experience problem. And in the years I've been doing this, and I've been a qualified FBAN [Fire Behavior Analyst] since '97, and I've always grated at that business of, 'Well, this unexpected wind, this unexpected behavior, and we've never seen anything like that.' And my answer to that is, 'Well, you may be telling the truth, but you were surrounded

by people that have seen that before [and] you didn't ask them about it.'"

Beyond their general consensus about the normalcy (yet explicability) of observations of unexpected fire behavior, the interviewees also suggested that the cumulative effects of climatic and environmental change, fire suppression and lack of fuels management, and growth of the wildland-urban interface (WUI) can shape wildfire in ways that may be influencing the perceptions of earlier career firefighters today, as described below.

#### 3.3 Reflections on more Recent Observations of Unexpected Fire Behavior

"I think what we're seeing is a cumulative effect of a lot of things. Number one has to be climate change. There is no doubt in my mind that we are changing the climate [...]. It's warmer, drier, longer seasons, more fuel build-up. That's my number one reason we're seeing these larger fires. The second one is you have to look at the wildland-urban interface because that changes our tactics."

-SENIOR CAREER WILDLAND FIREFIGHTER

As indicated above, the interviewees also suggested that the cumulative effects of climatic and environmental change, fire suppression and lack of fuels management, and growth of the WUI can shape wildfire in ways that may be influencing the perceptions of earlier career firefighters. For example, with respect to climatic and environmental change, the interviewees noted longer fire seasons, shorter fire return intervals, longer and more frequent periods of drought, higher nighttime temperatures, reductions in mass grazing, increased fuel buildup from insect activity (e.g., beetle kill), introduction of invasive plants (e.g. cheatgrass), and associated changes in fuel regimes as contributing to frequent, large, and sometimes fast growing fires. Regarding fire suppression and lack of fuels management, the interviewees commented on the combination of fuel loading, low fuel moisture levels, and critical fire weather in accelerating rates of spread and fire intensity and growth. Finally, with respect to growth of the WUI, they noted the encroachment of housing developments and related structures in wooded areas as increasing the risk of wildfire starts and forcing changes in wildfire strategies and operational tactics. As one interviewee explained, "It's that we're now seeing the results of this fuel buildup and the influx of people, which have made the problem very problematic because we spend more time trying to protect structures than we do putting out the fire, which means that the fire continues to roar by as we're saving houses that shouldn't have been built there in the first place."

It should also be noted, however, that despite their general consensus that the above cumulative effects may be influencing the perceptions of earlier career firefighters, several interviewees again cautioned that any changes observed over the course of their careers are limited in time and perspective relative to the history of fire that has preceded them, as in one example:

"I think our fires have responded to the worsening of the conditions under which they occur. So, there's that many more dead trees on the landscape providing that much more fuel. If you subscribe to more intense Santa Ana [i.e., southern California offshore wind] events due to climate change, then certainly more wind leads to an increase in tempo. So, the fire itself probably hasn't changed a lot [but] the variables going into it have. And whether that's a trend or just cyclic, I don't pretend to know."

Some interviewees additionally cautioned that numerous variables can factor in shaping wildfire and, relatedly, perceptions thereof. One example they provided is of the generalized shift toward indirect attack over the last decades to increase firefighter safety, namely by way of the "big box" approach which can result in large fire growth and accordingly may influence perception:

"It's not uncommon for us to take a 40,000-acre fire and make it 100,000 acres. And we do that by backing off and building a box around it. A big box, that's a safe box. And I think that's where we're seeing a lot of the growth in our fires is because we're not tolerating unsafe conditions. [...] We started seeing that coming about after South Canyon and a slow migration in that direction [i.e., distancing from the fire line]. We saw South Canyon, we saw the Cramer Fire [...] where we had multiple fatalities and people start saying, 'No, we're too close.' [...] So we started moving away from that saying, 'We really don't need to be on that ridge at this time. We need to be four ridges back. So if it does blow up, it's still got two days before it touches us, and we don't have any problem."

For this reason, again, the above cumulative effects should not be interpreted as exhaustive. These effects may influence the perceptions of firefighters for their noted role in contributing to frequent, large, and sometimes fast-growing fires, but among other potential variables. The surest way to verify these suggested and other potential influencing factors is likely through direct study of the circumstances and/or conditions in which observations of unexpected fire behavior occur (see Section 4.1). The implications of the above effects for fire management are described in conjunction with related concerns the interviewees expressed about the decrease in recruitment and retention of earlier career firefighters, below.

#### 3.4 Implications for Future Wildfire Management

"We've got to be smart with how we're planning projects in the future and making sure that we're putting the right burns in place and making them a priority. The suppression, because it's an emergency, is always a priority, but we've got to get to a point where those prescribed fire projects can be at as equal priority to the agency as the suppression is, and we're not there. I don't know that we'll ever get there, but we certainly have some room that we can move in, that we need to move in that direction."

-SENIOR CAREER WILDLAND FIREFIGHTER

There was consensus among interviewees that the trends of climatic and environmental change, suppression and lack of fuels management, and growth of the WUI will likely continue into the near future. Given the challenges associated with abating the first and third of these, most interviewees stressed the need for increased fuels management, whether it be through opportunistic use of wildfire, mechanical treatment, or prescribed burns. Regarding the latter, it was noted that a substantial increase in prescribed fire could reduce fire-free intervals and the potential for wildfire damage, make fire suppression safer (and likely) easier, and provide earlier career firefighters with important opportunities to gain additional experience and knowledge. Interviewees also acknowledged, however, that resource and personnel availability, public policy and acceptance of prescribed fire, and changes in fuel type can present obstacles to fuel management. In one example, "We know that things have to burn. We know that. The problem is in most of the fuel types, they've gone too far. They're not the same fuel type and you're not going to run a low-intensity vacuum fire through those. You simply can't do it."

Beyond their discussion of those obstacles, several interviewees also expressed concern about the decline in recruitment and retention of earlier career firefighters, not only at a time when the conditions of wildfire may be changing but also at a time when many later career firefighters are retiring, resulting in an overall reduction in personnel and risking loss of experiential knowledge in transition. As one interviewee explained: "A lot of folks are retiring [and] the folks starting to retire now aren't even the ones that had the most experience. We've already lost the majority of those people. There's just a handful left. I'm just giving you an example, at one point, in our region, just in the Southeast, we had nearly 100 Type I burn bosses. We're down to less than ten." Several of the interviewees themselves and/or their colleagues were even retired then returned to work when vacant higher-level management positions began to go unfilled; in one example: "I've got a Type I Team, and right now I'm running my finance shop. The chiefs are both retirees, and one's been retired for over ten years. I don't know how much longer that's going to be an option. We've got to come up with some fixes along those lines if we're going to survive."

Some speculated that the decline may be related to a lack of interest among younger generations in career wildland firefighting, a reluctance to assume additional responsibilities in the case of advancement (and potential liabilities, particularly with growth of the WUI), and a desire for work-life balance which is increasingly difficult to maintain under longer fire seasons. As one interviewee explained, "Our pool of resources are continually shrinking, which is forcing us to have to disband teams or a reduction in teams across the nation at the Type I and II level. When you consider work-life balance, work-rest ratios, etc., and longer seasons and you know, employee burnout, I don't think we're doing anything proactively to fix the situation at a national level." Following we summarize the above results against the existing literature and offer ideas for the expansion of recent and the development of new research to further explore and better understand those results.

"And then after I joined Anchorage Fire Department, we had some memorable fires in and around the Anchorage area. I skipped another memorable fire I meant to mention there, and that was the Miller's Reach Fire, which was in 1996, and that fire ended up being one of the worst urban interface fires of modern times here. Burned about 400 structures, and of course there was concern for loss of life, and because it was a wildland-urban interface fire, many evacuations, and at that time people were well aware that we couldn't force them to leave so we had a lot of folks that stayed within the fire perimeter and very close calls. [...] There was a class action lawsuit by most of the residents out there that lost property, formed a class action and sued the State of Alaska. [...] Probably the most meaningful thing about that incident in the court, we were in court for nine weeks for that trial and the weather meteorologist, the fire weather guy we had subpoenaed as a witness, he testified on our behalf about the unforecasted gap winds that caused that fire to, it was actually knocked down, not fully contained, but when it took off again [it] burned about 36,000 acres. It went from 60 acres to 36,000 in like three days."



# 4. DISCUSSION

Given the long-acknowledged salience of experience in shaping expectations of fire behavior (see Burrows 1984), it should not be surprising that observations of unexpected fire behavior occur, especially in earlier career firefighting. For example, as Gisborne noted in the 1948 Fundamentals of Fire Behavior: "If you have fought fires in every different fuel type, under all possible kinds of weather, and if you have remembered exactly what happened in each of these combinations, your experienced judgment is probably very good. But if you have not fought all sizes of fires in all kinds of fuel types under all kinds of weather, then your experience does not include knowledge of all the conditions." Similarly, the cumulative effects of climatic and environmental change, fire suppression and lack of fuels management, and growth of the WUI that interviewees noted as shaping the frequency, size, and spread/growth of wildfire have been documented (e.g., Davies et al. 2015; Hicke et al. 2012; Pausas and Fernández-Muñoz 2012; Rocca et al. 2014; Taylor et al. 2013; Tiribelli et al. 2018; Wade et al. 2015). Increasingly, too, there is documentation of the national decline in wildland firefighter recruitment and retention, with emphasis on the 10% drop in non-career personnel over the last decade (Greene and Hendershot 2017). Still, given the anticipated continuation of these trends — both in cumulative effects and in decline in recruitment and retention — we suggest the expansion of recent and the development of new research that will help to identify: 1) observations of unexpected fire behavior that result in surprise for earlier career firefighters to help inform education and training; 2) factors influencing earlier career firefighter recruitment and retention to sustain and/or grow the workforce; and 3) opportunities for the preservation and inter-generational transfer of experiential knowledge to earlier career firefighters under changing conditions and as senior career firefighters retire.



#### 4.1 Identifying Observations of Unexpected Fire Behavior

To understand specifically which aspects of fire behavior are observed as unexpected and/ or result in surprise, we recommend further research that addresses this topic directly with earlier career firefighters. This research should be interdisciplinary and could explore firefighter surprise open-endedly across a particular fire season or career-level(s) as a means of broad inquiry and pattern-seeking (e.g., Wall et al. 2018). It could also explore firefighter surprise by way of case study of one or more specific fires, geographic regions, forest types, and/or novel fire environments (e.g., changes in vegetation mat associated with melting permafrost in Alaska) as a means of specific inquiry and pattern-seeking (e.g., Moriarty et al. 2019). In an example of broad inquiry, again, Wall et al. (2018) examined 227 firefighter observations of unexpected fire behavior, finding that about half of these were perceived to have resulted from weather-related drivers, almost two-thirds of which were wind. In an example of specific inquiry, Moriarty et al. (2019) examined firefighter observations of unexpected fire behavior and resulting changes in fire suppression tactics in lodgepole pine forests following pine beetle outbreak. The findings included observations of: 1) elevated levels of spread and intensity under moderate weather and fuel moisture conditions, increased spotting, and faster surface-to-crown fire transitions with limited or no ladder fuels during the red phase, and 2) short periods of crown ignition and crown fire propagation during the gray phrase (Moriarty et al. 2019). The findings also included changes to suppression tactics, namely the use of indirect methods due to the potential fire behavior and tree-fall hazards (Moriarty et al. 2019). Despite the previously noted salience of experience in shaping expectations of fire behavior (see Burrows 1984), such studies nonetheless offer valuable insights that may be used to inform firefighter education and training (e.g., by identifying potential gaps in knowledge and/or training), fire management (e.g., by identifying changes in, or the need for changes in, strategies and operational tactics), and public awareness (e.g., by informing officials and general public of what to expect) (see Moriarty et al. 2019; Wall et al. 2018). For example, Wall et al. (2018), suggested that enhanced dissemination of accurate, real-time weather information may help improve risk mitigation. Moriarty et al. (2019) suggested that following pine beetle outbreak, firefighters may be more likely to see active fire behavior in varied fire weather and fuel moisture conditions as opposed to only critically dry and windy conditions, and across pine beetle attack phases.

#### 4.2 Identifying Factors Influencing Recruitment and Retention

As stated, recently researchers have given increased attention to the national decline in firefighter recruitment and retention, with emphasis on understanding this trend among non-career firefighters within specific agencies (Cote et al. 2014; Decremer 2018; Greene and Hendershot 2017). Findings from that work include a number of influencing factors, for example, an overall decrease in volunteerism within the US, family obligations and changes in social and family demographics, training requirements and level of responsibility, differences in firefighter expectations and occupational actualities, and budgetary and legislative restrictions (Cote et al. 2014; Decremer 2018; Greene and Hendershot 2017; Howard 2007). Additional research in recruitment and retention should seek and be tailored to meet the information needs of interested fire agencies but could include a synthesis of the lessons learned across existing non-career, agency-specific studies to identify potential patterns or trends in recruitment and retention therein. Other research could move beyond examination of recruitment and retention among non-career firefighters to include their career counterparts within and/or across particular agencies and/or geographic regions. Comparative studies could be conducted to identify potential similarities and differences in the factors influencing recruitment and retention for noncareer and career firefighters, earlier and more senior career firefighters, and agencies and/or geographic regions to better understand the degree to which recommendations for increasing recruitment and retention may be generalizable. A longitudinal study could also provide insight into potential changes in factors influencing firefighter recruitment and retention over time. Any of these efforts promises to generate recommendations for improving the effectiveness of recruitment and retention (see Cote et al. 2014; Decremer 2018; Greene and Hendershot 2017; Howard 2007) but, again, should seek and be tailored to meet the specific information needs of interested fire agencies.



# 4.3 Identifying Opportunities for the Preservation and Inter-generational Transfer of Knowledge

There is already a substantial body of research on methods for the preservation and inter-generational transfer of experiential knowledge within different industries and economic sectors, including energy, natural resource management, weather forecasting, and occupational health and safety (Boiral 2002; Hoffman et al. 2005; Podgórski 2010; Rintala and Hyttinen 2006). These works could serve as a starting point for exploring whether and how the same and/or other methods may be adapted to the preservation and inter-generational transfer of experiential knowledge within fire agencies as relevant and to the extent that such methods are not already in place. Further, as noted by one interviewee, an increase in prescribed fire could create important opportunities for earlier career firefighter learning. Regardless of the form the transfer of knowledge takes, whether through the adaptation of existing or development of new methods, it should be done in close collaboration with participating fire agencies to ensure that the methods chosen are appropriate to and meet the requirements of those involved. Once implemented, the methods should also be evaluated and modified iteratively as needed, again, to ensure the above.



## 5. CONCLUSION

This report presents the findings from 31 semi-structured interviews with senior career and retired wildland firefighters that explore their reflections on observations of unexpected fire behavior over the past 34 to 50+ years, representing either the current or full duration of their respective careers. The motivation for this study has been to understand whether observations of unexpected fire behavior should be anticipated to occur more frequently given the reported increase in wildfire activity throughout much of the US, and if there are associated implications for fire management. Overall, the findings align with the current literature in suggesting the following. Experience is among the primary factors that shape firefighter expectations of fire behavior (e.g., Burrows 1984; Moriarty et al. 2019), but interviewees considered that observations of unexpected fire behavior should largely be preempted through education and training (see also Wall et al. 2018). The cumulative effects of climatic and environmental change, fire suppression and lack of fuels management, and growth of the WUI, among other factors, can shape the frequency, size, and spread/growth of wildfire (e.g., Abatzoglou and Williams 2016), with interviewees adding that this may be influencing the perceptions of earlier career firefighters and their observations of unexpected fire behavior. There is a national decline in recruitment and retention of firefighters (e.g., Greene and Hendershot 2017) which, interviewees noted, combined with the retirement of more senior career firefighters, poses challenges to future fire management, namely, the filling of rosters and preservation and inter-generational transfer of experiential knowledge. Based on these findings, we propose three areas of research that may help fire agencies address some of the above-noted trends as they are anticipated to continue into the future. These are to identify: 1) observations of unexpected fire behavior that result in surprise for earlier career firefighters to help inform education and training; 2) factors influencing earlier career firefighter recruitment and retention to generate recommendations for sustaining and/ or increasing the workforce; and 3) opportunities for the preservation and inter-generational transfer of experiential knowledge to earlier career firefighters under changing conditions and as senior career firefighters retire.



# **REFERENCES**

- Abatzoglou, J. T., & Williams, A. P. (2016). Impact of anthropogenic climate change on wildfire across western US forests. Proceedings of the National Academy of Sciences of the United States of America, 113(42), 11770-11775. doi:10.1073/pnas.1607171113
- An, H., Gan, J. B., & Cho, S. J. (2015). Assessing Climate Change Impacts on Wildfire Risk in the United States. Forests, 6(9), 3197-3211. doi:10.3390/f6093197
- Barbero, R., Abatzoglou, J. T., Larkin, N. K., Kolden, C. A., & Stocks, B. (2015). Climate change presents increased potential for very large fires in the contiguous United States. *International Journal of Wildland Fire*, 24(7), 892-899. doi:10.1071/wf15083
- Bernard, R. H. (2006). Research Methods in Anthropology: Qualitative and Quantitative Approaches. Lanham, MD: AltaMira Press.
- Boiral, O. (2002). Tacit knowledge and environmental management. Long range planning, 35(3), 291-317.
- Cote, M., Hasskamp, B., Chevuru, P., & Verma, M. (2014). Empty Boots, Quiet Sirens: The State of Non-Career Firefighting in Minnesota. Report prepared for the Minnesota State Fire Chiefs Association, p. 89. Available: https://conservancy.umn.edu/bitstream/handle/11299/172516/Hasskamp\_etal\_Firefighting.pdf?sequence=1.
- Davies, K. W., Boyd, C. S., Bates, J. D., & Hulet, A. (2015). Dormant season grazing may decrease wildfire probability by increasing fuel moisture and reducing fuel amount and continuity.

  International Journal of Wildland Fire, 24(6), 849-856.
- Decremer, J. (2018). Improving Recruitment and Retention of Volunteer Firefighters.

  Doctoral dissertation, Walden University, p. 141. Available: https://scholarworks.

  waldenu.edu/cgi/viewcontent.

  cgi?article=6455&context=dissertations.

- Doerr, S. H., & Santín, C. (2016). Global trends in wildfire and its impacts: perceptions versus realities in a changing world. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 371(1696), 20150345.
- Greene, D. A., & Hendershot, M. E. (2017).

  Exploring the Retention Calculus: The Motives,
  Expectations, and Satisfaction of South
  Carolina Volunteer Firefighters. International
  Fire Service Journal of Leadership & Management
  (11), 27-39.
- Hicke, J. A., Johnson, M. C., Hayes, J. L., & Preisler, H. K. (2012). Effects of bark beetle-caused tree mortality on wildfire. Forest Ecology and Management, 271, 81-90.
- Howard, P. S. (2007). The Impact of Firefighter Retention Rates in the Beach Park Fire. Report prepared for the Beach Park Fire Department, p. 58. Available: https://pdfs.semanticscholar.org/31a1/ e2ae61befba5be7c2100d6ba23c2a2333a2f. pdf.
- Moriarty, K., Cheng, A.S., Hoffman, C.M., Cottrell, S.P., & Alexander, M.E. (2019). Firefighter Observations of "Surprising" Fire Behavior in Moutain Pine Beetle-Attacked Lodgepole Pine Forests. Fire, 2(34), https://doi.org/10.3390/fire2020034
- Pausas, J. G., & Fernández-Muñoz, S. (2012). Fire regime changes in the Western Mediterranean Basin: from fuel-limited to drought-driven fire regime. *Climatic Change*, 110(1-2), 215-226.
- Rintala, N., & Hyttinen, L. (2006). Methods for sharing tacit nuclear knowledge and expertise. International Journal of Nuclear Knowledge Management, 2(1), 38-45.
- Rocca, M. E., Brown, P. M., MacDonald, L. H., & Carrico, C. M. (2014). Climate change impacts on fire regimes and key ecosystem services in Rocky Mountain forests. *Forest Ecology and Management*, 327, 290-305. doi:10.1016/j. foreco.2014.04.005

## **REFERENCES**

Ryan, G. W., & Bernard, H. R. (2003). Techniques to identify themes. *Field methods*, 15(1), 85-109.

Taylor, M. H., Rollins, K., Kobayashi, M., & Tausch, R. J. (2013). The economics of fuel management: Wildfire, invasive plants, and the dynamics of sagebrush rangelands in the western United States. *Journal of Environmental Management*, 126, 157-173.

Tiribelli, F., Kitzberger, T., & Morales, J. M. (2018).

Changes in vegetation structure and fuel characteristics along post-fire succession promote alternative stable states and positive fire-vegetation feedbacks. *Journal of Vegetation Science*, 29(2), 147-156.

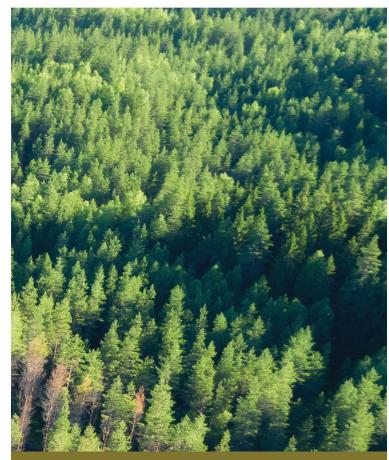
Wade, D., Miller, S.R., & Underwood, R.J. (2015).
The Need for Appropriate Fire Regimes
and a Pathway Forward. In B. Leblon and
M.E. Alexander (Eds.), Current International
Perspectives on Wildland Fire, Mankind and
the Environment (pp. 1-65). New York: Nova
Science Publishers, Inc.

Wall, T., Brown, T., & Nauslar, N. (2018). Fire Stories: Understanding Wildland Firefighters' Perceptions of Unpredictable and Extreme Fire Behavior. Desert Research Institute: Reno, NV, p. 27.









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